HOW IS RIDE-HAILING AFFECTING PUBLIC TRANSPORTATION?

MARCO GONZALEZ-NAVARRO AND JONATHAN D. HALL

1. OBJECTIVES

New transportation technologies have repeatedly reshaped cities. The invention of steam railways allowed cities to start expanding beyond walking distance (Heblich et al. 2018), the invention of the automobile changed where rich and poor lived within cities (LeRoy and Sonstelie 1983), and the construction of limited access highways caused cities to further spread out (Baum-Snow 2007). Ride-hailing, as exemplified by firms such as Uber and Lyft, is the latest new transportation technology to affect cities. Because of the importance of transportation in our everyday lives, the entry of ride-hailing firms into cities have been controversial. Ride-hailing has been credited with providing a reliable and affordable transportation option, serving neglected areas of cities, and providing meaningful employment. Against these benefits, they have also been accused of being unsafe, creating congestion, destroying stable jobs, flouting the law, and undermining public transportation. Cites have struggled with deciding how to regulate ride-hailing, in part because of a poor understanding of their actual effects. The objective of this research proposal is to explore how ride-hailing is changing cities and and the lives of those living there by estimating how ride-hailing is affecting public transportation.

This project will estimate how ride-hailing is affecting public transit by studying how Uber usage changes when new light rail or subway service opens in the vicinity. While this is estimating how transit affects Uber, rather than how Uber affects transit, it provides a new approach to answer the question of whether Uber and public transit are complements or substitutes.

We will additionally investigate the mechanisms by which public transit and Uber affect each other by using the timing of rides and their origin-destination to quantify what share of trips are last mile trips to and from the new subway station, and what share of trips is to and from other destinations around the city. Further, by leveraging individual level data on Uber use in the vicinity in the months leading up to and after subway service begins, this research will be able to directly estimate heterogeneous substitutability by user type (for example, long distance commuter, short distance commuter, occasional user) and by trip type (weekend, weekday, late night).

Beyond contributing to our understanding of the effect of ride-hailing on cities, this project also provides preliminary insight into the economic impact of another technological innovation within urban transportation: autonomous vehicles. While there is much speculation about how autonomous vehicles may change cities, no empirical estimates exist to date because the technology is so new. However, inasmuch as the change from taxi to ride-hailing is similar to the change from ride-hailing to autonomous vehicles, in that autonomous vehicles will make transportation more convenient, accessible and affordable, then our results will be informative about this next technological innovation's effect on cities, and will help cities prepare for the change.

2. CONTEXT

Ride-hailing's affect on public transportation is theoretically ambiguous. It could be hurting transit because ride-hailing provides another method of getting around, one that is faster and more

convenient. While ride-hailing is more expensive than public transit, it is cheaper than a taxi.[1] On the other hand, Uber could complement public transportation since most public transit systems use fixed routes with fixed schedules. Uber can fill in these gaps in time and space, making public transportation more appealing. This can show up in several ways. First, the combination of public transit and Uber can make it possible for many households to complete all desired trips without owning a car, or for families to reduce the number of cars they own. Second, the first and last portions of a trip on public transit typically account for a small share of the distance traveled but a large share of the travel time; by substituting for this portion of a trip, Uber can lower the cost of using transit for the main portion of the trip. This can especially make traveling by train more appealing. Third, Uber helps deal with the risks of relying on fixed-schedule public transit. Some people might be happy to use public transit if it provided similar flexibility to personal driving but choose not to do so because the schedule cannot respond to personal emergencies or changes in work schedules. The ability to use Uber if the person needs to get home because a child is sick or does not want to wait for the bus in the rain could make riding public transit more appealing, increasing transit ridership.

There is a quickly growing literature estimating the relationship Uber's effect on public transportation. Surveys on ride-hailing use show clear correlations between Uber and public transit use, but such data have not concluded what the causal effect of Uber is on public transit. A Pew (2016) survey reports that public transit use is highly correlated with Uber use, with 9 percent of those who do not use Uber at all taking public transit each week and 56 percent of those who use Uber weekly taking public transit each week. This clearly shows that the two transportation modes are being used by the same set of people, but could be consistent with Uber either complementing or substituting for public transportation. In favor of Uber complementing transit, Murphy and Feigon (2016) found that the share of people who use ride-hailing apps, car-sharing, or bike-sharing report and say that these shared modes lead them to ride public transit more exceeds those who say the opposite by 15 percentage points; however, Rayle et al. (2016) found that 33 percent of those using a ride-hailing app in San Francisco said their next best alternative for their current trip was using public transit.

Finally, in previous work, Hall et al. (2018) estimate Uber's net effect on public transit using aggregate data on public transit ridership and a difference-in-differences approach across all Metropolitan Statistical Areas (MSAs) in the United States with public transit. Two sources of variation across MSAs are exploited. The first is variation in when Uber entered each market, and the second is variation in the intensity of Uber penetration, as measured using the relative number of Google searches for "Uber" in each MSA. This measure is strongly correlated with the number of Uber drivers per capita in each market (Cramer 2016).

This proposal's approach will expand upon this work by considering a better identified estimation strategy using microdata to estimate the relevant elasticities between Uber and public transportation for more than 80 cities around the world with current UberX service that have also experienced recent subway expansions. Since the expansion of subway systems is usually a long process subject to delays and planned long before Uber became a feasible alternative, this offers an ideal setting for studying the interactions between Uber and public transit. The second key innovation relies of our access to individual-level longitudinal data on travel behavior (instead of metropolitan area aggregates).

[1]Greenwood and Wattal (2017) show that UberX provides a 20 to 30 percent reduction in prices relative to traditional taxis. Uber is also more convenient in most cases as a ride can be hailed easily through an smartphone application and users know both how long it will take for the ride to arrive and that it will indeed arrive.

3. DATA

This project will combine our own, hand-collected, data on new transit station openings around the world with Uber's proprietary trip data. We have signed data usage agreements that give us access to the data while protecting rider and driver privacy and our ability to publish the results.

4. METHODOLOGY

This project's primary question is whether the number of Uber trips increase or decrease when a new subway stop opens nearby. We will answer this using an event-study specification, following the methodology of Andrews (1993, 2003) and Hansen (2000). We test for a structural break in Uber trips around the time the new subway station opens by estimating a series of regressions of the number of Uber trips on a step function, and testing whether (1) a structural break exists and (2) it occurs at the time the station opens. Conditional on the evidence pointing towards a structural break at the time of the subway expansion, we can then estimate the average effect of subways on Uber ridership.

Let y_{it} denote the number of rides beginning or ending within X kilometers of a subway expansion in city i at date t (and the dollar value and number of unique users associated with those rides). A city may undergo multiple expansions during this time period, but we omit a sub-city index for clarity. If the subway expanded at month t', define $\tau_{it} = t - t'$ to be the number of months since/to the subway expansion. Describe a set of indicator variables as follows:

$$D_{it}(j) = \begin{cases} 1, & \tau_{it} = j. \\ 0, & \text{otherwise,} \end{cases} \qquad D_{it}(j, j') = \begin{cases} 1, & \tau_{it} \in \{j, ..., j'\} \\ 0, & \text{otherwise,} \end{cases} \qquad D_{it}(\tau \lesseqgtr j') = \begin{cases} 1, & \tau_{it} \lesseqgtr j' \\ 0, & \text{otherwise.} \end{cases}$$

To test for structural breaks, we estimate the following series of regressions

$$y_{it} = \alpha_0 + \alpha_{1j} D_{it}(j,k) + \alpha_2 D_{it}(\tau < -k) + \alpha_3 D_{it}(\tau > k) + \text{controls}_{it} + \varepsilon_{it}$$

for each $j \in \{-0.75k, ..., 0.75k\}$. Our main specification will consider a $k = 6$ month window around the subway expansion, so $j \in \{-4, ..., 4\}$. A Wald test of $\alpha_{1j} = 0$ for each j will constitute a test for a structural break in ridership occurring j months since or to the subway expansion. If we observe an increase from low Wald statistics to high and statistically significant Wald statistics near $j = 0$, we will take this as evidence that a structural break occurred, warranting the subsequent specification

$$y_{it} = \alpha_0 + \sum_{j \in \{-k, ..., k\} \setminus 0} \alpha_{1j} D_{it}(j) + \alpha_2 D_{it}(\tau < -k) + \alpha_3 D_{it}(\tau > k) + \text{controls}_{it} + \varepsilon_{it}$$

The α_{1j} are the parameters of interest, mapping out the entire time profile of the impact of a subway expansion on ridership. The α_{1j} for pre-treatment periods will provide a test of the validity of our specification. The set of controls will include city fixed effects, time fixed effects, city-level covariates (demographics, income, etc.), and in iterations of the main specification, controls for various trends.

We can also use a difference-in-differences specification if we choose as control locations, similar areas surrounding pre-existing subway stations or yet to be built subway stations. These areas will benefit less from the subway expansion and are unlikely to benefit from network effects along the expanded transportation system.

For the individual level analysis, we first partition individuals based on pre-subway system characteristics and estimate similar models to those above. We can obtain what happens to Uber users

for commuters going downtown, for weekend trips, late night trips, etc. More generally, considering individuals who have a large share of rides of a certain type by origin destination, or time of day trips, the event study specification would measure whether an individual's use of Uber changes after the expansion of a subway system into the relevant area. Another direction to expand this research will be to consider the substitution channel along other nodes of the transportation system to measure the role of network effects.

In terms of limitations of the research, it is worth noting that we will have limited information on aspects of transportation behavior that would be relevant such as vehicle ownership, and subway trip destinations. We can proxy for these using the data on Uber origin-destination, but the study is fundamentally limited to current Uber users, and as such will be relevant only for the population under study (relatively young, and relatively wealthy individuals). On the other hand, these are precisely the switchers that are driving the relationship between Uber and public transit.

There are two ways we will extend this analysis. First, Uber may be required to stop operating in London, UK. If this happens, we will use transit card data for London's public transit, such as is used in Larcom et al. (2017), to estimate how Uber's exit affects public transit ridership at a granular level. We will further compare how the distribution of trip origins and destinations compares to the trips that had been occurring on Uber.

Second, preliminary analysis of Uber's trip data shows that only a small share of Uber trips are round-trips. That is, it is rare to see someone take Uber from A–B, and then from B–A. If Uber is being used for half the trip, then it is very unlikely a personal automobile is being used for the return trip (at least with just one occupant). It seems likely that this is evidence of Uber replacing personal automobile trips. We will investigate this phenomenon, using trip diary data from the National Household Travel Survey, Transportation Tomorrow Survey, and by estimating how the share of one-way Uber trips varies with city or neighborhood characteristics, and how it changes when new train stations opens nearby.

5. Research Team

The principal investigators for this project are Marco Gonzalez-Navarro, an associate professor at the University of California-Berkeley, and Jonathan D. Hall, an assistant professor at the University of Toronto. The research assistant for this project is Harrison Wheeler, a PhD student in Economics at the University of California-Berkeley.

Gonzalez-Navarro has a strong publication record, with two publications in top general interest journals and four publications in the second tier of general interest journals or top field journals. Of these, the most relevant are Gonzalez-Navarro and Turner (2018), which evaluates the effect of new subways on urban growth, and Gendron-Carrier et al. (2018), which evaluates the effect of new subways on pollution.

Hall also has a strong publication record, with four publications in top field journals. The most relevant of these is Hall et al. (2018), discussed above, which uses aggregate data to estimate the effect of ride-hailing on public transportation.

6. Conflict of Interest Statement

We declare that we have no relevant or material financial interests that relate to the research described in this proposal, including no ties to the transportation industry.

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