2019

Can Uber and Lyft Save Public Transit?

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April 26, 2019

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Submitted in partial fulfillment of the requirements for a Bachelor of Arts degree with a major in Economics/Public Policy Analysis

Acknowledgements

Thank you to my readers, Bowman Cutter and Jennifer Ward-Batts, for their advising and guidance throughout the thesis writing process. I would also like to thank Warren Lee and Sebastian Hack for their valuable feedback and coding expertise. Finally, a big thank you to my family for their continuous, unwavering support over the years.

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Section I: Introduction

In 2015, the average American commuter traveling to and from an urban center spent 42 hours in traffic every year. Compare this to 2000 when the time spent in traffic was 37 hours, and 1982 when the number was merely 18 (Crow 2018). This congestion is largely due to America's car-centric travel: in 2017, 82.6 percent of trips nationwide were made by private vehicle, 10.5 percent by bike or foot, and only 2.5 percent by public transit (McGuckin and Fucci 2018, 30).

A potential solution to this traffic congestion is public transit, since it transports more people than a private vehicle while using less road space per capita. Public transit is defined as transportation by bus, rail, or similar conveyance that is provided for the public on a regular basis (Glenn 1994, 22). However, transit ridership has been consistently declining nationwide. In 2017, the number of rides taken on a public transit system fell in 31 of 35 major United States metropolitan areas. Transit planners such as Jarrett Walker, who is redesigning Houston's bus network to curb declining ridership, consider this trend an emergency because "when we don't share space efficiently, we get in each other's way. And that is a problem for the livelihood, the viability, the livability and the economy of a city... It means more traffic, more congestion" (Siddiqui 2018).

However, Transportation Network Companies (TNCs) – ride-sharing service companies like Uber and Lyft – have changed how people commute in recent years. In major cities, 21% of adults use TNCs, and 24% of these riders use TNCs on a weekly or daily basis. College-educated and affluent Americans have adopted these new services at a faster rate than less educated, lower income populations. 7% of users cite parking as the main reason why they use TNCs instead of driving themselves. Among those who use TNCs, 38% use them to travel to bars and parties, 24% to restaurants and cafés, and 11% for shopping and services (Clewlow et al. 2017, 4).

There is presently no consensus in the literature on TNCs' effects on public transit ridership, likely because these services are still new: Uber was founded in 2009 and Lyft was founded in 2012. One survey on travel behavior in seven major metro areas by the UC Davis Institute of Transportation Studies suggests that TNCs are substitutes for public transit. Over half of trips taken using TNCs either would not have occurred or passengers would have used public transit, biking, or walking if TNCs did not exist (Badger 2017). On the other hand, Manville, Taylor, and Blumenberg (2018) suggest that TNC and transit are not substitutes: since "the typical TNC user does not resemble the typical transit rider, the typical TNC trip does not occur when and where most transit trips occur, and most TNC users report no change in their travel by other modes" (Manville, Taylor, and Blumenberg 2018, 9). These two studies exemplify the lack of consensus about the relationship between TNCs and public transit.

Despite this, cities like Philadelphia, Oakland, and Tampa have explored potential synergies by directly connecting TNCs to commuters through subsidies so commuters can access public transit systems more effectively. These subsidies encourage passengers to take TNCs to public transit stops and target potential public transit riders who are discouraged or limited by their distance from public transit systems (the "first mile / last mile" problem). The potential benefits to these cities and their transit agencies include increased ridership and lower overall public transit costs. TNC subsidies have been particularly favorable for Tampa, FL, which discontinued a bus line that connected the suburb of East Lake to the city of Tampa, and replaced it with TNC subsidies. The bus line cost the transit agency $16 per rider to operate but charged commuters only $2.25, which created a $13.75 deficit per passenger per ride. County residents can now ride TNCs anywhere in the county or from the nearest bus stop, and the transit authority contributes $5 per passenger for ride's cost. This saves the transit agency $8.75 per passenger per ride (Business Insider Intelligence 2016). However, the number of commuters in the region may increase because of this subsidy, so the transit agency's total costs may substantially increase if enough additional people were motivated to travel. Commuters may prefer having an additional bus line over the subsidy if riding the bus were more affordable than riding a combination of subsidized TNCs and public transit. Also, the potentially widespread use of TNCs may increase congestion and vehicle miles traveled, exacerbate environmental harms, and worsen mobility issues for communities underserved by TNCs such as disabled and low-income riders.[1] Thus, policies connecting TNCs to public transit have potential to increase public transit ridership, but the results are currently inconclusive and the use of TNCs may create negative consequences.

Therefore, I examine whether transportation network companies (TNCs) like Uber and Lyft can help increase public transit ridership. In Section II, I investigate if TNCs are currently substitutes or complements for public transit. I find that TNCs do not have a statistically significant effect on public transit ridership overall, but are complements of public transit for certain populations. In Section III, I investigate how city governments and transit agencies can help TNCs become (stronger) complements of public transit through policy. For instance, policies that give discounts for TNC rides taken to and from transit stops could help solve the first mile / last mile problem, which would increase transit ridership.

[1] Since TNC drivers often operate their personal vehicles, riders do not usually have access to Americans with Disabilities Act (ADA)-compliant vehicles when they request TNC rides. Further, TNC fares are too costly for low-income riders to benefit from their services, since their prices are typically more expensive than alternative modes of transportation like walking, biking, and riding public transit.

Chapter 1: Literature Review

Most literature on public transit ridership includes the same variables, but results vary. Common explanatory variables include private vehicle access, transit service quality and efficiency, public funding for transit, employment levels, transit fares, population and housing density per acre, and attractiveness of driving (measured by traffic congestion, gasoline price, and parking availability and cost). Taylor and Fink (2009) note that common problems across many studies' models are multicollinearity and endogeneity, which involve correlation between variables that are assumed to be independent, potentially biasing results. For instance, some transit agencies may point to service expansions as the reason for increased ridership, although the increase in service is usually in response to rising demand. Despite these limitations, understanding the influence of these variables on ridership is central to public policy debates over public transit. This literature review will discuss research on nationwide ridership trends from the past 30 years and how the rise of new technologies has changed strategies to increase public transit ridership. Then, I will discuss applications of this literature to my research question. Overall, the studies agree that access to private vehicles is the single most important variable affecting public transit ridership, and creating mobility options through technology can reduce car ownership and consequently increase public transit ridership.

National Ridership Trends

Ridership variables are typically divided into external and internal factors. External factors occur outside the control of transit agencies, such as the region's employment levels. Internal factors can be controlled by transit agencies, such as fares and service levels.

External Factors

The most significant variables influencing transit use are private vehicle access and employment variables. These variables change commuting patterns of traditional transit riders, who are typically employed persons of color with lower incomes (Clark 2017, 4). Other important factors include demographics, spatial factors, and extent of public funding.

Costs for gasoline, purchasing cars, and parking are examples of variables related to private vehicle access. The availability and convenience of personal automobiles most significantly influence ridership because transit often functions as an inferior substitute (Taylor and Fink 2009, 7) for private vehicles (Dickens and Cromwick 2018, 12). Taylor and Fink (2009) observe that transit use decreases with increasing household incomes, and increases with higher unemployment and higher costs of car ownership. Dickens and Cromwick (2018) note that the rise of auto loans, which returned to pre-recession levels in 2018, has spurred the decline of private vehicle costs because lower-income transit users are becoming increasingly able to take low credit score (sub-prime) loans and become car owners. Though the price of gasoline was included in many models as being positively correlated with ridership, Chen, Varley, and Chen (2011) find the relationship is statistically significant but small because gasoline is only a small fraction of total car ownership costs. Further, the timing of ridership decline often does not align with fuel prices: Manville, Taylor, and Blumenberg (2018) observe that "per capita transit use in Southern California has been mostly falling since 2007," even when fuel prices were rising. Out of all private vehicle variables, studies agree that the costs and availability of parking are most influential on transit ridership (Taylor and Fink 2009, 9).

Employment influences travel patterns, which affect transit ridership. A one percent decrease in Boston's number of central city jobs between 1970 and 1990 correlated with a 1.24

to 1.75 percent decrease in ridership (Taylor and Fink 2009, 8). This study finds a greater concentration of employment helps increase ridership since "transit works best when a large number of people are traveling to and from concentrated nodes of activities" (Taylor and Fink 2009, 10). Therefore, housing and employment density per acre, physical region size, and distance between stations are also important variables. Another factor decreasing ridership is telecommuting, which is working from home through the Internet, email, and telephone. The percentage of people working from home has increased from 9 percent of workers in 1995 to 32 percent in 2006 to 37 percent in 2015 (Mallett 2018, 10). In the 2016 National Study of Employers, 40 percent of employers stated they allow working from home regularly while 66 percent allow working from home occasionally, which is a 20-percentage point increase from ten years prior (Dickens and Cromwick 2018, 4–5). Riders commuting to and from work make up a large portion of regular transit users (49 percent in 2017), so this shift towards telecommuting decreases ridership and overall use of transportation, including cars (Clark 2017, 5).

The market for transit riders has shifted over time as regional demographics change. Markets that have grown since the 90s include travelers with limited access to private vehicles – such as children, the elderly, the disabled, and the poor – and "commuters to large employment centers" such as "downtowns with limited and/or expensive parking" (Taylor and Fink 2009, 7). On the other hand, many immigrants start as frequent users of transit soon after moving into the country often because of driver's license eligibility and socio-economic constraints (Misra 2017), but decrease their use over time (Mallett 2018, 13). Researchers speculate that this phenomenon, combined with the declining number of immigrants allowed into the country, is contributing to decreasing public transit ridership (Mallett 2018, 13). Other markets that have shrunk are traditional transit riders, since the increased affordability of private vehicles incentivize them to purchase cars instead of riding transit. This behavior is perpetuated by the increased costs of urban living, which displaces traditionally transit dependent communities to more affordable and less transit-oriented areas, forcing these groups to choose travel options other than public transit (Dickens and Cromwick 2018, 5).

Finally, federal and state funding allows transit agencies to invest in transportation projects, but public funding's dearth often prevents these agencies from meeting ridership goals. Many agencies do not have sufficient funds to meet rising demand because they cannot even cover current operating costs, which presents a major obstacle to increasing ridership (Taylor and Fink 2009, 6). When funding is available, Dickens and Cromwick (2018) find that "large investments in new rail systems [have] been successful in attracting riders" and is "increasingly becoming preferred to bus travel," with total bus ridership decreasing by nearly 16 percent from 2000 to 2017 and rail ridership increasing by 43 percent. However, buses still provide more than half of all trips in 2016 and twice as many trips as rail services nationally, excluding New York City (Mallett 2018, 7). Major limitations for rail include its large capital maintenance and state of good repair issues, which "hold back rail's reliability and potential growth" (Dickens and Cromwick 2018, 4). Mallett (2018) suggests that federal funding should focus on buses that last 10 years, rather than constructing new rail systems that last for over 30 years. While rail can transport many passengers while using little road space (Mallett 2018, 17), the flexibility of buses would allow transit agencies to address the uncertainty of autonomous vehicles' and TNCs' impact on transit ridership (Mallett 2018, 2). Either way, transit agencies should be strategic and conscious as to where they are investing their funds. New rail service can often be detrimental to existing bus networks since resources are shifted toward the new rail lines. Some have suggested that this focus on rail and the restructuring of bus routes in response has contributed to lower ridership in Los Angeles (Mallett 2018, 7–8).

Internal Factors

Many studies include transit fare prices in their models. Though fares play a role in influencing ridership, most studies agree that reducing fares is far less effective at increasing transit ridership than other solutions. Litman (2004) observes that "higher decreases in transit fares would be needed to attract the same number of transit riders than if automobile costs were increased" (Chen, Varley, and Chen 2011, 1896). However, deep discounting of fares can significantly increase ridership when they are targeted towards specific market segments, such as students through university partnerships (Taylor and Fink 2009, 11).

Customer service, safety, and service frequency are highlighted as the most important internal factors in attracting riders (Taylor and Fink 2009, 12), though distance from someone's home or workplace to a transit stop and service times are also associated with how often a commuter will use transit (Mallett 2018, 11). There is some limited evidence that riders feeling unsafe on transit vehicles in recent years may have contributed to the ridership decline (Manville, Taylor, and Blumenberg 2018, 8). Overall, the convenience for riders to use transit in easily accessible locations, throughout the day, and without long wait times would incentivize people to use transit more often. Mallett (2018) notes, "the greater the supply, the greater the demand for transit." Taylor and Fink (2009) agree, finding that reducing fares is less effective at increasing ridership than increasing service.

Shared Mobility, Technology, and Transit Ridership

The literature finds that creating a large network of mobility options through technology will help reduce car ownership and increase public transit ridership, though existing research concerning the interaction among shared mobility, technology, and transit ridership is still very limited. Schwieterman and Livingston (2018) find in their study of TNCs in Chicago that "passengers are five times more likely to opt for ridesharing when they perceive the experience of using transit as unfavorable than when it is perceived as favorable" even though TNC-only trips are generally $6 to $16 more than riding public transit, because TNC trips are estimated to be 10 to 22 minutes faster (Schwieterman and Livingston 2018, 8–11). The authors point to the lack of integration between different modes of transportation as a "missed opportunity to improve mobility and enhance the effectiveness of public transit," and offer recommendations such as offering discounts on ridesharing trips to and from select rail stations when bus service is weak (Schwieterman and Livingston 2018, 19).

Murphy and Feigon (2016) conducted in-depth interviews with transportation officials and surveyed more than 4,500 shared mobility users from Austin, Boston, Chicago, Los Angeles, San Francisco, Seattle, and Washington, D.C., and found that the more people that use shared modes of transportation such as public transit, bike sharing through companies like Lime and Spin, car sharing through companies like Zipcar, and ride sharing through companies like Uber and Lyft, the more likely they are to own fewer cars and spend less money on transportation overall. They find that shared modes[2] are not substitutes for public transit because they serve different trip types. Rideshares are usually used for social trips between 10 pm and 4 am when

[2] In this sentence, I am talking about shared modes other than public transit, since I am investigating the relationship between other types of shared modes in relation to public transit.

transit service is infrequent or unavailable, and for commuting to work on occasion. Rather, Murphy and Feigon (2016) conclude that ridesharing substitutes for private automobile trips. If ridesharing were not available, 34 percent of respondents reported they would drive alone or with a friend instead. Therefore, ridesharing gives private automobile owners more opportunities to "leave [their] car at home more often" (Murphy and Feigon 2016, 18).

Transportation Network Companies (TNC) like Uber and Lyft have changed how people are commuting, though the literature has no consensus on their effects on ridership because they are so new. Manville, Taylor, and Blumenberg (2018) suggest that TNC and transit are not substitutes since TNC users and trips do not replace transit users and trips, which aligns with Murphy and Feigon (2016)'s findings. Mallett (2018) notes that TNCs can actually make commuting on transit easier by providing first mile and last mile service for transit users, allowing people to live car-free because they are able to get to and from transit stops easily. However, Dickens and Cromwick (2018) observe that TNCs may be converting traditional transit users into private vehicle owners if they drive for the company. TNCs "assist drivers with owning or leasing a vehicle," and the revenue made from driving can help fulfill car payments (Dickens and Cromwick 2018, 5).

Conclusion

In this literature review, I examined possible reasons why public transit ridership has declined in recent years and how emerging technologies and policies may help remedy this issue. Changing travel patterns, especially the rise of private vehicle access and ownership, has decreased public transit ridership nationwide. However, TNCs can help reverse this trend if they are complements of public transit. Relatively little research to date has empirically investigated whether TNCs and public transit are substitutes or complements, or determined how policy could be created to encourage their collaboration. Therefore, my thesis will examine whether TNCs can help increase public transit ridership.

Section II: How TNCs Currently Affect Public Transit Ridership

The rapid adoption of TNCs pose "significant challenges" for cities and transportation agencies because "there is limited information and data about how these services affect transportation decisions and travel patterns" (Clewlow et al. 2017, 4). Past research finds conflicting conclusions as to how TNCs influence public transit ridership and overall consumer transportation choices, which place policy makers in a difficult position as they attempt to address mobility, congestion, and environmental issues surrounding transportation. Therefore, this data section aims to clarify the relationship among individual commuters, public transit, and TNCs to determine if TNCs are complements or substitutes of public transit.

In this section, I first outline the theoretical framework behind my regression analysis. My regression focuses on a consumer's choice among different modes of transportation. Then, I describe my data from the American Time Use Survey, which covers United States metropolitan areas from the years 2005 to 2017. Next, I examine whether certain demographics are more likely to ride public transit after TNCs begin service in their metropolitan areas. Finally, I run my regressions and determine if TNCs are complements or substitutes of public transit. I find that TNCs do not have a statistically significant effect on public transit ridership overall, but are complements of public transit for certain populations.

Chapter 2: Theory

This chapter describes the regression model I built to investigate the relationship between TNCs and public transit ridership.

My dependent variable is the probability that an individual uses public transit. My key independent variable is whether TNCs are in operation. If this probability increases after TNC services start being offered, then there is a positive correlation between TNCs and public transit ridership, which implies that they are complements.

My independent variables are divided into four categories: family, work, individual characteristics, and external controls. The family and work categories affect how much time and money an individual has, which influences whether they take public transit. The other two categories primarily serve as controls for consumer characteristics and external factors (Barff, Mackay, and Olshavsky 1982, 371).

I include two variables under the Family category. The number of young children (under 13 years old[3]) in the household is the first variable, because children decrease an individual's availability of time. Children attend school, participate in extracurricular activities like soccer practice, need to be looked after and taken care of, and more. Having children increases not only day-to-day responsibilities, but also an individual's need for convenient modes of transportation because unexpected events may occur. For instance, if a child falls ill and needs to be picked up from school, then having a more flexible mode of transportation like a personal car may be more practical than waiting for the next bus or train, which may not even go directly to the child's

[3] Teenagers are generally more capable of taking care of themselves than children under 13 years old. For instance, most parents can trust teenagers to walk home by themselves, while parents may be more hesitant for younger children. Older teenagers also have opportunities to acquire drivers' licenses, which give them even more autonomy.

school. I therefore hypothesize a negative correlation between the number of young children and public transit ridership. The second variable is the presence of a spouse or unmarried partner in the household, which I believe increases an individual's availability of time because the spouse or partner could help complete household tasks and look after any children they may have. Thus, I predict a positive correlation between the presence of a spouse and public transit ridership.

Income, hours worked per week, industry, and occupation are the four variables in the Work category. Individuals with higher incomes can afford multiple modes of transportation. I measure income by using family income rather than the individual's salary, since it is more representative of the overall wealth the person can access. For instance, someone may be a homemaker and not earn any income. However, it would be incorrect to state that they have no income if they have access to their spouse's salary and use that money to fund expenditures. Income also serves as a proxy for the value of travel time and has a strong, positive correlation with automobile ownership (Barff, Mackay, and Olshavsky 1982, 377). Therefore, I predict a negative correlation between income and public transit ridership. The second Work variable is hours worked per week. I predict that individuals who work longer hours have less free time. Thus, I hypothesize that someone with a longer work day would prefer a more convenient mode of transportation, and would therefore be less likely to ride public transportation. Industry and Occupation control for job characteristics that also affect a worker's availability of time and money. For instance, certain industries like business services may have more opportunities for employees to work remotely – perhaps during the employee's commute, which would make traveling on public transportation more convenient – while other industries like construction may place a higher emphasis on employees working on-site. This flexibility varies based on an employee's occupation, as well: an engineer designing the construction site could work remotely more easily than a construction worker.

The final two categories are controls for individual characteristics and external factors. Individual characteristics include sex, age, education level, and metropolitan area. The metropolitan area variable controls for region characteristics and the modes of transportation available to commuters (Barff, Mackay, and Olshavsky 1982, 378). I examine transportation choices made on weekdays, because an individual's commuting behavior likely differs on the weekend. For instance, an individual may ride the bus every day to work, but may drive a car during the weekend for longer trips outside of the city.

Therefore, the model for determining if TNCs are complements or substitutes of public transit can be conceptually expressed as the following regression:

$$\begin{aligned} P(Rode\_Public\_Transit) = \; & \beta_0 + \beta_1\, TNC\_in\_Operation + \beta_2\, Family + \beta_3\, Work \\ & + \beta_4\, Individual\_Characteristics + \beta_5\, External\_Controls + \mu \end{aligned}$$

With the specific variables outlined earlier in this chapter, the regression expands to:

Equation 1: Probability of Riding Public Transit

$$\begin{aligned} P(Rode\_Public\_Transit) = \; & \beta_0 + \beta_1\, TNC\_in\_Operation + \beta_2\, NumberOf\_YoungChildren \\ & + \beta_3\, Spouse\_Partner + \beta_4\, Family\_Income \\ & + \beta_5\, Hours\_Week + \beta_6\, Industry + \beta_7\, Occupation + \beta_8\, Sex \\ & + \beta_9\, Age + \beta_{10}\, Education + \beta_{11}\, Metropolitan\_Area \\ & + \beta_{12}\, Year + \mu \end{aligned}$$

Chapter 3: Data

I use individual-level repeated cross-sectional data from the American Time Use Survey (ATUS) to determine if TNCs are complements or substitutes for public transit. The ATUS is sponsored by the Bureau of Labor Statistics (BLS) and conducted by the U.S. Census Bureau. The survey provides annual, nationally representative estimates of "how, where, and with whom Americans spend their time" (Bureau of Labor Statistics 2018c). Its data includes information from 190,000 interviews conducted from 2003 to 2017. One respondent per household is randomly selected from a subset of households that recently completed the Current Population Survey (CPS). All ATUS data is collected using computer-assisted telephone interviewing. The interview is a combination of structured questions and open-ended conversations, and covers topics including the respondent's household roster and time diary. The time diary outlines how the respondent spent their time starting at 4 AM the previous day and ending at 4 AM on the interview day. For each activity, the interviewer asks how long the activity lasted, who was in the room or accompanied the respondent, and where the activity took place (Bureau of Labor Statistics 2018a, 18). The data in this paper ranges from 2005 to 2017: 2017 is the most recent year-long data available as of this writing, and 2005 predates Uber and Lyft's founding dates (2009 and 2012, respectively) and comes after ATUS' survey design change, which occurred between 2003 and 2004.

The dependent variable, *Rode Public Transit*, is a dummy variable that indicates whether the respondent took public transit on the diary day. The aggregate data from this variable reflects the probability of an individual using public transit. This variable is derived from the ATUS' mode of transportation variables, which include categories like taxi/limousine service[4]; car,

[4] TNCs are categorized under taxi/limousine service.

truck, or motorcycle; walking; bus; subway/train; bicycle; boat/ferry; airplane; and other mode of transportation (Bureau of Labor Statistics 2018b, 28). *Rode Public Transit* is 1 if the individual took a bus, subway, or train on the diary day, and 0 if otherwise. 3.3% of individuals in this paper's dataset rode public transit, with a standard deviation of 0.179 (Table 1).

Table 1. Summary Statistics for Dummy Variables

Variable	Obs.	Mean	Std.Dev.	Min	Max
Rode Public Transit	79,258	0.033	0.179	0	1
TNC in Operation	79,258	0.280	0.449	0	1
Spouse or Unmarried Partner	79,258	0.701	0.458	0	1
Female	79,258	0.560	0.496	0	1

My key independent variable, *TNC in Operation*, is a dummy variable that denotes whether TNCs were serving the respondent's metropolitan area when the diary day was recorded. To create this variable, I first dropped respondents from the dataset if they were not living in a metropolitan area, since my research focuses solely on metropolitan areas in the United States. Then, I linked each Metropolitan Core Based Statistical Area Code (*Metropolitan Area Code*) in the dataset to the metropolitan area's name (Appendix A). Next, I found each metropolitan area's Uber or Lyft launch date online by reading local newspaper articles and the companies' blog posts. Using the month and year of the earliest TNC launch date[5] specified in these online articles, I changed the dummy variable for *TNC in Operation* from 0 to 1 if the respondent recorded their diary day after Uber or Lyft launched in their metropolitan area. TNCs

[5] Often, Uber and Lyft enter markets at different times. I used the earliest launch date available to better measure how the presence of TNCs in a metropolitan area affects public transportation ridership. I use Uber and Lyft launch dates because they are currently the most widely used TNCs in the United States.

were in operation for 28% of the respondents in this dataset, with a standard deviation of 0.449 (Table 1). In addition to creating *TNC in Operation*, the *Metropolitan Area Code* variable controls for types of transportation options available, frequency of public transportation, population density, and other characteristics that vary among metropolitan areas.

56% of respondents are female, with a standard deviation of 0.496, and 70.1% have a spouse or unmarried partner, with a standard deviation of 0.458 (Table 1). On average, respondents are 43.477 years old, with a standard deviation of 16.389, and have 0.744 children under 13 years old living in their household with a minimum of 0 children, maximum of 9, and standard deviation of 1.026 (Table 2). Respondents work an average of 25.595 hours per week, ranging from 0 to 160 hours with a standard deviation of 21.733 (Table 2).

Table 2. Summary Statistics for Continuous Variables

Variable	Obs.	Mean	Std.Dev.	Min	Max
Number of Children (<13 y/o)	79,258	0.744	1.026	0	9
Work Hours per Week	79,258	25.595	21.733	0	160
Age	79,258	43.477	16.389	15	85

Family Income is a categorical variable that ranges from 1 to 16. The variable represents the combined income of all family members during the last 12 months, and includes money from jobs, dividends, net income from business, rent, interest, and Social Security payments (American Time Use Survey 2018, 17). The average income of the sample is $83,880[6] with a standard deviation of 70,261. Table 3 outlines each family income's frequency in the dataset.

[6] To find average income, I took the midpoint of each income category and calculated the weighted average of all the midpoints.

Table 3. Family Income Frequencies

Variable	Family Income	Frequency	Percent
1	Less than $5,000	1,398	1.76
2	$5,000 to $7,499	934	1.18
3	$7,500 to $9,999	1,086	1.37
4	$10,000 to $12,499	1,597	2.01
5	$12,500 to $14,999	1,522	1.92
6	$15,000 to $19,999	2,718	3.43
7	$20,000 to $24,999	3,530	4.45
8	$25,000 to $29,999	3,922	4.95
9	$30,000 to $34,999	4,210	5.31
10	$35,000 to $39,999	3,857	4.87
11	$40,000 to $49,999	6,370	8.04
12	$50,000 to $59,999	6,644	8.38
13	$60,000 to $74,999	8,839	11.15
14	$75,000 to $99,999	11,444	14.44
15	$100,000 to $149,999	11,781	14.86
16	$150,000 and over	9,406	11.87

Education Level is another categorical variable that represents the respondents' highest level of school completed or the highest degree received. The variable ranges from 0 to 2. The average education level is 1.401 with a standard deviation of 0.575. Table 4 outlines each education level's frequency in the dataset.

Table 4. Education Level Frequencies

Variable	Education Level	Frequency	Percent
0	Less than High School	3,580	4.52
1	High School or Some College	40,334	50.89
2	Associate Degree and above	35,344	44.59

Industry is also a categorical variable that represents the industry of the respondent's main job. The variable ranges from 0 to 13. Table 5 outlines each industry's frequency in the dataset.

Table 5. Industry Frequencies

Variable	Industry	Frequency	Percent
0	None (No Job)	28,091	35.44
1	Agriculture, forestry, fishing, and hunting	460	0.58
2	Mining	158	0.20
3	Construction	2,881	3.63
4	Manufacturing	5,267	6.65
5	Wholesale and retail trade	6,358	8.02
6	Transportation and utilities	2,303	2.91
7	Information	1,319	1.66
8	Financial activities	4,091	5.16
9	Professional and business services	6,500	8.20
10	Educational and health services	13,011	16.42
11	Leisure and hospitality	3,796	4.79
12	Other services	2,444	3.08
13	Public Administration	2,579	3.25

Occupation is a categorical variable that represents the occupation of the respondent's main job. The variable ranges from 0 to 3. Blue Collar occupations (*Occupation* = 1) involve manual labor and include jobs in construction and maintenance. Pink Collar occupations (*Occupation* = 2) involve personal service and include jobs in administrative support and sales. White Collar occupations (*Occupation* = 3) are often based in an office and include jobs in computer science and financial operations. Table 6 outlines each occupation's frequency in the dataset.

Table 6. Occupation Frequencies

Variable	Occupation	Frequency	Percent
0	None (No Job)	28,091	35.44
1	Blue Collar (Manual Labor)	11,441	14.44
2	Pink Collar (Service)	21,488	27.11
3	White Collar (Office)	18,238	23.01

Comparing Sample Groups

I compared the dataset before and after TNC began operation to confirm that the two sample groups are similar. Otherwise, any effects I observe in the regression may be more reflective of the sample's composition rather than influences from the variables. In Tables 7, 8, 9, 10, and 11, respondents who were surveyed before TNCs started operating are listed in the 0 columns, while those surveyed after TNCs started operating are listed in the 1 columns.

First Sample Group Test: Mean Differences

I conducted mean differences tests with each continuous variable to determine if the samples before and after TNC began operation are different. The null hypothesis is that the difference between each variable's means before and after TNC began operation is zero, which is what we want. The alternative hypothesis posits that the null hypothesis is untrue. We can either reject the null if the hypothesis test's p-value is small (less than or equal to 0.05), or fail to reject the null if otherwise. Results are listed in the p-value columns of Tables 7, 8, 9, 10, and 11.

Table 7. Summary Statistics before and after TNC began operation[7]

Variable	Mean			Std.Dev.		Min		Max	
	0	1	p-value	0	1	0	1	0	1
Rode Public Transit	0.029	0.044	0***	0.168	0.204	0	0	1	1
Number of Children (<13 y/o)	0.765	0.692	0***	1.038	0.995	0	0	9	8
Spouse or Unmarried Partner	0.698	0.710	0.0010***	0.459	0.454	0	0	1	1
Work Hours per Week	25.736	25.232	0.0033***	21.736	21.720	0	0	160	120
Female	0.564	0.551	0.0011***	0.496	0.497	0	0	1	1
Age	42.921	44.902	0***	16.226	16.716	15	15	85	85

*** p<0.01, ** p<0.05, * p<0.1

[7] The number of observations for before and after TNC began operation are 57,029 and 22,229, respectively.

All continuous variables (Number of Children <13 y/o, Work Hours per Week, and Age) and dummy variables[8] (Rode Public Transit, Female, and Spouse or Unmarried Partner) have a p-value that is less than 0.05 so we reject the null (Table 7).

For categorical variables (Family Income, Education Level, Industry, and Occupation), I conducted proportion difference tests for each category. For Family Income, families earning less than $5,000 have a p-value of 0.5054, and families earning between $7,500 and $9,999 have a p-value of 0.0706, so we fail to reject the null. For all other Family Income categories, the p-value is less than 0.05 so we reject the null (Table 8). For Education Level, respondents who never went to high school have a p-value of 0.1370 so we fail to reject the null. We reject the null for all other Education Level categories (Table 9).

Table 8. Family Income Frequencies before and after TNC began operation

	TNC in Operation				
	0		1		
Family Income	Frequency	%	Frequency	%	p-value
Less than $5,000	1,017	1.78	381	1.71	0.5054
$5,000 to $7,499	744	1.30	190	0.85	0***
$7,500 to $9,999	808	1.42	278	1.25	0.0706*
$10,000 to $12,499	1,213	2.13	384	1.73	0.0003***
$12,500 to $14,999	1,138	2.00	384	1.73	0.0135**
$15,000 to $19,999	2,019	3.54	699	3.14	0.0060***
$20,000 to $24,999	2,665	4.67	865	3.89	0***
$25,000 to $29,999	2,976	5.22	946	4.26	0***
$30,000 to $34,999	3,140	5.51	1,070	4.81	0.0001***
$35,000 to $39,999	2,886	5.06	971	4.37	0***
$40,000 to $49,999	4,767	8.36	1,603	7.21	0***
$50,000 to $59,999	4,955	8.69	1,689	7.60	0***
$60,000 to $74,999	6,586	11.55	2,253	10.14	0***
$75,000 to $99,999	8,338	14.62	3,106	13.97	0.0197**
$100,000 to $149,999	8,108	14.22	3,673	16.52	0***
$150,000 and over	5,669	9.94	3,737	16.81	0***
Total	57,029	100%	22,229	100%	

*** p<0.01, ** p<0.05, * p<0.1

[8] For each dummy variable, I conducted proportion difference tests. The null hypothesis is that the difference between the proportions before and after TNC began operation is zero.

Table 9. Education Level Frequencies before and after TNC began operation

	TNC in Operation				
	0		1		
Education Level	Frequency	%	Frequency	%	p-value
Less than High School	2,615	4.59	965	4.34	0.1370
High School or Some College	30,045	52.68	10,289	46.29	0***
Associate Degree and above	24,369	42.73	10,975	49.37	0***
Total	57,029	100%	22,229	100%	

*** p<0.01, ** p<0.05, * p<0.1

We fail to reject the null for seven industries: Mining (p-value=0.4061), Transportation and utilities (0.0910), Information (0.0910), Financial Activities (0.9892), Educational and health services (0.5235), Leisure and hospitality (0.1749), and Public Administration (0.2785). We reject the null for seven industries: Agriculture, forestry, fishing, and hunting; Construction; Manufacturing; Wholesale and retail trade; Professional and business services; Other services; and None (No Job) (Table 10). We reject the null for all occupations (Table 11).

Table 10. Industry Frequencies before and after TNC began operation

	TNC in Operation				
	0		1		
Industry	Frequency	%	Frequency	%	p-value
None (No Job)	19,967	35.01	8,124	36.55	0***
Agriculture, forestry, fishing, and hunting	354	0.62	106	0.48	0.0166**
Mining	109	0.19	49	0.22	0.4061
Construction	2,131	3.74	750	3.37	0.0142**
Manufacturing	3,900	6.84	1,367	6.15	0.0005***
Wholesale and retail trade	4,774	8.37	1,584	7.13	0***
Transportation and utilities	1,693	2.97	610	2.74	0.0910*
Information	970	1.70	349	1.57	0.0910
Financial activities	2,944	5.16	1,147	5.16	0.9892
Professional and business services	4,401	7.72	2,099	9.44	0***
Educational and health services	9,332	16.36	3,679	16.55	0.5235
Leisure and hospitality	2,768	4.85	1,028	4.62	0.1749
Other services	1,806	3.17	638	2.87	0.0300**
Public Administration	1,880	3.30	699	3.14	0.2785
Total	57,029	100%	22,229	100%	

*** p<0.01, ** p<0.05, * p<0.1

Table 11. Occupation Frequencies before and after TNC began operation

	TNC in Operation				
	0		1		
Occupation	Frequency	%	Frequency	%	p-value
None (No Job)	19,967	35.01	8,124	36.55	0***
Blue Collar (Manual Labor)	8,505	14.91	2,936	13.21	0***
Pink Collar (Service)	15,832	27.76	5,656	25.44	0***
White Collar (Office)	12,725	22.31	5,513	24.80	0***
Total	57,029	100%	22,229	100%	

*** p<0.01, ** p<0.05, * p<0.1

Second Sample Group Test: Demeaning Variables

From the mean differences test, I find that a large portion of variables are significant. This may be because American demographics are changing over time, and these changes vary depending on the metropolitan area. The mean differences test did not consider yearly and regional differences, so I run a second test controlling for these two factors by demeaning variables through regressions. I regress every variable on TNC, Metropolitan Area, and Year, which are the regressions' three independent variables (Equation 2). The Metropolitan Area and Year variables control for regional and yearly effects on the dependent variable. I use fixed effects (FE) rather than linear variables, because I do not want to assume that Metropolitan Area and Year have linear effects on public transit ridership. After running the regression, if the TNC variable is not significant, then the samples before and after TNC began operation are similar, which is preferable. If the TNC variable is significant, then the samples are different.

Equation 2: Demeaning Variables Example

$$P(Rode\_Public\_Transit) = \beta_0 + \beta_1\, TNC\_in\_Operation + \beta_2\, Metropolitan\_Area\_FE + \beta_3\, Year\_FE + \mu$$

The results from demeaning variables are listed in Table 12. To determine the p-values for categorical variables, I first ran Seemingly Unrelated Regressions (SUR). A SUR contains several regression equations, which each has their own dependent and independent variables. Using Occupation as an example, Blue Collar, Pink Collar, and White Collar serve as the dependent variables of their own regressions, and None (No Job) is omitted to prevent multicollinearity. TNC, Metropolitan Area, and Year serve as the independent variables for each small regression. Then, I conducted a joint test among the three Occupation SURs to examine whether TNC's coefficient in relation to Blue Collar = TNC's coefficient in relation to Pink Collar = TNC's coefficient in relation to White Collar = 0. If the coefficients are all zero (p-value ≥ 0.05), then the joint test is insignificant and we can conclude that TNCs do not influence the number of workers in Blue Collar, Pink Collar, and White Collar occupations, which is preferred. After testing each variable, I find that the populations before and after TNC began operation are not significantly different (Table 12). Therefore, any effects I observe in the regression reflects influences from the variables instead of the sample composition.

Table 12. TNC's Significance after Demeaning Variables

Variable	**P-Value for TNC**
Rode Public Transit	0.375
Number of Children (<13 y/o)	0.372
Spouse or Unmarried Partner	0.798
Family Income*	0.166
Work Hours per Week	0.695
Industry*	0.130
Occupation*	0.631
Female	0.378
Age	0.291
Education*	0.667

Note: Asterisk (*) denotes categorical variables.

Chapter 4: Who Uses TNC and Public Transit

In this chapter, I investigate if TNCs affect certain groups of people more than others when it comes to changing transportation behavior. These findings can help guide policy creation regarding the relationship between TNCs and public transit ridership by identifying groups of people who are more likely to begin riding public transit after TNC services become available ("sensitive groups"). First, I outline the relationship among sensitive groups, TNCs, and public transportation. Then, I discuss how TNCs' flexibility makes the service more valuable, because having an additional, on-demand transportation option gives individuals far more flexibility than solely relying on public transit. Finally, I discuss which sensitive groups I have identified, which will be tested in the following Results section.

TNCs are not drastically different than personal automobiles, since both take approximately the same amount of travel time and use the same mode of transportation. Though TNC riders do not have to drive their own vehicles, TNC rides are generally less convenient and more expensive than driving a personal automobile. Therefore, it seems less likely that people who currently use personal automobiles and transit together would switch automobiles for TNCs.

Sensitive groups, on the other hand, are interested in riding public transit and have a high option value for TNCs because of the flexibility they provide. Option value means that a person places value on having an option to do something, even if they may never actually use it. The concept exists because having an option to do something affects what choices someone makes. For instance, someone may be interested in commuting with public transit because it is a cheaper mode of transportation, but worry that they may need their personal automobile in emergency situations. Their child may get sick from school so they would need a car to pick up the child at a moment's notice, or they may have a job that requires working past public transit operation hours on occasion so they drive their car to work every day to prevent being stranded at the office. TNCs allow these people to use public transit for most of their trips, but give them the option to get where they need when unexpected events occur. In addition, people who have time constraints and can get work done during their public transit commute may be more incentivized to switch to public transit, because they can begin working before arriving in the office, which would not be possible if they drove their own vehicle.

Another example of option value is people who take infrequent, discretionary trips. These individuals use TNCs and transit in conjunction to travel to places where transit lacks flexibility. For example, public transit may only be able to take someone to a transit hub instead of their destination. TNCs allow these individuals to take transit for most of their trip and complete their journey with a TNC ride. Without the availability of TNCs, these individuals may have driven a car to the location or not gone at all. An additional benefit for these riders is that TNCs are less expensive than owning a personal vehicle if discretionary trips are infrequent and if they live in high cost cities where vehicle ownership costs – such as parking – is expensive.[9]

With this background, I identify three sensitive groups: women with children,[10] white collar occupations, and longer work hours. First, women with children may drive a personal automobile because they want to be available if their children need to be picked up from school at a moment's notice. TNCs give mothers the option to take these discretionary trips when needed, so they can use public transit for regular commutes. Second, people in white collar

[9] Would anyone subtract transit trips due to the availability of TNCs? This scenario seems unlikely, because TNCs just provide an additional option and are significantly more expensive than transit. Thus, these individuals would be more likely to substitute transit with private automobiles than TNCs.

[10] I assume women are primary caretakers of children in the household even if they are working, which has historically been the case for most households in the United States.

occupations can work during their public transit commute, unlike those in service or manual labor occupations, so they have an incentive to ride public transit. TNCs also provide a flexible transportation option in special circumstances, such as occasional off-site meetings. Third, workers who work long hours and may occasionally go into the office early or leave late to complete their work can use TNCs when public transit is not operating.

As I run regressions in the Results section, I will add controls for these sensitive groups to determine their relationship with public transit ridership and TNCs through data. These controls will appear as interaction terms between the sensitive group and TNC variable. For example, for the "white collar occupation" sensitive group I will add "*White Collar Occupation* x *TNC in Operation*" as a variable in my regression. I will add separate interaction terms in separate regressions for each sensitive group.

Chapter 5: Results and Discussion

Table 13. Regressions on the Probability of Riding Public Transit

	(1)	(2)	(3)	(4)	(5)
TNC in Operation	0.0068	-0.0009	0.0107*	0.0027	8.59e-05
	(0.0044)	(0.0065)	(0.0061)	(0.0046)	(0.0053)
Number of Children (<13 y/o)	-0.0158***	-0.0159***	-0.0125***	-0.0158***	-0.0158***
	(0.0011)	(0.0011)	(0.0016)	(0.0011)	(0.0011)
Spouse or Unmarried Partner	-0.0358***	-0.0358***	-0.0359***	-0.0359***	-0.0359***
	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)
Work Hours per Week	-0.0003***	-0.0003***	-0.0004***	-0.0003***	-0.0004***
	(9.73e-05)	(9.72e-05)	(9.78e-05)	(9.73e-05)	(0.0001)
White Collar Occupation	0.0169***	0.0169***	0.0167***	0.0118***	0.0168***
	(0.0032)	(0.0032)	(0.0032)	(0.0034)	(0.0032)
Female	-0.0142***	-0.0143***	-0.0093***	-0.0142***	-0.0142***
	(0.0026)	(0.0026)	(0.0034)	(0.0026)	(0.0026)
Age	-0.0018***	-0.0018***	-0.0018***	-0.0018***	-0.0018***
	(9.15e-05)	(9.16e-05)	(9.18e-05)	(9.14e-05)	(9.15e-05)
Less than High School	0.0399***	0.0399***	0.0398***	0.0400***	0.0399***
	(0.0071)	(0.0071)	(0.0071)	(0.0071)	(0.0071)
Associate Degree and above	-0.0022	-0.0021	-0.0020	-0.0021	-0.0021
	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0021)
Female x No. of Children x TNC			-0.0015		
			(0.0045)		
Female x No. of Children			-0.0049**		
			(0.0021)		
Female x TNC			-0.0046		
			(0.0064)		
No. of Children x TNC			-0.0009		
			(0.0035)		
White Collar x TNC				0.0173***	
				(0.0060)	
Work Hours x TNC					0.00027**
					(0.0001)
Constant	0.123***	0.123***	0.121***	0.124***	0.124***
	(0.0153)	(0.0172)	(0.0151)	(0.0153)	(0.0153)
Observations	39,385	39,385	39,385	39,385	39,385
R-squared	0.092[11]	0.092	0.092	0.092	0.092

Notes: Robust standard errors in parentheses. Family Income, Industry, other Occupation categories, Metropolitan Area, and Year are additional control variables that are included in all models.
*** p<0.01, ** p<0.05, * p<0.1

[11] Because this data is from individuals and one diary day, behavior is hard to predict. Other studies that use individual-level data like ATUS have similar R-squared values.

Table 13 outlines the five regressions I ran to test whether TNCs are substitutes or complements of public transit, and the variables' coefficients.[12]

Regression 1 is based on Equation 1 from the Theory chapter. I used fixed effects (FE) for each categorical variable because I do not want to assume linear effects (Equation 2). In this regression as well as Regressions 4 and 5, the coefficient for TNC in Operation – the key variable – shows a positive effect on the probability of riding public transportation, although it is not statistically significant. This means that we cannot conclude whether TNCs and public transit are complements or substitutes, which is consistent with the lack of consensus in the literature.

Equation 2: Probability of Riding Public Transit with Fixed Effects

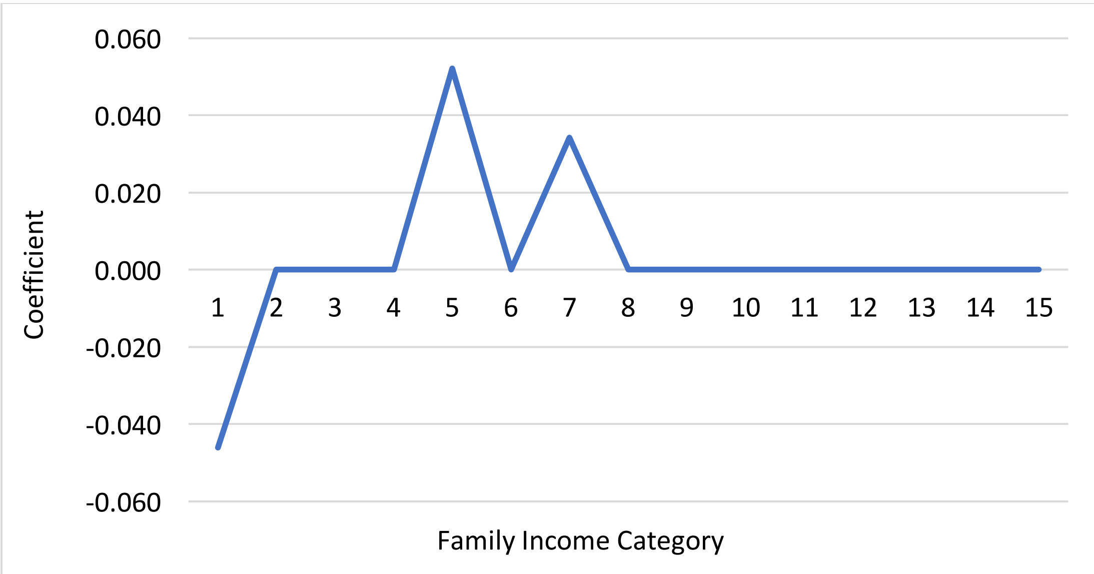
$$
\begin{aligned}
P(Rode\_Public\_Transit) = \quad & \beta_0 + \beta_1\, TNC\_in\_Operation + \beta_2\, NumberOf\_YoungChildren \\
& + \beta_3\, Spouse\_Partner + \beta_4\, Family\_Income\_FE \\
& + \beta_5\, Hours\_Week + \beta_6\, Industry\_FE + \beta_7\, Occupation\_FE \\
& + \beta_8\, Sex + \beta_9\, Age + \beta_{10}\, Education\_FE \\
& + \beta_{11}\, Metropolitan\_Area\_FE + \beta_{12}\, Year\_FE + \mu
\end{aligned}
$$

In Regression 2, I added interaction terms for each Family Income category with TNC to measure how an individual's income level influences their probability of riding public transit once TNCs are introduced. The Family Income category for individuals whose households earn between \$100,000 to \$149,999 a year is dropped from the equation to prevent multicollinearity. I

[12] To verify the validity of this linear regression model, I also ran probit and logit regressions. Probit and logit are often used if the dependent variable is a dummy variable or acting as a proxy for probability, which is the case for this paper. The results confirm that all three models have similar implications.

chose this category because it contains the highest concentration of individuals from the dataset. The coefficients are depicted in Figure 1.

Figure 1. Family Income x TNC Coefficients



Three coefficients are statistically significant: individuals whose households earn less than $5,000, between $12,500 to $14,999, and between $20,000 to $24,999 a year. The Family Income interaction term coefficients are not jointly significant (Prob>F=0.2743). Individuals with incomes between $12,500 to $14,999 and between $20,000 to $24,999 a year have the largest effects, which makes sense. Those with low incomes cannot afford TNC rides, so their coefficients are near zero. Those with high incomes are less affected by the availability of TNCs because they could afford similar services (like taxis) before TNCs started operating, so their coefficients are also near zero. The first Family Income category (less than $5,000) seems to be an outlier, because the coefficient implies that the availability of TNCs shifted their transportation behavior away from public transit. One possible explanation is that these individuals began driving for TNCs in order to supplement their income, which aligns with the findings of Dickens and Cromwick (2018), especially since TNCs "assist drivers with owning or leasing a vehicle," and the revenue made from driving can help fulfill car payments (Dickens and Cromwick 2018, 5).

The inclusion of Family Income interaction terms makes the TNC coefficient negative, so individuals are 0.088 percentage points less likely to ride public transit. This suggests that the insignificant though positive effect observed in Regression 1's TNC coefficient may be primarily driven by family income.

Regression 3 examines the women with children sensitive group. To measure the total effect of TNCs on a woman with young children, I conducted a F test using three interaction terms: Female x No. of Children x TNC, Female x No. of Children, and Female x TNC. The results show that three coefficient terms are jointly insignificant (Prob>F=0.4902), which means that TNCs do not have a conclusive differential effect on women with young children's probability of riding public transit. My hypothesis on this sensitive group did not hold.

Though TNCs do not have a conclusive effect on this sensitive group, controlling for their effects turned the TNC coefficient positive, statistically significant, and economically significant. Individuals are 1.07 percentage points more likely to ride public transit once TNCs are introduced, which suggests that TNCs may be complementary to public transit for the general population, excluding women with children.

It is also interesting to note that Number of Children (<13 y/o) and Female x No. of Children are negatively associated with public transit ridership, which makes intuitive sense because having more children means women have less free time and flexibility because they have more responsibilities. Having an additional child makes a woman 1.74 percentage points less likely to ride public transit. The coefficients are statistically significant and economically significant.

Regression 4 examines the White Collar Occupations sensitive group. From the interaction term's coefficient, we can see that those in White Collar occupations are 1.73 percentage points more likely to ride public transit once TNCs are introduced, relative to those in other types of occupations. This result is statistically and economically significant. This supports my hypothesis that TNCs are complements for public transit for this sensitive group. The White Collar Occupation variable on its own is also statistically and economically significant. Those in White Collar occupations are 1.18 percentage points more likely to ride public transit than those in other occupations, which makes sense since they are more likely to be able to work remotely during their public transit commute due to the nature of their jobs, and therefore have greater time flexibility.

Regression 5 examines the Long Work Hours sensitive group. From the interaction term's coefficient, we can see that working an additional 10 hours per week makes someone 0.27 percentage points more likely to ride public transit once TNCs are introduced, which is statistically and economically significant. This supports my hypothesis that TNCs are complements for public transit for this sensitive group. The Work Hours variable on its own is also statistically and economically significant. Working an additional hour makes someone 0.04 percentage points less likely to ride public transit, which makes sense since the individual would have less free time to travel. Taken together, these results indicate that availability of TNCs reduce the negative effect of long work hours on the probability of using public transit.

From the five regressions, one of the most interesting conclusions is that the TNC coefficients are consistently centered around zero, though their values and statistical significance change. This suggests that the introduction of TNCs do not have much influence over an individual's probability of riding public transit for the general population, though white collar workers and workers with long hours see a complementary relationship. We also see some positive effects for some income groups.

Section III: How TNCs Increase Transit Ridership Through Policy

City governments and transit agencies are starting to embrace the idea that partnering with TNCs can "enhance mobility" and "resolve transportation challenges," especially in areas with inadequate transit options and parking availability (Schwieterman, Livingston, and Van Der Slot 2018). TNCs can complement public transit because their flexibility fills in service gaps and provides greater cost efficiency for cities and transit agencies. To examine if policies that incentivize the use of TNCs in conjunction with public transit increase transit ridership, I conducted case studies of public-private TNC partnerships in Los Angeles County. Through these case studies, I aim to contextualize my larger-scale data analysis and provide an in-depth understanding of how TNC and public transit partnerships are created, advantages and disadvantages of such policies, funding mechanisms, and implementation hurdles. These findings can provide useful context for transit agencies and cities that have seen a decline in transit ridership and are considering partnering with TNCs to address this problem.

Discounts on ridesharing trips in Los Angeles County are offered by Monrovia, the Los Angeles County Metropolitan Transportation Authority ("Metro"), and Claremont. The three programs serve as my case studies. They each have different transportation problems, models for increasing public transit ridership, and theories on people's transportation behavior, but share a common goal of using TNCs to alleviate transportation problems in their region.

Monrovia is a small city in the suburb of Los Angeles County. The city's goal in partnering with Lyft is to reduce their citizens' reliance on automobiles. Their partnership grew out of Monrovia's need to provide more viable transportation options other than private automobiles, since the area is transit poor and popular shopping, dining, and public transportation areas have limited parking. Monrovia currently offers any rider in its service area discounted Lyft rides across the city. The Lyft subsidy is funded by money previously allocated to Monrovia's Dial-a-Ride program, which has been declining over time. Most notably, with the same amount of money, Monrovia is now serving 27 times more people with the Lyft partnership compared to their previous Dial-a-Ride offering, which is a win-win for the city and its residents.

Metro is collaborating with a TNC called Via for three of its transit stations. All rides must begin or end at one of these stations. Metro's main goals for this partnership are to address first mile/last mile difficulties with riding public transit, increase public transit ridership on their Metro lines, and make the benefits of TNCs more accessible to low-income riders and the disabled. They are more directly focused on increasing public transit ridership than Claremont or Monrovia, but also seem less interested in altering people's travel behaviors. Rather, they are trying to incentivize more people to travel to and from the transit station, but do not have bigger aims like Monrovia's goal to decrease private automobile usage.

Claremont's partnership with Lyft is inspired by Monrovia's, but differs in its motivations. The city needs to address parking limitations in its popular downtown shopping and dining area, which will soon welcome a new light rail station that will increase visitors to the city by tenfold. Their primary goal is to decrease congestion in high-traffic areas, mainly by incentivizing people to travel using TNC rides instead of private automobiles. However, their plans may increase congestion if TNC usage increases vehicle miles traveled, especially during peak times. They draw from Dial-a-Ride funding like Monrovia but have not scaled down the former program, which gives them less funding in comparison to Monrovia for TNC subsidies.

These case studies primarily rely on interviews and local newspaper articles. I conducted one in-person interview with Colin Tudor, who is the Assistant City Manager of Claremont and spearheaded the city's partnership with Lyft. I also conducted three phone interviews with Oliver

Chi, Cari Dillman, and Emma Huang. Oliver Chi is the City Manager of Monrovia. He helped conceive of and finalized the details for Monrovia's partnership with Lyft, and currently oversees the program's implementation at a high level. Cari Dillman is a Management Analyst in the Transit Services Department in Claremont. She is currently the lead for the city's partnership with Lyft since many transit-related projects fall under her domain. Emma Huang is a Transportation Planner in the Office of Extraordinary Innovation of Metro. She led Metro's partnership with Via from the beginning, even before Via was chosen as the official TNC for the partnership.

Chapter 6: Monrovia, California

The City

Monrovia is a suburb of Los Angeles County, California. According to the 2010 Census, Monrovia has a population of 36,590, with 2,689.5 residents per square mile and 13.71 total square miles of land. 88.5% of residents graduated from high school, 37.7% of residents have a Bachelor's degree or higher, and 70.3% of residents are in the labor force. The mean travel time to work for workers over 16 years of age is 31.6 minutes, and the median household income in 2017 dollars is $71,373 (U.S. Census Bureau 2018b).

The Policy

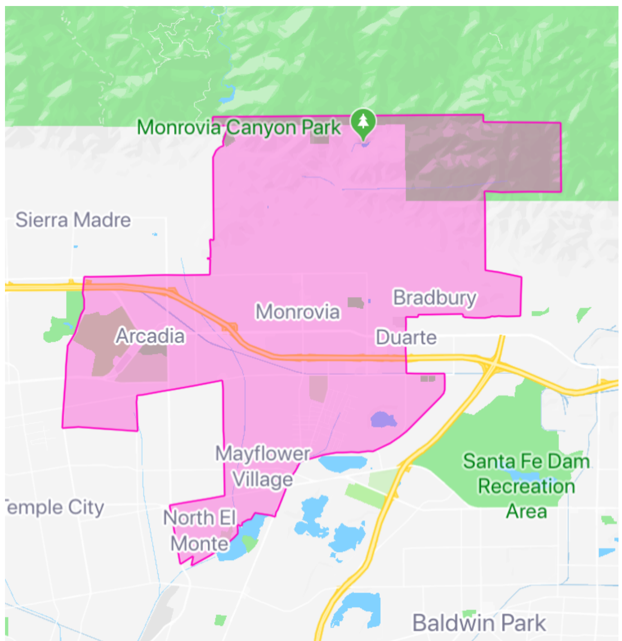
GoMonrovia is a multi-modal transportation program in partnership with Lyft and LimeBike[13] that aims to provide "fast and affordable transportation all throughout Monrovia" so residents would rely less on personal automobiles (City of Monrovia 2019b). Currently, residents drive cars everywhere because public transportation options are limited. By introducing a subsidy for Lyft rides, Monrovia hopes to shift people's travel behavior towards walking, biking, and shared modes of transportation like Lyft, light rail, and bus.

The program's launch in March 2018 made Monrovia the first city in the United States to have a long-term partnership with TNCs (Pimentel 2018). Anyone in the *GoMonrovia* service area can take a Lyft ride at a reduced rate. The service area includes the cities Monrovia, Bradbury, and Arcadia; unincorporated areas of Los Angeles County that are adjacent to Monrovia; and a Target store in Duarte that is a designated transfer point for riders to take buses

[13] I will be focusing on the city's partnership with Lyft because my thesis concerns TNCs, which do not include bike sharing companies.

from Duarte Transit, a local transit agency. The program also applies to passengers who have medical appointments at the local hospital called City of Hope, or physician's offices within three miles of Monrovia's city limits (City of Monrovia 2019b). *GoMonrovia* is currently the most used city program in Monrovia, with over 18,749 residents signed up for the program.

Figure 2. *GoMonrovia* Coverage Area (Source: Lyft app)



GoMonrovia's goal is to "create an affordable transportation program that [is] so easy to use that the broader community might seriously consider public transit in Monrovia as a real option" (City Manager's Office 2018). Currently the city is "transit poor," says City Manager Oliver Chi, because "there are not many high-quality transit routes outside of the Gold Line." The Metro Gold Line is a light rail service that serves 50,000 individual rides per day, with approximately 1,200 riders boarding or getting off at Monrovia's Gold Line station (Chi 2019). The only other public transportation alternatives are two bus lines from Foothill Transit, which is a local transit agency that serves the San Gabriel Valley, and the city's Dial-a-Ride shuttle bus program (City of Monrovia 2019c). Far fewer residents take the bus compared to light rail, and the historical Dial-a-Ride program served "only a very narrow range of public transit users," was "inconvenient for general everyday use," and was "an incredibly costly way to move people around" (City Manager's Office 2018). Monrovia is required by Los Angeles County to provide some variant of a Dial-a-Ride program for its citizens. Dial-a-Ride costed $1 million but provided only 30,000 rides every year. Now, for about the same price, Monrovia's partnership with Lyft provides between 65,000 and 70,000 rides per month (Chi 2019). Said another way, Monrovia is now serving 27 times more people with the Lyft partnership compared to Dial-a-Ride, without needing to drastically change their budget. Partnering with a TNC allowed the city to use their existing infrastructure in conjunction with TNCs' effective new transportation model to better serve their community (American Public Transportation Association 2018, 3).

Monrovia was also motivated to revamp its mobility options because of the city's expected future growth. There are over 2,200 proposed multi-family units in the housing development pipeline, over 2,000 new jobs added over the past three years (2015 to 2018), and Southern California's population is expected to grow by over 4 million people in the next 25 years (City of Monrovia 2019a). If the city's mobility constraints remain unaddressed, then residents will have steadily worsening parking and traffic problems. *GoMonrovia* aims to address the city's transit deficit by providing additional transportation options that are faster and more convenient, and subsidizing trips to public transit stations to encourage their use.

Why Lyft?

Monrovia chose to partner with Lyft to take advantage of the speed and convenience of their service, and because the company's goal is to use their ride-sharing platform "to complement existing public transportation services, not replace them" (City Manager's Office 2018). It was important for Monrovia to "build collaborative partnerships" so the city and TNC could "build a shared vision and work alongside on challenges and solutions," and Lyft stood out as a company that is willing to work through the details with a city (American Public Transportation Association 2018, 3).

One concern that arises when public entities collaborate with private companies is data privacy. All data shared with cities is public information, and Lyft did not want to release specific details on trips because that information could be traced back to individuals and used to recreate their rider-driver matching algorithm, which is a core part in their business model. As a compromise, Lyft shares data in an "aggregated and anonymous level" with the city to protect user privacy and their business interests, while also giving cities useful information about how residents use the *GoMonrovia* program (American Public Transportation Association 2018, 3).

Enactors and Implementers

The primary enactor and implementer of *GoMonrovia* is the City Manager's office. Specifically, the City Manager, Assistant City Manager, Deputy City Manager, and the Assistant to the City Manager were integral in creating and executing the program. The process from creating the idea to implementing the full program took less than eight months, which is highlighted in Table 14 (American Public Transportation Association 2018, 2). Currently, the

Assistant to the City Manager oversees the day-to-day administration of the program. Public Works continues to run Dial-a-Ride (Chi 2019).

Table 14. *GoMonrovia* Program Timeline (Source: City of Monrovia)

Date	Task
January 2018	Initial Mobility Study Session
February 2018	Agreements with Lyft and LimeBike approved
March 2018	*GoMonrovia* program launched
July 2018	Study Session to discuss *GoMonrovia* program changes
August 2018	New Lyft pricing structure contracts approved
September 2018	\$0.50 Shared Rides / \$3 Standard Rides instituted
December 2018	Study Session to discuss program revisions to stabilize *GoMonrovia* costs
February 2019	New pricing and Dial-a-Ride services take effect

Pricing Structure

During *GoMonrovia*'s pilot program from March 2018 to January 2019, every Lyft ride was \$0.50. The program grew so quickly that Monrovia was worried that the city would run into a budget deficit, so incremental price increases were necessary to slow ridership growth and reduce costs (City of Monrovia 2019a). In September 2018, fares increased to \$3 for only Classic Rides. On February 1, 2019, fares increased to \$1 per Shared Ride (Lyft's carpool option), \$3.50 per Classic Ride, and remained \$0.50 per Shared Rides taken to or from the Monrovia Gold Line Station or Old Town Monrovia. Shared Rides allow one person to request a ride for up to two passengers, with a possibility of being joined by other riders who also requested a Lyft along the same route (Lyft 2018). Classic Rides are private rides for groups of up to four passengers.

February's new pricing announcement is one of many to come. The program's key to success is transparency and gradual change, so residents expect incremental fare increases throughout the evolution of the program (Chi 2019). "You can't make too much change too quickly to a program people love," explains Chi. The city informed the public since the beginning that the program's initial $0.50 fare for all rides would not be permanent because that price is financially unsustainable for the city. Rather, the city promised that fares to the Gold Line station and Old Town Monrovia would never increase, and all other ride fares will gradually increase over time, usually by $0.50 increments.

Monrovia places great importance on keeping fares low for trips to the Gold Line Station because the city's leadership wants to deliberately "influence behavioral change" so their residents will be less reliant on single occupancy vehicles and more reliant on shared mobility options like Lyft (Chi 2019). For example, take a Monrovia resident who rides the Gold Line to commute to work every day, and drives a car from their home to the transit station since that is the only viable way of getting there. With Lyft, this resident can now commute to the transit station on-demand for only $0.50 per ride. This person may not even need to own a personal vehicle anymore if they do not use it for other purposes, since Lyft provides the mobility they need.

To further incentivize ridership on the Gold Line, fares to the Gold Line Station will permanently remain at $0.50 because Metro will soon begin charging $3 per day for parking at any Gold Line Station parking structure. If *GoMonrovia* increased their prices to $1, for instance, then taking Lyft would cost $2 per day while driving a personal vehicle would cost $3. Chi worries that the $1 difference between the two transportation options would not be enough incentive for drivers to switch to Lyft. By keeping round trip fares at $1, Chi hopes that Lyft's more competitive pricing would encourage more people to use *GoMonrovia* instead of driving to travel to and from the Gold Line Station. As of February 2019, an average of 20,000 rides every month travel to and from the Gold Line station. Trips to and from the station make up 30% of all

Lyft trips (City of Monrovia 2019a). 56% of all Gold Line rides from the Monrovia station use Lyft to get to and from the station.[14]

Fares will also remain low for trips to Old Town Monrovia, the city's downtown area. Though Old Town has many restaurants and entertainment options, it does not have many parking spaces. Lyft gives residents the option of traveling to the area at an affordable price without needing to worry about finding parking. Further, Old Town Monrovia includes a Foothill Transit bus stop, which is an additional incentive for using public transit. As of February 2019, 16% of all *GoMonrovia* Lyft trips were taken to Old Town (Chi 2019).

Funding Sources

Monrovia relies on three funding sources for the Lyft subsidy: revenue from transportation sales tax ballot measures, cost deductions by collaborating with Lyft, and contributions from neighboring areas who are serviced by *GoMonrovia*.

First, Monrovia has access to four different revenue streams from four different Los Angeles County transportation sales tax ballot measures. These measures increase the sales tax and use the revenue for only transportation-related purposes (American Public Transportation Association 2018, 4). Before *GoMonrovia*, all the $1 million of funding that Monrovia received from the sales tax revenue was used to fund the city's Dial-a-Ride program. The city reallocated most of this funding to *GoMonrovia* instead. To ensure that *GoMonrovia* had a transportation option for passengers with disabilities, the city partnered with Access Services to more efficiently provide paratransit services. Access Services is run by Los Angeles County and

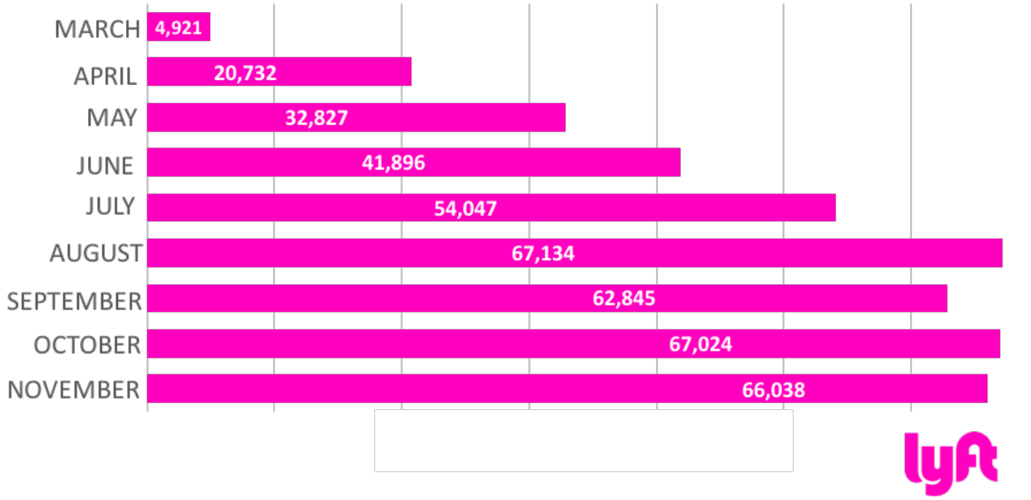
[14] 20,000 rides every month travel to and from the Gold Line station ÷ (1,200 riders boarding or getting off at Monrovia's Gold Line station per day * 30 days per month) = 55.56%

provides persons with disabilities with access to public transportation. Their partnership with Monrovia saves the city half a million dollars every year (City of Monrovia 2019c). Monrovia also runs a significantly scaled-down Dial-a-Ride program called Monrovia Transit to provide access for ADA riders, which requires registration and costs $0.50 per ride (American Public Transportation Association 2018, 4).

Second, Lyft works closely with the city to bring down each ride's costs. When the program first launched with $0.50 rides, each ride costed the city $6.03; now, each ride costs $3.85. The city's goal is to have each ride cost under $3 (Chi 2019). One of the largest shifts in costs was attributed to ride types. Shared Rides are significantly cheaper than Classic Rides (in some cases, less than half the price) because the former allows Lyft drivers to service more customers. Thus, the city provides a larger discount for Shared Rides to encourage more users to take the cheaper option ($1 per Shared Ride versus $3.50 per Classic Ride), which has proven effective because 80 to 90% of *GoMonrovia* Lyft rides are taken using the Shared Ride option. Because Monrovia has such a high volume of Lyft users every day, the city is also negotiating for a better baseline pricing per ride (Chi 2019). Even at Lyft's original price of $6.03, *GoMonrovia* is a significant cost savings from the city's previous Dial-a-Ride program, which costs $19.70 per passenger (City of Monrovia 2019a).

Third, unincorporated areas and neighboring cities that are in *GoMonrovia*'s service area contribute funds to the program (Chi 2019). Overall, the program costs about $1.2 million a year. Monrovia's spending today on public transportation services is comparable to what the city was spending before *GoMonrovia*, but *GoMonrovia* serves far more people than any previous city transportation program. Monrovia and Lyft's continued collaboration allows both private and public interests to better serve the community's mobility needs.

Figure 3. *GoMonrovia* Lyft Usage Since Launch, 2018 Statistics (Source: City of Monrovia)



Current State and Future Implications

GoMonrovia has been a successful program from the start, serving thousands in its community within the city's budget, which is a win-win for the city and its residents. From the program's launch in March 2018 to December 2018, *GoMonrovia* provided a total of 450,789 Lyft trips (Figure 3). "It's not just a couple of people using *GoMonrovia*, [but rather] a lot of people using it a little bit," remarks Chi. Lyft sees its highest use from noon to 6 PM, usually for lunch trips, running errands, or commuting to and from meetings (Figure 4). Rides are evenly distributed throughout the week, though Sunday has the least number of rides and Tuesday to Friday have the most, since Monrovia has a large daytime workforce. About 20% of all rides were used for commuting. Most rides are for short distances: 60% of all rides were less than 2 miles, and 99% of all rides were less than 6 miles[15] (Figure 5) (City of Monrovia 2019a). Old Town Monrovia and the Monrovia Gold Line station are the two most popular destinations, with shopping areas as a distant third (Chi 2019).

[15] Monrovia covers 13.71 square miles.

Figure 4. Lyft Usage by Time of Day (Source: City of Monrovia)

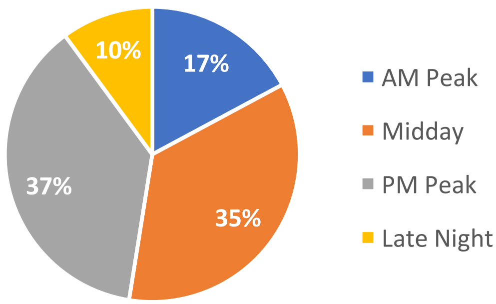
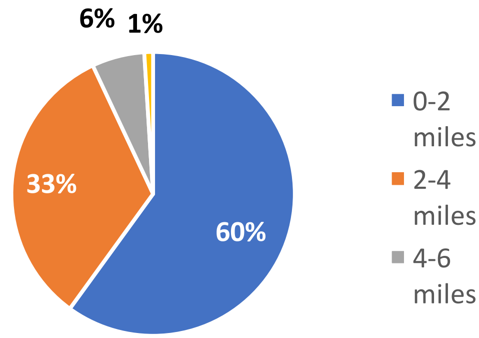


Figure 5. Lyft Usage by Trip Length (Source: City of Monrovia)



Major benefits that have resulted from the Lyft partnership include bridging first mile/last mile connections, significantly changing residents' mobility behavior, substantial savings from the city's previous Dial-a-Ride model, reducing parking demand, reducing greenhouse gas emissions[16], and increasing public transit ridership, especially since Shared Rides are considered as public transit by Monrovia (City of Monrovia 2019a). When asked about how the residents of Monrovia feel about the program, Chi responded, "I cannot express how much people have appreciated this program. [...] Feedback from the community is incredible, and people are using this constantly. [...] We don't get complaints that there aren't enough parking spaces anymore." (Chi 2019). No residents have complained about February's fare increase either, which Chi attributes to the city's transparency about fares and the incremental increases in price.

In the future, Monrovia hopes to partner with Lyft to make TNCs more environmentally friendly (American Public Transportation Association 2018, 5). Lyft does prioritize reducing greenhouse gas emissions: for instance, the company has committed to purchasing carbon offsets for every ride, making rides carbon neutral[17] (American Public Transportation Association 2018,

[16] Every Lyft ride is carbon-neutral.
[17] Lyft purchases carbon offsets to ensure that all rides are carbon neutral.

3). Future additions could include decreasing driver idling time when waiting for their next ride, and introducing more incentives to increase the percentage of shared rides (City of Monrovia 2019a). Monrovia will be conducting a study in the near future to determine whether Lyft is increasing or decreasing Vehicle Miles Traveled (VMT) in the service area, strategize how to work with employers to increase the use of *GoMonrovia* for commutes, determine how to make the program financially sustainable in the long term, and decide if dedicated Lyft pick-up and drop-off locations are necessary for high traffic areas like Old Town Monrovia and schools (City of Monrovia 2019a).

Chapter 7: Los Angeles Metro

The Transit Agency

Metro is a quasi-governmental regional transportation planning agency that was established in 1993. Metro is the primary transportation agency in Los Angeles County, which has an area of 4,084 square miles, a population of 10.16 million, and 88 cities and unincorporated areas. Los Angeles County is plagued with a variety of transportation issues. For instance, its commuters are stuck in traffic 81 hours a year on average, and only 6.8% of residents ride public transit (Metro 2019b).

Metro directly operates bus and rail services, and funds and plans transportation projects. The agency currently has 13,978 bus stops along its 165 bus routes, and 93 rail stations for its 4 light rail lines and 2 subway lines. Metro also oversees 219 miles of HOV carpool lanes and over 2,000 miles of bikeways. 9,817 people currently serve on Metro's full-time staff (Metro 2019a).

The Policy

Metro launched their partnership with Via on January 28, 2019 to provide on-demand rides to and from three transit stations. Via's service is intended to be "quick, easy, and inexpensive" to use and accessible to all (Korosec 2019). Metro as a transit agency has significant interest in increasing public transit ridership, so the year-long pilot program aims to "solve the first- and last-mile problem that makes it challenging to get to and from public transit stations" and "combat decreasing public transit ridership" that Metro partially attributes to the rise in TNC usage (Korosec 2019). Metro also hopes to increase the accessibility of TNCs to low-income riders and the disabled through this partnership by offering rides that cost less than

TNCs typically charge on ADA-compliant vehicles, which companies like Uber and Lyft do not offer (Huang 2018).

Riders can book a shared carpool ride on Via's iPhone or Android app[18] anytime from Monday to Friday between 6 am and 8 pm. Each ride must take place within the service area (outlined in Figures 6, 7, and 8) and begin or end at Metro's North Hollywood/Burbank, El Monte, or Artesia stations. Each station has a designated Via pickup area to increase the service's efficiency, since drivers can pick up multiple riders from one location. Fares are a flat rate per ride: Metro LIFE (Low Income Fare Program)[19] participants ride for free, TAP card[20] holders pay $1.75 per ride, and all other rides are $3.75 (Metro 2019d).

Metro selected the North Hollywood/Burbank, El Monte, and Artesia stations based on the following criteria (Huang 2018):

1. **Equity and access for vulnerable populations**. Metro identified communities that have not had as many opportunities to benefit from ride sharing services, such as low income and minority populations.
2. **Geographic diversity**. The three stations serve different geographic areas in Los Angeles County.

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[18] For riders without smartphones, a call center is available to help book rides. Bank accounts are not needed to use Via because payment is accepted by credit, debit, or pre-paid card (Hymon 2019).

[19] LIFE stands for Low-Income Fare is Easy. To be eligible for this Metro program, a rider's annual household income must fall under a certain threshold depending on their household size. For example, a rider is eligible if they live in a household of 1 and earn $33,950 or less in annual income, or if they live in a household of 4 and earn $48,450 or less (Metro 2018a).

[20] TAP is a reusable card that holds stored values and Metro passes. A rider boarding a bus or train pays their fare by tapping their card on a card reader machine (Metro 2018b). To be eligible for a lower Via fare, riders must input their TAP card number into Via's app.

3. **Current first and last mile access and feasibility**. Metro's staff compared stations based on parking availability, presence of safe pick-up and drop-off locations, and nearby trip generators such as residences, shopping centers, and recreation facilities.
4. **Diversity of transit modes**. Each service area contains multiple transit modes, such as light rail and heavy rail.
5. **Level of efficient service from Via**. Via helped Metro finalize the list of participating stations by determining which service areas would work most efficiently with their business model (Huang 2019).

Figure 6. Artesia Service Area

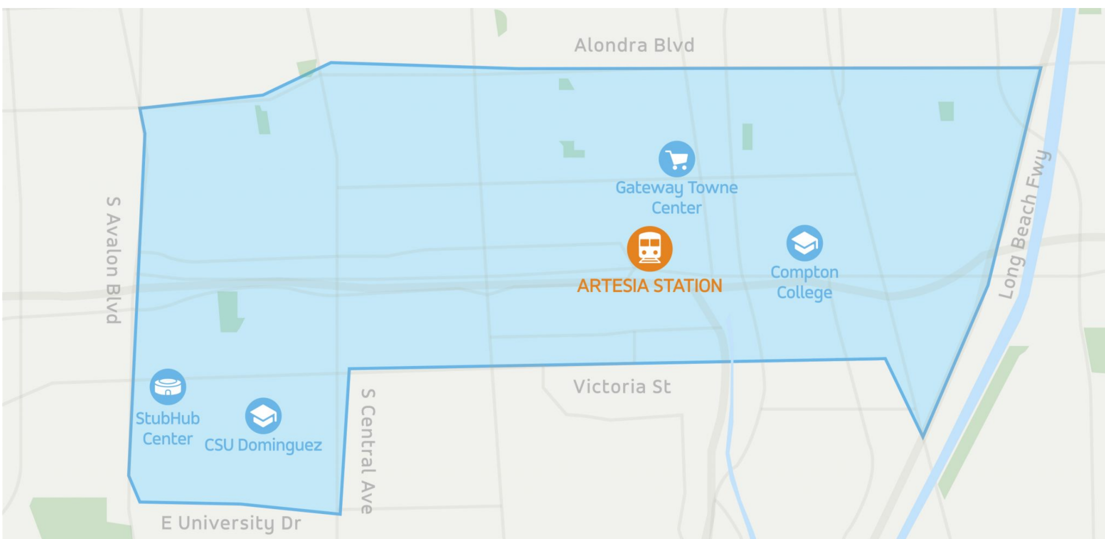


Figure 7. El Monte Service Area

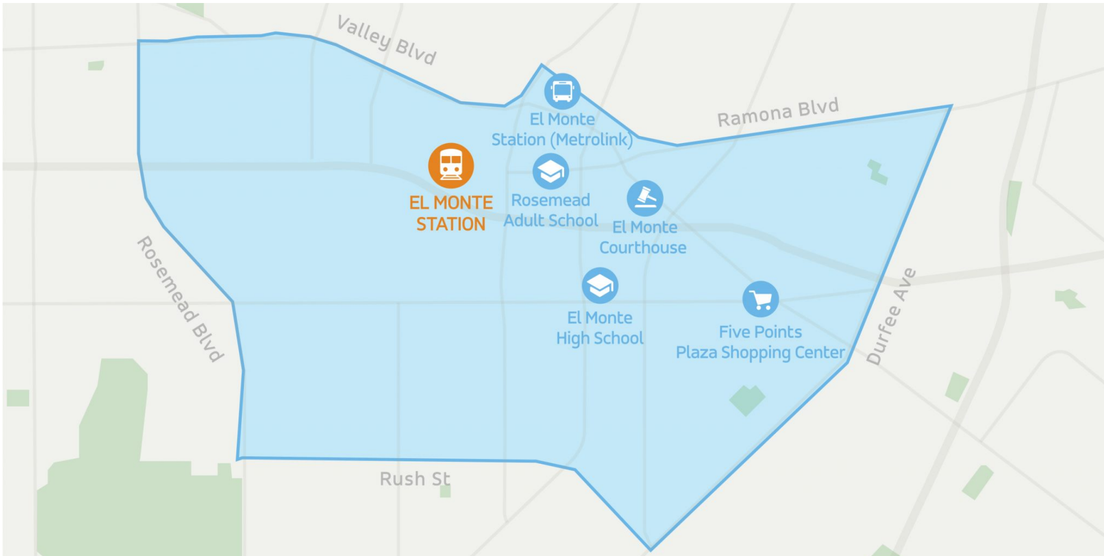
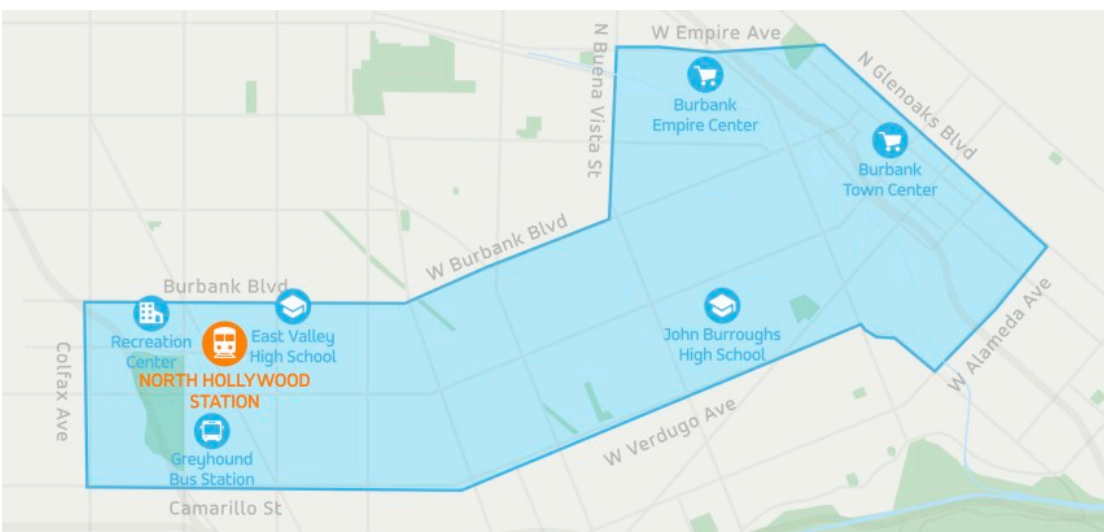


Figure 8. North Hollywood/Burbank Service Area



Policy Creation

Metro's Office of Extraordinary Innovation (OEI) oversees the transit agency's partnerships with TNCs. OEI was created in 2015 to improve mobility in Los Angeles County by finding and testing new ideas (Metro 2019c). OEI conceives of projects through unsolicited proposals from private companies working on transportation innovations; implementing Metro Vision 2028, which is the transit agency's "big picture plan to improve mobility in Los Angeles County"; and researching innovations that other transit agencies and cities are piloting (Metro 2019c). OEI oversees the Via program because the partnership deals with new mobility services. The Metro-Via partnership lead is Emma Huang, a Transportation Planner in OEI. She was involved since the beginning and continues to oversee its implementation today.

The idea for the partnership was conceived because of the Federal Transit Administration (FTA)'s Mobility on Demand Sandbox program, which grants money to transit agencies so they can leverage "on-demand information, real-time data, and predictive analysis to provide travelers with transportation choices that best serve their needs and circumstances" and provide "better mobility options for everyone" (Federal Transit Administration 2016). Metro applied for this grant because the agency was "really interested in taking the benefits that TNCs offer, but wanted to expand them to a wider audience," and was chosen as a recipient (Huang 2019).

Initially, Metro was considering 8 different TNCs. Lyft was one of the front runners, but Metro decided not to partner with the company because Metro wanted to work with a TNC that would be able to provide wheelchair-accessible vehicles and give Metro access to detailed data so the agency can learn about riders' travel behavior. Lyft was unwilling to provide either request, so Metro decided to work with a different company (Huang 2019).

After approximately 13 months of negotiation, Via agreed to Metro's requests and officially partnered with the transit agency. Founded in 2012, Via is "an on-demand transit system that takes multiple passengers heading in the same direction and books them into a shared vehicle" (Via 2018). Unlike Uber and Lyft, Via offers only a corner-to-corner service, so drivers pick up and drop off their riders within a couple blocks of their exact requested location in order to decrease overall trip time. Because of this business model, the company likens themselves to an on-demand bus service and tends to partner with public transit agencies and cities to provide transit services (Via 2018).

To reach a data sharing agreement with Via, Metro first considered which variables related to the Via user experience that the agency would be interested in, such as where the trip originated and terminated, how long it took for the rider to be picked up, and how long the ride took. Then, Metro negotiated with Via for permission to use this data internally. Their agreement allows Metro to have access to trip-level data for five years, but Metro must aggregate the data to a significantly higher level before publishing any findings. Data privacy is such a big concern for TNCs because someone could easily reverse engineer the data to recreate the company's driver-rider matching algorithm, which forms the foundation of their business (Huang 2019).

Metro based the Via fare structure on their TAP system. Originally, the transit agency envisioned full integration between the TAP and Via systems so riders could transfer onto Via for free after taking public transit. However, that idea never came to fruition because it was too costly and time intensive for both parties. As a compromise, Metro offers a lower fare for people who input their TAP card number into Via's app so the agency can track how people travel from public transit to Via. Even so, Via's fare is currently higher than most bus and train fares for all riders except LIFE participants. Metro is planning on lowering fares later in 2019 to create greater incentives for riders to change their commuting behavior. At the current fare, riders would have to pay more to use Via than drive their personal vehicle, because parking at these transit stations currently costs \$2 a day, which is cheaper than paying \$3.50 round trip[21] for Via (Huang 2019).

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[21] Assuming that the rider is charged the TAP card fare of \$1.75 per ride.

Current State and Future Implications

The year-long partnership will cost $2.5 million, $1.35 million of which is funded by the FTA grant (Korosec 2019). The rest of the costs are funded by local dollars from transportation sales tax ballot measures. Metro ended up choosing three stations for its pilot program because of the amount of funding available, but may expand the program to more stations in the future (Huang 2019).

Metro does not currently have a vision for this program's future because they are still in the experimenting and testing stage. "At this point it's really too soon to tell what is next," says Huang. "We'll see what the data shows." Potential additions include increasing the availability of accessibility services and integrating TAP into the Via software. Metro would also like to investigate if TNCs add to congestion or help mitigate it. The agency partnered with university research centers like University of California, Los Angeles' Center for Transportation, which will be examining the data for ridership trends and environmental implications (Huang 2019).

Chapter 8: Claremont, California

The City

Claremont is a suburb of Los Angeles County, California. According to the 2010 Census, Claremont has a population of 34,926, with 2,616.6 residents per square mile and 13.35 total square miles of land. 94.2% of residents graduated from high school, 55.9% of residents have a Bachelor's degree or higher, and 60.8% of residents are in the labor force. The mean travel time to work for workers over 16 years of age is 27.2 minutes, and the median household income in 2017 dollars is $96,923 (U.S. Census Bureau 2018a).

Background

Claremont's downtown Village is a hub for dining, shopping, and entertainment. Parking congestion has become an increasingly prominent problem in the area as businesses grow economically (Schultz 2018). This issue will be intensified when the Claremont Gold Line begins offering rides from the Village's train station.[22] The station's current passenger rail provider, Metrolink, transports approximately 200 riders to and from Claremont every day. The Gold Line is expected to transport 2,000 riders a day, which increases the number of people going through the Village by 10 times (Tudor 2019). To address these concerns, Claremont's leadership decided to develop a comprehensive Parking Management Plan for the Village, which includes a Lyft Subsidy Program.

[22] The Gold Line was scheduled to begin service in Claremont in 2026. However, on November 12, 2018 Metro announced that the Gold Line's planned extension to the cities of Pomona, Claremont, and Montclair will be delayed by at least two years due to considerable construction cost increases. The project's cost estimate, which was calculated two years ago, is short $570 million. However, Metro announced in a press release that the Gold Line may still be completed on time if funding is secured before 2021 (Metro 2018c).

Initially, this Parking Management Plan included a Paid Parking System, which would be implemented through a pay by plate system. The proposed rate for non-residents was \$3 for the first two hours and \$1 for each additional hour for up to four hours, and for residents was \$2 for the first two hours and \$0.50 for each additional hour for up to four hours. Annual revenue was estimated between \$2.9 million and \$3.3 million, which would have been the fourth highest revenue generator in the city (Schultz 2018). However, "there was a lot of public pushback on the paid parking," recounts Assistant City Manager Colin Tudor. Thus, the city abandoned those efforts and instead focused on their partnership with Lyft to help alleviate the Village's parking problems (Tudor 2019).

The Policy

Claremont's Lyft Subsidy Program will be launched in Summer 2019. The city's primary goal is to decrease congestion and increase parking availability in high-traffic areas by incentivizing people to take TNCs instead of private automobiles to and from those areas. Claremont chose to partner with Lyft because of the example *GoMonrovia* set, and Lyft's willingness to cooperate with the local government. The city government also considered Uber, but after a couple of interactions concluded that "Uber doesn't really want to play nice with anybody" and is "more set on the disrupter model" (Tudor 2019). Similar to how Monrovia's program provides additional savings on Old Town Monrovia and their Gold Line station, Claremont's program provides subsidies for rides only to and from the Village, which includes the city's future Gold Line station. The initial rate structure is \$1.50 per Lyft ride (maximum four passengers) and \$3.00 per Lyft Plus ride (maximum six passengers), which is similar pricing to what people would have paid for parking and Dial-a-Ride services. Each person can take a maximum of 20 rides per month (Schultz 2018).

Claremont plans to designate pick up and drop off locations in the Village because its streets are narrow. Currently, TNCs stop in the middle of the street to drop off or pick up riders, which worsens congestion. Rather than adding to this problem, the city hopes that these designated zones will be an effective prevention measure (Tudor 2019). However, TNCs may still end up increasing vehicle miles traveled and congestion in the Village if the subsidy substantially increases the number of people visiting the popular shopping and dining area.

Funding for this partnership comes from transportation sales tax ballot measure funds that are designated for transportation uses like Dial-a-Ride, which are funding sources similar to the previous partnerships covered in this section. Because the city's Dial-a-Ride usage has been decreasing for the last five years, the city is able to maintain that service at its current capacity and spend the remaining funds to the subsidy (Tudor 2019). This approach is different than Monrovia's, which significantly scaled down the city's Dial-a-Ride program and allocated most funding towards the Lyft partnership. Claremont plans to spend $50,000 in the partnership's first year, which will fund about 3,500 to 5,000 rides. If successful, Claremont plans to commit up to $100,000 for the subsidy (Schultz 2018).

The partnership is still in its early stages. "We've really only just started to see what kind of opportunities there might be," says Tudor, though he anticipates that there will be support for the program because funding is not an issue (Tudor 2019). The primary implementer of this partnership is the Community Services Department, which oversees transit operations like Dial-a-Ride (Dillman 2019). If successful, Claremont may offer Lyft subsidies to other shopping centers in the area and Wilderness Park, a popular hiking destination in Claremont (Tudor 2019).

Section IV: Key Takeaways

I find that TNCs do not have a statistically significant effect on public transit ridership overall, but are complements of public transit for white collar workers and workers with long work hours. These sensitive groups are more likely to change their transportation behavior and begin riding public transit once TNC services are available because of the flexibility TNCs offer. This complementary relationship can be further strengthened through policy: three Los Angeles County TNC partnerships with cities and transit agencies display how public and private interests can collaborate to increase public transit ridership.

The three policy models are based on fundamentally different motivations and theories on people's transportation behavior, but all reveal valuable insights that cities and transit agencies can use when creating their own partnerships with TNCs to increase public transit ridership.

The most outstanding benefit is from Monrovia's policy: their partnership costs about the same as their historic Dial-a-Ride program, but the city is now able to serve significantly more people in their community by scaling down Dial-a-Ride and reallocating these funds to Lyft. This politically popular program has made it possible for Monrovia to better address their residents' mobility needs without overextending their budget.

All three partnerships provide discounted rides to popular destinations like shopping areas and transit stations. The pricing for these discounted TNC trips largely depend on prices of related items, such as parking and public transit ride fares. Linking popular destinations to transit stations seems like a good model to increase public transit usage, because people may be more incentivized to ride public transit if they can easily run errands like picking up groceries on their way home by using TNCs, rather than relying on a personal vehicle to make these multi-stop trips because public transit by itself is not flexible enough. Such policies strengthen the complementarity of TNCs and public transit.

Also notable was Los Angeles Metro's ability to negotiate a greater data sharing plan than Monrovia and Claremont could receive. Los Angeles Metro, despite being a public entity, has access to trip-level data but does not have to disclose all its data publicly. The transit agency was able to receive this valuable data because they agreed to release only aggregate data publicly. Even with this constraint, Los Angeles Metro can inform their future public transportation and TNC decisions by using this data to examine how their commuters use TNCs to travel to and from transit stations.

Some limitations of this paper include the type of data studied. If I had more time, I would examine aggregate data in conjunction with individual-level data to determine if both show similar results. Since the individual-level data from ATUS is based on one diary day of someone's life, the data presents noisy information so transit behavior is hard to predict. In addition, the TNC partnerships that I studied are quite new, so it is difficult to conclude whether the proposed projects are economically sustainable and can provide benefits over the long term. I would revisit these case studies in the future to see if the TNC partnerships actually change transit behavior.

Opportunities for future research include investigating the environmental impact of TNCs with and without policy incentives, and other modes of transportation that can help increase public transit ridership. A worry that policymakers share about TNC subsidies is whether they will increase vehicle miles traveled in high-traffic areas, the number of vehicles idling on streets as drivers wait for new customers, and congestion. All these potential effects negatively impact the environment by releasing car emissions because of the increase in TNC usage. However, a potential way to decrease these worries is by incentivizing modes of transportation other than TNCs. For instance, cities and transit agencies that adopt TNC subsidies can also look into how these policies can work in conjunctions with campaigns to get people to walk and bike more instead of relying on personal automobiles. If fully incorporated in their lifestyles, residents could rely on only one family car and embrace using multiple modes of transportation in their daily lives, which will ultimately be better for their health and the environment.

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Appendix A. Metropolitan Core Based Statistical Areas and Codes

Code	Name	Code	Name
10180	Abilene, TX	16980	Chicago-Naperville-Joliet, IL-IN-WI
10420	Akron, OH	17020	Chico, CA
10500	*Albany, GA	17140	Cincinnati, OH-KY-IN
10580	Albany-Schenectady-Troy, NY	17300	Clarksville, TN-KY
10740	Albuquerque, NM	17420	Cleveland, TN
10900	Allentown-Bethlehem-Easton, PA-NJ	17460	Cleveland-Elyria, OH
11020	*Altoona, PA	17660	Coeur d'Alene, ID
11100	*Amarillo, TX	17780	College Station-Bryan, TX
11260	*Anchorage, AK	17820	Colorado Springs, CO
11300	*Anderson, IN	17860	Columbia, MO
11340, 24860	Greenville-Anderson-Mauldin, SC	17900	Columbia, SC
11460	Ann Arbor, MI	17980	Columbus, GA-AL
11500	*Anniston-Oxford, AL	18140	Columbus, OH
11540	Appleton, WI	18580	Corpus Christi, TX
11700	Asheville, NC	19100	Dallas-Fort Worth-Arlington, TX
12020	Athens-Clarke County, GA	19300	Daphne-Fairhope-Foley, AL
12060	Atlanta-Sandy Springs-Roswell, GA	19340	Davenport-Moline-Rock Island, IA-IL
12100	Atlantic City-Hammonton, NJ	19380	Dayton, OH
12220	Auburn-Opelika, AL	19460	*Decatur, AL
12260	Augusta-Richmond County, GA-SC	19500	*Decatur, IL
12420	Austin-Round Rock, TX	19660	Deltona-Daytona Beach-Ormond Beach, FL
12540	Bakersfield, CA	19740	Denver-Aurora-Lakewood, CO
12580	Baltimore-Columbia-Towson, MD	19780	Des Moines-West Des Moines, IA
12620	Bangor, ME	19820	Detroit-Warren-Dearborn, MI
12700, 70900	Barnstable, MA	20100	Dover, DE
12940	Baton Rouge, LA	20260	*Duluth, MN-WI
12980	*Battle Creek, MI	20700	East Stroudsburg, PA
13140	Beaumont-Port Arthur, TX	20740	*Eau Claire, WI
13380	Bellingham, WA	20940	El Centro, CA
13460	Bend-Redmond, OR	21140	Elkhart-Goshen, IN
13740	Billings, MT	21340	El Paso, TX
13780	Binghamton, NY	21500	Erie, PA
13820	Birmingham-Hoover AL	21660	*Eugene, OR
13980	Blacksburg-Christiansburg-Radford, VA	21780	Evansville, IN-KY
14010	Bloomington, IL	22020	Fargo, ND-MN
14020	Bloomington, IN	22140	Farmington, NM
14060	Bloomington-Normal, IL	22180	Fayetteville, NC
14260	Boise City, ID	22220	Fayetteville, AR-MO
14460, 71650	Boston-Cambridge-Newton, MA-NH	22420	Flint, MI
14500	Boulder, CO	22460, 22520	*Florence-Muscle Shoals, AL
14540	Bowling Green, KY	22500	Florence, SC
14740	Bremerton-Silverdale, WA	22660	Fort Collins, CO
14860, 71950	Bridgeport-Stamford-Norwalk, CT	22900	Fort Smith, AR-OK
15180	Brownsville-Harlingen, TX	23020	*Fort Walton Beach-Crestview-Destin, FL
15380	Buffalo-Cheektowaga-Niagara Falls, NY	23060	Fort Wayne, IN
15500	*Burlington, NC	23540	Gainesville, FL
15540, 72400	Burlington-South Burlington, VT	23580	Gainesville, GA
15680	California-Lexington Park, MD	24020	Glen Falls, NY
15940	Canton-Massillon, OH	24140	Goldsboro, NC
15980	Cape Coral-Fort Myers, FL	24340	Grand Rapids-Wyoming, MI
16060	Carbondale-Marion, IL	24540	*Greeley, CO
16300	Cedar Rapids, IA	24580	Green Bay, WI
16540	Chambersburg-Waynesboro, PA	24660	Greensboro-High Point, NC
16580	Champaign-Urbana, IL	24780	Greenville, NC
16620	Charleston, WV	25060	*Gulfport-Biloxi, MS
16700	Charleston-North Charleston, SC	25180	Hagerstown-Martinsburg, MD-WV
16740	Charlotte-Concord-Gastonia, NC-SC	25260	Hanford-Corcoran, CA
16820	Charlottesville, VA	25420	Harrisburg-Carlisle, PA
16860	Chattanooga, TN-GA	25500	Harrisonburg, VA

25540, 73450	Hartford-West Hartford-East Hartford, CT
25860	Hickory-Morgantown-Lenoir, NC
25940	Hilton Head Island-Bluffton-Beaufort, SC
26100	*Holland-Grand Haven, MI
26180	Urban Honolulu, HI
26380	*Houma-Bayou Cane-Thibodaux, LA
26420	Houston-Baytown-Sugar Land, TX
26580	Huntington-Ashland, WV-KY-OH
26620	Huntsville, AL
26820	Idaho Falls, ID
26900	Indianapolis, IN
26980	Iowa City, IA
27100	Jackson, MI
27140	Jackson, MS
27260	Jacksonville, FL
27340	Jacksonville, NC
27500	Janesville-Beloit, WI
27740	Johnson City, TN
27780	Johnstown, PA
27900	*Joplin, MO
27980	Kahului-Wailuku-Lahaina, HI
28020	Kalamazoo-Portage, MI
28100	Kankakee-Bradley, IL
28140	Kansas City, MO-KS
28420	Kennewick-Richland, WA
28660	Killeen-Temple-Fort Hood, TX
28700	Kingsport-Bristol, TN-VA
28740	*Kingston, NY
28940	Knoxville, TN
29100	*La Crosse, WI-MN
29180	Lafayette, LA
29200	Lafayette-West Lafayette, IN
29340	Lake Charles, LA
29460	Lakeland-Winter Haven, FL
29540	Lancaster, PA
29620	Lansing-East Lansing, MI
29700	Laredo, TX
29740	Las Cruces, NM
29820	Las Vegas-Paradise, NV
29940	Lawrence, KS
30020	*Lawton, OK
30340	Lewiston-Auburn, ME
30460	Lexington-Fayette, KY
30700	Lincoln, NE
30780	Little Rock-North Little Rock, AR
30980	Longview, TX
31080, 31100	Los Angeles-Long Beach-Santa Ana, CA
31140	Louisville, KY-IN
31180	Lubbock, TX
31340	*Lynchburg, VA
31420	Macon, GA
31460	Madera, CA
31540	Madison, WI
31700	Manchester-Nashua, NH
32580	McAllen-Edinburg-Pharr, TX
32780	*Medford, OR
32820	Memphis, TN-MS-AR
32900	*Merced, CA
33100	Miami-FortLauderdale-WestPalmBeach, FL
33140	Michigan City-La Porte, IN
33260, 36220	Odessa, TX and Midland, TX
33340	Milwaukee-Waukesha-West Allis, WI
33460	Minneapolis-St Paul-Bloomington, MN-WI
33660	Mobile, AL
33700	Modesto, CA
33740	Monroe, LA
33780	Monroe, MI
33860	Montgomery, AL
34060	Morgantown, WV
34580	Mount Vernon-Anacortes, WA
34740	Muskegon-Norton Shores, MI
34820	Myrtle Beach-Conway, SC-NC
34900	Napa, CA
34940	Naples-Immokalee-Marco Island, FL
34980	Nashville-Davidson-Murfreesboro, TN
35300, 75700	New Haven, CT
35380	New Orleans-Metairie, LA
35620	NY-Northern NJ-Long Island, NY-NJ-PA
35660	Niles-Benton Harbor, MI
35840	North-Port-Sarasota-Bradenton, FL
35980, 76450	Norwich-New London, CT-RI
36100	Ocala, FL
36140	Ocean City, NJ
36260	Ogden-Clearfield, UT
36420	Oklahoma City, OK
36500	*Olympia, WA
36540	Omaha-Council Bluffs, NE-IA
36740	Orlando, FL
36780	Oshkosh-Neenah, WI
37100	Oxnard-Thousand Oaks-Ventura, CA
37340	Palm Bay-Melbourne-Titusville, FL
37460	Panama City, FL
37860	Pensacola-Ferry Pass-Brent, FL
37900	Peoria, IL
37980	Philadelphia-Camden-Wilmington, PA-NJ-DE
38060	Phoenix-Mesa-Scottsdale, AZ
38220	Pine Bluff, AR
38300	Pittsburgh, PA
38860, 76750	Portland-South Portland, ME
38900	Portland-Vancouver-Hillsboro, OR-WA
38940	Port St. Lucie-Fort Pierce, FL
39100	*Poughkeepsie-Newburgh-Middletown, NY
39140	Prescott, AZ
39300, 77200	Providence-Warwick, RI-MA
39340	Provo-Orem, UT
39380	*Pueblo, CO
39460	Punta Gorda, FL
39540	Racine, WI
39580	Raleigh -Cary, NC
39740	Reading, PA
39820	Redding, CA
39900	Reno-Sparks, NV
40060	Richmond, VA
40140	Riverside-San Bernardino-Ontario, CA
40220	Roanoke, VA
40380	Rochester, NY
40420	Rockford, IL
40900	Sacramento--Arden-Arcade–Roseville, CA
40980	Saginaw-Saginaw Township North, MI
41060	*St. Cloud, MN
41100	St. George, UT
41180	St. Louis, MO-IL
41420	Salem, OR
41500	Salinas, CA

41540	Salisbury, MD	46140	Tulsa, OK
41620	Salt Lake City, UT	46220	*Tuscaloosa, AL
41700	San Antonio, TX	46340	Tyler, TX
41740	San Diego-Carlsbad-San Marcos, CA	46540	Utica-Rome, NY
41860	San Francisco -Oakland -Fremont, CA	46660	*Valdosta, GA
41940	San Jose-Sunnyvale-Santa Clara, CA	46700	Vallejo-Fairfield, CA
42020	San Luis Obispo-Paso Robles, CA	46940	Vero Beach, FL
42060	Santa Maria-Santa Barbara, CA	47020	*Victoria, TX
42100	Santa Cruz-Watsonville, CA	47220	Vineland-Bridgeton , NJ
42140	Santa Fe, NM	47260	VA Beach-Norfolk-Newport News, VA-NC
42220	Santa Rosa-Petaluma, CA	47300	Visalia-Porterville, CA
42260	Sarasota-Bradenton-Venice, FL	47380	Waco, TX
42340	Savannah, GA	47580	Warner Robins, GA
42540	Scranton--Wilkes-Barre, PA	47900	Washington-Arlington, DC-VA-MD-WV
42660	Seattle-Tacoma-Bellevue, WA	47940	Waterloo-Cedar Falls, IA
43300	Sherman-Dennison, TX	48060	*Watertown-Fort Drum, NY
43340	*Shreveport-Bossier City, LA	48140	Wausau, WI
43620	*Sioux Falls, SD	48540	*Wheeling, WV-OH
43780	South Bend-Mishawaka, IN-MI	48620	Wichita, KS
43900	Spartanburg, SC	48660	Wichita Falls, TX
44060	Spokane-Spokane Valley, WA	48700	Williamsport, PA
44100	Springfield, IL	49020	Winchester, VA-WV
44140	Springfield, MA-CT	49180	Winston-Salem, NC
44180	Springfield, MO	49340	Worcester, MA-CT
44220	Springfield, OH	49420	*Yakima, WA
44700	Stockton-Lodi, CA	49620	York-Hanover, PA
45060	Syracuse, NY	49660	*Youngstown-Warren-Boardman, OH-PA
45220	Tallahassee, FL	49740	Yuma, AZ
45300	Tampa-St. Petersburg-Clearwater, FL	72850	Danbury, CT
45460	Terre Haute, IN	74500	*Leominster-Fitchburg-Gardner, MA
45780	Toledo, OH	75550	*New Bedford, MA
45820	Topeka, KS	77350	Rochester-Dover, NH-ME
45940	Trenton, NJ	78700	Waterbury, CT
46060	Tucson, AZ		

Notes: The asterisk (*) means that Uber or Lyft was not serving the metropolitan area before the end of 2017, or that the code was no longer in use for that metropolitan area when Uber or Lyft started service. Some areas have multiple codes because the CPS changed their code definitions during the period examined (2005-2017).