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Ridesourcing for the first/last mile: How do transfer penalties impact travel time savings?

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Problem statement

The first and last mile of public transportation (PT) trips are a long known problem to planners: low and dispersed spacio-temporal demand is expensive to serve with large-capacity vehicles, yet they deter many potential passengers from using PT. Demand-responsive feeders have been suggested as a remedy (see Chandra and Quadrifoglio, 2013, for an overview) in three phases:

In the 20th century (‘phase 1’), demand-responsive transportation generally faced technological constraints (manual routing, scheduling and dispatching, corresponding high labor costs, long lead times), resulting in low levels of ridership and/or high expenditures (Mageean and Nelson, 2003; Davison et al., 2014).

The dissemination of GPS-enabled smartphones, advances in routing algorithms and computing power, and regulatory voids have enabled new (cost-)efficiencies in demand-responsive transportation and led to the popularity of ridesourcing companies such as Uber or Lyft (‘phase 2’). Their use as first/last mile feeders has often been suggested (e.g., Feigon and Murphy, 2016; Westervelt *et al.*, 2017; Shaheen and Chan, 2018) and many US transit agencies have engaged in partnerships to subsidize first/last mile rides (e.g., Charlotte, Austin, Centennial, Pinellas County) or are planning to do so (e.g., Los Angeles, Chicago). Ridership, however, has so-far been low and operations of ridesourcing companies remain deficient.

Perhaps most importantly, the first and last mile is seen as one area of application where automated taxis could complement PT (‘phase 3’) (Chong *et al.*, 2011; Liang *et al.*, 2016; Cervero, 2017; Moorthy *et al.*, 2017; Shen *et al.*, 2018). While profitable operations can be expected (Loeb and Kockelman, 2017; Boesch *et al.*, 2018), it is unclear whether ridership on the first/last mile will finally meet expectations or whether a conceptual barrier to demand-responsive feeders for the first/last mile persists.

Literature review

So-far, mostly *operational* explanations for low ridership of first/last mile ridesourcing services have been identified (e.g., sparse marketing, short pilot duration, small pilot area, high costs) (City of Centennial, 2017; PSTA, 2018).

Despite a long history of research into transfers and associated disutilities (‘transfer penalty’) (Algers *et al.,* 1975; Alter, 1976; Allen and DiCesare, 1976; Newell, 1979; Horowitz, 1981), the additional transfers caused by first/last mile demand-responsive feeders have not been considered as a *conceptual barrier* to their use. Yet, this seems important as passengers prefer to avoid additional transfers due to factors such as anxiety to reach the subsequent connection, security, activity disruption and comfort (Currie, 2005; Iseki and Taylor, 2009; Cheng, 2010).

Studies investigating the general size of the transfer penalty exhibit wide value ranges. Currie (2005) provides a review finding an average transfer penalty for bus-bus transfers of 22 min of in-vehicle travel time (ranging between 5 and 50 minutes). Reasons for these wide ranges are context-sensitivity (e.g., climate, security, local amenities, type of vehicle) (Iseki and Taylor, 2010; Guo and Wilson, 2011) and measurement scope (e.g., waiting time, walking time to the subsequent vehicle, and/or the disutility of the transfer itself) (Garcia-Martinez *et al.,* 2018). In a recent effort to improve comparability, Garcia-Martinez *et al.* (2018) investigate the ‘pure transfer penalty’ (i.e., without walking or waiting times). Using SP data in Madrid, they find the pure transfer penalty to average 15.2 min.

Yan *et al.* (2018) are the first to consider a transfer penalty in their survey-based investigation of traveler responses to a potential first/last mile ridesourcing service on the University of Michigan Ann Arbor campus. Despite finding a transfer penalty of 10.9 min in-vehicle travel time, they conclude: “when used to provide convenient last-mile connections, ridesourcing could provide a significant boost to transit”. (p. 1)

Research objectives

Complementing popular *operational* explanations, we argue that the additional transfer and associated penalty provide a *conceptual* explanation for low ridership of current first/last mile ridesourcing services as well as future first/last mile usage of automated taxis. In this study, we aim to quantify the relative impact of transfer penalties on the total time travel time savings using first/last mile demand-responsive feeders empirically.

Methodological approach

As a case study, we chose Pinellas County, Florida, which is home to the longest operating first/last mile ridesourcing partnership (‘PSTA Direct Connect’). We obtain block-group level origin-destination commuting trip information from the 2015 US Census Origin-Destination Employment Statistics (99 470 observations). For each, we construct PT travel times including access/egress walking times and intermediate wait times using the Google Directions API (Alternative A). We then obtain the coordinates of the first and last PT station used and, using the Google Directions API, construct first/last mile car trips from the origin to the first PT station used, and from the last PT station to the destination (Alternative B). We

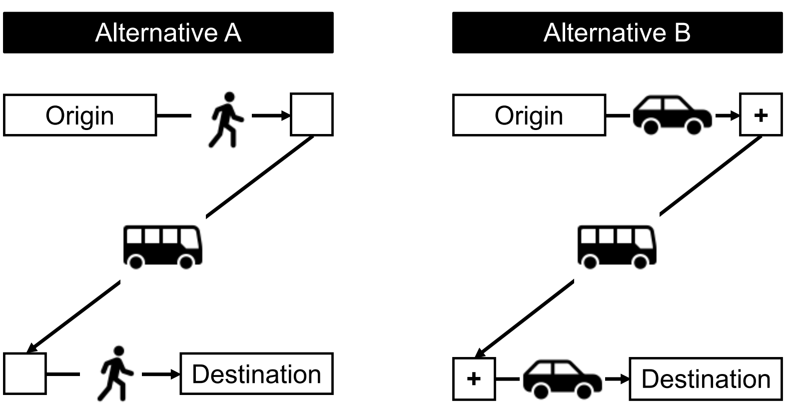

Fig. 1: Alternatives without (A) and with (B) first/last mile DRF, for which travel times are being compared. Transfer penalties are added to Alternative B.

then compare weighed travel times for A and B adding a transfer penalty between 5 and 15 minutes for the first/last mile transfer (Figure 1).

Results

We find that a first/last mile service leads to average travel time savings of 15.7 minutes. However, transfer penalties of 5, 10 and 15 minutes diminish travel time savings by 54%, 82% and 95%, respectively (Figure 2). Thus, even at small values the transfer penalty presents an important conceptual barrier to first/last mile demand-responsive feeders.

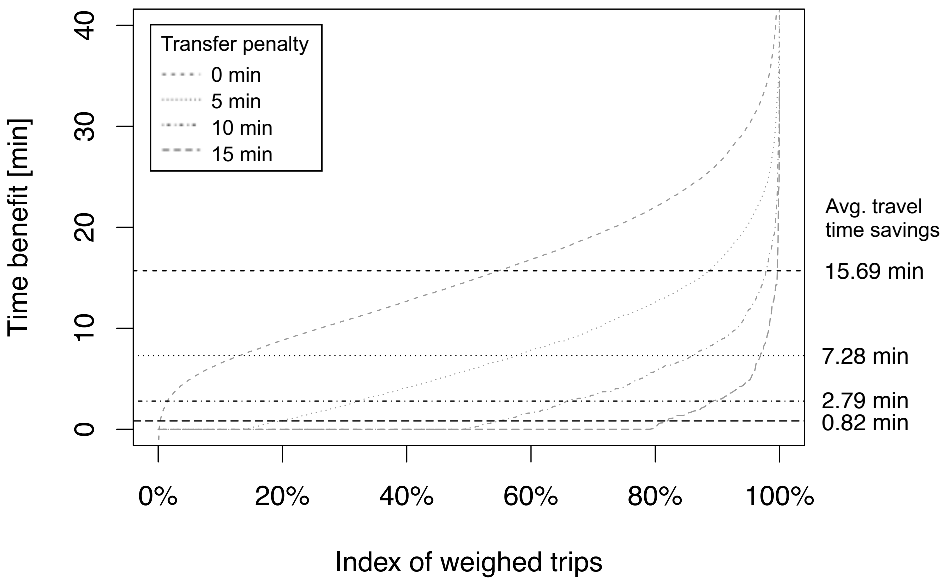

Fig. 2: Travel time savings for first/last mile trips after applying transfer penalties.

Discussion

Our results not only help to explain the low ridership of current first/last mile ridesourcing services, they also help to explain why a significant and substantive positive relationship between ridesourcing and public transit ridership for urban areas has not been found yet. Furthermore, they conceptually question the usefulness of demand-responsive feeders on the first/last mile, including automated taxis.

Future work investigating ridesourcing or automated taxis as potential first/last mile solutions similar to Moorthy *et al*. (2017) and Shen *et al*. (2018) might come to a different conclusion once considering transfer penalties. Taking into account a distribution of transfer penalties, however, might be more accurate to reproduce real-world preferences than our simplistic, yet illustrative approach of considering averages. As values are highly context-dependent, it seems important to study local factors such as the built environment, safety and weather conditions carefully to make meaningful assumptions.

Our results finally suggest the following policy implication. Vehicle-based first/last mile services in general (including automated taxis) appear to decrease perceived travel times (including the transfer penalty) only in areas with particularly long ingress/egress distances. Even in suburban Pinellas County with an average population density of 1368/km2 and an average first/last mile of 900m, distances seem too close for a first/last mile demand-responsive feeder to improve perceived travel times substantially. Thus, in contrast to current studies, first/last mile services appear more relevant in less urbanized / rural areas or for connections to (sub)urban high-speed PT such as rail or BRT.

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