Subsidized ridesourcing for the first/last mile: How valuable for whom?

Author(s):
Reck, Daniel Jan; Axhausen, Kay W.

Publication Date:
2019-07-24

Permanent Link:
https://doi.org/10.3929/ethz-b-000354730

Rights / License:
In Copyright - Non-Commercial Use Permitted
Subsidized ridesourcing for the first/last mile: how valuable for whom?

Daniel J. Reck, Corresponding Author
IVT, ETH Zürich
CH-8093 Zürich
Email: reckd@ethz.ch
ORCiD: 0000-0001-9969-1400

Kay W. Axhausen
IVT, ETH Zürich
CH-8093 Zürich
Email: axhausen@ivt.baug.ethz.ch
ORCiD: 0000-0003-3331-1318

Word Count: 6,121 words + 2 tables and 2 figures (1,000 words) = 7,121 words

Submitted for presentation at the 99th Annual Meeting of the Transportation Research Board,

Submission Date: 23 July 2019
Many transit agencies partner with ridesourcing companies to offer subsidized first/last mile services. Ridership, however, has been low in many cases. Complementing popular operational explanations for low ridership, we explore two conceptual ones: using ridesourcing for the first/last mile adds an additional transfer and costs to the overall transit trip. We quantify both hypotheses simulating commuting trips in three structurally different regions currently piloting first/last mile services: Seattle, Pinellas County (FL) and Marin County (CA). Our results show that even low transfer penalties of 5 (15) minutes exceed travel time savings for 40% (92%) of all trips in urban and 10-15% (68-80%) in suburban areas. Surcharges under the three most common subsidy schemes (USD 5 flat-fee discount, 20% reduction on trip cost and USD 1.75 fixed price) exceed the value of travel time savings for most trips of low-income households.

Our findings not only help explain low ridership on current subsidized first/last mile ridesourcing services but also elucidate why a significant and substantive positive relationship between ridesourcing and transit ridership has not yet been found. They challenge the frequent view that driverless taxis could complement transit on the first/last mile as a transfer penalty will persist for all vehicle-based first/last mile services. Our methodology relies entirely on open data, enabling transit agencies to assess the potential of first/last mile partnerships and social equity of different subsidy schemes in their locality.

Keywords: First Mile, Last Mile, Ridesourcing, Transfer Penalty, Public-Private Partnership, Driverless Taxis
INTRODUCTION

Most transit users walk to/from the closest stop at the beginning or end of a trip. Depending on the actual distance, this ‘first/last mile’ can be a deterrent to public transportation (PT) use due to the time it takes to overcome a relatively short proportion of the trip, safety concerns and weather conditions. This is long known to transportation planners, however, remains difficult to solve with typical fixed-route, large-capacity vehicles due to dispersed spatiotemporal demand.

Demand-responsive feeders have been suggested as a remedy to the ‘first/last mile problem’ in varying forms at different times (for an overview, see Chandra and Quadrifoglio, 2013). We identify three phases. First deployments in the 20th century (‘phase 1’) included minibuses and taxis called via landline. Technological constraints (manual routing, scheduling and dispatching) often resulted 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 rise of ridesourcing companies such as Uber or Lyft. Their use as first/last mile feeders (‘phase 2’) has often been suggested (e.g., Feigon and Murphy, 2016; Westervelt et al., 2017; Alemi and Rodier, 2018; Shaheen and Chan, 2018; Bian and Liu, 2019) and many transit agencies in US cities have engaged in partnerships to subsidize first/last mile rides (e.g., Austin, Centennial, Charlotte, Los Angeles, Pinellas County, Seattle) (for an overview, see Schwieterman et al., 2018). Ridership, however, has often remained low (e.g., Shaheen et al., 2016; City of Centennial, 2017; Murphy and Karner, 2019) and operations of many ridesourcing companies remain financially deficient.

So-far, mostly operational explanations for low ridership on first/last mile ridesourcing services have been identified (e.g., sparse marketing, short pilot duration, small pilot area) (e.g., Shaheen et al., 2016; City of Centennial, 2017; Murphy and Karner, 2019). This paper explores two conceptual explanations. On shorter distances, the additional transfer between the ridesourcing vehicle and the subsequent/previous PT vehicle and its associated disutility (‘transfer penalty’) could diminish perceived travel time savings. On longer distances, the additional cost to be borne by the user might exceed the value of travel time savings (VTTS) despite a given level of subsidy. We quantify the impact of each by simulating a first/last mile service for commuting trips in three US regions that currently partner with ridesourcing companies, however, structurally differ in terms of population density and PT availability: Seattle (Washington), Pinellas County (Florida) and Marin County (California).

This paper makes three contributions. First, we connect two streams of research (demand-responsive feeders and the transfer penalty) that have previously remained largely detached. Second, propose two alternative explanations for low ridership on first/last mile ridesourcing services and quantify their impact. We develop and a describe a methodology that solely relies on open data, enabling transit agencies to assess the potential of first/last mile partnerships in their locality. Lessons are distilled for the suitability of first/last mile feeders for three different regions and the equity implications of the type of subsidy scheme employed. Third, and perhaps most importantly, our findings can be applied to any vehicle-based first/last mile feeder service in the future, i.e. automated taxis (‘phase 3’), challenging the frequent view that automated taxis could
This paper is structured as follows. We first review the literature on transfer penalties, explore the missing link to demand-responsive feeders, and develop the argument for costs as a potential barrier to use. We then introduce our methodology to quantify the impact. A short introduction of the empirical contexts is followed by the results of our analyses. We conclude with a summary and a discussion of the implications for transport policy.

LITERATURE REVIEW

This section reviews the literature on transfers and costs as potential barriers to the use of demand-responsive feeders for the first/last mile.

Transfers

First/last mile services cause an additional transfer between the feeder vehicle and subsequent/previous PT vehicle. Passengers, however, generally 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). Despite a long history of research into transfers and associated disutilities (‘transfer penalty’, usually quantified in minutes passengers would prefer to continue their journey to avoid a transfer) (Algers et al., 1975; Alter, 1976; Allen and DiCesare, 1976; Newell, 1979; Horowitz, 1981), this stream of research has not been systematically connected to demand-responsive feeders for the first/last mile. Yet, this is important as, by definition, first/last miles tend to be rather short distances, thus the time gain using a ridesourcing vehicle is in the magnitude of the typical size of the transfer penalty itself.

Studies investigating the size of the transfer penalty exhibit wide ranges in values. 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, service reliability) (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 stated-preference data in Madrid, they find the pure transfer penalty to average 15.2 min.

Yan et al. (in Press) are the first (and only to our knowledge) to explicitly consider the disutility of the additional transfer caused by the first/last mile feeder in their survey-based investigation of traveler responses to a hypothetical 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) The apparent contradiction between average first/last mile distances/travel times and a transfer penalty of 10.9 minutes, however, remains unresolved.
To our knowledge, previous studies have not systematically contrasted travel time savings enabled by first/last mile services with concomitant transfer penalties. As argued above, they may present a strong barrier to the use of first/last mile services, especially on short distances. We thus aim to close this gap and explore this hypothesis empirically in the next sections of this paper.

Costs

First/last mile services may cause additional costs for the user depending on the type of subsidy scheme employed. Given the high share of transit-using households in the US with an income of less than USD 15,000 (30% of bus-using households (Clark, 2017)), additional costs may be another barrier to the use of demand-responsive feeders for the first/last mile.

Current first/last mile ridesourcing service subsidy schemes broadly fall into four categories (as of July 2019):

- Most offer a USD 4-5 discount on the Uber/Lyft/Taxi charge (Charlotte, Marin County, Pinellas County), which covers short distances. However, in some regions (e.g., Pinellas County), Uber’s minimum ride price of about USD 6 leaves at least an USD 1 surcharge even for the shortest distances.
- Seattle integrates its three first/last mile providers into their ORCA card based PT pricing scheme, offering first/last mile connections (or subsequent/previous PT rides) for free. PT standard trip fares apply (2.75 for adults, 1.5 for youths). First/last mile services were offered for free without PT fare integration in Centennial, CO, and Austin, TX.
- Los Angeles offers first/last mile rides for a flat fare of USD 1.75 (with a TAP card), with free rides for low-income subsidy program eligibles and a surcharge of USD 2 without a TAP card.
- Phoenix, AZ, offered a 20% discount on the total fare of first/last mile rides to/from a number of selected transit stops.

While any surcharge may present a barrier in itself, flat fee discount-based subsidy schemes penalize long first/last mile rides disproportionally. It is an open empirical question whether the value of travel time savings for US transit riders exceeds the remaining surcharge, and how this depends on income.

While a comprehensive review of the value of travel time savings literature would exceed the scope of this paper, we focus on reported values for US transit rides. Since 1997, the US Department of Transportation (US DOT) publishes its ‘Departmental Guidance for the Valuation of Travel Time in Economic Analysis’. Since 2011, US DOT calculates the VTTS for personal travel (including commuting) at 50% of the hourly median household income (Belenky, 2011). This value follows the recommendations developed by Concas and Kolpakov (2009) and Zhang et al. (2005) for the US and Canada and is within the range found by Zamparini and Reggiani (2007) in their meta-study for commuting trips in Europe, North America and Australia. While the approach to consider a single VTTS value for transport appraisals has recently been criticized for negating increasingly flexible work practices, variations in income and interpretations of travel time (Hensher, 2019), it is widely used in practice and recommended by the US DOT.

Using 50% as their guiding metric, US DOT calculates the VTTS/h at US median household income to be USD 12, 12.50, 13.60 in 2009, 2013, 2015, respectively (Belenky, 2011;
Endorf, 2015; Timothy, 2016). For 10 minutes of travel time savings, these values amount to USD 2, 2.1 and 2.3, respectively. Households with incomes lower than the US median are likely to exhibit lower VTTS values, too. Given median minimum Uber fares of USD 5 (Hall et al., 2018) it is thus natural to question whether surcharges exceed VTTS on the first/last mile, and how this depends on distance, income and subsidy scheme employed. This is an open question to our knowledge and another potential explanation for low ridership on the first/last mile, which we explore in the next sections of this paper.

**METHODOLOGY**

We simulate commuting trips using three different transport options (PT with walking for the first/last mile, PT with ridesourcing for the first/last mile, and the private car for the entire journey) in three different regions using R. For a short introduction to the regions and their first/last mile pilots, see next section.

Block-group level origin-destination (OD) commuting trip information is obtained for all three regions from the 2015 US Census Origin-Destination Employment Statistics (US Census Bureau, 2019a). This includes 137,954 OD pairs for Seattle, 103,216 OD pairs for Pinellas County and 11,605 OD pairs for Marin County. For each OD pair, we obtain PT travel times including access/egress walking times and intermediate wait times during morning peak using the Google Directions API (Alternative A). We then obtain the coordinates of the first and last PT station used and, again using the Google Directions API, obtain 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 add transfer penalties of 5, 10 and 15 minutes for each first/last mile transfer. Additionally, we obtain direct car travel times (Alternative C). Figure 1 visualizes the three alternatives.

*Figure 1: Transport alternatives for which travel times are being compared. Transfer penalties are added to Alternative B.*

We then weigh each OD pair according to the number of commuters and compare overall travel times under the assumption of different transfer penalties.

We calculate VTTS/h values using the above outlined US DOT guidelines yet vary yearly household incomes (and resulting VTTS/h) between USD 15,000 (VTTS/h USD 3.61) and USD 150,000 (VTTS/h USD 3.61).
90,000 (VTTS/h: USD 21.63) to account for different realities of US transit riders. For each income level and first/last mile trip, we calculate and compare VTTS and ridesourcing prices in four common set-ups: without subsidies, with a USD 5 flat fee discount, with a 20% fare reduction and priced at a fixed price of US 1.75. Ridesourcing prices are calculated by using publicly available information from Lyft in Seattle (Lyft, 2019a) and the San Francisco Bay Area (Lyft, 2019b) and a secondary source for the Tampa Bay Area (Estimate Fares, 2019), where official information from Lyft was unavailable. Fare structures consist of a base fare, costs per mile and minute, a maximum / minimum fare, service and city fees.

CASE STUDIES

We apply our methodology to three case studies that currently pilot first/last mile ridesourcing partnerships, however, structurally differ in terms of population density and PT availability: Pinellas County (Florida), Marin County (California) and Seattle (Washington). This section provides an overview of each region including a brief description of the respective first/last mile service. Data is extracted from the latest edition of the American FactFinder (US Census Bureau, 2019b) and the National Transit Database (FTA, 2019) where not otherwise noted.

**Pinellas County**

Pinellas County, FL has an estimated population of 975,280 (2018). The overall population density is 3,559 inh. / sq. mi. and its largest city is St. Petersburg with 265,098 inh. (2018). Pinellas County has a median age of 47.6 (US median: 37.8) and a median household income of USD 48,968 (US median: 57,652) (2017).

The large majority commutes to work driving alone (79.1%) with very few using PT (1.8%) (2017). Pinellas Suncoast Transit Authority (PSTA) reported 12.2 annual unlinked trips per capita within the service area and operates mainly with busses (2017).

PSTA’s first/last mile partnership with Uber (‘Direct Connect’) was reportedly the first of its kind (Murphy and Karner, 2019). Having evolved through three stages since its foundation in Feb. 2016, it now offers a subsidy of USD 5 for Uber and taxi rides to/from 24 bus stations.

**Marin County**

Marin County, CA (San Francisco Bay Area) has an estimated population of 259,666 (2018). The overall population density is 499 inh. / sq. mi. (one seventh the density of Pinellas County) and its largest city is San Rafael with 58,704 inh. (2018). Marin County has a median age of 46.1 and a median household income of USD 104,703 (2017), more than twice as much as Pinellas County, ranking as 13th richest county by median household income in 2016.

The majority commutes to work driving alone (65.3%) (2017). Interestingly, the percentage of commuters using PT is more than five times higher than in Pinellas County (9.8%) despite a similar reported number of 11.7 annual unlinked trips per capita (2017). This suggests a different PT usage (i.e., more regular commuters and less infrequent users) or different work realities (i.e., more part-time commuters). Marin Transit operates mainly with busses (2017). Sonoma-Marin Area Rail Transi (SMART) runs an additional commuter rail between Sonoma and Marin counties which carried an additional 772,961 passengers in fiscal year 2017/2018 (SMART, 2018).
SMART’s first/last mile partnership with Lyft (‘GETSMART17’) started in Sep. 2017 and offers a subsidy of USD 5 for Lyft rides to/from 4 rail stations.

Seattle

Seattle is the largest city in the state of Washington and has an estimated population of 744,955 (2018). The overall population density is 8,883 inh. / sq. mi. (more than 2x / 17x as dense as Pinellas County / Marin County, respectively) (2018). Seattle has a median age of 35.7 (11.9 / 10.4 years younger than Pinellas County / Marin County, respectively) and a median household income of USD 79,565 (2017).

The majority commutes to work driving alone (48.8%), however a substantial share uses PT (21.4%) or walks (10.2%). Seattle is home to three transit organizations: King County Metro, Seattle Center Monorail Transit and Central Puget Sound Regional Transit Authority. In sum, they reported 77.85 annual unlinked trips per capita within their respective service areas (about 7 times as many as in Pinellas and Marin counties) on a variety of vehicles (e.g., light rail, commuter rail, monorail, busses, trolleybuses) (2017). In 2018, King County Metro was named the best large transit system in North America by the American Public Transportation Association.

King County Metro started its first/last mile partnership with three different providers in three different regions of the city in Oct. 2018. Fares are integrated into PT pricing: customers paying with the ORCA card can transfer to a subsequent PT vehicle for free.

RESULTS

In this section, we report on the results of our simulations for both hypothesized barriers to the use of first/last mile ridesourcing services.

Transfers

We find that the first/last mile services yield substantial average gross travel time savings per trip in the three areas: from 9.36 min in Seattle to 15.69 min in Pinellas County and 17.62 min in Marin County. Differences can largely be explained with average first/last mile distances, ranging from 0.48 miles in Seattle to 0.77 miles in Marin County.

When adding low-moderate transfer penalties, however, the outcome changes. A transfer penalty of 5 minutes reduces the percentage of trips with positive net travel time savings by the first/last mile service to 59.87%, 85.03% and 90.94%, for Seattle, Pinellas County and Marin County, respectively. A transfer penalty of 15 minutes, which is still at the lower end of empirical values reported by various researchers, reduces the percentage of trips with positive net travel time savings to 8.27%, 20.41% and 32.17% and for the three regions. These results confirm intuition in that first/last mile services remain most attractive after deducing transfer penalties in regions with longer first/last mile distances (here: Marin County), however, quickly lose their appeal in cities with shorter first/last mile distances / good PT accessibility (here: Seattle).

For trips where net travel time savings remain positive after applying a transfer penalty, they diminish by 48.07% to 95.94% depending on the height of the transfer penalty and region. Table 1 summarizes the results for each region.
Table 1: Travel time savings after application of transfer penalties.

<table>
<thead>
<tr>
<th></th>
<th>Pinellas County</th>
<th>Marin County</th>
<th>Seattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean first/last mile distance</td>
<td>0.75 mi</td>
<td>0.77 mi</td>
<td>0.48 mi</td>
</tr>
<tr>
<td>Mean gross travel time savings with first/last mile service per trip</td>
<td>15.69 min</td>
<td>17.62 min</td>
<td>9.36 min</td>
</tr>
</tbody>
</table>

% of trips with positive net travel time savings, i.e. after deduction of transfer penalty of

<table>
<thead>
<tr>
<th>Transfer Penalty (minutes)</th>
<th>Pinellas County</th>
<th>Marin County</th>
<th>Seattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 5 min</td>
<td>85.03%</td>
<td>90.94%</td>
<td>59.87%</td>
</tr>
<tr>
<td>- 10 min</td>
<td>48.02%</td>
<td>63.92%</td>
<td>21.90%</td>
</tr>
<tr>
<td>- 15 min</td>
<td>20.41%</td>
<td>32.17%</td>
<td>8.27%</td>
</tr>
</tbody>
</table>

Mean travel time savings with first/last mile service accounting for transfer penalties of

<table>
<thead>
<tr>
<th>Transfer Penalty (minutes)</th>
<th>Pinellas County</th>
<th>Marin County</th>
<th>Seattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 5 min</td>
<td>7.28 min</td>
<td>9.15 min</td>
<td>2.98 min</td>
</tr>
<tr>
<td>- 10 min</td>
<td>2.79 min</td>
<td>4.14 min</td>
<td>1.03 min</td>
</tr>
<tr>
<td>- 15 min</td>
<td>0.82 min</td>
<td>1.67 min</td>
<td>0.38 min</td>
</tr>
</tbody>
</table>

Importantly, after applying transfer penalties of 5 (15) minutes, mean first/last mile distances with positive net travel time savings increase from originally (without a transfer penalty) 0.75 to 0.98 (1.36) miles in Pinellas County, from 0.77 to 0.97 (1.33) miles in Marin County, and from 0.48 to 0.74 (1.28) miles in Seattle. This confirms intuition as using a ridesourcing vehicle for the first/last mile becomes less attractive with larger transfer penalties especially for shorter distances. However, it raises the question whether for longer distances surcharges exceed value of travel time savings.

Costs

In this section, we report on our findings how the value of travel time savings for different income groups compare to surcharges under three different subsidy schemes.

We find that unsubsidized costs for ridesourcing on the first/last mile exceed the value of travel time savings for most trips and income levels. Only at the highest income level, for a small share of trips, VTTS exceed the unsubsidized ridesourcing costs (see unfilled circles in Figure 2 for Marin County).
A USD 5 subsidy, as employed by many current partnerships, changes the picture, however only for the higher income groups (see upward shift of fitted average red lines in Figure 2). For households with an annual income of USD 60,000 (and a corresponding VTTS according to US DOT VTTS guidelines of USD 14.42), the share of trips where VTTS exceed ridesourcing costs increases to 28% in Marin County. For households with an annual income of USD 90,000, this share naturally further increases to 50%. For households with a lower annual income of USD 15,000 or USD 30,000, however, the share stays low at 0% and 2%, respectively. For Pinellas County and Seattle, the value ranges are similar in order of magnitude (see Table 2 for the results for all three regions).
A 20% discount is similar, yet less pronounced in effect. While the share of trips where VTTS exceed ridesourcing costs stay at 0% for households with lower incomes, it just reaches 5-10% for households with an annual income of USD 90,000.

Charging flat fees (here: USD 1.75 as currently employed in Los Angeles) has the most pronounced effect on the financial viability of ridesourcing on the first/last mile. While, again, shares stay at 0% - 1% for low income households in all three regions, they climb to 5% - 20% for households with an annual income of USD 30,000 and reach 38% - 70% for high-income households.

Table 2: Share of trips where VTTS exceed ridesourcing costs on the first/last mile for different household incomes at different subsidy schemes.

<table>
<thead>
<tr>
<th>Pinellas County</th>
<th>Marin County</th>
<th>Seattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD 15,000</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>USD 30,000</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>USD 60,000</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>USD 90,000</td>
<td>2%</td>
<td>3%</td>
</tr>
</tbody>
</table>

Share of trips where VTTS exceed ridesourcing costs on the first/last mile with a USD 5 subsidy at VTTS corresponding to different annual household incomes

| USD 15,000      | 0%  | 0%  | 0%  |
| USD 30,000      | 2%  | 2%  | 9%  |
| USD 60,000      | 23% | 28% | 35% |
| USD 90,000      | 43% | 50% | 54% |

Share of trips where VTTS exceed ridesourcing costs on the first/last mile with a 20% discount at VTTS corresponding to different annual household incomes

| USD 15,000      | 0%  | 0%  | 0%  |
| USD 30,000      | 0%  | 0%  | 0%  |
| USD 60,000      | 1%  | 2%  | 1%  |
| USD 90,000      | 7%  | 10% | 5%  |

Share of trips where VTTS exceed ridesourcing costs on the first/last mile at a USD 1.75 flat fee and VTTS corresponding to different annual household incomes

| USD 15,000      | 0%  | 1%  | 0%  |
| USD 30,000      | 12% | 20% | 5%  |
| USD 60,000      | 44% | 54% | 21% |
| USD 90,000      | 63% | 70% | 38% |

Subsidizing ridesourcing on the first/last mile using the common USD 5 flat-fee or 20% discount schemes, thus, appears to create viable economic incentives only for households with higher incomes. For those with lower annual household incomes than USD 25,000 (46% of bus-
using households (Clark, 2017)), surcharges exceed VTTS in almost all cases. Even flat fees (here: USD 1.75) appear to exceed VTTS for the lowest income households.

**DISCUSSION**

In the outset of this paper we observed that many transit agencies in the US (and increasingly in Europe, too) partner with ridesourcing companies to offer subsidized first/last mile services. Ridership, however, has been low and some pilots had to be discontinued. So-far, mostly operational explanations for low ridership have been offered (e.g., sparse marketing, short pilot duration, small pilot area, high costs).

In this paper, we explored two conceptual explanations. First, using a ridesourcing vehicle for the first/last mile adds an additional transfer to the overall PT trip. The associated disutility (‘transfer penalty’) reduces the perceived travel time savings when compared to the alternative (walking). For our first case study (Seattle), we find that low transfer penalties of 5 (15) minutes already exceed travel time savings gained by ridesourcing on the first/last mile in 40% (92%) of all trips, respectively. For suburban Pinellas and Marin counties with longer first/last miles, the impact is less profound, however nonetheless substantial: transfer penalties of 5 (15) minutes exceed travel time savings for 15% (80%) and 10% (68%) of all trips, respectively.

As a second explanation for low ridership, we explored surcharges to be borne by the user under three different subsidy schemes currently employed by transit agencies: a USD 5 flat-fee discount, a 20% reduction on the total cost of the first/last mile ride and USD 1.75 fixed price for the entire first/last mile trip. Using distinct VTTS/h for four different income groups, we find that surcharges under all three schemes exceed the value of travel time savings for the large majority of trips for households with an annual income of USD 30,000 or lower. Only for households with higher annual incomes (here: USD 60,000 and 90,000) the subsidy results in a substantial number of trips with positive net VTTS after deducing ridesourcing surcharges. These results are consistent with Alemi et al. (2019), who find that individuals with higher willingness to pay for travel time savings use ridesourcing more often. They also correspond with Yap et al. (2016), who conclude from their SP experiments that autonomous vehicles for the first/last mile are preferred over alternative modes only by first class train riders.

Given these two conceptual explanations, it is not surprising that many first/last mile ridesourcing partnerships have experienced low ridership. They also help explain why a significant and substantive positive relationship between ridesourcing and PT ridership has not yet been found. Current PT users might find that surcharges exceed the value of travel time savings or the disutility of the additional transfer exceed perceived travel time savings (especially for short distances). Potential new PT users face a different set of barriers. Despite improved first/last mile connections for some trips, the private car continues to be more comfortable, less costly (if only out-of-pocket expenses are considered) and faster (for our three case studies, the average car ride is between 2.5x and 3.1x faster than PT). Investments only in first/last mile improvements to increase PT usage, particularly in urban areas, are therefore likely to miss their purpose.

Our analyses show that ridesourcing partnerships for the first/last mile might not be the panacea as which they are often portrayed. However, they also show that where first/last miles are particularly long, ridesourcing partnerships can provide substantial travel time savings (or
accessibility improvements) despite transfer penalties. Public subsidy schemes, though, usually endeavor to serve all members of the public equally. Our analyses show that under many current subsidy schemes, only high-income households might find this new option economically viable. Instead of flat fee or percentage-based discounts, an integration into transit smart card systems (as currently piloted in Seattle) offering first/last mile rides for free if previously or subsequently PT is used presents a more equitable solution, especially where low demand bus routes are discontinued simultaneously. This also allows to monitor and prevent misuse of subsidies by using ridesourcing at a PT fare for a direct connection without subsequently/Previously using PT.

Finally, our analyses are not limited to current variants of ridesourcing. Several scholars have started to propose automated taxis as future first/last mile solutions (e.g., Chong et al., 2011; Liang et al., 2016; Yap et al., 2016). Our results challenge this view as transfer penalties persist for any vehicle-based first/last mile services. Studies aiming to quantify the potential of automated taxis on the first/last mile (e.g., Scheltes and de Almeida Correia, 2017; Shen et al., 2018; Wen et al., 2018) might come to a different conclusion once considering moderate penalties for transfers between the feeder and transit.

AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: D. J. Reck and K. W. Axhausen; data collection: D. J. Reck; analysis and interpretation of results: D. J. Reck; draft manuscript preparation: D. J. Reck and K. W. Axhausen. All authors reviewed the results and approved the final version of the manuscript.
REFERENCES


