Center for Teaching Old Models New Tricks (TOMNET)

A USDOT Tier 1 University Transportation Center

PROJECT PROPOSAL

Title: Consumer Attitudes and Behavioral Implications in the New Era of Shared Mobility

Principal Investigator:
Zhongju Zhang, Associate Professor, W. P. Carey School of Business, ASU.

Co-Principal Investigator (if applicable):
Daoqin Tong, Associate Professor, School of Geographical Sciences and Urban Planning, ASU.

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1. Introduction/Problem Statement (1 page)

In the last few years, the concept of *platform-based sharing economy* has received tremendous attention (Sundararajan, 2016). This concept is mainly made possible by digital platforms that leverage advanced technologies (e.g., smartphones, GPS, integrated payment systems) to connect the demand and supply for a particular product or service in an efficient and cost effective manner. One such innovative use case is in the transportation industry where *on-demand shared mobility*—the real-time shared use of a vehicle, bicycle, or other transportation mode—is having transformative impacts on travelers' attitudes, mobility choices, and behavioral responses to a wide range of daily activities. Rayle et al. (2014) conduct a survey and find that ride-share fulfills an unserved demand for convenient, point-to-point urban travel; users of ride-share tend to be younger and own fewer vehicles. The American Public Transportation Association published a report[1] in 2016, highlighting that people who use a shared form of transportation (bike-sharing, car-sharing, or ride-sharing service) drive less, own fewer cars, and spend less on transportation overall. The number of vehicles on the road could also decrease due to shared mobility options (Alonso-Mora et al. 2017). This, along with higher vehicle occupancy levels (Hall et al., 2017), increased vehicle utilization (Cramer and Krueger, 2016), and increased public transit usage (Barbar and Burtch, 2017), can serve as important solutions to reducing traffic congestion in urban areas (Li et al., 2018).

Among the shared mobility applications, *dockless bike-sharing services* suddenly became popular in 2017 (Qi et al., 2018). A few companies have recently started operating in many cities across the United States. Unlike traditional dock-based bike rent/share programs, services offered by these companies do not require city funding or sponsorship for their infrastructure or operational management. Dockless bike share offers a flexible, low-cost, and alternative mode of transportation. A customer of the dockless bike share service uses a smart phone app to locate and unlock a bike nearby and rides it to the destination where he/she parks and locks the bike, making the bike available for other customers to use. While such a shared mobility application has a great potential to improve the efficiency of short-distance urban travel and create a positive impact on the community and environment, there is little research on the *attitudes, perceptions, and preferences* of user's mobility choices toward dockless bike share and the *associated impacts* on other modes of transportation as well as the local economy.

In this proposed research, we use the *dockless bike-sharing services introduced by Lime (formerly LimeBike)* to examine these important research questions. Lime is an American transportation company that runs dock free pedal bikes, e-assist bikes, and electric scooters in various cities. Founded in January 2017, Lime has launched services in over 70 markets across the United States. It started operations in the City of Scottsdale in November 2017. Since its introduction in Scottsdale, the adoption of Lime bikes is rapid and the usage is steadily increasing. According to a 2018 City of Scottsdale Council Report,[2] 55,000 rides were reported in its first two months of operation in Scottsdale. The average travel distance per trip is 1.35 miles with an average travel time of approximately 10 minutes and an average speed of 4 miles-per-hour. In July 2018, Uber announced that it is investing in Lime as part of a deal led by Alphabet, which values Lime at $1.1 billion. As part of the deal, Uber plans to promote Lime services in its mobile application (Newcomer and Stone, 2018).

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[1] https://www.apta.com/resources/reportsandpublications/Documents/APTA-Shared-Mobility.pdf

[2] City Council Report, "*Bike Share Study Session*," City of Scottsdale, February 13, 2018.

2. Project Objectives (1/2 page)

The main objectives of the proposed research are to:
(1) understand the perceptions, attitudes, and user's mobility choices toward dockless bike-sharing services,
(2) develop advanced analytics and machine learning algorithms to uncover patterns associated with mobility choice, activity-travel, and additional spending related to dockless bike sharing,
(3) empirically evaluate if and how the introduction of the dockless bike-sharing services influences public transit ridership and business sales.

While mobility choices of other modes of transportation have been extensively studied, the research on attitudes, perceptions and patterns associated with the new platform-based dockless bike-sharing program is lacking. This study will be one of the first attempts to fill in the research gap. The research builds on previous successful collaboration with the City of Scottsdale Transportation Department, Lime, as well as other public agencies. To achieve Objective 1, we will conduct a comprehensive survey. Responses from the survey will be integrated with other spatial variables and analyzed using the machine learning algorithms developed in Objective 2. Macro-level impacts of dockless bike sharing on public transportation and business sales will be examined in Objective 3.

3. Proposed Methodology and Data (1 page)

To achieve Objective 1, we will conduct a survey of general public residents as well as visitors in Scottsdale in order to gain qualitative and quantitative insights into users' attitudes, perceptions and travel behavior associated with dockless bike sharing and its impacts on other transportation modes. We will partner with the *City of Scottsdale* and *Scottsdale neighborhood associations* to distribute the survey (through their websites and social media outlets such as facebook, linkedin, twitter, Instagram); survey of Scottsdale visitors will be distributed through *Experience Scottsdale.* The principal investigator of this research has worked with the directors at the above agencies, who have verbally agreed to help distribute the survey to their constituents.

The survey will consist of three sections. The first section collects respondents' demographic and socioeconomic attributes (e.g., gender, age, ethnicity, education attainment, household income, home address, car ownership, occupation, employment status). The second section collects data on respondents' choice and preference of mode of mobility, key factors (e.g., cost, time, service quality, comfort) affecting their choices, major daily trip destinations, and their usage pattern (frequency, time, and intensity of usage). The third section focuses on perception, attitude, and usage of dockless bike sharing. Perception questions include the perceived value of dockless bike sharing (e.g., congestion, environment, costs, convenience), familiarity of bike sharing, perceived quality of service, and satisfaction. Attitude questions include preference, interest, future adoption, and advantage/disadvantage of dockless bike sharing. Behavior questions concern use/no use of dockless bike-sharing services. For those who are current dockless bike users, additional questions include the travel characteristics (e.g., destination, trip purpose, activities involved, connection with other modes of transportation, amount of time spent on each activity, induced personal spending, mode of transportation replaced if there is) and how likely they would continue use of dockless bike sharing and why. For those who are no longer dockless bike users, we collect data on why they stopped using the service.

With the survey data, we will develop analytics and machine learning algorithms to uncover patterns associated with mobility choice, activity-travel and additional spending related to dockless bike sharing. First, we will apply supervised learning algorithms (e.g., Naïve Bayes, Decision Tree, Logistic Regression, Support Vector Machine, Random Forest) to predict the propensity of an individual adopting dockless bike sharing and her trip purpose as a function of her general characteristics, mobility choice and preference, major daily trip destinations, and their personal perception and attitudes. Association rule mining will be employed to identify what activities are likely to be bundled together with a bike trip. The output of the association rule mining will provide us insights such as when a user rides bike to public transportation, she is more likely to stop by a coffee shop, or when a visitor rides a bike, she is more likely to go sightseeing or shopping. Additionally, we will use clustering algorithms (a type of un-supervised learning) to understand the hidden segments of dockless bike users, such as commuter cluster, tourist cluster, leisure cluster, residential cluster. For each of the consumer segment, we will further explore the temporal and spatial characteristics of the consumers. Finally, we will develop a finite mixture model to automatically segment consumers and in the same time predict their induced spending behavior associated with dockless bike share. This exercise will offer us insights into questions such as how often a specific segment of consumers visit a business and how much they tend to spend.

At the macro-level, in order to examine the relationship between dockless bike-sharing usage and public transit ridership, we will collect secondary data including bike-sharing data (e.g., entry time of bike-sharing services and presence/coverage of bike share; available through the City of Scottsdale Transportation Department and Lime), public transit ridership data (available from the Valley Metro Ridership Report https://www.valleymetro.org/ridership-reports), business sales data (through Arizona Department of Revenue), and other control variables (e.g., population, gas prices, GDP, household income; available from public sources such as Census Bureau). These data will be fused together at the appropriate granularity level into a panel data set. We will then use a difference-in-differences (DID) approach to identify and quantify the impacts of dockless bike sharing on public transit ridership and consumer spending in a certain area, compared with those areas that have not yet adopted dockless bike-sharing services. The complete model specification is given by:

$$Ridership_{it} = \alpha + \delta\ Dockless\_bike\_entry_{it} + \lambda\ Controls_{it} + \theta_i + \gamma_t + \varepsilon_{it},$$

Where $Controls_{it}$ represent the control variables for city i at time t, α is the grand mean public transit ridership. $Dockless\_bike\_entry_{it}$ is a dummy variable. It equals to one if city i has dockless bike-sharing service at time t, and zero otherwise. The parameters δ and λ are coefficients; θ_i and γ_t represent the city fixed effect and the time fixed effect, respectively; and ε_{it} denotes the error term.

4. Work Plan (Project Tasks) (1 – 2 pages)

We will complete the project in four stages over a twelve-month period.

Stage 1 consists of survey instrument design and collection of survey data in the study area. We will work closely with our partners to carefully design the survey. A pilot survey will be conducted before the full implementation. In addition to the survey data, we will collect parcel data to extract important points of interest in the study area. Detailed tasks include

- Form the collaboration team with partners from City of Scottsdale Transportation Department, Experience Scottsdale, and Lime
- Design Survey instrument
- Conduct the pilot survey
- Distribute the survey and collect survey data
- Extract important points of interest from parcel data

In Stage 2, we will develop data mining algorithms to uncover patterns associated with mobility choice, activity-travel and additional spending related to dockless bike sharing. Specific tasks include

- Develop supervised learning algorithms to predict the propensity of an individual adopting dockless bike share, examine the impact of dockless bike sharing on other modes of transportation and identify the activities associated with dockless bike trips
- Develop unsupervised algorithms to examine the hidden segments of dockless bike users
- Construct a finite mixture model to automatically segment consumers and analyze induced spending patterns associated with dockless bike trips

In Stage 3, we will collect relevant data and empirically evaluate if and how the introduction of the dockless bike share in an area influences public transit ridership and business sales. Important tasks include

- Transit data collection (routes, ridership by month, boarding per mile, etc.)
- Demographic and socioeconomic data collection (population, GDP)
- Business sale tax data collection
- Construct a DID model to quantify the impact of the dockless bike share entry on transit ridership
- Construct a DID model to examine the impact of dockless bike share on business sales

In Stage 4, we will complete the project by writing the technical report and research articles and presenting our research findings.

- Complete the technical report
- Write research article(s) for publication

5. Project Schedule (1/2 – 1 page)

The following table outlines our project plan and tasks to be executed by month.

Table 1: Tasks executed by month

Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Form collaboration team	■											
Survey instrument design	■	■										
Conduct pilot survey			■									
Survey data collection			■	■	■							
Supervised learning algorithm development						■	■					
Unsupervised learning algorithm development							■	■				
Develop DID to quantify the impact on transit ridership									■	■		
Develop DID to quantify the impact on business sales										■	■	
Write the final report											■	■

6. Relevance to the Center Theme/Mission (1/2 page)

Our project aligns very well with the mission and theme of TOMNET. This research presents one of the first attempts to study a new platform-based shared mobility application and its transformative impacts on travelers' attitudes, mobility choices and behavior responses. More specifically, we focus on the adoption and use of dockless bike sharing, its impact on mobility and other modes of transportation, destination choices, activity-travel, and induced consumer expenditures. Our research findings will provide important insights into the benefits and externality effects of the innovative bike-sharing program and will inform decision makers to formulate effective policies and strategies on transportation planning and economic development.

Methodologically, we provide a holistic approach that involves a survey design to collect the primary data on travelers' perception and attitudes, application of advanced analytics and machine learning to uncover the underlying relationships among behavioral and attitudinal variables, as well as collection of secondary data and development of statistical models to empirically test these relationships.

7. Anticipated Outcomes and Deliverables (1/2 page)

The study collects both primary and secondary data related to the perceptions, attitudes, and user's mobility choices toward dockless bike sharing. It provides TOMNET, the City of Scottsdale, MAG (Maricopa Association of Governments), Valley Metro, local business owners, and the general public with data driven results for a better understanding of dockless bike sharing as well as its impacts. It will also serve as a baseline for ongoing data collection and a means for making impactful decisions on transportation and economic development initiatives to the community. The project will create replicable data and methodology for other communities to use in making their own informed decisions regarding bike share, public transportation, city planning, and economy.

The final deliverables of the project include: (1) a report detailing the perceptions, attitudes, and user's mobility choices toward dockless bike sharing, (2) two research papers with one paper focusing on leveraging advanced data analytics algorithms to uncover meaningful patterns associated with dockless bike sharing and the other paper on leveraging secondary data to examine whether and how the introduction of a dockless bike sharing program influences public transit ridership and business sales, (3) presentations given at TOMNET, the Transportation Research Board annual meeting, International Conference on Information Systems annual meeting and INFORMS annual meeting, (4) a K-12 workshop in Scottsdale to provide information on future mobility options and dockless bike sharing.

8. Research Team and Management Plan (1/2 – 1 page)

Zhongju (John) Zhang is a PI and will lead the efforts on designing the survey to gather consumers' perceptions, attitudes, and mobility choices toward dockless bike sharing, developing advanced analytics and machine learning algorithms to uncover interesting patterns from the survey data, as well as collecting secondary data and conducting statistical analysis. Zhang's research focuses on how information technology and data analytics impact consumer behavior and decision making, create business value, and transform business models. He has extensive experience in platform-based sharing economy, online community and social collaborative platforms, big data analytics and predictive modeling. One of his studies examines how on-demand ride sharing services can affect traffic congestion using a novel data set combining the entry time of Uber into various geographic regions and the traffic patterns from the Urban Mobility Report. He has also conducted surveys to gather users' perceptions and attitudes towards social networking systems as well as their continued usage of such systems. Zhang has consulted extensively for the industry on various data-centric analytics projects. Most recently, he is the co-PI of an analytics project for Adidas that seeks to understand customer segment and behaviors toward Adidas products, and help Adidas to develop recommender systems to support consumers' product selections and retailers' marketing/selling strategy.

Daoqin Tong is a co-PI and will lead the efforts on spatial data collection, data integration, and travel-activity pattern analysis. Dr. Tong's research has mainly focused on spatial analytics including geographic information systems, spatial optimization and spatial statistics to study urban access, activity space and transportation network design. Among all the research that Tong has worked on, most relevant to this project includes activity space delineation, travel studies based on big data including taxi data and cell phone data, and public transportation access. Tong also has extensive experience working with government agencies and local communities.

Two graduate research assistants (student workers) with one in information systems and another in transportation geography will be hired to help collect data, construct the spatial database, conduct the activity-travel analysis, develop the machine learning algorithms and construct the DID statistical models. Two undergraduate students with one in business and another in geography will be hired to help with survey design, and data collection and compiling.

PI Zhang, co-PI Tong, and hired students will hold weekly research team meetings in person to facilitate collaborative results and monitor progress. We will schedule project team meetings with the City of Scottsdale (Transportation Department), Experience Scottsdale, and Lime every other month during the 12 month research period. These key project meetings will be used to facilitate survey design and distribution, collect relevant data, and help refine research questions. This regular, scheduled communication will ensure that the research team is kept abreast on the developments of the project and that these partners have opportunities to review and comment on the research and finding codification.

9. Technology Transfer Plan (1/2 page)

The final project report will be shared with the TOMNET members, city of Scottsdale, MAG, valley metro, Lime, and other government agencies. PIs plan to present the research at one of the ASU transportation seminars. PIs will attend a number of conferences (including the Transportation Research Board annual meeting, International Conference on Information Systems annual meeting, and INFORMS annual meeting) to present preliminary findings of the research project. The completed manuscripts are expected to be submitted (and eventually get published) in top-tier journal outlets including Information Systems Research, MIS Quarterly, Management Science, Transportation Research Record, Journal of Transport Geography, Transportation Research Part C: Emerging Technologies, etc. Additionally, we will hold a K-12 workshop to educate the young generation on different urban transportation options and to promote a green and environment friendly solution to urban traffic and sustainability.

10.Workforce Development and Outreach Plan (1/2 page)

The project will involve two graduate students and two undergraduate students directly. We encourage women and minority students to join the research team. In addition, we will bring the research project into classroom teaching and the K-12 workshop development, and to share with the younger generation about the exciting development in mobile technologies, artificial intelligence, and emerging trends in the transportation industry. The effect of automation and shared mobility will be far reaching and the concept of transportation will be fundamentally changed. The sticky point is how travelers are going to respond to such disruptive technologies. At this point, it is not clear if users will fully utilize a shared bicycle network, purchase privately owned autonomous vehicles, or share those cars with other users. Each of these scenarios could have different implications on urban design and complicates a city's efforts to plan ahead. It is our hope that, through these initiatives, the younger generation will be prepared for the new technologies and moving towards more sustainable mobility options.

11.References (No Page limit)

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- Hall, J. D., Palsson, C., and Price, J. 2017. "Is Uber a Substitute or Complement for Public Transit?" Working Papers tecipa-585, University of Toronto, Department of Economics.
- Li, Z., Hong, Y., and Zhang, Z., 2018. "Do On-demand Ride-sharing Services Affect Traffic Congestion? Evidence from Uber Entry," Available at SSRN: https://ssrn.com/abstract=2838043 or http://dx.doi.org/10.2139/ssrn.2838043
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- Qi, G., Chen, J., and Zhang, Z., "Mobike: A Smart Bike-Sharing Service Platform," Ivey Publishing, Product Number: 9B18M004, 1/12/2018.
- Rayle, L., Shaheen, S., Chan, N., Dai, D., and Cervero, R. 2014. "App-Based, On-Demand Ride Services: Comparing Taxi and Ridesourcing Trips and User Characteristics in San Francisco University of California Transportation Center (UCTC)," UCTC-FR-2014-08.
- Sundararajan, A. The Sharing Economy: The End of Employment and the Rise of Crowd-Based Capitalism. The MIT Press, Cambridge, MA, 2016.

12.Qualifications of Investigators (One-page CV per Investigator)

Please see attached below the budget page.

13.Budget Including Non-Federal Matching Funds

Institution: Arizona State University

Project Title: Consumer Attitudes and Behavioral Implications in the New Era of Shared Mobility

Principal Investigator: Zhongju Zhang and Daoqin Tong

Budget Period: 8/1/2018 - 07/31/2019

CATEGORY	Budgeted Amount from Federal Share	Budgeted Amount from Matching Funds	Explanatory Notes; Identify Source of Matching Funds
Faculty Salaries	$12,000	$35,000	PIs' 1.5 month salary each used for matching
Other Staff Salaries			
Student Salaries	$24,000		2 graduate student workers ($15/hr*15hrs/wk*40wks) + 2 undergraduate workers ($10/hr*10hrs/wk*30wks)
Fringe Benefits	$3,740		ASU employee related expenses
Total Salaries & Benefits	$39,740		
Student Tuition Remission			
Operating Services and Supplies	$2,000		Survey incentives; 5 iPads used for sweepstakes
Domestic Travel	$4,000		Conference travel to present research findings
Other Direct Costs (specify)			
Other Direct Costs (specify)			
Total Direct Costs	$45,740		
F&A (Indirect) Costs	$23,583		ASU indirect cost rate (56.5%) for year 2018
TOTAL COSTS	$69,324		

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Education

Ph.D., Information Systems (minor areas: Economics and Operations Research), University of Washington School of Business, 2003
M.Sc., Computer Science & Information Systems, National University of Singapore, 1999
B.Sc., Computer Science, Xi'an Jiaotong University, 1996

Employment and Professional Experience

Associate Professor, Department of Information Systems, W. P. Carey School of Business, Arizona State University , 8/2015–now
Associate Professor, Department of Operations and Information Management, School of Business, University of Connecticut, 8/2009–8/2015
Founding Program Director, Master of Science in Business Analytics and Project Management (MS-BAPM), School of Business, University of Connecticut, 8/2011–8/2012.
Assistant Professor, Department of Operations and Information Management, School of Business, University of Connecticut, 8/2003–8/2009

Fields of Interest and Expertise

(1) Incentives, user behaviors, and decision choices related to digital platforms and social media; (2) Sharing economy business models and impacts; (3) Economic aspects of e-business operations and management; (3) Design science and big data analytics

5 Recent Relevant Publications

1. Dong, W., Liao, S., and Zhang, Z., "Leveraging Financial Social Media for Corporate Fraud Detection," *Journal of Management Information Systems*, 35(2), pp. 461-487, 2018.
2. Zhang, Z. and Feng, J, "Price of Identical Product with Gray Market Sales: An Analytical Model and Empirical Analysis," *Information Systems Research*, 28(2), pp. 397-412, June 2017.
3. Abrahams, A., Fan, W., Jiao, J., Wang, G., and Zhang, Z. "An Integrated Text Analytic Framework for Product Defect Discovery," *Production and Operations Management,* 24(6), 975-990, June 2015.
4. Bapna, R., Goes, P., Wei, K.K., and Zhang, Z. "A Finite Mixture Model to Predict B2B Electronic Payments Systems Adoption," *Information Systems Research*, 22(1), pp. 118-133, March 2011.
5. Zhang, Z. "Feeling the Sense of Community in Social Networking Usage," *IEEE Transactions on Engineering Management*, 57(2), pp. 225-239, May 2010.

Graduate Student Supervision/Advising

Graduated: 4 PhDs (includes 1 woman), numerous Masters; **Current Supervision**: 1 PhD (woman)

Recent Honors and Awards

INFORMS eBusiness Best Paper (Runner-up) Award, INFORMS, Houston, October 2017.
AWS Cloud Credits for Research, Amazon, February 2017.
Center for the Study of Economic Liberty (CSEL) Research Award, Arizona State University, February 2017.
Dean's Summer Research Grant, UConn School of Business, May 2012, 2013 & 2014.

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Education
Ph.D., Geography, The Ohio State University, 2007
M.A.S., Statistics, The Ohio State University, 2007
M.S., Civil Engineering, The Ohio State University, 2004
B.S., Civil Engineering, University of Shanghai for Science & Technology, 2001

Employment and Professional Experience
Associate Professor, School of Geographical Sciences and Urban Planning, Arizona State University, Tempe, AZ, 8/2017–present
Associate Professor, School of Geography and Development, University of Arizona, Tucson, AZ, 8/2013–8/2017
Assistant Professor, School of Geography and Department, University of Arizona, Tucson, AZ, 8/2007–8/2013

Fields of Interest and Expertise
(1) Spatial analytics, including spatial optimization, GIS, and spatial statistics; (2) Accessibility, activity-travel and urban mobility; (3) Geotagged big data analytics; (4) Network science analytics and network design

5 Recent Relevant Publications
1. Li R. and **D. Tong** (2017) Constructing human activity spaces: A new approach incorporating complex urban activity-travel. *Journal of Transport Geography* 56: 23-35
2. Chi G., J.-C. Thill, **D. Tong**, L. Shi and Y. Liu (2016) Uncovering regional characteristics from mobile phone data: a network science approach. *Papers in Regional Science* 95(3): 613-632
3. Mack J. and **D. Tong** (2015) Characterizing the spatial and temporal patterns of farmers' market visits. *Applied Geography* 63: 43-54
4. **Tong D.** and D. Plane (2014) New perspectives on delineation of metropolitan and micropolitan statistical areas. *Geographical Analysis* 46(3): 230-249
5. Lee. S., M. Hickman and **D. Tong** (2013) Development of a temporal and spatial linkage between transit demand and land use patterns. *Journal of Transport and Land Use* 6(2): 33-46

Graduate Student Supervision/Advising
Graduated: 3 PhDs (includes 1 woman), numerous Masters; **Current Supervision**: 3 PhD (all are woman)

Recent Honors and Awards
Geoffrey J.D. Hewings Young Scholar Award, North American Regional Science Council (NARSC), 2016.
Udall Center Fellowship, University of Arizona, 2016