UBER ECONOMICS

Evaluating the Monetary and Nonmonetary Tradeoffs of TNC and Transit Service in Chicago, Illinois

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ABSTRACT

The potential diversion of passengers from public transit to Transportation Network Companies (TNCs) is attracting considerable attention in metropolitan regions. Despite this, relatively little microeconomic analysis has been made available to explore how service attributes affect choices between ridesharing and public transit. To fill this shortfall, this study evaluates prices and service levels for Lyft, Lyft Line, Uber, UberPool and Chicago Transit Authority (CTA) services in Chicago. Through analyzing search results involving 3,075 fares for 614 trips in the 4 – 11 mile range, the report draws several notable conclusions:

- **The fares charged for Lyft Line and UberPool** – ridesharing services in which several parties share a vehicle – **have fallen both in absolute terms and relative to fares for Lyft and Uber**. Despite a recent increase in the city's tax on TNCs, the inflation-adjusted cost of riding these services fell by around 5% between 2016 and 2018.

- **TNCs tend to be relatively costly for those traveling to and from the downtown area.** When expressed in terms of the cost per hour, the average TNC trip costs more than $50 per hour saved across the entire sample. The cost for downtown trips tends to be twice that, making them uneconomic for most commuters. Between the neighborhoods, however, the value proposition from TNCs is greater.

- An economic model created for this study shows that, when accounting for both *monetary and nonmonetary costs* (including a desire to avoid walking and perceived difference in comfort), the average commuter is **six times less likely** to rideshare when the public transit experience is considered favorable rather than unfavorable.

These conclusions indicate that TNCs and public transit tend to serve different mobility roles and that the CTA could build greater synergy between these travel options by:

- **Integrating transit trips involving ridesharing into the Ventra app** and other online tools;
- Working with TNCs to offer **discounted rides to CTA bus and rail-transit stations at times when feeder bus service is limited**, such as during late-night hours;
- Creating **pilot programs** with TNCs for disabled passengers;
- Exploring the feasibility of **"guaranteed ride home"** programs that provide commuters who avoid driving additional flexibility.

For a brief overview of the potential synergies that may arise from discounts for TNC rides to outlying CTA stations during late-night hours, click here.

I. INTRODUCTION

Transportation network companies (TNC) have gained great prominence in large metropolitan areas over a relatively short period of time. Within a span of less than nine years, these door-to-door service providers have expanded across most of the country and have rolled out new options to customers, some of which allow several parties to share the same vehicle in exchange for a lower price. Although helping to improve mobility, the growth of TNCs is also raising questions about congestion and the potential diversion of passengers from transit services.

To foster a greater understanding of this issue, this study compares the performance characteristics of four TNC services – Lyft, Lyft Line, Uber, and UberPool[1] – with public transit services in Chicago, IL, the third largest city in the United States. Using a stratified sample of 3,075 fare and travel time estimates, it evaluates the costs, time, predictability, and convenience associated with each trip made. The sample compares the qualities of trips between the city's central business district and its neighborhoods, as well as those occurring between neighborhoods, which tend to be more difficult using public transit alone.

Unlike other studies that draw inferences about competition from passenger surveys, aggregated travel statistics, and the characteristics of TNC trips in isolation, this analysis evaluates the prices and travel time estimates that are provided to travelers at the point in which they are making decisions about whether to use public transit or a TNC. Using a randomization technique, it compares the characteristics of trips for simultaneous departures on the four TNC options mentioned above with Chicago Transit Authority (CTA) bus and train services. By applying federally recommended estimates about the value of travel time savings to transit users, it draws conclusions about the propensity for travelers to divert to TNCs under different scenarios.

The analytical portions of the analysis are divided into five sections. Section II offers a background perspective on the expansion on TNC and reviews the relevant research on the effect of various forms of "ridesharing" on travel behavior. Section III summarizes the methodology and offers descriptive statistics on the characteristics of the two modes. Section IV summarizes the findings. The final section offers conclusions and recommendations.

Chicago is an attractive location for undertaking the analysis, due to its large and heavily used transit system and its relatively liberal policies on TNCs. This city, which has a population of 2.7 million[2], has a vibrant downtown district that is well served by both "heavy rail" rapid-transit lines and buses operated by the CTA, along with commuter rails operated by its sister agency Metra. The CTA handles the equivalent of nearly 200 rides per city resident annually (Chicago Transit Authority, 2017). Throughout the city, 26.1% of workers reach their jobs primarily on

[1] Uber markets its pooling service as "UberPOOL", which is denoted as "UberPool" throughout this report.

[2] Population estimate based on 2016 U.S. Census.

transit, but in the downtown region, a much larger share use public transit to reach their places of employment.

II. BACKGROUND

Transportation network companies were nonexistent in many markets before Uber launched in the United States in 2010. Initially, its offerings were largely confined to UberX, a service taking passengers to their destinations in conventional automobiles without other stops, in manner similar to taxicabs but using an app-based reservation system. Lyft launched a similar service in 2012 and, like Uber, was soon available in most major cities. A variety of small operators also entered the fray.

Starting in 2014, these major TNCs rolled out services allowing several travel parties to share one vehicle at the same time, even when traveling between different origins and destinations. Uber formally launched UberPool service in August of that year after a successful test of the concept in California. The service was soon expanded to most large U.S. cities, although gaps remain; UberPool is still not widely available in most metropolitan areas with populations of less than 100,000. Lyft began a similar service, Lyft Line, in 2014, which also offers extensive coverage in larger U.S. cities. Both have characteristics similar to jitneys, which have long been available in many densely populated corridors and similarly operate over flexible routes (see Wright and Curtis, 2005). A notable difference, however, is that these newer offerings use sophisticated (and proprietary) algorithms that optimize the routing of passengers and thereby help keep costs low and travel times to a minimum.

A wide body of research has recently emerged to shed light on the role of TNCs in urban transportation. Rayle, Dai, Chan, Cervero, and Shaheen (2016) collect a large amount of data from surveying ridesourcing and taxicab customers to demonstrate how TNCS serve a niche that is largely distinct from taxicabs. Not only do customers of TNCs have shorter waits, but they serve customers who are unlikely to use taxis, catering to younger clientele less likely to own an automobile than taxi users. This study suggests that TNCs are often complementary to transit use rather than the source of traffic diversion, in part by cultivating car-free lifestyles.

Some of these same conclusions are reached by the Shared-Use Mobility Center (SUMC) in a study conducted in cooperation with the American Public Transit Association. Using data from surveys of 4,500 users of all types of shared-mobility modes, this study shows that “sharers” are more likely to use public transit than their non-sharing counterparts (Shared-Use Mobility Center, 2016). Those heavily reliant on TNCs, however, are less apt to use transit than those that use other “sharing” options. Those using TNCs live more automobile-oriented lifestyles, for example, than bikesharers and carsharers.

More extensive analysis of these issues are provided in a subsequent SUMC study, published earlier this year, which evaluates survey responses from 10,000 TNC riders and data provided by the companies themselves (Shared Use Mobility Center, 2018). Trips on TNCs were found to generally be relatively short and more heavily concentrated in downtown areas than the typical transit trip. TNC trips were also found to be relatively uncommon among commuters traveling between residential areas and central business districts and other major job centers. The analysis suggests that trips taken on TNCs, which include many late-night trips and those to airports, would likely not otherwise be made on transit. It concludes competition between these modes tends to be a secondary concern.

Other research, however, paints a somewhat different picture. The Boston-based Metropolitan Area Planning Council surveyed 1,000 area residents and found that a significant number of TNC trips in its region were during peak travel periods, which tended to aggravate congestion. The analysis in this study suggests riders are willing to pay a substantial premium for the convenience and predictability of TNCs – which is particularly relevant for the analysis provided in this paper. Roughly two thirds of the trips are shown to cost more than $10, making them much higher than transit fares. During rush hours, almost one sixth of all trips on TNCs resulted in additional traffic on areas roads, rather than shifts from one type of motor vehicle to another. An estimated 42% of all TNC trips would otherwise have been made on public transit -- a far greater number than observed in other studies.

A study of central Manhattan by Bruce Shaller, while focusing primarily on TNC/taxi competition, makes a similar conclusion and shows that traffic volume from these modes rose 15% between 2013 and 2017 when TNC and taxi trips are added together. Using a residential survey as its primary methodology, the study found trips on these modes (largely due to the growing popularity of TNCs) are becoming longer. Moreover, the number of unoccupied vehicles has risen, with the greatest increases taking place between 4 and 6 p.m. (Shaller, 2017).

A study by Clewlow and Mishra draws up a survey of 4,094 riders in heavily populated metropolitan areas around the United States to determine the extent to which they have changed their travel patterns in response to TNCs. Using this multi-region sample, it concludes that about a fifth (21%) of adults are users of TNCs, while another 9% use them with friends without having the apps installed. An estimated 37% of TNC users are motivated to use TNCs out of concerns over parking. The study's most heavily publicized conclusion is that TNCs have been responsible for a 6% drop in public transit ridership in large cities. Urban metro and commuter rail services are shown to be less affected than bus service (Clewlow and Mishra, 2017).

Despite the growing body of research on TNCs, however, relatively few researchers have explored pricing strategies. Oie and Ring (2015), explore the temporal patterns of price fluctuations that occur in response to changing market conditions, which include the tendency for rates to occasionally "surge". The aforementioned Boston study has results about prices, but this information is self-reported by survey respondents. The present study attempts to partially fill the void of direct analysis of pricing and travel time estimates.

III. METHODOLOGY

The characteristics of TNC and public-transit trips were measured across a stratified sample involving app-based searches for 610 trips between 105 origins and destinations. Data was collected on 16 different occasions between November 1, 2018 and March 4, 2018. This resulted in 3,075 fares and estimated travel times, as well as information on a wide range of other variables such as wait times and walk distances to public transit stops.

Data collectors recorded prices and estimated travel times (which were computed based on projected arrival times) for trips on Lyft, Lyft Line, Uber and UberPool using the downloadable apps that the TNCs provide. To select the best available transit route and avoid subjective judgments, the data collectors recorded the fastest route suggested by the Google Transit app, regardless of the number of connecting legs or mode of travel (bus or rapid transit). Data was collected no more than a minute apart between the five travel options over each route considered.

Criteria for Selecting Routes

To identify origins and destinations, a geographic information system was used to categorize the geometric center of official Community Areas, as defined by the U.S. Census Bureau, on the north and northwest sides of Chicago. The nearest residential address to the geometric center of the area was then selected. For locations in the downtown and "outer downtown" areas, the centroids of zip code areas were used to identify the nodes (Figure 1).

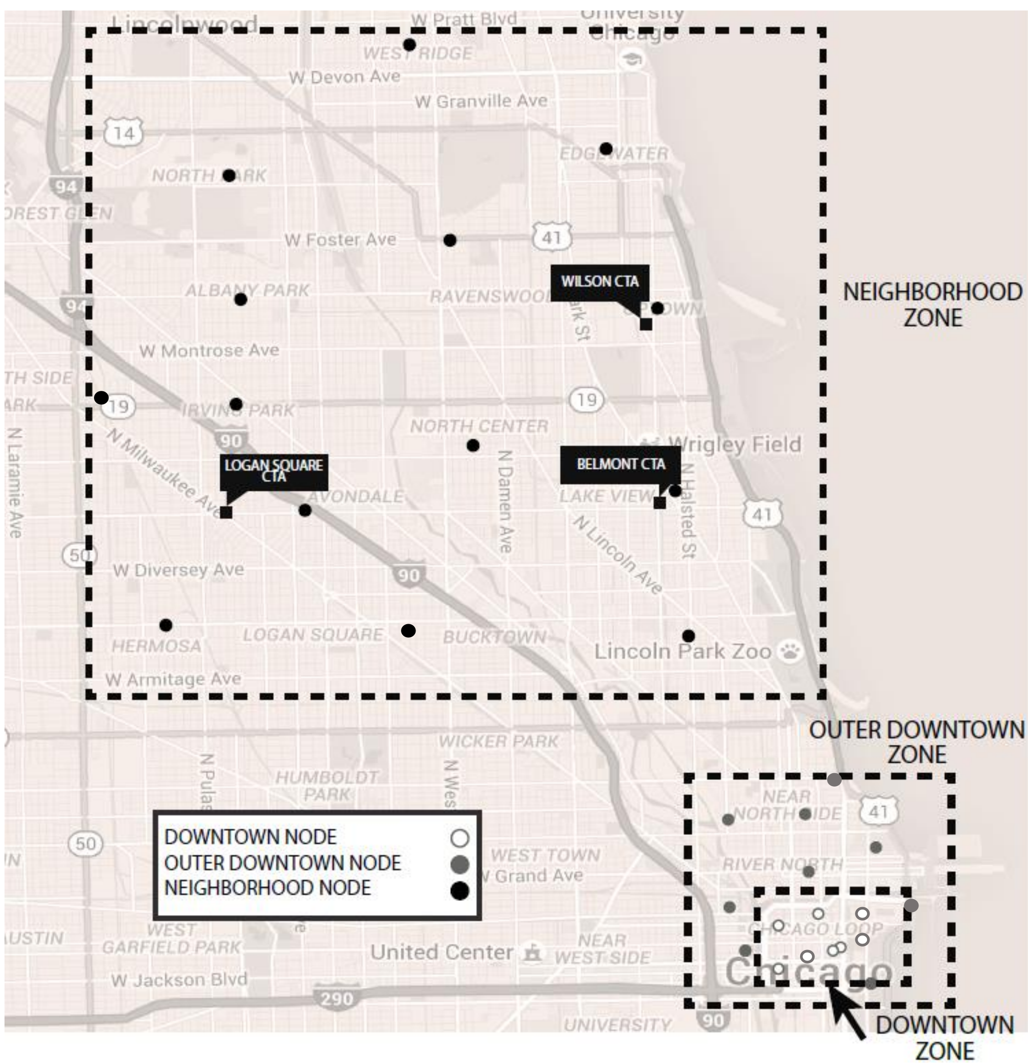
These nodes fall into three categories, based on a typology created for the Chaddick Institute from the earlier *Have App will Travel* study in 2016:

- *Downtown Core Zone*: Nodes in this zone fall east of Canal Street and south of Kinzie Street (one of the first streets north of the Chicago River). Almost all points in this zone are within close proximity to CTA rapid transit service.
- *Outer Downtown Zone*: Nodes in this zone are located outside downtown but east of the Dan Ryan/Kennedy Expressway and south of North Avenue. Public transit service, particularly rail rapid-transit, is less pervasive in this zone.
- *Neighborhood Zones*: These nodes are located outside of the greater downtown area, as depicted in Figure 1. This includes both residential-, industrial-, and commercial-oriented areas north and west of Chicago's busy "Loop" (the downtown district).

All searches involved trips starting or ending on the city's north and northwest sides, due to the study's goal of holding constant as many factors as possible when comparing travel times and costs. However, the origins and destinations vary, with some trips confined to the Neighborhood zone, while others linked the Neighborhood zone to the Downtown or Outer Downtown Zone. Approximately 60% of observations involved travel between the Downtown and Outer Downtown zones and the Neighborhood zones, while the remaining 40% were between neighborhood locations.

This geographically focused sample was selected due to a desire to focus on routes in which both transit and ridesharing have relatively high market shares. The market for UberPool service on the south and southwest sides of Chicago appears less well-developed than those on the north and northwest sides, as population densities and average incomes tend to be lower and transit service more sporadic in some neighborhoods.

Figure 1: Neighborhood Nodes on Chicago's North and Northwest Sides serving as Origins and Destinations for Paired Observations



Timing and Distances of Trips Evaluated

Observations were made during three time periods: the *weekday peak period* (defined as 7:30 – 8:59 a.m., and 4 – 6:30 p.m.), the *weekday off-peak period* (9:00 a.m. – 3:59 p.m.) and

Saturdays late afternoon/early evening (4 p.m. – 8 p.m.). The sample does *not* include late night or early morning trips, which are often widely associated with surge pricing, to remain consistent with its desire to focus on periods when public transit use is more abundantly provided and commonly used by urban travelers.

The sample consists of 110 routes in the 4 - 11 miles range, as measured by highway distances. This range was chosen to allow the analysis to focus on routes in which TNCs and transit extensively compete for certain types of passengers. For shorter trips, a disproportionate share of travel time among transit users is spent walking to stations and waiting for buses and travel; in these instances, the speed of the transit vehicle can be less important than the proximity of the passenger to the transit route. On trips over 11 miles, the cost of using TNCs can become prohibitive. By using only trips in this mile range, the analysis

Table 1: Notable Differences in the Characteristics of the Five Travel Modes Considered

<table>
<tr><th rowspan="2">Travel Option</th><th rowspan="2">Type of Service</th><th colspan="2">Notable Uncertainties</th><th rowspan="2">Assumptions Made in Analysis</th></tr>
<tr><th>Departure Time & Price</th><th>Speed & Arrival Time</th></tr>
<tr><td>UberPool</td><td rowspan="2">Shared-Ride Services
“Ridesplitting”
Vehicle makes stops to pick up and drop off other passengers. Number of stops not known in advance. Door to door service</td><td rowspan="2">Fare known only know at time of booking. Estimated wait time estimate in the form of a range.</td><td>Arrival time provided in the form of a range.</td><td rowspan="2">Midpoint of range of arrival times used to estimate trip duration for UberPool (see Appendix A).</td></tr>
<tr><td>Lyft Line</td><td>Precise estimate arrival time provided, despite uncertainty over # of stops.</td></tr>
<tr><td>Uber</td><td rowspan="2">Exclusive Ride Service
“Ridesourcing”
Vehicle does not make stops for other passengers. Door to door service.</td><td rowspan="2">Fare known only know at time of booking. Precise wait time estimate provided.</td><td rowspan="2">Precise estimate arrival time provided.</td><td rowspan="2"></td></tr>
<tr><td>Lyft</td></tr>
<tr><td>Chicago Transit Authority (CTA)</td><td>Public transportation
Travelers directed to nearby transit stop using Google Maps or another online tools. Fares are knowable in advance.</td><td>Precise departure times provided. Online search assumes service follows schedule to allow connections. Trip recommendations often call for passenger to wait before beginning journal to minimize waiting.</td><td>Standard walking speed assumed. Assumes space available on next arriving bus or train.</td><td>Assumption made that traveler immediately proceeds to transit station. Accepts random arrival pattern.</td></tr>
</table>

focuses more intensively on the differences between trips of moderate distances. However, as noted in the conclusions section, evaluating the tradeoffs in trips of other distances would be a fruitful line of future research.

Each of the five travel options differ with respect to the type of information knowable in advance (Table 1). Lyft Line, UberX and Lyft provide customers precise arrival times at the destination. Regular users of Lyft Line and UberPool recognize that arrival times are only estimates, since the number of stops that will be made is not known either to the passenger or company at the time the booking is made. UberPool does not provide a precise arrival time when a booking is made; instead, it provides the traveler with a range of possible arrival times. In the sample, the average range of possible arrival times was 15.8 minutes.

To deal with the lack of specificity in travel times on UberPool, data collectors made 20 actual trips involving randomly selected routes among the sample. These results showed actual arrival times on this service tend to be approximately midway between the minimum of range and the midpoint (see Appendix A for detailed estimates). In the analysis, the assumption is made that the traveler arrives at the midpoint of the time range due to wide fluctuation in arrival times across the range.

Estimates of the length of time required for public transit trips assume the traveler proceeds immediately to a designated transit stop at a randomly selected time after searching for the best option on his/her smartphone. As a result, the traveler accepts the longer waits than a customer who uses a published schedule or an app, such as a "bustracker" or "traintracker" app, which can allow travelers to reduce waiting. The implications of relaxing this assumption are considered in the analysis below, as are the complexities posed by delays once a trip begins.

Public transit users are able to know the price of their trip well in advance. Regular CTA fares are presently $2.50 for trains and $2.25 for buses, with an additional 25 cents for transfers. Seventy two percent of the public transit trips in the sample involved at least one transfer and five percent involved two. Prices of TNCs, however, are only knowable at the time a reservation is made. The implications of the uncertainty associated with these types of issues are discussed in further detail below.

V. FINDINGS

The performance of the two modes varied widely according to the geographic and service-related properties of the trips, with the notable results summarized below.

Comparison of Average Fares

Across the sample, the average CTA fare is $2.69, while Lyft and UberX average $18.13 and $17.90 respectively, and Lyft Line and UberPool average $14.04 and $9.33, respectively. **This**

suggests that exclusive-ride TNC services in the mileage range considered tend to average $15 - $16 more than services transit, while shared-ride services average $6 - $11 more. TNC prices are generally marginally higher during the weekday peak than during the off peak period, while UberX services are highest during the late afternoon/evening period on Saturdays. Surge pricing was relatively rare, occurring in only about 3% of observations, and are not a major factor in the analysis below.

Table 2: Comparison of Fares by Type of Route and Period of Travel

	Average Price					Percent Savings	
Type of Trip	CTA	Lyft Line	UberPool	Lyft	UberX	UberPool over UberX	Lyft Line over Lyft
Downtown - Neighborhood	$2.58	$15.73	$10.77	$20.99	$20.02	46.2%	25.1%
Outer Downtn - Neighborhood	$2.70	$13.36	$8.70	$17.55	$17.39	49.9%	23.9%
Between Neighborhoods	$2.76	$13.15	$8.72	$16.19	$16.63	47.5%	18.8%
Weekday Offpeak	$2.68	$14.61	$9.03	$18.00	$17.85	49.4%	18.9%
Weekday Peak	$2.68	$13.60	$9.34	$18.21	$17.88	47.8%	25.3%
Saturday evening	$2.70	$13.81	$9.86	$18.20	$18.15	45.7%	24.1%
All Trips	***$2.69***	***$14.04***	***$9.33***	***$18.13***	***$17.90***	***47.9%***	***22.6%***

These two major TNCs differ sharply with respect to the amount of savings provided for passengers who are willing to share a vehicle with other travel parties. The savings from using Lyft Line rather than Lyft averaged 22.6%, whereas those using UberPool saved 47.9% over Uber. The savings tends to be similar across the time periods considered, with the largest savings on Lyft Line (25.3%) during the weekday peak and on UberPool during the weekday off peak (49.4%). The differences are quite similar across geographic categories; the savings from Lyft Line are greatest (25.1%) for trips involving downtown, while those on UberPool savings are greatest in the Outer Downtown zone (49.9%). Clearly, there is notable consistency in pricing across the scenarios considered.

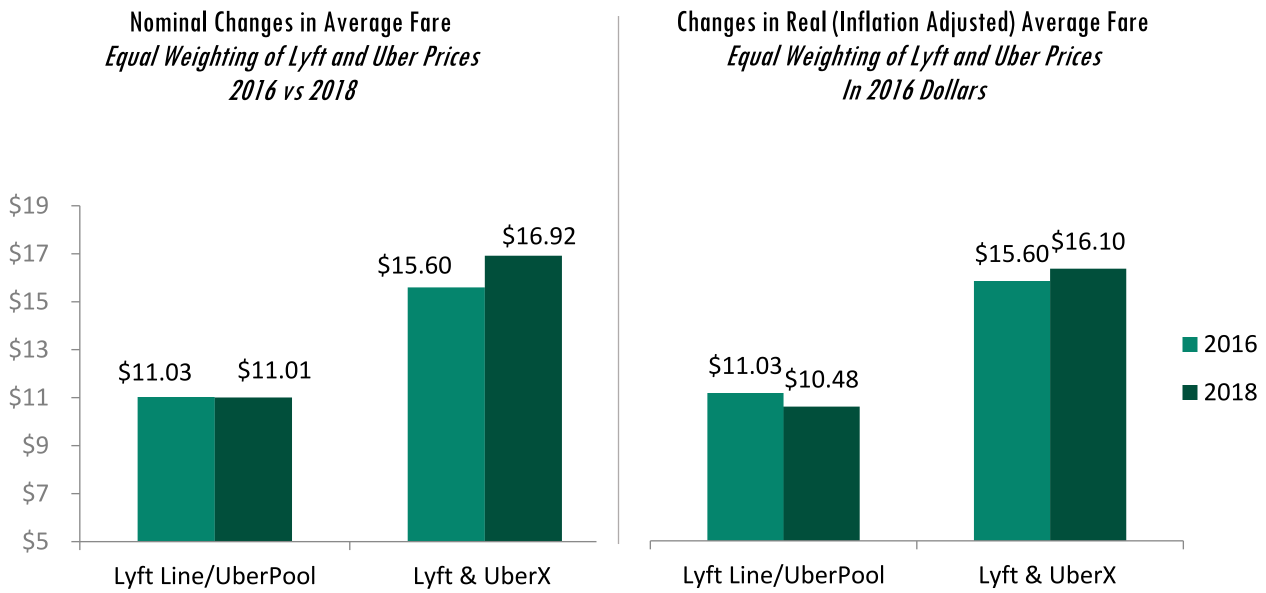
Changes in Average Fare, 2016 – 2018

The changes in average fares over the past two years are measured by analyzing a subset of prices that involve identical routes from early 2016 and early 2018. The earlier sample is much smaller, and its composition slightly different, so only the trips in the 4 – 10 mile range are compared. Lyft and Uber prices are also combined due to the small size of the sample in 2016. Cumulatively, the sample from 2016 involved 200 total fares whereas the 2018 sample involve 3,100.

When Lyft Line and UberPool are weighted equally, the average fare for shared-vehicle services barely changed, falling from $11.03 to $11.01; on the other hand, the price of Lyft and UberX, similarly weighted, rose from $15.60 to $16.92. Since the earlier sample was collected, the city has raised its tax on TNCs from $0.52 per ride to $0.67, making it one of the highest taxes in the country. (This study did not consider premium services, such as Uber Black or Lyft Lux.)

If prices are expressed in constant 2016 dollars, the shared-ride services (UberPool and Lyft Line) dropped from $11.03 to $10.48 – a decline of 5.0% – while the exclusive-ride services (UberX and Lyft) rose from $15.60 to $16.10, an increase of 3.2%. Across the entire sample, real TNC fares fell from $13.31 to $13.29, a 0.2% drop, suggesting that these companies have mostly absorbed the tax increase.

Figure 2: Changes in Nominal and Real Average Fares from 2016 to 2018



In constant 2016 dollars, the shared-ride services (UberPool and Lyft Line) dropped from $11.03 to $10.48 – a decline of 5.0% – while the exclusive-ride services (UberX and Lyft) rose 3.2%. CTA fares rose, in real terms, by 4.9%.

The ability for TNCs to either reduce or hold the line on fares for shared-ride trips despite significant rises in gasoline costs may be explained by the apparent rise in the match rate (i.e., the rate in which multiple parties share the same vehicle). During this same period, CTA fares have risen by $0.25, an increase of about 10%. A notable implication of these results is that the intensity of price completion has escalated.

Travel Time

Travelers using any of the TNC options generally enjoy faster trips than on transit, except when the trip involves the Downtown zone, in which case the results are mixed. Based on the travel time estimates recorded from the respective apps, **UberPool trips are four minutes faster than public transit trips, whereas Lyft Line trips are estimated to be 10 minutes faster. UberX and**

Lyft are estimated to be 19 and 22 minutes faster than public transit, respectively. Nevertheless, customers face a clear tradeoff with respect to price and speed. On average, UberPool is four minutes (or about 10%) slower than transit on trips to the Downtown zone, while Lyft Line is just two minutes (about 4%) faster than transit. From the Outer Downtown, where transit tends to be somewhat less convenient, partially due to longer walking distances to bus and train stops, UberPool is three minutes faster, whereas Lyft Line is 9 minutes faster. Even so, as shown below, the higher cost of using TNCs makes them difficult to justify based solely on saving travel time or for consumers on limited budgets.

On trips involving only the Neighborhood zone, TNCs offer much greater timesavings, with users of Lyft and UberX saving an average of 24 and 20 minutes, respectively, while those using Lyft Line and UberPool save 15 and 4 minutes, respectively. However, UberPool is slower than public transit on Saturday evenings; the service's comparative slowness during this period is the result of a higher "match rate", which increases the number of stops.

Table 4: Comparison of Travel Times by Type of Route and Period of Travel

Type of Trip	CTA	Lyft Line	UberPool	Lyft	UberX
Average Travel Time					
Downtown - Neighborhood	0:44	0:42	0:48	0:29	0:33
Outer Downtn - Neighborhood	0:48	0:39	0:45	0:27	0:31
Between Neighborhoods	0:51	0:36	0:47	0:27	0:31
Weekday Offpeak	0:48	0:39	0:47	0:28	0:32
Weekday Peak	0:48	0:39	0:46	0:27	0:31
Saturday evening	0:47	0:40	0:49	0:30	0:33
All Trips	***0:48***	***0:38***	***0:44***	***0:26***	***0:29***
Share of Trips Offering Time Savings vs. Public Transit					
Downtown - Neighborhood		59.6%	41.0%	91.0%	83.0%
Outer Downtn - Neighborhood		86.9%	61.7%	94.9%	94.9%
Between Neighborhoods		92.0%	65.6%	96.7%	96.7%
All Trips		***80.3%***	***56.7%***	***96.1%***	***91.9%***

The estimated times for trips linking downtown to the neighborhoods were slower on UberPool than on transit and only two minutes faster on Lyft Line; other types of trips, however, the time savings are more significant. The bottom section of the chart shows the share of trips that were faster by type of service.

These uses of categorical averages to compare travel time, however, can be deceptive, as each trip has unique qualities. UberPool trips in particular are highly variable. To account for these differences, the analysis also considers the 614 trips individually to determine *share of all trips* in which TNC options are faster than transit. **Across the sample, the results show 56.7% of trips taken with UberPool are quicker than on the CTA, as are 80.3% of trips with Lyft Line. The exclusive-ride options (UberX and Lyft) are quicker for more than 90% of the trips**. *(See the bottom section of Table 2 for the detailed results.)*

For travel involving the Downtown zone, however, transit is much more competitive, with just 59.6% of Lyft Line trips and 41.0% of UberPool trips being quicker than public transit. (*Note that while the average UberPool trip is slower than public transit, nearly two in five is faster, due in part to variation in walk distances and the need for transfers when taking transit*). On trips within the Neighborhood zone, more than 90% of trips are faster on TNCs for each of the travel options with the exception of UberPool, in which 65.6% are quicker.

The "Cost" of Saving Time Using TNCs

Travelers deciding whether to use a TNC rather than public transit invariably must confront the question of whether the time savings is worth the additional cost. Making this determination not only requires the traveler to implicitly assign a value to his or her time but also to weigh the *uncertainty* associated with the travel times.

The analysis evaluates these tradeoffs by assessing whether TNC are cost effective when standard assumptions are made about the value of a traveler's time. Among the most widely used sources for assigning such values is the U.S. Department of Transportation's Guidance on Value of Time by the US Department of Transportation, which is updated regularly. This document assigns different values for use in analysis for various types of passengers. Its most recent recommendations (for 2015) for economic analysis called for using a rate of $14.10 per hour as the value of time savings for transit users traveling on personal time and $25.40 per hour for those traveling on business. When figures are converted to 2018 dollars, this results in a value of time savings of $14.95 for travelers on personal time (which includes most commuters) and $28.85 for business travelers.

The analysis shows consumers who use exclusive-ride TNC services are buying time savings at a lower cost than those using the shared-ride options. **The average traveler pays the equivalent of $42 and $40 per hour of travel time saved on Lyft and UberX, respectively, versus $38 and $108 on Lyft Line and UberPool, respectively.** The high cost of *per hour savings* on UberPool reflects the fact that a higher share of trips using this option are slower than public transit. The cost of savings tends to be highest on trips involving the Downtown zone, largely due to the modest time saving provided in exchange for the additional cost. On trips between the neighborhoods, travelers pay $24 per hour saved on Lyft Line and $34 on Lyft, compared to $41 on UberX and $89 for UberPool. The higher average cost for the latter is attributed to their tendency for relatively little time per dollar saved.

The use of averages across the entire sample, however, can be deceptive due to trip-to-trip differences. To account for this, the analysis also considers the *share of trips* in which the time savings exceed the USDOT recommended $14.95 per hour value of time saving. **Just 0.8% of Lyft Line and 4.9% of UberPool trips met the USDOT standard for time savings, while just 0.2% of the exclusive-ride options did. As would be expected, the share of trips that met this benchmark that involved travel to or from the Downtown zone is the lowest, being just 1.1%**

for UberPool and none for the others. In other words, none of the downtown trips on the options besides UberPool saved enough time to be meet the USDOT standard. For example, it is not uncommon for UberX trips to save about 15 minutes of travel but cost around $17 more, which equate to spending about $68 per hour (or about $1.13 per minute) of travel time saved.

For trips between the neighborhoods, the cost effectiveness of TNCs is much higher. An estimated 1.9% and 7.5% of Lyft Line and UberPool trips, respectively, saves the traveler enough time to meet the UDOT standard, whereas less than one percent of the exclusive rider services do. When considering passengers traveling on *business*, who place a higher value on their time, however, a much different picture emerges. Again, the USDOT recommends using a rate of $25.40 per hour for those traveling on business. The share of Lyft Line and UberPool trips that meet this standard are both around 16%, compared to 11% on Lyft and 10% on UberX. More significantly, on trips within the Neighborhood zone, around 30% of Lyft Line and Lyft trips save enough to be worth the investment, which is far more than the other options.

Table 3: Cost of Time Saving using TNC rather than Public Service Per One Hour of Time Saved

	Rideshares		Exclusive Rides	
	Lyft Line	UberPool	Lyft	UberX
Average amount spent for hour saved vs. public transit				
Downtown - Neighborhood	$253.69	*No time saved*	$76.62	$99.93
Outer Dtn – Neighborhood	$37.74	$122.01	$41.80	$51.40
Between Neighborhoods	$24.02	$88.67	$33.84	$41.20
Weekday Offpeak	$42.00	$349.06	$45.81	$56.33
Weekday Peak	$41.59	$176.41	$43.28	$53.69
Saturday evening	$55.04	*No time saved*	$53.00	$65.86
All Trips	***$38.28***	***$108.35***	***$41.82***	***$49.39***
% of Trips in which Times Saving Exceeds USDOT Standard: Average Passenger ($14.95/hr)				
Outer Dtn – Neighborhood	0.5%	5.6%	0.0%	0.0%
Between Neighborhoods	1.9%	7.5%	5.0%	0.5%
All Trips	0.8%	4.9%	0.2%	0.2%
% of Trips in which Times Saving Exceeds USDOT Standard: Business Travelers ($25/hr)				
Downtown - Neighborhood	0.5%	5.9%	1.1%	2.1%
Outer Dtn – Neighborhood	4.7%	19.2%	13.6%	9.8%
Between Neighborhoods	26.9%	11.0%	31.6%	16.5%
All Trips	***11.1%***	***16.1%***	***16.0%***	***9.8%***

Consumers generally implicitly pay the equivalent of more than $35 per hour when using TNCs rather than transit to save time—am amount far exceeding of the $14.95 standard for time savings recommended by the USDOT for analysis of transit service.

This result is consistent with prevailing belief that travelers who face a high opportunity cost are more likely to switch to TNCs. As a general rule, for passengers placing lower values on their time, UberPool is most attractive, while those placing a higher value will likely prefer the Lyft offerings.

This caveat warrants emphasis: Although transit trips tend to be slower than TNC trips, they are more predictable with respect to both price and estimated travel time. An analysis of the variation on the subset of trips on an identical route[3] shows that transit is superior with respect to the predictability in travel times. Significant variations in price, including the possibility of "surge pricing", is, of course, also a negative aspect of using TNCs. See Appendix A for further discussion of this issue.

Accounting for Different Components of the Trip and Differing Perceptions of Quality

This final section demonstrates a technique for considering non-monetary factors associated with the five travel options. Such factors can include perceived differences in the onboard environment, safety, the quality of waiting environment, and, in the case of public transit, the uncertainty over the availability of a seat (or even ample standing room). The approach can also takes into account the tendency for travelers to implicitly disvalue time spent walking and waiting over time spent seated, as well as their desire to avoid transfers.

The "disutility" travelers place on spending time traveling under different circumstances is generally expressed in policy analysis as a percentage of the traveler's wage rate. Previous research shows the implicit cost of an extra hour of travel time (perhaps aggregated over several trips) under the most unpleasant conditions can exceed more than the travelers wage rate, whereas an extra hour in favorable conditions can be disvalued by as little as a quarter of the wage rate (VPTI,). When all these factors are taken into account, an estimate can be made of what is described in microeconomics as the "generalized cost" of the trip.

There are no recognized standards to measure the perceived differences for the degree to which these non-monetary factors impose costs on TNCs and public transit passengers. A study focusing on competition in Chicago transit by Frei, Hyland, and Mahmassani, however, provides insight by using a stated-preference survey giving respondents a choice between traditional transit, car, and a hypothetical flexible transit mode (such as UberPool) (Frei, et. Al, 2015). Based on 1,280 responses, their analysis shows passengers disvalue wait times, transfers, and access time at a rate of 1.5 to three times more than travel time.

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[3] *Each route was sampled at least 8 times to be considered for this analysis.*

Table 4: Recommended Travel Time Values (Relative to Prevailing Wages)

Category	Levels of Service (LOS) A-C	D	E	F	Waiting Good	Average	Poor
Personal vehicle driver	50%	67%	84%	100%		100%	
Adult car passenger	35%	47%	58%	70%		70%	
Adult transit passenger – seated	35%	47%	58%	70%	30%	50%	125%
Adult transit passenger – standing	50%	67%	83%	100%	50%	70%	175%
Pedestrians and cyclists	50%	67%	84%	100%	50%	100%	200%
Total Transfer Premium					5-min	10-min	15-min

This tables shows recommended values for the perceived nonmonetary cost of transportation journey as a share of wage rates at different levels of service, with "A" being highest and "F" being lowest. Source: Victoria Transportation Policy Institute (2017)

Other research explores how passenger valuations vary in accordance with the "Levels of Service" (LOS) associated with various travel outcomes. LOS is often measured on categorical scale, with LOS A and B being the most favorable, and LOS E and F the least. One might imagine the trips in the highest categories taking place in comfortable and climate-controlled vehicles with ample seating, pleasant waiting areas for transfers, and the expectation of an on-time arrival. LOS D is midway down the scale and involves greater levels of discomfort, unpredictability, and inconvenience. LOS E and F, at the low end, might include trips involving extreme temperatures, rainy conditions, poorly maintained equipment as well as crowded and unsafe conditions with frequent operational delays.

The Victoria Transport Policy Institute (VPTI), conducting a meta-analysis of studies on service levels, make explicit recommendations for economic analyses considering different levels of service (VPTI, 2017). For transit riders at LOS A, B, and C, it recommends assigning a value of travel time of 35% of traveler wage when there is seating, and at 50% when there is not. In LOS F, it recommends using 70% of traveler wage if seating is available, and 100% if there is not (Table 5).

Table 5: Assumptions Made in Estimating Total Generalized Cost

Trip Characteristic	Observed Average in Sample	Assumption Made in Analysis on Passenger Disvaluation of this Attribute	
		TNC Trips	*Transit Trips*
In-Vehicle Travel Time	See Table 2	Disvalued at 35% of wage, based on recommendation for average Adult Car Passenger by VPTI	Disvalued 35.0% of wage for LOS A, B, and C); 47.5 % for LOS D, 58% for LOS E, and 70% in LOS F per VPTI recommendation. See Table 4
Wait Time (minutes)	Transit 4:21 UberX 3:11 Lyft 6:21 Lyft Line 5:23 UberPool 4:11	Disvalued at 25% higher than in-vehicle time, based on "average" scenario by VPTI	Same as TNC
Transfers	68% of transit trips	No transfers involved	Disvalued at equivalent of 5 minutes in-vehicle travel times, based on the "good" conditions scenario by VTPI
Walking	0.41 miles for transit trips (14 minutes); Minimal walking involved for TNCs	None	Disvalued at 45% more than in-vehicle travel time, following VTPI recommendation
Wage Rate	___	$28.585	Same as TNC

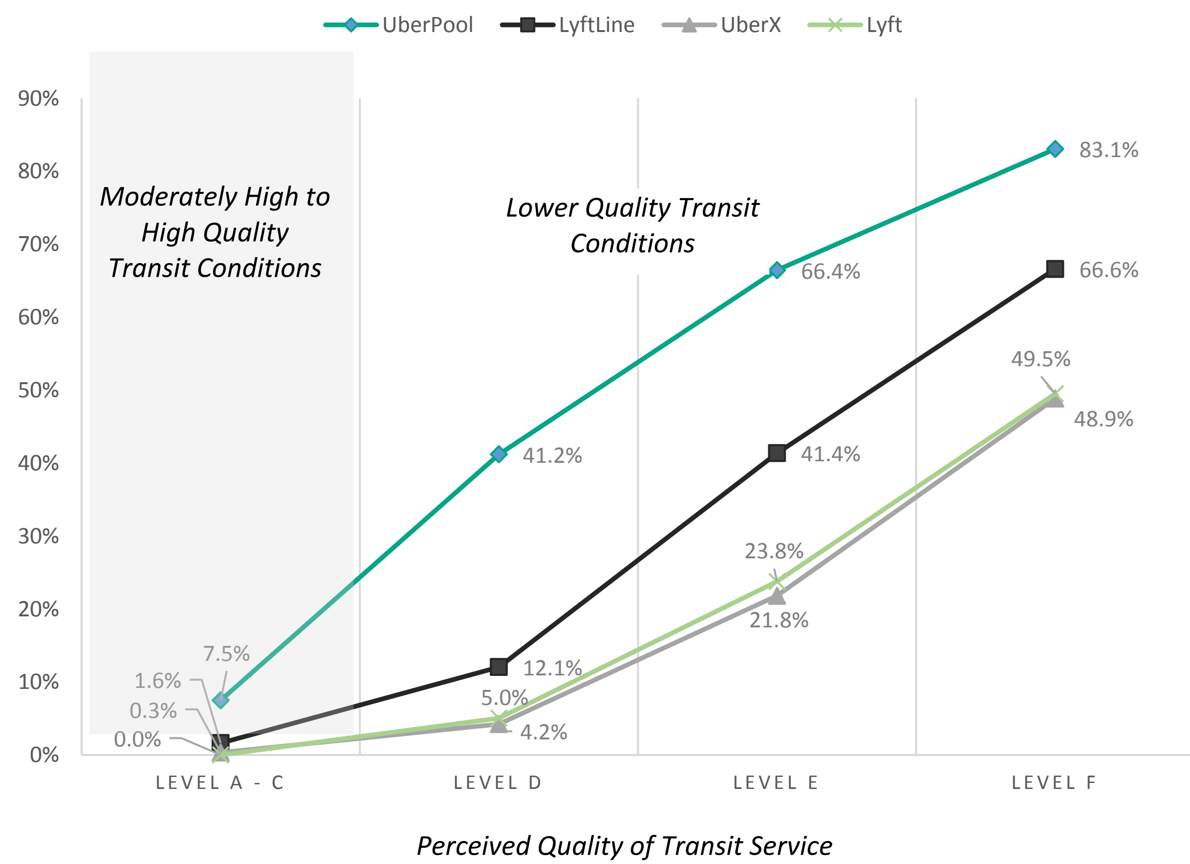
This table shows the assumptions used in the economic model created to compare the generalized cost of travel on transit and TNCs for each of the 614 trip scenarios considered.

The meta-analysis conducted by VPTI also suggests it is reasonable to assign a cost for transfers at the equivalent of 5 - 15 minutes of travel time. (This cost is in addition to the actual time required to make the transfer; it measures the inconvenience associated with having one's trip interrupted for a connection). Drawing on this recommendation, the analysis below assigns an added cost of 5 minutes to the total travel time for each transfer made on transit. VPTI recommends assigning a cost to wait time of 20 – 50% more than in-vehicle time and a cost to walking roughly 45% higher than in-vehicle travel time, depending on conditions. The analysis below assumes that waiting is disvalued at 25% more than pedestrian activity (walking) and about 45% more than in-vehicle time. All three of the above assumptions are relatively conservative (i.e., favorable to transit), based on the aforementioned VPTI analysis.

VPTI recommends assigning a value of time spent seated as a passenger in automobiles at 35% of the wage in LOS A-C and 70% in LOS F. The analysis below assigns a cost to time spent in a TNC at the 35% amount for LOS A-C. This is justified considering that TNCs drivers are expected to provide customers with comfortable and quiet in-vehicle conditions, which is enforced through rating systems. Drivers that fall below expected standards (as well as customers that repeatedly pose problems) are removed by Lyft and Uber from their platforms.

By building an analytical model that considers these components for each of the five modes in the 614 origin-destination scenarios considered, a comparison of the generalized costs can be made. Figure 4, which summarizes the results at different levels of services, shows that UberPool is far more likely than the other options to have a lower generalized cost than transit. **When the quality of transit service is high or moderately high (i.e., LOS A, B, or C), UberPool's generalized cost is less than transit in 7.5% of trips evaluated, compared to 1.6% on Lyft Line, 0.3% on UberX and none on Lyft.** As previously noted, in this scenario, travelers consider the nonmonetary cost of spending time in a transit vehicle no different than a TNC but assign a cost to walking, transferring, and waiting.

Figure 4: % of Trips in Which Total Generalized Costs for Average Transit Rider are Lower on a TNC than on Public Transit



This chart shows the share of the trips evaluated in which a TNC service is less costly to the average transit user than CTA service after taking into account both monetary and nonmonetary costs. The share of trips is low when conditions are favorable but rise sharply as conditions deteriorate.

When the LOS for transit falls to level D, the percent of trips evaluated that are less costly on UberPool jumps to 41.2%, compared to 12.1% on Lyft Line, and 5.0% and 4.2% on Lyft and UberX, respectively. In this scenario, passengers consider aspects of the transit trip as highly unfavorable. This scenario might be appropriate when there are perceptions that crime is high, the weather is poor, and there is much crowding. Some conditions may be uncommon on CTA on routes involving the North and Northwest sides, but *perceptions* of conditions may differ sharply between passengers. Indeed, concerns over the onboard environment of transit trips appear to weigh particularly heavy on travelers in the late evening hours, particularly in neighborhoods with high levels of crime. Infrequent travelers may also consider the difficulty of navigating a transit system with which they are unfamiliar as a negative attribute of transit. Despite this, only about 30% of trips from the Downtown zone are less costly on UberPool than transit in this scenario, showing the durability of transit demand in core markets.

When transit service falls to Level E, 66.6% of trips on UberPool have a lower generalized cost than transit, compared to 41.4% on Lyft Line. Less than a four of the Lyft and UberX trips, however, have a lower cost than transit. This scenario should be regarded as an extreme case, applicable when transit is regarded as option of last resort, perhaps due to extremely erratic service, highly unpleasant conditions, and heightened concerns over safety. The fact that, even in the worst conditions, a sizeable share still uses transit illustrates the importance of transit to mobility on some routes, regardless of the extent to which service deteriorates.

The above technique, while relying on many assumptions, demonstrates how microeconomic analysis can be used to assess TNC/transit competition. The approach has the advantage of being highly flexible, allowing different scenarios to be considered with relative ease. For example, the analysis examines the impact on transportation mode choice based on:

- **Higher valuations of time. When passengers assign a much higher cost to time spent on their journey, competition from Lyft and UberX become more intensive competitors due to their significant time-saving attributes**. In a scenario in which the travelers wage is set at $85 per hour, for example, the generalized cost of Lyft eclipses UberPool with respect to the percentage of trips with lower generalized costs than transit: 37.9% to 37.3% of trips, respectively, compared to 34.2% for Lyft Line and 25.2% for UberX under LOS A. At high wages, Lyft outperforms the other options by an even larger margin.

- **Effect of CTA fare increases**. The risk of diversion to TNCs tends to be more sensitive to the level of service of transit than changes in fares. **A $1 increase (roughly 40%) in public transit fare has only about one fourth the effect of diversion to shared-ride TNC options as does a shift in service in LOS from A-C to D.** For example, the share using UberPool rises from 7.5% to 16.1% after the fare increase. These results are consistent with a study by Miller and Savage, who find that CTA service tends to be relatively inelastic with respect to price (Milller and Savage, 2016).

- **Aversion to walking. The results are highly sensitive to the degree to which passengers disvalue walking.** When walking time is disvalued no differently than in-vehicle time, the share of UberPool trips in which the generalized costs are less costly than transit drops from 41.2% to 30.9% at LOS C.

The above examples illustrate that the analytical model can be used to assess how several factors work together to entice passengers to switch from transit to TNC. The analysis could also be calibrated to account for passengers' preference for having exclusive use of TNC vehicle and avoiding sharing it with other passengers. (The above analysis assumes passengers are indifferent to having other passengers in the vehicle with them, despite the potential loss in privacy.)

VI. IMPROVING MOBILITY THROUGH COLLOBORATION

Among the most important conclusions drawn from the above analysis is that ridesharing tends to serve a much different role than transit providers while offering significant convenience on routes poorly served by the city's buses and trains. An implication of these findings is that cities should avoid the oversimplified view that TNCs are, first and foremost, *competitors* to public transit service and that they provide few benefits beyond those provided by transit.

The analysis also lends support to the growing body of research, including that by the Shared Used Mobility Center (2016, and 2018), showing that a lack of integration between modes represents a missed opportunity to improve mobility and enhance the effectiveness of public transit. Unfortunately, many agencies – including the CTA – are not keeping pace with the dramatic opportunities to improve mobility created by these new technologies.

The following steps would help resolve this problem at modest expense to the agency and provide the CTA and other units of government valuable experience in developing creative mobility solutions:

Recommendation 1: Integrate transit and ridesharing services using the Ventra app and other online tools. Develop search algorithms that combine public transportation and TNC routing options on the same trip to give customers new choices combining these modes.

This form of integration would better allow users to take advantage of the comparative strengths of the two modes, while also enhancing the "brand image" of the Chicago Transit Authority and its sister agencies. It would allow consumers to easily blend transit with ridesharing trips while also illustrating to travels on how the time savings is often small compared to the additional monetary amount spent in major transit corridors. On trips where exclusively using transit to reach one's destination is inconvenient, such integration would likely generate new bus and rail customers. Furthermore, integrating CTA and TNC service – particularly on a single smartphone application – may incentivize travelers to get out of a TNC earlier than they might otherwise do so, and to complete the rest of their journey via public transit.

Recent initiatives in California and Texas point the way toward building such functionality. For example, the Dallas Area Rapid Transit (DART) system currently enables riders to connect with Uber through DART's mobile application; as a result, travelers can request an Uber to pick them up at a DART stop before their transit ride has completed. Similarly, the City of Los Angeles has developed an integrated mobility app that combines public transportation and Lyft routing options. This program by the Los Angeles's MTA (which uses the application program interfaces for ridesharing and transit) is a particularly good example for Chicago to emulate. It would provide attractive schedule options between different service providers in the same way that websites such as Travelocity do for airlines trips.

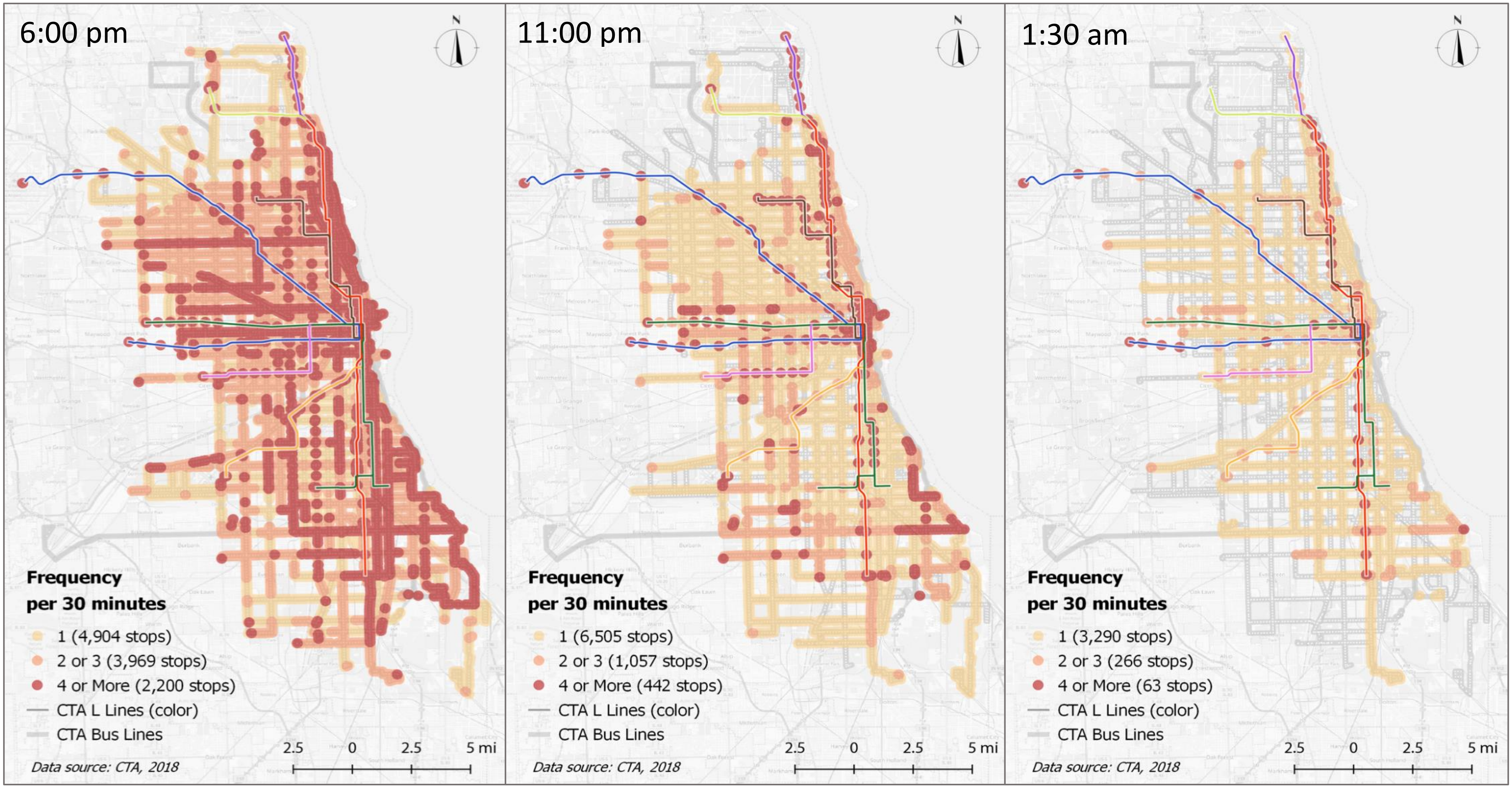
Recommendation 2: The Chicago Transit Authority should work with TNCs to arrange for discounts on ridesharing trips to and from select outlying rail stations at times when bus service is weak. The sharp reductions in feeder bus service on weekends and after 11 p.m. particularly impairs mobility. The expertise gained from these programs would provide the CTA valuable experience in leveraging new strategies for solving mobility gaps created by chronic – and growing – funding shortfalls.

By working with TNCs to provide discounts to passengers using ridesharing services at times when there are limited or nonexistent transit options, the CTA could support the mobility of residents at little cost to the public. Arrangements should be pursued in which TNCs offer residents "discount codes" for travel along select corridors for use during designated times. In exchange, the transit agency would work to promote the program, improve signage for ridesharing at selected stations, and move toward a less combative relationship than presently exist with ridesharing providers.

A discount as of around $0.50 to $0.75 – an amount roughly equal to the tax that TNCs pay per ride – would also send a signal that public agencies are looking for innovative ways to better serve outlying neighborhoods. The discounts could be limited to trips no longer than a few miles and starting or ending at an outlying station. Our analysis suggests that limiting discounts to trips of three miles or less and involving travel to and from outlying CTA rail stations between 11 p.m. and 5 a.m. would pose little risk of ridership loss on buses while creating synergies that boost rail ridership. Bus service on many routes during this interval is limited to no more than one or two buses every 30 minutes, making transfers difficult and time-consuming. Many travelers during this time no doubt feel inclined to drive or use TNCs for their entire journey, rather than making bus-rail transfers at these times.

For a brief overview of the potential synergies that may arise from discounts for TNC rides to outlying CTA stations during late-night hours, click here.

Figure 6: Weekday Public Transit Service



The frequency and scope of Chicago Transit Authority service falls significantly after 11 p.m. on many routes, resulting in service levels of one bus or less per thirty-minute interval on many bus routes (far right). Building synergy between TNCs and rail rapid-transit stations during these late-night hours would contribute to mobility by leveraging the comparative strengths of each mode of travel.

Acting on this recommendation would help restore some of the mobility lost by gradual cuts to CTA bus service and help disadvantaged neighborhoods overcome transportation issues that dampen their prospects for attracting development. As the funding issues facing our transit agencies worsen, little hope exists that new bus or rail services will alleviate their mobility problems in the next several years.

Initiatives in other regions indicate that transit agencies have much to gain by working with TNCs. For example, the Pinellas Suncoast Transit Authority (PSTA) in Pinellas County, Florida has implemented its "Direct Connect" program, which provides discounts on Uber rides to or from select PSTA stops, as well as on rides in a specific geographic zone. With this partnership, PSTA pays half the cost of the TNC ride (up to $3), and it enables greater access to existing bus routes. Similarly, the Southeastern Pennsylvania Transportation Authority (SEPTA) has partnered with Uber to provide discounted rides (up to 40% off) to or from 11 different suburban rail stations, thereby incentivizing car-free commutes from the suburbs. In other example from Florida, in 2016 five cities launched a pilot program offering discounted rides for Uber trips taken between the participating cities. Phase 2 of the pilot program has recently launched, with each city subsidizing 20% of the Uber fares that end within their respective limits.

Similar programs could be put in place to support travel to transit hubs during major events, such as Lolapalloza or the Taste of Chicago. Not only do passengers attending these popular gatherings tend to travel in small groups (making them less willing to make transfers between buses and trains than when alone), but their return trips often occur in the evening or wee hours of the night, when public transit may be considered less desirable or safe. This type of tightly controlled discount ride program would be directed toward passenger who already purchase transit fares; therefore, there would be few financial risks to the CTA. Furthermore, such incentives could help mitigate gridlock and parking congestion, as they would discourage use of private vehicle for transport to and from the event. Through partnership with Uber, the San Diego Metropolitan Transit System has already implemented such programs for Comic Con International and select sporting events by offering one-time $5 discounts for shared rides to or from 20 different transit centers.

The need to attend to issues posed by gaps in Chicago's transit system were richly documented in the Center for Neighborhood Technology's 2014 exploration of transit deserts in Cook County, which found that nearly one in ten County residents live in transit deserts (2014). These deserts (defined as areas more than half a mile from a rail transit stop and a quarter mile from a high-quality bus service) limit residents' ability to a pursue jobs and services throughout the city.

Recommendation 3: **Establish pilot programs involving ridesharing to improve mobility for disabled passengers and those on medical-related trips.** Chronic underfunding of transit agencies is creating major challenges in respect to serving disadvantage passengers.

Expansions to paratransit services, medical shuttle services, and facility improvements to ensure compliance with the American With Disabilities Act (ADA) are often put on hold due these funding shortfalls.

Since 2006, paratransit service in Chicago has been provided exclusively by Pace Suburban Bus. Through contracts with select carriers, Pace provides approximately 3.5 million paratransit rides per year in the Chicago area, and a 2018 Federal Transit Administration compliance review found Pace's paratransit service performance to be "very high" (Federal Transit Authority, 2018).

Nevertheless, pilot programs incorporating subsidized rides on TNCS would be an effective way to test new strategies to support disabled passengers. Such programs could help the Chicago Transit Authority, Pace, county governments, and other regional and municipal agencies find new ways to stretch limited dollars further. These program would not replace existing services but would supplement them and provide options for passengers meeting clearly established criteria and could require users to pay a bit more.

For instance, the Massachusetts Bay Transportation Authority (MBTA) is currently running a pilot program that partners with both Uber and Lyft to provide on-demand service to its paratransit riders. With this program, Boston's RIDE customers (customers with disabilities unable to use MBTA services) receive a limited number of subsidized TNC rides per month. This service enables them to request pick-up much faster than the MBTA's existing paratransit service. Furthermore, with this pilot, the cost to the traveler is typically lower than with traditional RIDE service; riders pay only $2 (or anything over a $42 fare) for an UberX or Lyft, while they pay $3.15 with RIDE. By leveraging the availability of TNC vehicles, MBTA is able to provide better service to its customers and reduce the high cost of providing that service itself.

Similarly, government leaders can provide incentives and technical expertise to support efforts by private companies and healthcare providers to provide free or discounted TNC rides for the elderly or those traveling to medical appointments. Lyft has already partnered with healthcare companies to provide transportation for at-risk populations to medical centers and primary care clinics; similarly, Uber's UberHealth desktop platform allows healthcare providers to order rides for patients to and from their appointments. Cook County officials and the City of Chicago can facilitate such partnerships here, particularly in collaboration with the Cook County hospital system.

Recommendation 4: Use the expertise of the city government and transit agencies to support the development of "guaranteed ride home" programs with TNCs that encourage commuters to avoid driving while addressing their need for access to a car in case of emergencies.

These programs encourage commuters to travel to work by bicycle, transit, or walking while giving them the ability to quickly and affordably return home during emergencies. Employers could be encouraged to pay the cost of the trip while limiting the number of times a year a person can exercise this option. The trips can be made via ridesharing, taxi or other means. These programs would be extremely attractive for workers who avoid public transit due to the need for the flexibility of a car; furthermore, they would both incentivize a reduction in private vehicle travel and enhance understanding of how transit and TNC modes can be complimentary.

The San Diego region has already launched such an initiative, which allows commuters to enroll in the program, receive promotional codes for emergency rides, and then save those codes for when they need to request a ride in case of illness or emergency. This program – called "iCommute" – is a partnership between Uber and the San Diego Association of Governments, and it is explicitly aimed at encouraging the use of transportation alternatives to reduce congestion and pollution.

Municipal incentives and technical expertise could accelerate the development of these program, which require coordination and efforts to educate and guide stakeholders through complex transitions. Our region is falling behind other major population centers in the creation of these types of programs.

VII. CONCLUSIONS

The methods used in this study illustrate how the mobility benefits and competitive issues posed by TNCs can be systematically evaluated by looking at the options presented to passengers in "real time" when they are making travel decisions. The analysis provided by this study suggests the following:

A. Ridesharing services generally save time, but are relatively costly options in terms of the amount spent per hour (or minute) saved. In many scenarios, consumers spend the equivalent of more than $50 per hour saved on TNC services. Between neighborhoods, using this time savings option comes at a lower cost, in part due to the comparative slowness of transit service. Even in this scenario, though, the average commuter would find TNCs difficult to justify solely on the basis of a quicker arrival. As general rule, services that allow multiple parties to share a vehicle – and UberPool in particular – create a much greater risk for traffic diversion by the average transit user than the exclusive ride options.

B. Transportation Network Companies serve a much different mobility role than transit. Based on the economic model created for this study, 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. This indicates that capital investments in transit are needed to assure that passenger satisfaction with transit use is high. Passengers must feel safe and comfortable when making their transit journey without fear of service interruptions. Considering the shortfalls in funding for capital investment in transit, there is a risk that perceptions about the transit experience will fall, adding to risk of diversion to TNCs.

Additional research is also needed to better understand the effects of perceived comfort, cleanliness and safety associated with various urban travel options. Future analysis might also consider the competitive issues posed by the newly unveiled Uber Express and Lyft Corridor services, which offer trips for less than $5 but require passengers to walk to designated stops. Furthermore, this study's narrow focus on trips in one part of one city that fall in a particular mileage range also points to the need for a larger data to help deepen understanding of the nuances of TNC/transit competition.

C. The Chicago Transit Authority should deliberatively move ahead with programs to integrate ridesharing and transit use in ways that present minimal risk of revenue loss to the agency. As noted in the previous section (see pages 19 - 22), these initiatives could enhance mobility and leverage the strengths of both transit and TNCs by:

- Integrating transit services and ridesharing into the Ventra app and other online tools;
- Working with TNCs to offer discounted rides to CTA bus and rail-transit stations at times when feeder bus service is limited, such as during late-night hours;
- Creating pilot programs with TNCs for disabled passengers and those on medical-related trips;
- Exploring the feasibility of "guaranteed ride home" programs that provide commuters who avoid driving additional flexibility.

In addition to their direct benefits to travelers, these efforts would provide the CTA and other units of government valuable experience in developing approaches to improving mobility. The need for such experience is growing sharply as new "shared mobility" technology changes the way we live and travel.

APPENDIX

A. UberPool Arrival Times within the Range of Times Provided

At the time of booking, UberPool provides customers only with a range of possible arrival times. On the 614 routes evaluated, the mean of this range was 15.8 minutes. To determine whether customers tend to arrive at their destination near the lower bound, upper bound, or midpoint of the range (or even outside the range) provided, 20 actual trips were made over sampled routes between February 12 and March 15, 2018.

The results show that users can be confident they will arrive within the range. Travelers on none of the 20 trips arrived later than upper end of the range. On two of the 20 trips, however, arrival times were below the lower end of the range. (In both cases, there were no intermediate stops made to pick up or drop off other passengers). The mean arrival time was slightly below the midpoint of the range, bear the 40% percentile of possible arrival times. In this study, the assumption is made that UberPool travel times will be at the midpoint of the range due to the associated uncertainty in the minds of consumers.

B. The Role of Uncertainty

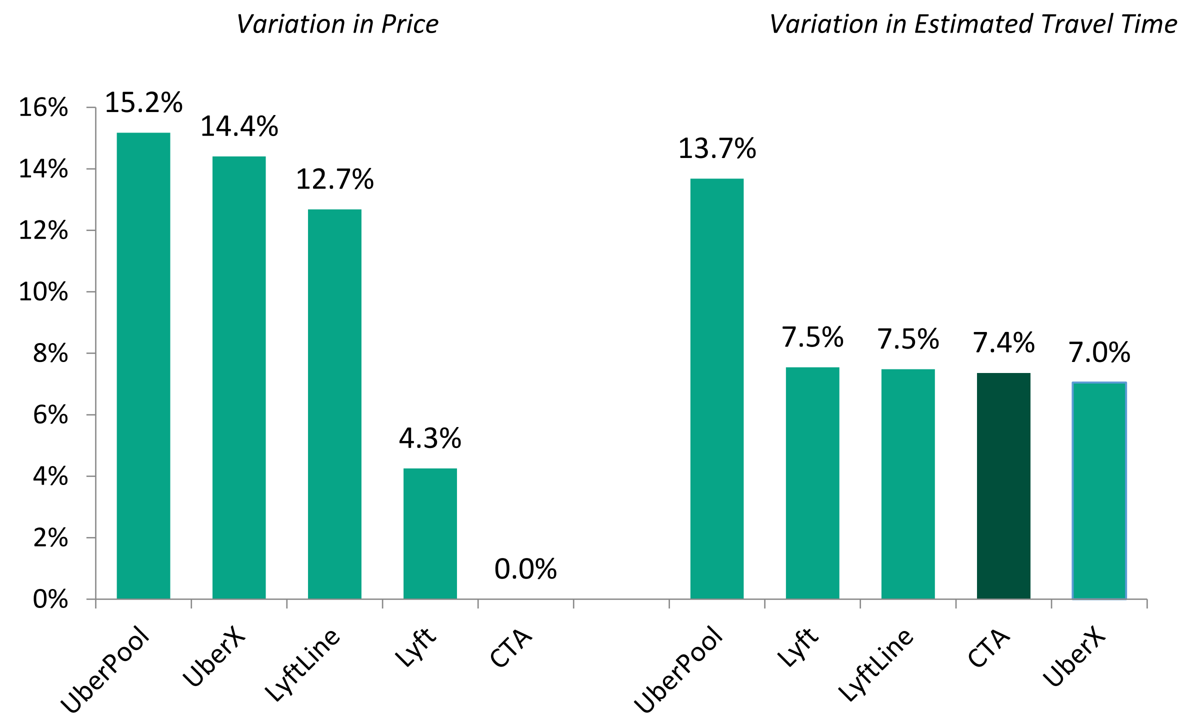
Although transit tends to be slower than TNCs, they are more predictable with respect to both price and estimated travel time. To measure the role of uncertainty, the analysis evaluated the variation on the subset of identical routes[4] when sampled at least eight times. There were 55 such trips.

With respect to price, the mean deviation percent (i.e., the average percent difference from the mean price) for TNCs was around 14 – 15% for Lyft Line, UberX and UberPool, but just 4.0% for Lyft (Figure 6). (Throughout the study, the prices for Lyft were found to have more predictable prices than the other options.) By virtue of having fixed fares, there is no variation in the price of transit trips. The uncertainty in the price of TNCs should be regarded as a negative attribute for travelers, although it does assure consistent availability. The possibility of "surge pricing" no doubt looms large in the decisions of some to avoid TNCs.

The differences were smaller with respect to variation in travel times, with Lyft, Lyft Line, and UberX having a mean deviation percent of slightly more than 7.0%, while UberPool had a rate of nearly twice that (14.2%), whereas transit is 7.0%. It is important to consider, however, that these represent differences in *estimated* travel time (i.e., those provided before the trip begins), rather than actual time. Users of Lyft Line and UberPool also face uncertainty in the number of stops they will make.

[4] *Same origin-destination pair.*

Figure 7: % Mean Deviation in Price and Travel Time
Transportation Network Companies vs. Public Transit
Within Same Origin – Destination Pair



There are other sources of uncertainty as well. Estimates of travel times for public transit trips on Google Transit appear to *understate* actual travel times to a greater extent than estimated TNC travel times. The Google Transit tool used to measure travel time (which is based on GTFS feed) assumes there are no delays once the trip commences when, in fact, such delays may be relatively common and sometimes cause connections to be missed. Congestion-related delays may also be common on TNCs, but the apps appear more likely to take such delays into account than Google Transit estimates.

Finally, estimates for transit travel time assume that on-board crowding will not prevent the traveler from boarding a desired bus or train. During the peak period, however, it is not uncommon for capacity constraints to necessitate that some passengers wait for several departures before boarding. The risk of missing connections is not a factor for TNC trips, which do not require transfers. Overall, however, the results suggest that uncertainty is a stronger negative consideration for TNC users than for transit users, especially for those using Lyft Line and UberPool.

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