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Smart Transportation in Small- and Medium-sized Cities in Central California

Hongwei Dong

CSUTC California State University Transportation Consortium

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Smart Transportation in Small- and Medium-sized Cities in Central California

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16. Abstract

The research on smart transportation in the United States has centered on large metropolitan areas. The adoption of smart transportation technologies in small- and medium-sized cities outside of large metropolitan areas is less studied and understood. This study examined the adoption of smart transportation technologies in small- and medium-sized cities in Central California. The analysis was based on the online survey responses from 29 transportation officials and professionals who worked for 18 municipal government departments and six metropolitan planning organizations (MPOs) in Central California as well as in-depth semi-structured interviews with seven of them. The study showed that smart transportation in small- and medium-sized cities was mainly car-centric. Slightly more than half of the survey respondents were either unsure or suspicious about the usefulness of smart transportation technologies in addressing local transportation problems. The study revealed several barriers to the adoption of smart transportation technologies in small- and medium-sized cities including insufficient funding, limited staff capacity, a lack of coordination among small cities within a region, small population sizes, and low-density of development. The interviews suggested that some of these barriers, particularly the funding issue, were more complicated than they first appeared. We offer four major policy recommendations based on the findings from this study.

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Executive Summary

Research on smart transportation in the United States has centered on large metropolitan areas. The adoption of smart transportation technologies in small- and medium-sized cities outside of large metropolitan areas is less studied and less understood. This study examined the adoption of smart transportation technologies in small- and medium-sized cities in Central California. The analysis was based on responses to our online survey from 29 transportation officials and professionals from 18 municipal government departments and six metropolitan planning organizations (MPOs) in Central California, as well as in-depth semi-structured interviews with seven of them.

The study showed that smart transportation In small- and medium-sized cities was mainly car-centric. Slightly more than half of the survey respondents were either unsure or suspicious about the usefulness of smart transportation technologies in addressing local transportation problems. Those who believed that smart transportation would be helpful tended to be more familiar with the intelligent transportation system (ITS) technologies that aimed to manage traffic and reduce congestion. They reported that ITS and EV charging stations were the two most popular smart transportation technologies in the study area.

The study revealed several barriers to the adoption of smart transportation technologies in small- and medium-sized cities, including insufficient funding, limited staff capacity, a lack of coordination among small cities within a region, small population sizes, and low-density of development. The interviews suggested that some of these barriers, particularly the funding issue, were more complicated than they first appeared. First, transportation funding sources appeared to be plentiful, but many small- and medium-sized cities lacked the staff capacity to prepare funding submissions. Second, the cities that received fixed-term smart transportation grants were unsure whether they would have enough money for maintenance and replacement once the grants expired. Third, the cities had difficulty building an integrated smart transportation system because transportation funds were distributed piecemeal and different parts of the system were purchased from different vendors.

Most of the smart transportation projects were initiated by municipal government departments. Public participation was limited to gathering feedback and learning about users' experiences following the implementation of smart transportation. Although they were still uncommon, new public, private, and non-profit partnerships emerged in the study area to provide low-income families with affordable shared mobility.

We offer four major policy recommendations. First, small cities within a region may overcome many of their disadvantages by forming a strong regional alliance directed by local MPOs and guided by a regional smart transportation plan. Second, MPOs and their city members should make long-term plans to create an integrated smart transportation system that is easier to

coordinate, maintain, and upgrade. Third, federal and state funding agencies may offer longer-term grants for smart transportation with a consideration of regional equity. Fourth, the federal and state departments of transportation should provide more learning opportunities on smart transportation for transportation officials and professionals in small- and medium-sized cities.

1. Introduction

The concept of smart transportation has received considerable scholarly attention during the last decade. New mobility technologies and innovations, such as autonomous vehicles, electric cars, and shared mobilities, are revolutionizing the transportation industry and transforming American cities (Sperling, Pike, & Chase, 2018). In 2015, the U.S. Department of Transportation (U.S. DOT, 2015) launched its Smart City Challenge and requested proposals from mid-sized American cities for smart transportation systems that "would use data, applications, and technology to help people and goods move more quickly, cheaply, and efficiently." A smart transportation system applies sensors and wireless communication technologies to infrastructure, vehicles, wearables, and other physical devices to seek new solutions to solve persistent transportation issues such as traffic, parking, air pollution, health, safety, and equity (U.S. DOT, 2021).

To date, both the research and the implementation of smart transportation technologies have been urban-centric, primarily focusing on large metropolitan areas (Bosworth, et al., 2020; Poltimäe et al., 2022; Spicer, Goodman, & Olmstead, 2021). A study in California (Alison et al., 2021) showed that the adoption of three prominent smart transportation technologies (access to EV chargers, micro-mobility, and ride-hailing services) is highly concentrated in the largest cities in the San Francisco Bay Area and the Greater Los Angeles Region but is much less common in smaller and lower-income jurisdictions. Small- and medium-sized cities, particularly those outside of major metropolitan areas, usually exhibit different socioeconomic and spatial contexts. Small- and medium-sized cities outside of large metropolitan areas face challenges in the new digital age because of fiscal and staffing constraints, low population density, spatial isolation, and car dependence (Hosseini et al., 2018; Lindtvedt, Frøhaug, & Nesse, 2021; Poltimäe et al., 2022; Spicer, Goodman, & Olmstead, 2021). We cannot simply transfer smart transportation technologies from large cities in major metropolitan areas to small- and medium-sized cities outside of large metropolitan areas. There is an urgent need to expand our understanding of the adoption of smart transportation technologies and their effectiveness in small- and medium-sized urban settings.

The purpose of this study is to partially fill this research gap by assessing the adoption of smart transportation technologies in small- and medium-sized cities in California's Central Valley (hereafter also referred to as *Central California*), which is the largest agricultural base in the United States. By carrying out online surveys and in-depth semi-structured interviews with transportation professionals employed by municipal government departments and metropolitan planning organizations (MPOs) in the study area, we attempted to address the following three research questions:

- What smart transportation technologies have been (or are being) adopted in small- and medium-sized cities in Central California and how effective are they in addressing transportation problems in these cities?

- What political and administrative procedures do small- and medium-sized cities usually follow to adopt smart transportation technologies?

- What are the major barriers to adopting smart transportation technologies in small- and medium-sized cities?

To answer these three research questions, we reviewed the websites of all the incorporated cities and MPOs in Central California to search for information on the adoption of smart transportation technologies. We also identified the contact information of transportation engineers, planners, and managers who worked for municipal government departments and MPOs. We designed and distributed online survey questionnaires to these transportation professionals to collect data about the adoption of smart transportation technologies in their jurisdictions, as well as their opinions on the research questions that we attempted to address. As a complement to the online survey, we conducted semi-structured in-depth interviews with seven transportation professionals to further explore smart transportation in small- and medium-sized cities in Central California.

The remainder of the report is organized as follows. We review relevant literature in the next section. We introduce the data and methodologies in the third section. The fourth section presents major findings from our online survey and in-depth interviews. The fifth section concludes by discussing the limitations of this study, the major findings, and the policy implications.

2. Background and Literature

In the past two decades, the definitions of 'smart city' and 'smart transportation' have evolved from technology-centered concepts to broader, more flexible, and more human-centered definitions (Bruno & Fontana, 2020). The U.S. DOT defines the three hallmarks of smart cities and communities as networks, connectivity, and open data (U.S. DOT, 2021). They also name a few typical smart transportation technologies, including "user-focused mobility services; connected, automated, and electric vehicles (eVs); intelligent, sensor-based infrastructure; new urban delivery methods; smart payment systems; and advanced analytics" (U.S. DOT, 2021). The concept of smart transportation encompasses a wide range of new mobility technologies. In their study of feasible new transportation options in western Arkansas and eastern Oklahoma, Gleason et al. (2021) surveyed a variety of new smart transportation technologies, such as transportation network companies (TNCs), ridesharing, transportation vouchers, community-based and volunteer programs, carsharing, shared use mobility, mobility on demand, and mobility as a service. Sperling, Pike, and Chase (2018) discussed three revolutions in the field of transportation: vehicle electrification, pooling and sharing, and vehicle automation.

Although previous studies have defined 'smart transportation' in various ways, there seemed to be a consensus that it should meet the needs of the people, particularly the needs of the most vulnerable residents, rather than widening the digital gaps between cities and residents of different socioeconomic groups (Bruno & Fontana, 2020; Hosseini et al., 2018; Lung-Amam, et al., 2021; Poltimäe et al., 2022). Smart cities should be viewed as an innovation ecosystem that empowers users' and communities' collective intelligence and co-creation capacities rather than just an innovation object (Schaffers et al. 2011, p. 432). The adoption of smart transportation technologies in small- and medium-sized cities should be aligned with the real needs of residents rather than the needs imagined by tech vendors and experts outside of these cities (Bosworth et al., 2020; Hosseini et al., 2018).

Small- and medium-sized cities have faced different challenges than large cities when it comes to the adoption of smart transportation technologies. Small- and medium-sized cities outside of large metropolitan areas have small population sizes and low population density. Residents in small- and medium-sized cities are more car-dependent and undertake more long-distance trips because of their spatial isolation and reliance on urban cores outside of their communities (Pucher & Renne, 2005). Their transportation infrastructures are car-centric and offer limited opportunities for public transit and active travel. Compared to their counterparts in large cities, the governments of small- and medium-sized cities have been less likely to adopt digital technologies and information technology (IT) infrastructures (Civil Pulse, 2021). Residents in small and rural communities have lower levels of technology ownership measured as access to broadband and ownership of smartphones and tablets (Vogels, 2021). Because of their small sizes and the lack of scale economics, the unit cost of technology tends to be higher (Spicer, Goodman, & Olmstead, 2021).

The socio-demographic characteristics of small- and medium-sized cities are also different from those of larger urban communities. Transit users in rural and smaller cities are mainly the residents who have limited access to cars, such as senior citizens, students, people with medical conditions, and low-income families (Mattson et al., 2020). The demand and budget for public transit in many small cities and rural communities has not been great enough to support a fixed-route system and their transit agencies have usually focused on demand-responsive transit services (Mattson et al., 2020). Small- and medium-sized cities have not been able to offer the same opportunities for economics of scale nor the potential for a technological and economic ecosystem with various players and high-frequency users (Lindtvedt, Frøhaug, & Nesse, 2021). In contrast, larger cities can profit more from economics of scale and a variety of business models because of their larger population, interconnectedness, and the availability of a wide range of transportation infrastructures and services (Hess et al., 2015; Schaffers et al., 2011). Private tech vendors and mobility-as-a-service (MaaS) companies have been much more likely to invest in large cities than in small ones (Bosworth et al., 2020).

Despite the lack of infrastructure and resources to support their widespread use, people in small- and medium-sized cities have a tremendous need for smart mobility technologies (Spicer, Goodman, & Olmstead, 2021). Because of their geographic isolation and reliance on larger urban cores, residents in small and rural communities drive more and take longer trips (Pucher & Renne, 2005), resulting in greater tailpipe emissions and expenses on vehicle ownership and traveling (Dong, 2021). Vehicle electrification could help to improve local air quality by emitting much fewer pollutants and reducing transportation expenses through lower fuel and maintenance costs (U.S. Department of Energy, 2021). For inhabitants in low-income and carless families, car-sharing programs have offered alternatives, easing the burden of vehicle ownership (Martin & Shaheen, 2011). Although the overall usage of public transit in small- and medium-sized cities is relatively low, smart transit could help transit riders by making it easier for them to schedule and pay for their transit trips. Research has shown that one significant advantage of public transit in rural and small urban regions is the ability to provide excursions that transit-dependent passengers would have otherwise forgone (Litman, 2018). A study in rural disadvantaged communities in Central California shows that new mobility services such as ride-hailing and car-sharing have the potential to replace existing transit services (Rodier and Podolsky, 2020). The study (Rodier and Podolsky, 2020) estimated that carsharing and split-carsharing have the greatest cost-saving potentials for riders relative to current transit services, while the cost-saving effects of ride-hailing are mixed.

3. Study Area, Data, and Methodology

3.1 Study Area

This study focuses on the eight-county region in Californi"s Central Valley (also referred to as Central California in this report), as shown in Figure 1. The region is predominantly rural. As California's largest agricultural region, the eight counties produce more than half of the state's agricultural output (Hanak et al., 2019). At the time of the 2016–2020 American Community Survey (ACS 2016–2020), the total population in the eight-county region was 4.25 million, accounting for about 10.7% of the population in California. Among the eight counties in the region, Fresno, Kern, and San Joaquin are the three most populous, with populations of 0.99, 0.89, and 0.75 million respectively, as shown in Table 1.

About 76.7% of the population in the study area live in the 62 incorporated cities. The largest city in the region is the City of Fresno with a population of 0.54 million. The average population of the 62 incorporated cities is 52,239. Only six cities in the region have populations greater than 100,000. In addition to the 62 cities, there are 255 census-designated places (CDPs), most of which have fewer than 10,000 residents.

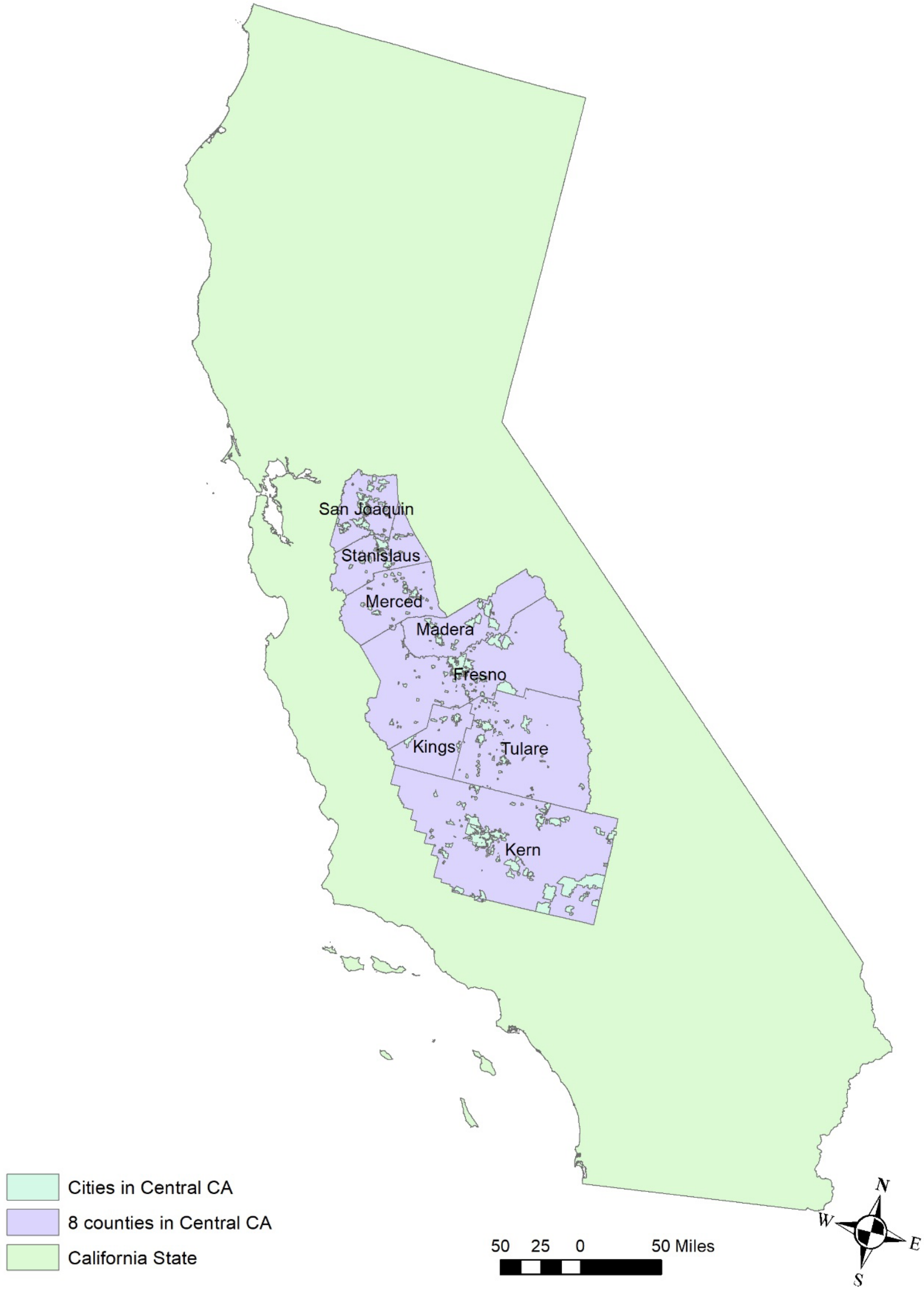

Figure 1. Study Area

Table 1. Socio-demographic Characteristics of the Study Area

	California	Eight counties in Central California							
		Fresno	Kern	Kings	Madera	Merced	San Joaquin	Stanislaus	Tulare
Population (in 100,000)	393.46	9.90	8.92	1.51	1.56	2.74	7.52	5.46	4.64
Minority population share									
Hispanic	39.1%	53.4%	53.9%	54.9%	58.3%	60.2%	41.7%	46.9%	65.1%
Black	5.4%	4.4%	5.1%	5.9%	3.1%	2.8%	6.8%	2.9%	1.3%
Asian	14.6%	10.4%	4.7%	3.6%	2.0%	7.4%	15.5%	5.7%	3.4%
Higher education attainment	34.7%	22.0%	17.1%	15.0%	15.2%	14.1%	19.2%	17.7%	14.5%
Household income (in $1000)	78.67	57.11	54.85	61.56	61.92	56.33	68.63	62.87	52.53
Poverty rate	12.6%	20.8%	20.4%	16.0%	19.0%	18.8%	13.7%	13.5%	21.8%
Employeed in ag. Industries	2.0%	8.8%	11.6%	15.2%	14.8%	11.9%	4.5%	5.2%	15.5%
Commute mode share									
Car	82.0%	90.2%	92.3%	91.1%	88.7%	88.3%	90.8%	90.9%	92.2%
Transit	4.6%	0.9%	0.7%	0.3%	0.4%	0.9%	1.6%	0.8%	0.6%
Bicycle	0.8%	0.4%	0.3%	0.5%	0.2%	0.4%	0.3%	0.4%	0.2%
Walking	2.5%	1.5%	1.1%	1.8%	1.9%	2.4%	1.3%	1.3%	1.4%

Data source: American Community Survey 2016–2020

In Table 1, we summarize the socio-demographic characteristics of the eight counties in the study area. More than half of the people in six of the eight counties are Hispanic, which is higher than their percentage in the state's population (about 39.1%). In five of the eight counties, more than 10% of the labor force is in the agricultural sector, which is much higher than the state average (about 2%).

The study area, like many areas dependent on agriculture, faces major social difficulties, such as low educational attainment, low income, and high poverty rates. All eight counties have median household incomes that are lower than the state average and have poverty rates above the state average. The poverty rates in three of the eight counties (Fresno, Kern, and Tulare) are above 20%, which is much higher than the state average (12.6%).

Not surprisingly, workers in the study area are much more car dependent than average workers in California. The shares of auto trips in commute trips in all eight counties are greater than the state average (82.0%). In six of them, more than 90% of commute trips are taken by private cars. In seven of the eight counties, less than one percent of commute trips are by public transit, which is well below the state average (4.6%). Commute trips using active travel modes (bicycle and walking) are much less popular in the eight counties than they are in other parts of the state.

3.2 Data and Methodology

This study adopted three methodologies to collect data on the adoption of smart transportation technologies in the cities in Central California.

We first searched for relevant information on the websites of the municipal governments and MPOs in the study area. We identified 62 incorporated cities and 32 CDPs with more than 5,000 residents in the study area. A student assistant browsed the websites of 59 cities and CDPs (35 cities and CDPs did not have official websites) and eight MPOs (one for each county in the study area). When conducting website browsing, the student searched for two types of information: (1) any information about smart transportation; and (2) the contact information (particularly email addresses) of transportation professionals working for municipal government departments and MPOs, such as city managers, directors and engineers in the departments of public works, transportation, engineering, and transit agencies, as well as directors and regional planners for the eight MPOs. The student assistant called some of these departments and agencies to obtain the email addresses of pertinent personnel if the email addresses were not available on their websites. We distributed online survey questionnaires via Qualtrics using the email addresses obtained.

We designed the survey questionnaire (Appendix A) to collect data on smart transportation from the transportation professionals mentioned above. The questionnaire contained four sections, in addition to a consent form. In the first section, we asked for information about the survey respondents, including occupational jurisdictions, job titles, and work experience.

The second section included three questions about the adoption of smart transportation technologies in local jurisdictions. In the first question, we provided a list of 11 typical transportation technologies that we discovered in the literature and asked survey respondents to choose the technologies that had been adopted (or were being adopted) in their jurisdictions. The respondents had the option to specify transportation technologies that were not included in the list. In the second section, we asked them whether their jurisdictions had formal plans to adopt any new smart transportation technologies. If they answered "yes" then we asked them to specify the technologies. The third question asked respondents whether or not they were aware of the successful uses of smart transportation technologies in other cities and counties within the study area.

The third section had six questions about the respondents' opinions of smart transportation in their local jurisdictions. We first asked respondents to choose major transportation challenges for residents. We next asked them if they felt that smart transportation technologies would be helpful in addressing the transportation challenges in their jurisdictions as well as what specific transportation problems were most suitable to be addressed through new technologies. In the next two questions, we asked about both the extent to which smart transportation technologies were a priority and the barriers to adopting smart transportation technologies in their jurisdictions. At the end of the section, we asked whether respondents were concerned about the smart transportation technology gap between the study area and bigger coastal cities in California such as San Jose and San Diego. The last section of the questionnaire asked respondents if they were interested in participating in our research interviews.

We conducted semi-structured interviews with seven transportation professionals. Six interviews were conducted through Zoom and one in person. Before the interviews, we reviewed the responses to our survey questionnaires to obtain knowledge about the adoption of smart transportation technologies in the respective jurisdictions. We also obtained knowledge about urban development, transportation infrastructure, and the socioeconomic profiles of their jurisdictions.

We prepared two interview templates (attached as Appendix B). The first template was for transportation professionals whose jurisdictions had adopted at least one smart transportation technology. We used this template for six interviewees. The second template was designed for transportation professionals whose jurisdictions had not adopted any smart transportation technologies. This template was used for only one interviewee. The first template contained two sections. The first section included general questions about local transportation needs, the usefulness of smart transportation technologies to address these needs, as well as the interviewee's definition of 'smart transportation.' The second section began with the specific procedures for the adoption of smart transportation technologies, including the motivation, the champion, the funding source, public participation, the stakeholders, and the efficacy of the technology. We also asked if their jurisdictions failed to adopt any smart transportation technologies and what lessons they had learned from the failure. We then asked whether the jurisdiction had formal plans to implement more smart transportation technologies. We finished the interview by asking about the smart transportation technology gap between large coastal cities and small- and medium-sized inland cities in California. For the jurisdictions that had not yet adopted any smart transportation technologies, we included similar questions in the general section of the second template. In the second section of the template, we posed four questions about the jurisdiction's reasons for not implementing smart transportation technologies and the technologies they would implement if given the chance.

The Committee for the Protection of Human Subjects at Fresno State University reviewed and approved both the online survey and the in-depth semi-structured interview.

3.3 Response Rates and the Profiles of Surveyed Cities and Respondents

We tested a draft of the survey questionnaire with three transportation professionals in late July 2022. In mid-August, we sent the final version of the survey questionnaire (Appendix A) to 114 transportation professionals in 59 cities and CDPs and 39 in the eight MPOs in the study region. We received 21 responses (out of 114, or 18.4%) from 19 incorporated cities (out of 59, or 32.2%) and 8 responses (out of 39, or 20.5%) from 7 (out of 8, or 87.5%) MPOs. None of the transportation professionals working for the CDPs responded to our survey requests.

Figure 2 shows the geographic locations of the 19 cities and 7 counties (represented by MPOs) from which we received at least one response to our survey requests. In Table 2, we present the socio-demographic characteristics of the 19 cities and compared them with those of the entire eight-county study region. The average population of the 19 cities (102,478) was larger than the average population of the incorporated cities in the study area (52,239). Four of the 19 cities had populations larger than 100,000, four between 50,000 and 99,999, ten between 10,000 and 49,999, and one below 10,000. The socio-demographic characteristics in the 19 cities vary widely, reflecting the diversity of cities in the study area. On one end, in Arvin, 94.0% of the population was Hispanic, only 2.2% of the city residents had bachelor's or higher degrees, the median household income was below $40,000, the poverty rate was 32.0%, and 45.1% of the labor force was in the agricultural sector. On the other end, in Clovis, 30.5% of people identified as Hispanic, 34.5% of the residents had bachelor's degrees or higher, the poverty rate was 8.8%, the median household income was $84,100, and only 1.3% of the labor force was employed in agriculture.

In Figure 3 we display the job titles and working experiences of the transportation professionals who responded to our surveys. Almost a third of them identified as regional transportation planners, 23% were city managers, 15% were city engineers, 15% were the managers of the municipal government department of public works, 12% were the directors of transit agencies, and 4% were the directors of the municipal department of transportation. More than half of them had worked for their cities or MPOs for more than 10 years, 15% for 6–10 years, 15% for 1–5 years, and 16% for less than a year.

Table 2. Socio-demographics of the Surveyed Cities

		Minority population			Higher	Income	Poverty	Agricultural	Commute mode share			
	Population	Hispanic	Black	Asian	education	(in $1000)	rate	job	Car	Transit	Bicycle	Walking
Arvin city	19495	94.0%	0.8%	0.5%	2.2%	39.8	32.0%	45.1%	92.2%	0.2%	0.0%	0.9%
Bakersfield city	403455	52.7%	6.5%	7.5%	22.6%	65.7	17.2%	5.4%	92.7%	0.8%	0.3%	0.8%
Ceres city	49302	64.1%	1.8%	8.3%	11.3%	59.2	14.5%	3.4%	94.8%	0.7%	0.2%	1.1%
Clovis city	120124	30.5%	2.5%	12.6%	34.5%	84.1	8.8%	1.3%	91.5%	0.3%	0.4%	0.8%
Corcoran city	22339	69.6%	12.8%	0.8%	4.1%	43.0	28.8%	29.5%	93.3%	0.5%	0.0%	1.5%
Dinuba city	24563	87.9%	0.3%	1.8%	9.3%	46.2	29.4%	20.9%	95.1%	1.2%	0.0%	0.4%
Fresno city	542107	50.5%	6.9%	14.2%	22.9%	53.4	23.5%	4.2%	89.9%	1.5%	0.4%	1.5%
Gustine city	6110	62.4%	0.3%	1.4%	13.0%	50.0	14.4%	8.3%	97.3%	0.0%	0.0%	2.7%
Kingsburg city	12380	48.3%	0.4%	3.3%	27.2%	73.3	5.9%	5.5%	92.1%	0.0%	1.3%	1.6%
Lemoore city	27038	48.0%	5.5%	8.1%	22.0%	68.7	13.5%	5.7%	92.9%	0.3%	0.4%	1.9%
Lodi city	66348	39.1%	1.2%	9.3%	21.4%	64.2	14.7%	6.1%	89.9%	0.8%	0.4%	2.9%
McFarland city	14161	95.0%	0.6%	0.8%	4.0%	36.6	29.2%	39.9%	91.4%	1.3%	0.0%	3.7%
Madera city	66224	80.7%	2.2%	2.5%	10.0%	49.3	26.1%	21.7%	88.8%	0.7%	0.4%	1.1%
Modesto city	218464	42.9%	3.7%	7.7%	19.3%	62.2	12.4%	2.2%	91.0%	1.0%	0.7%	1.0%
Selma city	24674	81.2%	0.6%	4.4%	10.1%	42.1	23.3%	12.3%	91.0%	0.7%	2.8%	0.4%
Tracy city	93000	38.7%	6.2%	20.8%	22.0%	95.7	8.6%	0.7%	89.6%	2.2%	0.2%	1.2%
Tulare city	68875	63.3%	2.6%	2.3%	10.2%	56.0	18.5%	10.1%	93.2%	0.8%	0.3%	1.0%
Visalia city	141384	52.7%	1.7%	5.4%	22.5%	66.7	14.6%	4.3%	91.3%	0.8%	0.3%	1.2%
Wasco city	27047	84.7%	5.3%	0.5%	4.4%	39.3	19.0%	28.5%	95.7%	0.1%	0.0%	0.8%
Average	102478	62.4%	3.3%	5.9%	15.4%	57.6	18.7%	13.4%	92.3%	0.7%	0.4%	1.4%
Regional average	52239	52.5%	4.3%	8.0%	18.1%	59.2	18.2%	9.5%	90.9%	0.9%	0.3%	1.4%

Data source: American Community Survey 2016–2020

Among the seven transportation professionals who participated in our research interviews, five completed our survey questionnaires and two, who were recommended by their colleagues, completed our online surveys. Two of the seven interviewees were engineers who worked for city public works or transportation departments, two were transportation engineers for city transit agencies, one worked for a city planning department, one was the director of a county regional transit agency, and one was a regional planner in an MPO. The seven interviews were conducted from September 19 to 26, 2022. Six were completed via Zoom video conference meetings and one was done in person. The length of the interview ranged from 18 minutes to 69 minutes, with an average of 41 minutes. We transcribed the seven interviews for analysis. We lightly edited the interview excerpts for readability. When directly quoting the interviews in the following section, we used only the ID numbers of the interviewees for confidentiality.

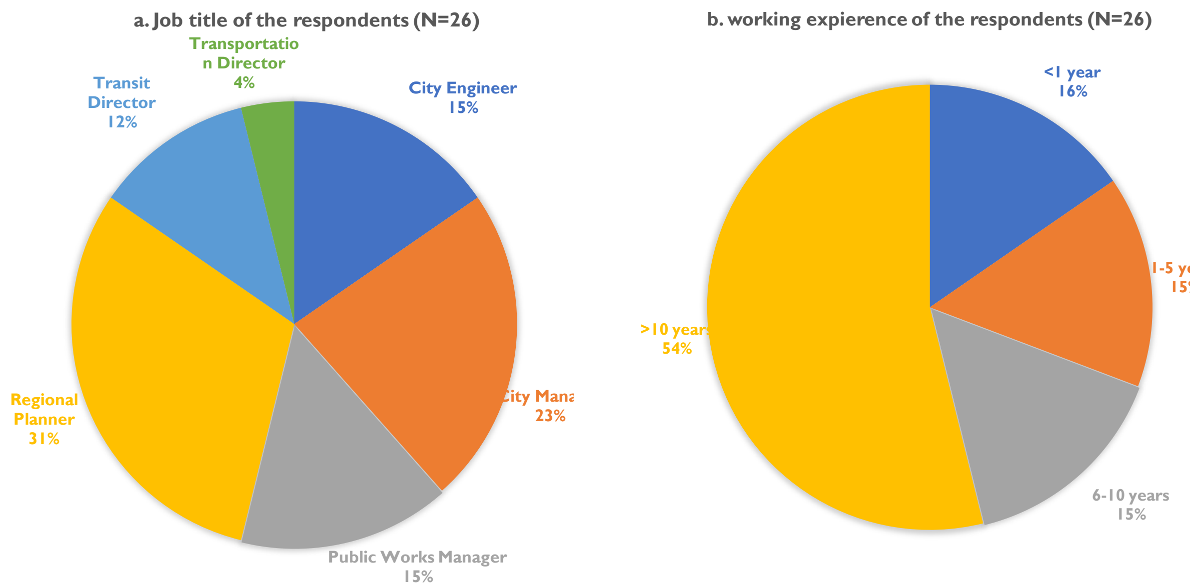

Figure 2. Job Titles and Working Experiences of Survey Respondents

4. Major Findings from Surveys and Interviews

4.1 Definition and Understanding of Smart Transportation

At the beginning of the in-depth interviews, we asked the interviewees about their definition and understanding of smart transportation. All seven interviewees referred to smart transportation as the application of new technologies, equipment, and infrastructure to improve transportation mobility and efficiency. At least two of them (Interviewees 5 and 6) emphasized that smart transportation is a whole ecosystem encompassing all travel modes.

However, when we asked them to specify the transportation technologies that could be helpful in addressing local transportation problems (discussed in the next two sub-sections), most of their responses were related to the intelligent transportation system (ITS) technologies that were used to manage vehicular traffic and reduce congestion at peak commute hours. This is not surprising given the level of car dependence in the study area.

4.2 Local Transportation Challenges

To put our surveys and interviews into local context, we asked the survey respondents and interviewees to identify major transportation problems and challenges that people in their jurisdictions face daily.

The survey results (Figure 4) showed that two of the three mostly commonly identified transportation issues were related to driving costs and access to private cars. This seems to reflect the great auto-dependence, relatively low income, and heightened poverty rates in the study area, as shown in Tables 1 and 2. Driving is almost the only option for trips that require travel beyond walking distance in most communities in the study area. Families without cars and low-income individuals found it challenging to access opportunities for employment, healthcare, and education. The second-most identified transportation problem was the lack of infrastructure for active travel, such as sidewalks and bike paths. Many neighborhoods, especially those constructed decades ago, were planned with the automobile in mind, and there are few facilities that allow people to walk or ride bicycles. While a lack of transit infrastructure and services was also common, poor access to intra- and inter-regional transit were only the fourth and fifth most frequently identified transportation problems. We speculate that this reflects the thinking of many transportation professionals who tend to believe that residents in the study area are more familiar with and prepared to use active transportation (particularly walking) rather than transit.

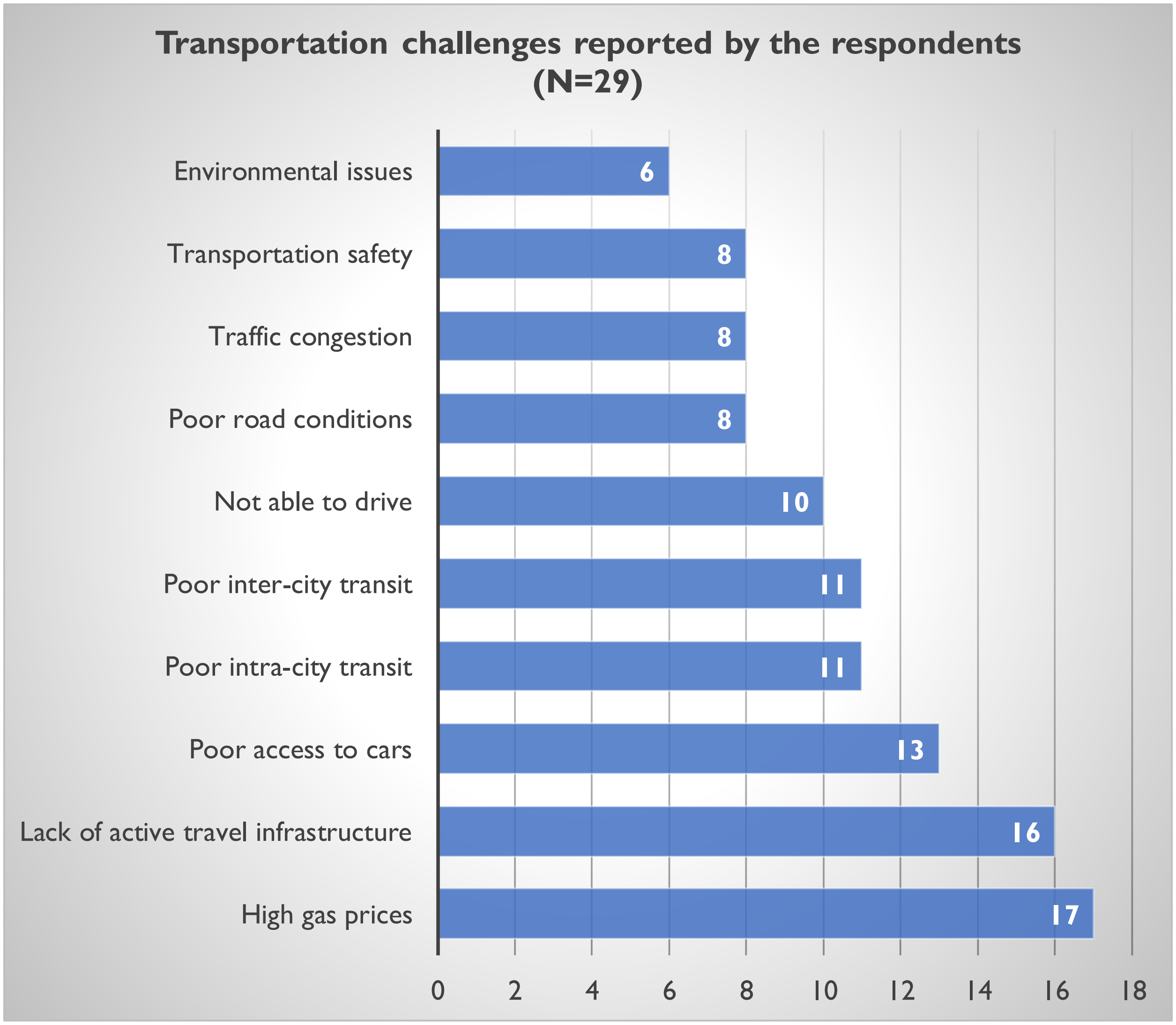

Figure 3. Local Transportation Challenges

Our interviews confirmed the prevalence of auto-focused transportation planning among the transportation professionals in the study area. At least four of the seven interviewees (Interviewees 1, 2, 4, and 5) believe that the major transportation problem in their jurisdictions is vehicular traffic management and congestion.

> "I think immediately would just be to help improve traffic or congestion management. I think that we are reliant on cars—for now anyway—and I think we need to manage the way we get around and I think that's where the issue of current transportation problems is just traffic congestion." (Interviewee #5)

Interviewees 3 and 6, both working for transit agencies, discussed inadequate and slow transit service in their jurisdictions and the difficulty of providing cost-effective transit service. Interviewee

7, employed by a small rural town without a fixed-route transit system, however, expressed satisfaction with the on-demand transit service provided by the community.

> "We were able to satisfy the needs of our customers within reasonable pickup times. As we stated earlier, we were trying on-demand service. So you pick up the phone at 8:15 you ask for a ride you can get picked up within 5–20 minutes and get to your destination fairly quickly." (Interviewee 7)

4.3 Usefulness of Smart Transportation Technologies

When asked about how helpful smart transportation technologies are in addressing the transportation challenges in their jurisdictions, only 14% (4 out of 29) of respondents selected "very helpful" and 31% chose "somewhat helpful", as shown in Figure 5. Almost half (48%) were unsure about the usefulness of smart transportation technologies in addressing local transportation problems and 7% reported that they are not very helpful or not helpful at all.

Only 16 of the 29 respondents answered our survey question about the specific transportation challenges that smart transportation technologies were most suitable to address. This is not surprising given that slightly more than half were either unsure or suspicious about the usefulness of smart transportation technologies. The most mentioned challenges were related to automobiles and traffic. Specifically, five of them (31.2%) believed that smart transportation technologies were most suitable to improve traffic conditions and reduce congestion. Four (25.0%) suggested that smart transportation technologies were most relevant in EV use and charging stations. Only four of them (25.0%) believed that smart transportation technologies were most helpful in improving transit services and accessibility of on-demand transit.

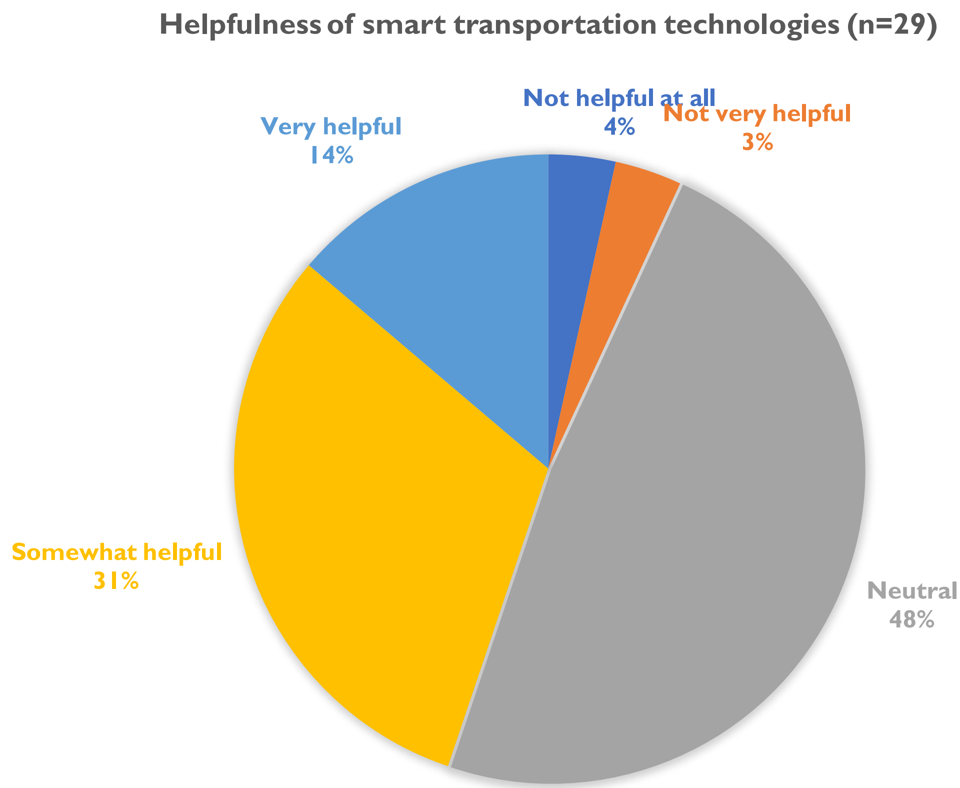

Figure 4. Helpfulness of Smart Transportation in Addressing Local Problems

In the interview, we also asked the interviewees to discuss how smart transportation would help their jurisdictions to address transportation problems. The responses were generally vague and tended to focus on the improvements of basic transportation infrastructure and service. The interviewees (1, 2, 4, and 5) who were mostly concerned about vehicular traffic and congestion provided responses including offering regional rail transit for long-distance commuters (most to the San Francisco Bay area), adding fast-track lanes, widening local roads, digitalizing and synchronizing traffic signals, and monitoring traffic speed. The interviewees who were more focused on public transit (Interviewees 3 and 6) mentioned regular ITS hardware to aid transit operation, technologies that could provide both the operators and riders with real-time information, and smartphone apps that allowed smart payment and trip planning. Interviewee 1 expressed skepticism about the usefulness of smart transportation technologies, particularly those involving autonomous and smart vehicles, expressing concern that locals might not be ready to use them and that autonomous technology might encourage more reckless driving.

4.4 Adoption of Smart Transportation Technologies in Local Jurisdictions

The online survey asked respondents to identify the smart transportation technologies that have been adopted in their jurisdictions. Figure 6 shows the smart transportation technologies that have been adopted in 18 surveyed cities (Figure 6a) and six counties (Figure 6b) respectively. Intelligent transportation systems (ITS) and EV charging stations are the two most popular smart transportation technologies in surveyed cities (61.1% or 11 out of 18) and counties (six out of six). In the 18 surveyed cities, half reported having adopted electric buses and smart transit technologies. Only eight of the 18 (44.4%) surveyed cities and four of the six counties reported offering on-demand micro-transit services. This is in contrast to the finding of our survey of municipal websites in the study area, which suggested that on-demand micro-transit was the most readily available smart transportation technology. It is unclear whether this discrepancy resulted from the respondents' incomplete knowledge of the availability of on-demand micro-transit in their jurisdictions or from some respondents' perceptions that on-demand transit was insufficiently advanced to qualify as a smart transportation technology. All six counties reported the availability of ride-hailing services, while only six of the 18 cities reported having ride-hailing services. This is not surprising because, geographically, a county contains many cities. Similar statements can be made about the varying degrees of carpool availability reported by the surveyed cities and MPOs. New micro-mobility technologies, such as bike and scooter sharing, were still uncommon in the study area.

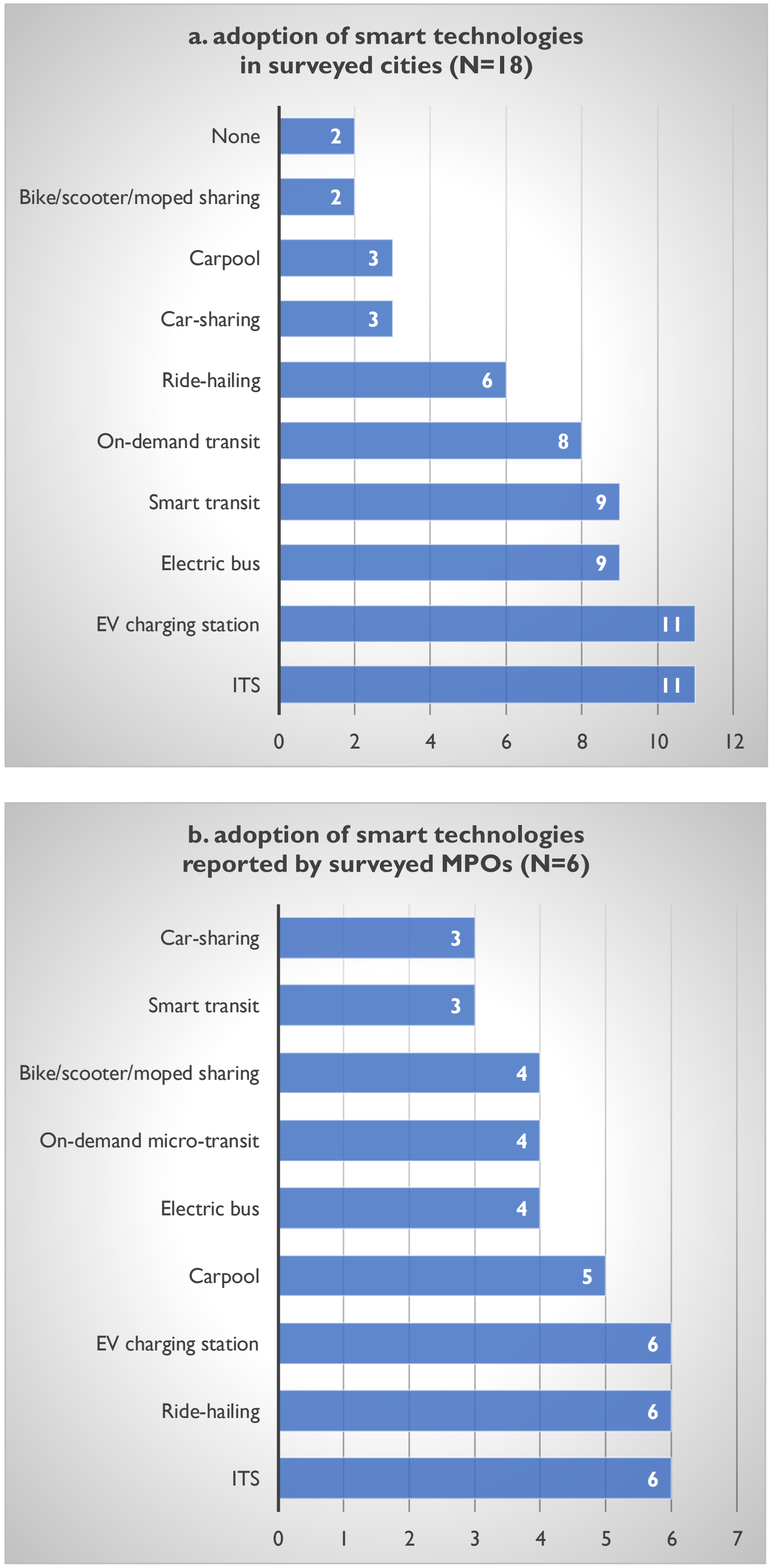

Figure 5. Adoption of Smart Transportation Technologies

The in-depth interviews with the seven transportation professionals showed that many of the smart transportation technologies that their cities and counties had adopted were not necessarily the most advanced technologies available. Some of these technologies, such as ITS, mobile transit payment, real-time bus locator, electric buses, and electric charging stations, might be considered standard transportation infrastructure and service in large coastal metropolitan areas in California.

4.5 Political and Administrative Procedures for Smart Transportation

In our in-depth interviews, we asked about the political and administrative procedures for the adoption of smart transportation technologies. We were particularly interested in whether the cities and counties in the study area had formal smart transportation plans, the involvement of other public sectors and stakeholders, public participation, and the role of private tech vendors.

None of the seven interviewees reported having formal plans for smart transportation or having a chapter of their transportation plans focusing on smart transportation. Interviewee 5 noted that his city captured it in the ITS plan. The lack of comprehensive planning and the piecemeal distribution of transportation grants mean that different parts of the smart transportation systems were not well integrated. Interviewee 4 emphasized how much they wanted to create an integrated smart transit system.

> "Instead of having a different software for fixed routes, a different software for paratransit, a different software for our on-demand transit services, we want to have something that is as integrated as possible…so we have fewer different platforms to use as possible. We don't want ten software platforms to do ten different things. We want maybe two or three that can do ten different things. That would be ideal to kind of consolidate as much as possible and integrate everything together." (Interviewee 4)

Most interviewees working at the city level saw the adoption of smart transportation technologies as "just an internal city thing" (Interviewee 4), which was usually initiated by the engineers and staff in the municipal government department of public works or transit agencies. Most (Interviewees 2, 3, 4, 5, and 6) recognized MPOs as stakeholders. The two interviewees working at the regional level (Interviewees 2 and 6) felt frustrated with their MPO's bottom-up approach to regional transportation planning and hoped that the MPOs could "take the lead with heavy hands" (Interviewee 6). Interviewee 6 held that the biggest barrier to the adoption of smart transportation technologies in small cities was that individual cities in the region were not being connected and coordinated as one working group. "We often are just working on our own and competing against each other" (Interviewee 6). Interviewee 6 further described how he would like the MPOs to take the lead.

> "I think that can be led by the MPO. Normally if an MPO says they wanna do it, take for the champion, that is vocal and that is trusted, and get it done. I'll tell you at times it would be nice if they would just make the decision right there and then have everyone in each community work towards it. I think that's probably what needs to happen to actually move the needle…" (Interviewee 6)

Interviewees 2 and 3 highlighted a collaboration between an MPO, a county housing authority, and a non-profit organization to establish an electric car-sharing program in low-income neighborhoods. The purpose of the electric car-sharing program is to provide low-income and carless families with access to automobiles at affordable rates. The program is available to its members through a smartphone application, through which users can also plan their trips and buy tickets from different transit operators. In addition, interviewees 1, 4, and 6 mentioned the potential for collaboration between the city transportation agencies and first responders (police and fire departments) to share data and the costs of installing ITS equipment.

Public participation seemed to be limited to gathering feedback and learning about users' experiences following the implementation of smart transportation. Interviewees 3 and 6 underlined the significance of marketing and outreach after observing the low adoption rates of smartphone apps for mobile transit ticketing. Interviewee 2 noted that the public was involved in deciding the sites of the electric car-sharing stations mentioned above. Interviewee 1 was cautious about promoting the adoption of a smart transportation project among the public with a concern that the failure of the project could generate frustration and anger.

Local and regional transportation agencies have relied on private tech vendors to purchase smart transportation equipment and technologies. Sometimes they have also relied on private tech vendors to tell them what technologies are available and useful for their systems. Because most procurement must be done through public bidding, they have ended up having different vendors for different parts of the system, making it difficult to integrate them. Interviewee 4 expressed a strong desire to have full control of not only the ownership of smart transportation equipment but also its operation as they were worried about over-dependency on tech vendors (in case some of them potentially go out of business). Interviewee 6 suggested that local transit agencies should unify as a region when they select contractors and establish uniformity to ensure the same equipment across vehicle fleets for the entire region.

4.6 Barriers: survey findings

When asked about the major barriers to the adoption of smart transportation technologies in the survey, lack of budget and funding was the most cited barrier among the respondents (75.9% or 22 out of 29), as shown in Figure 7. The next most cited obstacles were lack of personnel with relevant expertise (48.3% or 14 out of 29) and lack of awareness of and demand for smart transportation (also 48.3% or 14 out of 29). Nine of the 29 (31.0%) respondents also identified a lack of public support and political will as a barrier to the adoption of smart transportation technologies in their jurisdictions. Only three of the 29 (10.3%) respondents reported that higher-level (state or federal) government support, guidance, and advice would have helped to implement smart transportation technologies in their jurisdictions.

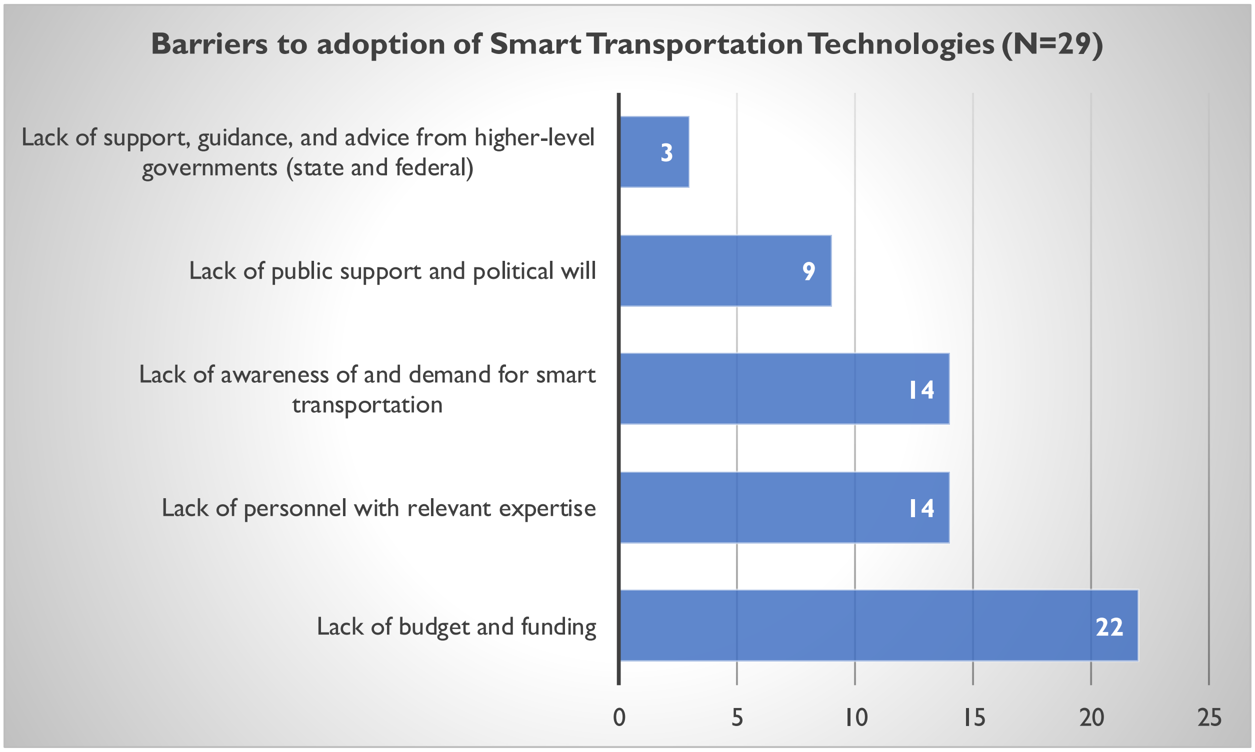

Figure 6. Barriers to Adoption of Smart Transportation Technologies

4.7 Barriers: Funding and Staff Capacity

Our interviews suggest that the funding issue is more complicated than it first appeared to be. Three interviewees (1, 2, and 4) felt that funding was not a major problem at the time of the interview. They cited multiple transportation funding sources at the state and federal levels from which they were able to obtain transportation grants. Interviewee 4 mentioned that they obtained much more funding than previously because of the 2020 Coronavirus Aid, Relief, and Economic Security Act (the CARES Act).

When funding was a problem, it manifested in multiple ways. First, some cities and transportation agencies lacked the expertise and personnel to apply for funding and grants. Interviewee 6 explained that many of the city transit managers came from the operation side and did not have the capacity to write a compelling grant application. After recognizing that transportation grants were available from multiple sources, interviewee 2 said: “I’ll tell you right now the number one thing that I am seeing. We need to hire people in all our cities. We need to go after that money now." Therefore, funding and staffing shortages were intertwined issues. Interviewees 2 and 7 found it difficult for smaller communities to compete with bigger cities in California for state and federal funding because they lack grant writers and their smaller footprints make the application of technology less cost-effective.

Second, the sustainability of the funding for smart mobility technologies was a concern because most transportation grants provided them with a one-time, fixed amount of funding. "What people don't always realize is that getting the money to purchase something is one thing, but then there's ongoing maintenance that you have to deal with that also costs money that you have to factor in as well" (Interviewee 4). Interviewee 7 echoed this concern based on their prior experience in installing cameras on their buses and bus stops.

> "A couple of years ago, … we had them all installed. But over the years as cameras wear out and they need maintenance, we don't have the funding in our regular accounts to constantly replace them and move them forward so once again that's always an issue." (Interviewee 7)

Third, local jurisdictions found it challenging to develop and deploy smart transportation technologies in a consistent and integrated manner since grants and funds for transportation were distributed piecemeal.

> "…you get money piecemeal so maybe year by year and it becomes really difficult because you have all these moving parts that were installed at different times and with different technologies and systems that changed." (Interviewee 3)

Lastly, local governments had to strike a balance between enhancing the basic transportation infrastructure and implementing a new smart transportation technology when they received funding. For the public works departments in local cities, they tended to prioritize the need to fix potholes and bumpy roads rather than the adoption of new smart transit technology. "We try to make strides when it comes to smart technology but a lot of times it's probably easier to do an infrastructure project" (Interviewee 2).

4.8 Barriers: Urban Patterns and Regional Gap

Almost half of the 29 survey respondents were either very concerned or somewhat concerned about the smart transportation technology gap between large coastal Californian cities and small- and medium-sized cities in Central California (Figure 8).

The seven interviewees outlined a few reasons for the regional gap. One was the small footprints of the cities in Central California. They explained that the small community size was relevant in at least two ways. First, the small user base made the adoption of smart transportation technology less cost-effective. Second, the small capacities of the transportation and public works departments made them less competitive in applying for federal and state grants. In addition, the small capacity indicated a lack of expertise in smart transportation. As interviewee 3 put it, "one of the reasons why we had difficulties with that initial first project with our ITS hardware on our buses was because there was no expertise in the city."

The disadvantage of small- and medium-sized communities in adopting smart transportation technologies is made worse by their sprawl-style development patterns. Low population density increases the costs of building smart transportation infrastructure. Scattered small cities within a region have different needs and priorities, making regional coordination difficult. It is challenging to maintain regional cooperation among the small municipalities in a county.

> "Even if they were coordinated and we're trying to bring everyone to the table, at the end the day, they're gonna back community. So they have the ability to make a decision on what's best for their community and they typically don't have the capacity. Either they're short on staff or don't even have the knowledge. Although they agree and shake their heads, saying 'yes, this is great', they go back to their own community and say I still do not have the time. I got other problems to deal with. That sounds great but the reality is we probably don't need that for 10 years." (Interviewee 6)

Interviewees 3 and 4 cited the different levels of educational attainment and environmental awareness between the Central and Coastal parts of California as reasons for the regional gap. Interviewee 4 pointed out that transit users in the San Francisco Bay area are much more diverse and more familiar with new information technologies than the transit users in his city. Interviewee 5 underlined that people in coastal Californian cities are more conscious of the environmental and health implications of smart transportation.

Because of their limited budget and capacity, small- and medium-sized cities in Central California usually did not pursue the most advanced smart transportation technologies. Before spending money, they needed to see proof that a smart transportation technology worked in a similar city, or at least in Central California. "If Fresno hasn't done it, if Modesto hasn't done it, then it's going to be hard to gain traction. If San Francisco did it, that doesn't matter because we know that they are on a completely different level" (Interviewee 2).

5. Summary & Conclusions

Research on smart transportation in the United States has centered on large metropolitan areas. The adoption of smart transportation technologies in small- and medium-sized cities outside of large metropolitan areas is less studied and understood. This study partially fills this gap by examining the adoption of smart transportation technologies in small- and medium-sized cities in Central California, the largest agricultural base in the United States. We conducted an online survey among transportation professionals who worked for municipal government departments and MPOs in Central California. We also conducted in-depth semi-structured interviews with seven transportation professionals. Through the surveys and interviews, we collected detailed data about the adoption of smart transportation technologies in small- and medium-sized cities in Central California, particularly concerning their effectiveness in addressing local transportation problems, the political and administrative procedures for their adoption, and the barriers to adopting them.

5.1 Limitations

Before drawing conclusions and analyzing the policy implications, it is important to remind readers about two major limitations of this study. First, 28 of the 29 survey respondents worked for jurisdictions with a population greater than 10,000, meaning that cities and Census-designated places (CDPs) with less than 10,000 people were not represented in our data sample. Second, all the survey respondents and interviewees worked for municipal government departments and MPOs. Their viewpoints and professional experiences were limited to smart transportation projects that directly involved municipal governments and MPOs

5.2 Conclusions

Despite its limitations, this study provided first-hand data about the adoption of smart transportation technologies in small- and medium-sized cities outside of large metropolitan areas in the United States. A few major findings merit further discussion.

Smart transportation in small- and medium-sized cities outside of large metropolitan areas is mainly car-centric, reflecting the high degree of auto-dependency in these communities. Slightly more than half of the transportation professionals who responded to our survey were either unsure or suspicious about the usefulness of smart transportation technologies in addressing local transportation problems. For those who believed that smart transportation technologies would be helpful, they tended to be more aware of and familiar with the ITS technologies that aimed to better manage vehicular traffic and reduce congestion, though, in general, they understood that smart transportation is a broad concept, encompassing all transportation modes. They suggested that the major transportation problems faced by residents on daily basis are mostly related to access to private cars and driving costs. Although they were also concerned about insufficient active travel infrastructure and transit service in their jurisdictions, they seemed to think that smart transportation technologies are primarily related to automobiles and vehicular traffic.

ITS and EV charging stations were the two most popular smart transportation technologies in the study area, according to our survey results. The in-depth interviews suggested that many of the smart transportation technologies that surveyed cities and counties had adopted were not necessarily the most advanced technologies. Some of these technologies, such as ITS, e-tickets for transit, real-time passenger information, electric buses, and electric charging stations, might be considered standard transportation infrastructure and service in large coastal metropolitan areas in California. Because of their limited budget and staff capacity, local municipal governments had to strike a balance between enhancing basic transportation infrastructure and implementing new smart transportation technology. Before adopting a new smart transportation technology, they needed to see proof that the technology worked in a similar city.

The study revealed several barriers to the adoption of smart transportation technologies in small- and medium-sized cities in Central California, including insufficient funding and budget, limited staff capacity, small populations, and low-density of development. These are largely consistent with the obstacles that were identified by previous studies in small and rural communities. However, the research interviews suggested that the funding issue is more complicated than it first appeared. Transportation funding sources appeared to be plentiful, but many small- and medium-sized cities lacked the staff capacity and expertise necessary to prepare funding submissions, especially when the funding requests had to go through a selection process and compete with proposals from larger cities. The cities that received transportation grants to buy equipment and technologies were unsure whether they would have enough money for maintenance and replacement once the grants ended. Furthermore, the cities also had difficulty building an integrated smart transportation system because transportation funds were distributed piecemeal and different parts of the system were purchased from different vendors.

Very few studied cities have comprehensive plans for smart transportation and instead have adopted new technologies piecemeal. Most existing smart transportation projects were initiated by the city's public works, transportation, or transit agencies who pitched ideas, applied for grants to finance them, and selected private tech vendors to install and operate them. Public participation was limited to gathering feedback and learning about users' experiences following the implementation of smart transportation. Although they were uncommon, new public–private and public–non-profit partnerships had formed in the study area to provide low-income families with affordable shared mobility.

5.3 Policy Implications

We offer four main policy recommendations based on the study's findings.

First, small cities within a region can overcome many of the disadvantages brought on by a lack of funding and staffing and a small population by forming a strong regional alliance guided by a regional smart transportation plan. In Central California, MPOs and regional transit agencies at the county level make regional transportation and transit planning based on a bottom-up approach. In many cases, their regional planning is more of a recommendation than a mandate. Stronger regional planning and even a top-down approach can serve smaller cities in multiple ways. For example, city members of an MPO may collectively employ grant writers whom they would not otherwise be able to afford. In order to increase their negotiating leverage with private tech vendors and contractors, they could form a regional coalition or ask their MPOs to act as their representatives.

Second, a comprehensive smart transportation plan is required to build an integrated and coordinated smart transportation system. Currently, the adoption of smart transportation technology is fragmented, and each part of the system is developed independently by different tech vendors. A long-term plan, ideally at the regional level, will help create an integrated system that is easier to coordinate, maintain, and upgrade. A long-term plan will also serve as a guide for selecting vendors and contractors.

Third, federal and state funding agencies may offer longer-term grants with a consideration of regional equity. A fixed-term grant may allow a small city to purchase and install smart transportation equipment. The equipment, however, may be left unused within a short period because the city does not have the budget for upkeep and to replace broken parts. Smaller cities are at a disadvantage when competing with larger cities for funding intended for the deployment of innovative transportation technologies due to their smaller footprints and lack of experience implementing comparable technology. It is thus important for funding agencies to take regional equity into account in the allocation of funds.

Fourth, transportation planners and engineers in small- and medium-sized cities outside of large metropolitan require more training and education opportunities to learn about new smart transportation technologies. Transportation planners and engineers in small cities usually have to handle a wide range of responsibilities because of limited staff capacity. Very few small cities in Central California have full-time employees dedicated to the adoption of smart transportation technologies. Compared to their counterparts in larger coastal cities such as San Francisco and San Diego, these employees have fewer opportunities to learn about the most innovative transportation technologies. They thus have to rely on private tech vendors to inform them about the most suitable technologies for their jurisdictions. The federal and state departments of transportation and MPOs may collaborate with the universities in various regions to offer training and informational courses and seminars for transportation planners and engineers in small- and medium-sized cities outside of large metropolitan areas.

Appendix A

Survey Questionnaire

First, we would like to know some information about your background, solely for the context for our study.

Q 1.1 What city/county do you work for/with?

Q 1.2 What is your current job title?

Q 1.3 How many years have you been working for/with the city/county?

Next, we would like to know the adoption of smart transportation in your city/county.

Q 2.1 Please choose any of the following technologies or projects that have been adopted, are underway, or are available in your city/county (Select all that apply).

- ☐ Intelligent transportation system (ITS), including connected traffic signal and traffic monitoring sensors/cameras
- ☐ Electric buses
- ☐ Smart transit (any new technologies applied in transit, including but not limited to smart transit signal, smart payment, smartphone app for transit riders, and public Wifi on transit vehicles)
- ☐ On-demand micro-transit (paratransit)
- ☐ Business-to-individual car-sharing or carpool (e.g., zipcar & miocar)
- ☐ Individual-to-individual carpool program
- ☐ Ride-hailing (e.g., Uber & Lyft)
- ☐ Bike/scooter/moped sharing
- ☐ Electric charging station for private electric cars or electric transit
- ☐ Smart parking
- ☐ Smart street lighting
- ☐ Other. Please specify (type “NA” if there isn’t any smart transportation adoption in your city) ____

Q 2.2 Does your city/county have a plan to adopt any new smart transportation technologies?

- ◯ Yes. Please specify ____

- ◯ No, at least not that I'm aware of.

Q 2.3 What cities/counties in Central California do you believe are most successful in adopting smart transportation technologies? Please specify the city/county names and smart transportation technologies that they have adopted. Type "NA" if you are not aware of any.

____

____

____

In the following few questions, we would like to know your opinion of smart transportation in your city/county.

Q 3.1 What are the major transportation challenges for the residents in your city/county? (Select all that apply)

- ☐ Poor or no access to public transit for travelling within the city.
- ☐ Poor or no access to public transit that connects our city to other cities in the region.
- ☐ Poor or no access to private cars due to affordability issues.
- ☐ Not able to drive due to medical conditions, disabilities, or age.
- ☐ High fuel prices.
- ☐ Poor road/street/highway conditions.
- ☐ Poor or lack of infrastructures for walking and riding bicycles.
- ☐ Traffic congestion.
- ☐ Transportation safety.
- ☐ Environmental problems related to transportation (e.g., air pollution).
- ☐ Other. Please specify: ______________________________

Q 3.2 Do you feel smart transportation technologies are helpful in meeting transportation needs and challenges in your city/county?

- ◯ 5 (very much helpful)
- ◯ 4
- ◯ 3
- ◯ 2
- ◯ 1 (not helpful at all)

Q 3.3 What are the transportation problems in your city/county that smart transportation technologies are most suitable to address?

____

____

____

Q 3.4 To what extent, smart transportation is a priority in your city/county?

- ◯ 5 (very high priority)
- ◯ 4
- ◯ 3
- ◯ 2
- ◯ 1 (not a priority at all)

Q 3.5 What are the major barriers to adopting smart transportation technologies in your city/county? (Select all that apply)

- ☐ Lack of budget and funding
- ☐ Lack of personnel with relevant expertise
- ☐ Lack of public support and political will
- ☐ Lack of support, guidance, and advice from higher-level governments (state and federal)
- ☐ Lack of awareness of and demand for smart transportation in local communities
- ☐ Other. Please specify

Q 3.6 Our research shows that bigger coastal cities in California (e.g., San Jose and San Diego) are more active in deploying smart transportation technologies than rural and small urban communities in central California. To what extent, the disparities in adopting smart transportation among Californian cities is a concern for you and your city/county?

- ○ 5 (very much a concern)
- ○ 4
- ○ 3
- ○ 2
- ○ 1 (not a concern at all)

Q 4.1 Can you recommend someone with whom our research team should speak to (in or outside of your city/county) on this topic?

○ Yes. Please specify name, affiliation, and contact

○ No

Q 4.2 Are you interested in a 30-minute interview on this topic with our research team?

○ Yes. Please let us know your email address or phone number so we can contact you to schedule a time. Thank you!

○ No

Q 4.3 What do you think of this survey? (Select all that apply)

☐ Too long

☐ Not easy to understand

☐ OK

☐ Other (please specify) ____

Q 4.4 If you have any questions or suggestions, leave me a comment below.

____

____

____

Appendix B

Template I (for jurisdictions already adopted smart transportation technologies)

General conversations about local transportation needs and the usefulness of smart transportation

1. What are your definition and understanding of smart transportation?

2. What are the major transportation problems that people in X city face daily?

3. Do you believe smart transportation technologies are suitable to solve to solve any of the transportation problems in X city? If yes, what specific problems and how? If no, why?

The adoption of smart transportation technologies in X city

1. We would like to learn more about the smart transportation technology that X city has adopted. In your response to our survey questionnaire, you suggested that multiple smart transportation technologies have been adopted. Due to time limitation, maybe we can focus on one or two important smart transportation technologies that were adopted in the past few years in X city.
    a. What are the most important smart transportation technology that X city helped to adopt in the past few years?
    b. What led X city to adopt this technology?
    c. Who were the initial champions of the proposal?
    d. How did X city fund this project?
    e. Was there any public participation in the process of adopting this technology?
    f. How did the residents and stakeholders in the city initially receive the technology?
    g. Did the technology meet the initial expectations?
2. Did city consider adopting other technologies? Why haven't these technologies gained traction?
3. Do you have a specific plan for the adoption of smart transportation technologies? Is smart transportation a priority in X city's future transportation investment? If yes, in what ways?
4. Who are the major stakeholders in the adoption of smart transportation technologies? Why are they interested in smart transportation?
5. Do you have a plan to adopt more smart transportation technologies in the next few years? If yes, what technologies? If no, why?
6. In comparison to bigger coastal cities in California, rural and small urban cities in the Central Valley lag in smart transportation technology. In your opinion, what are the most significant barriers to the adoption of smart transportation technologies in the Central Valley? What can be done to overcome these barriers?

Template II (for jurisdictions not adopted smart transportation technologies)

General conversations about local transportation needs and the usefulness of smart transportation

1. What are your definition and understanding of smart transportation?

2. What are the major transportation problems that people in X city face daily?

3. Do you believe smart transportation technologies are suitable to solve any of the transportation problems in X city? If yes, what specific problems and how? If no, why?

The adoption of smart transportation technologies in X city

1. Have you considered implementing smart transportation technologies in your city? Why hasn't smart transportation gained traction?

2. If given the opportunity and resource, what smart transportation technologies should be adopted in your city?

3. If the city X is about to adopt a new smart transportation technology, who are likely to be the champions of it?

4. In your opinion, what are the most significant barriers to smart transportation adoption in your city?

5. Some Californian cities, particularly those larger coastal cities like San Jose and San Diego have led the way in adopting smart transportation technologies. Small urban and rural communities in the Central Valley have lagged them. Is this a concern in your city? Are there anything that need to be done to narrow the gap?

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