Center for Teaching Old Models New Tricks (TOMNET)

A USDOT Tier 1 University Transportation Center

PROJECT PROPOSAL

Title: Are On-Demand Mobility Services Cost-Effective for First/Last Mile Travel? A Comparative Analysis

Principal Investigator: Qing Shen, Professor, Department of Urban Design and Planning, University of Washington

Co-Principal Investigator (if applicable): Cynthia Chen, Professor, Department of Civil and Environmental Engineering, University of Washington

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1. Introduction/Problem Statement (1 page)

Many cities are expanding rail transit systems to meet the travel needs of growing populations in sprawling urbanized areas. Efficient rail transit operation requires adequate transportation infrastructure and services to support convenient, affordable, and safe travel to and from rail stations, i.e., first/last mile. For rail transit users who reside in low-density suburban areas, travel options for first/last mile trips are quite limited, with driving alone to the nearest station's park-and-ride facility as the most common choice. Many transit agencies and planners are exploring alternative modes to serve first/last mile trips to increase transit ridership while meeting the diverse travel needs of different population groups.

The advent of app-based mobility-on-demand (MOD) services has created many exciting opportunities for transit agencies to build new partnerships with new mobility providers to supplement existing public transportation with flexible and efficient travel options (Clewlow et al., 2017; McCoy et al., 2018; Schaller, 2018; Shaheen et al., 2018; Shen et al. 2020; Schwieterman et al., 2018; Yan et al., 2019). A recent survey by TRB shows that first/last mile connection is the most common target market of transit agencies-mobility service providers partnerships, tackling one of the main barriers to transit ridership (Curtis et al., 2019). However, much of the existing discussion of the cost-effectiveness of using MOD to supplement first/last mile usually compares MOD pilot services with non-performance-equivalent alternatives, i.e., past transit lines serving the areas or different mobility pilots implemented in other areas (Gifford et al., 2021; Grellier, 2020; Ong, 2019). Prior studies also tend to use the average cost of pre-existing fixed-route service as the basis for evaluating the cost-effectiveness of MOD services, which may misinform decision-making because the marginal cost of running a fixed-

route transit in low-demand areas or for first/last mile travel can be substantially higher than the system-wide average cost.

While contributing to understanding the potential of using MOD in the first/last mile, existing studies are either exploratory, considering hypothetical MOD services, or are limited to evaluating particular MOD pilots that involve specific arrangements with transit agencies (Ashour and Shen, 2022; Ong, 2019; Yan, 2019). For example, published studies that evaluate Via to Transit, a first/last mile MOD pilot created by transit agencies in the Seattle region in partnership with a private mobility provider, do not consider privately-operated MOD such as app-based carpooling, micromobility, and ride-hailing/Transportation Network Companies (TNCs) (Gifford et al., 2021; Wang and Shen, 2022). In addition, existing studies are typically limited in considering variations in geographic contexts and users' socioeconomic characteristics in their assessment of new alternatives, leaving many important issues, including social equity implications, unaddressed. Rigorous research efforts are needed to fill the significant knowledge gaps and inform transportation decision-making.

2. Project Objectives (1/2 page)

The main objective of this study is to understand the relative cost-effectiveness of using different types of MOD services to supplement transit by filling first/last mile gaps compared to conventional alternatives, especially expanding fixed-route services and supporting driving alone with park-and-ride facilities. To do so, this study further develops a cost-effectiveness evaluation approach from a societal perspective and then applies it to selected geographic contexts. In addition, this study aims to inform transit agencies' decision-making on establishing partnerships with MOD providers to serve first/last mile trips. Moreover, the research will investigate the conditions under which the socially more cost-effective alternatives are consistent with the individual preferences of users from disadvantaged socioeconomic backgrounds. To achieve these objectives, this research will address the following questions:

1) From a societal perspective, what factors determine the comparative cost-effectiveness of alternative modes for first/last mile travel? Does lower travel demand density, for example, increase the likelihood for MOD to be more cost-effective? How do socioeconomic factors associated with the riders affect the possibility for fixed-route buses to be a more cost-effective alternative?

2) Under what conditions and arrangements are transit agencies-private service providers partnerships most cost-effective?

3) From the user's perspective, what factors differentiate the comparative cost-effectiveness among alternative modes for first/last mile trips? What are the equity implications of each alternative mode?

3. Proposed Methodology and Data (1 page)

The study addresses the questions above with two methodological components. First, we substantiate a cost-effectiveness evaluation approach from a societal perspective while considering social equity implications. Second, we build a transportation simulation procedure that allows transit agencies to empirically compare the cost of providing first/last mile trips through MOD with that of traditional service expansion and provision of park-and-ride facilities for driving.

3.1 Conceptualizing cost-effectiveness of first/last mile travel modes

Building upon the conceptual framework developed in Wang and Shen (2022), we substantiate and enrich economic cost variables to compare first/last mile travel modes, including:

1) Cost for mobility service providers, including public transit agencies and private service providers (e.g., TNCs and Via to Transit). This typically includes the costs of labor (i.e., drivers, service managers, and planning staff), fuel/propulsion, capital, and maintenance.

2) Generalized costs for users from different socioeconomic backgrounds, including monetary and time costs of travel (waiting time, in-vehicle travel time, access time for first-mile trips, and egress time for last-mile trips).

3) External costs, primarily environmental externalities, road congestion, and road accidents.

3.2 Alternative Modes Scenario Comparison

We will assess the cost-effectiveness of MOD, including Via to Transit and privately-operated mobility services (specifically TNCs), against conventional alternatives, including providing park-and-ride facilities and improving fixed-route services (e.g., service expansion and frequency increase). Because Via to Transit involves special arrangements between MOD service providers and transit agencies, and their operation is limited to certain geographic areas with similar characteristics (e.g., density, sociodemographics), we also consider TNCs as an alternative first/last mile mode and plan to select two different light rail station areas for comparative analysis.

For Via to Transit, we plan to use existing service trip data that include the request, pick-up, and drop-off times (in minutes) for every trip, origin and destination geo-coordinates, trip distance, and the number of seats requested. For TNCs, we will use publicly available service apps to estimate the service costs and trip duration for the same trips in the counterfactual scenario where Via to Transit was unavailable. For transit service improvements and expansion, we will work with King County Metro (KCM) to obtain the costs for providing performance-equivalent services for the same trips, assuming the counterfactual scenario where Via to Transit was

unavailable. In the case of driving alone, the primary cost for service provision is the construction of park-and-ride facilities, which can be estimated using KCM data. To obtain the travel times for these alternative modes, we plan to use Eclipse SUMO, a free and open-source software, to simulate the same trips for the three counterfactual scenarios. These estimated travel times will be monetized considering the different opportunity costs for different users. The resulting comparative cost-effectiveness will be based on the total cost, consisting of service provision cost, travel time cost, and externalities which will be measured using an extensive literature review and publicly-available data on emissions, traffic, and accidents. Fig 1 illustrates the proposed composition of the different alternative modes and user groups we will investigate.

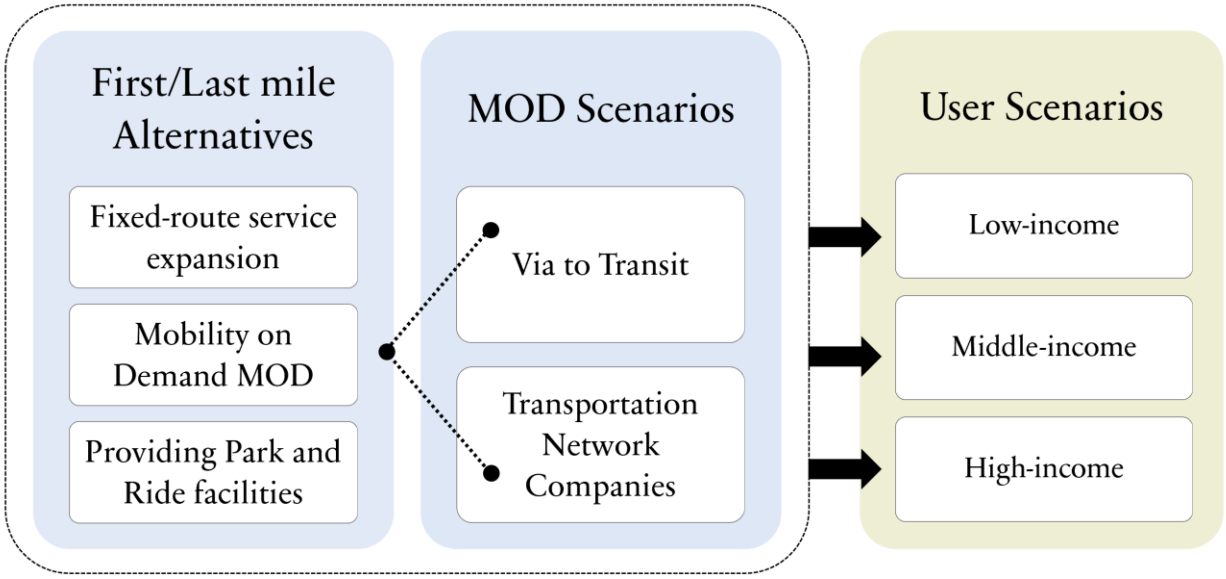

Fig 1. Alternative first/last mile modes and user groups

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

The project tasks include the following:

1) Expanding literature review: in this task, we aim to conduct a systematic review of existing literature on the cost-effectiveness evaluation of transit and MOD pilot projects. We will also search for prior studies on first/last mile issues and alternatives, mobility-on-demand role in supporting transit, social equity implications of incorporating MOD into public transit, and up-to-date findings on external costs of transportation modes.

2) Refining research design: this task will focus on substantiating our research methodology in light of the literature review conducted in task 1.

3) Collecting and processing data: this task consists of selecting two light rail station areas that match our criteria and collecting the necessary data, as described in section 3.2.

4) Data analysis and simulation: this task includes the analysis of travel times in simulated and observed scenarios, estimation of the riders' generalized costs and the external costs associated with each alternative, and calculation of the total economic cost for each mode/scenario and selected site.

5) Interpretation of the results: We will compare the different first/last mile alternative modes based on their economic costs and interpret and discuss the results from transit agencies' and individual users' perspectives. Our discussion will also consider the social equity implications of each mode and user group scenario.

6) Writing project report: the research team will produce a project report that will be submitted to TOMNET for online publication.

7) Writing journal article: the team will prepare a journal article to publish the research design, results, and policy implications.

5. Project Schedule (1/2 – 1 page)

Tasks	**2022 – 2023**										
	10	11	12	1	2	3	4	5	6	7	8
Expanding literature review											
Refining research design											
Collecting & processing data											
Data analysis and simulation											
Interpreting the results											
Writing project report											
Writing journal paper											

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

This project closely aligns TOMNET UTC center's theme of understanding unprecedented mobility changes and predicting the behavioral impacts of these changes. This project conducts an innovative and practical simulation modeling and applies the approach to address some of the important topics identified by the center: equity, vehicle ownership, land use impacts on travel, and ride-hailing apps. Our results will inform transportation planning practice in this era of rapid advancement in mobility technology and major societal shifts in demographics and values.

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

This proposed study will generate two significant outcomes. First, it will build a framework for analyzing and comparing the cost-effectiveness of different first/last mile travel modes, including new options incorporating MOD, and it will identify and evaluate the factors contributing to each mode's cost-effectiveness. Second, it will deepen our understanding of practical approaches that public transit agencies can take to fill first/last mile service gaps and increase transit ridership.

The resulting research approach and findings will serve as valuable references for transit agencies as they explore innovative and cost-effective ways to improve transit ridership while promoting transportation equity.

The project deliverables will include a project report and a journal article.

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

Research Team:

This project will be led by Professor Qing Shen (PI) and Professor Cynthia Chen (Co-PI), with two doctoral students working as research assistants.

Management Plan:

The research will be conducted at the University of Washington in Seattle. The project PIs will work closely with the research assistants and use the Project Schedule (see section 5 above) to guide the completion of the research tasks (detailed in section 4 above). To ensure high quality of the research, the PI will hold weekly project meetings where the research assistants will report their work progress, and the team will discuss any issues raised and decide on tasks for the next week. The team plans to use Google Drive to store data and document files, which can effectively support research collaboration among team members.

The project will require Via to Transit trip data from King County Metro, which is the primary public transit agency in the Seattle region. The team will build on its existing collaboration with King County Metro and work with relevant professionals in the agency to access the data. In

addition, the team will involve these professional in refining the research questions and approaches to make sure that the work will be policy relevant.

9. Technology Transfer Plan (1/2 page)

We will present our research at academic conferences, including TRB. We will also submit a paper for publication in a peer-reviewed journal. In addition, we plan to use the research as a basis for seminars and discussions.

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

This research will provide an important opportunity to involve graduate students as research assistants in studying critical, timely topics in transportation planning and policy and thus help them get well-prepared for their future academic or professional careers. Additionally, the work will help relevant transportation planners and decision-makers gather timely insights into state-of-the-art approaches to improving public transportation service and addressing social equity issues and ridership challenges.

11.References (No Page limit)

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Schwieterman, Joseph P., Mallory Livingston, and Stijn Van der Slot. 2018. Partners in Transit: A Review of Partnerships between Transportation Network Companies and Public Agencies in the United States. Chicago: DePaul University.

Shen, Qing, Yiyuan Wang, and Casey Gifford. 2021. "Exploring Partnership between Transit Agency and Shared Mobility Company: An Incentive Program for App-Based Carpooling." Transportation. doi:10.1007/s11116-020-10140-w.

Wang, Yiyuan, and Qing Shen. 2022. "Supplementing Fixed-Route Transit With On-Demand Shared Mobility Services: A Marginal Cost Comparison Approach". SSRN Electronic Journal. doi:10.2139/ssrn.4085300.

Yan, Xiang, Jonathan Levine, and Xilei Zhao. 2019. "Integrating Ridesourcing Services with Public Transit: An Evaluation of Traveler Responses Combining Revealed and Stated Preference Data." Transportation Research Part C: Emerging Technologies 105: 683–96. https://doi.org/10.1016/j.trc.2018.07.029.

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

Qing Shen, Ph.D.

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Phone: 206-685-3937, Email: qs@uw.edu

EDUCATION

Ph.D., City and Regional Planning, University of California, Berkeley, USA, 1993
M.A., Urban Planning, University of British Columbia, Canada, 1986
B.S., Architecture, Zhejiang University, China, 1982

ACADEMIC APPOINTMENTS

Professor, Urban Design and Planning, University of Washington, 2009-present
Professor, Urban Studies and Planning, University of Maryland, 2006-2009
Associate Professor, Urban Studies and Planning, University of Maryland, 2001-2006
Associate Professor, Urban Studies and Planning, MIT, 1999-2001
Assistant Professor, Urban Studies and Planning, MIT, 1993-1999

SELECTED PUBLICATIONS

1. Ashour, L.A. and Shen, Q., 2022. Incorporating ride-sourcing services into paratransit for people with disabilities: Opportunities and barriers. *Transport Policy, 126,* pp.355-363.
2. Shen, Q., Wang, Y. and Gifford, C., 2021. Exploring partnership between transit agency and shared mobility company: An incentive program for app-based carpooling. *Transportation, 48*(5), pp.2585-2603.
3. Guan, J., Zhang, K., Shen, Q. and He, Y., 2020. Dynamic modal accessibility gap: measurement and application using travel routes data. *Transportation Research Part D: Transport and Environment*, *81*, p.102272.
4. Shen, Q., Chen, P. and Pan, H., 2016. Factors affecting car ownership and mode choice in rail transit-supported suburbs of a large Chinese city. *Transportation Research Part A: Policy and Practice*, *94*, pp.31-44.
5. Yang, L., Shen, Q. and Li, Z., 2016. Comparing travel mode and trip chain choices between holidays and weekdays. *Transportation Research Part A: Policy and Practice*, *91*, pp.273-285.
6. Hong, J., Shen, Q. and Zhang, L., 2014. How do built-environment factors affect travel behavior? A spatial analysis at different geographic scales. *Transportation*, *41*(3), pp.419-440.
7. Kawabata, M. and Shen, Q., 2007. Commuting inequality between cars and public transit: The case of the San Francisco Bay Area, 1990-2000. *Urban Studies*, *44*(9), pp.1759-1780.
8. Shen, Q., 2000. Spatial and social dimensions of commuting. *Journal of the American Planning Association*, *66*(1), pp.68-82.
9. Shen, Q., 2000. New telecommunications and residential location flexibility. *Environment and Planning A*, *32*(8), pp.1445-1463.
10. Shen, Q., 1998. Location characteristics of inner-city neighborhoods and employment accessibility of low-wage workers. *Environment and planning B: Planning and Design*, *25*(3), pp.345-365.

SYNERGISTIC ACTIVITIES

1. Associate Editor, *Journal of the American Planning Association*, 2019-present
2. Editorial Board Member of five major journals, including *Journal of the American Planning Association*, 2000-present; *Journal of Planning Education and Research*, 2006-present; and *Journal of Transport and Land Use*, 2007-present
3. Member, Organizing Committee of PacTrans Annual Conference, 2019-present

13.Budget Including Non-Federal Matching Funds

Institution: University of Washington
Project Title: Are On-Demand Mobility Services Cost-Effective for First/Last Mile Travel? A Comparative Analysis
Principal Investigator: Qing Shen

Budget Period: 8/1/20XX - 07/31/20YY

CATEGORY	Budgeted Amount from Federal Share	Budgeted Amount from Matching Funds	Explanatory Notes; Identify Source of Matching Funds
Faculty Salaries	$9,310		
Other Staff Salaries			
Student Salaries	$32,057		
Fringe Benefits	$9,072		
Total Salaries & Benefits			
Student Tuition Remission	$14,940		
Operating Services and Supplies			
Domestic Travel	$1,621		
Other Direct Costs (specify)			
Other Direct Costs (specify)			
Total Direct Costs	$67,000		
F&A (Indirect) Costs	$28,893		
TOTAL COSTS	$95,893	$95,893	Matching funds are from: 1) WSDOT TOD, Budget #63-7128; 2) MIC COMMUTE STUDY 2022, Budget #68-6806; if necessary 3) my regular UW faculty salary

Grant Deliverables and Reporting Requirements for UTC Grants (November 2016)

Exhibit F

UTC Project Information	
Project Title	
University	
Principal Investigator	
PI Contact Information	
Funding Source(s) and Amounts Provided (by each agency or organization)	
Total Project Cost	
Agency ID or Contract Number	
Start and End Dates	
Brief Description of Research Project	
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	
Impacts/Benefits of Implementation (actual, not anticipated)	
Web Links ● Reports ● Project Website	