Shared-Cab Matching for Airport and Railway Station Departures: A Survey-Based Simulation Study of Holding Windows and Passenger Tolerances in Pune, India

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Abstract—Passengers leaving an airport or railway station often travel to nearby places but book separate cabs and pay full fares. A shared-cab service could reduce the fare, but it must decide how long to hold passengers and whom to group, and passengers will refuse matches that go against their own limits on saving, waiting, detour, group size and safety. This paper studies that problem using an anonymous online survey of 30 travellers and a computer simulation of passengers leaving a hub in Pune. The survey answers were used to give simulated passengers realistic limits. Five matching policies were compared in 30 paired simulation runs. Under the survey limits, matching that respects every passenger's limits matched 35.6% of passengers and gave an estimated fare saving of 15.5%, compared with 52.3% when limits were assumed instead of measured. The main reason is that 13 of 30 respondents asked for a saving of at least 50%, which a shared cab can rarely provide. Holding passengers for no more than 2 minutes kept everyone within their own waiting limit; at 5 minutes, 21.7% waited longer than they wanted. A same-gender option lowered the saving by 2.7 to 4.1 percentage points. The survey is small and not representative, and fares and demand are simulated, so the results are first estimates and not measured outcomes.

Index Terms—shared cab, ride-sharing, taxi sharing, transport hub, holding window, passenger preferences, simulation, survey, Pune

I. INTRODUCTION

Passengers who arrive at an airport or railway station in an Indian city usually book a cab and travel alone, even when other passengers from the same flight or train are going to nearby areas. A shared cab could reduce the fare per person and the number of vehicles waiting at the pick-up point. Shared airport taxi services already exist in some cities, for example at Munich Airport, so the idea itself is not new.

Sharing, however, has a cost for the passenger. Passengers arrive one after another, so a system that waits longer can find better matches but makes people wait. A match that looks good on paper may also be refused because of an extra detour, limited luggage space, too many co-passengers, or a safety concern such as sharing with a stranger of a different gender. If such limits are ignored, a simulation can report savings that real passengers would not accept.

This paper uses Pune as a case and asks three questions about passengers leaving a transport hub:

RQ1. How much fare saving is possible when matching respects the limits that travellers say they have?

RQ2. How does the length of the holding window affect savings, waiting, and the share of passengers pushed beyond their own waiting limit?

RQ3. What do a same-gender preference and a maximum group size cost in savings?

The work has two parts: a survey to find out what limits travellers report, and a simulation that compares five matching policies using those limits. A further result is how much the conclusions change when assumed limits are replaced by survey limits.

II. RELATED WORK

Dynamic ride-sharing has been reviewed by Agatz et al. [2] and simulated for Atlanta by Agatz et al. [1], where optimisation-based matching did better than simple rules. Santi et al. [4] introduced shareability networks and showed large potential savings on New York taxi data, with little extra gain beyond pairs. Alonso-Mora et al. [3] assigned requests to vehicles of capacity up to ten. The stability of matches was studied by Wang et al. [9], and a partition-based algorithm for taxi sharing was proposed by Xiao et al. [10].

Waiting and matching time have also been studied. Özkan and Ward [6] model random customer patience in customer–driver matching, and Bao et al. [7] show that the timing of matching matters, using windows of a few seconds. Peng et al. [8] model passenger-specific gender, detour and cost limits in a stable-matching formulation for taxi sharing with at most two passengers per taxi. (I could read only a partial text of [8], so I cite it only for these points.)

The closest work on airport access is Ma et al. [5], who compare two shared-taxi policies for trips to JFK Airport: passengers from one zone wait for a partner, or passengers from different zones are matched with a detour. Their model is analytical, uses pairs only, and has no matching algorithm, holding window or individual limits. Indian studies of carpooling [11]–[13] concern commuters and point to trust and safety, but do not test matching policies. In the papers I reviewed, I did not find one that combines hub departures, a holding window, individual limits, groups above two, and tolerances taken from an Indian survey. This describes my reading only and is not proof that no such study exists.

III. METHODOLOGY

A. Research design

The study is quantitative and has two parts. First, a cross-sectional online survey collected the limits that travellers say they have. Second, a discrete-event style simulation of passengers leaving a hub was run, in which each simulated passenger is given the answers of one real respondent. The simulation compares policies on identical random demand so that differences come from the policy and not from chance.

B. Survey

The survey was a 25-question anonymous Google Form with four parts: past trips, willingness to share, safety and trust, and optional background. It collected no names or email addresses and began with a consent statement. I shared it online with people I could reach, so the sample is a convenience sample. It was open from 1 to 5 November 2026 and returned 30 responses. Answers given as ranges were converted to numbers for the simulation: "up to X minutes" became X, "more than 20 minutes" became 25, and "no waiting" was treated as 2 minutes, the shortest limit the simulation allows.

C. Simulation model

Passengers arrive over four hours in bursts that imitate flights or trains (average six passengers per burst, spread over eight minutes). Destinations are drawn from eight approximate Pune zones. A cab seats four and its boot holds three large bags. The system collects requests for a holding window of W minutes, forms groups, and sends each group in one cab; a passenger whose waiting limit would end before the next window leaves alone. Fares use a placeholder tariff, and the shared fare is divided in proportion to each passenger's solo fare, so every member receives the same percentage saving. Table I lists the settings.

TABLE I. SIMULATION SETTINGS

Item	Value
Period / base demand	4 hours / 1.0 passenger per minute
Arrival pattern	bursts, mean 6 passengers
Destinations	8 Pune zones (approximate)
Distance, speed	straight line × 1.35; 25 km/h
Tariff (placeholder)	Rs 60 + Rs 16 per km per cab
Cab size, boot	4 seats; 3 large bags
Passenger limits	resampled from survey answers
Runs	30 paired runs per setting

D. Matching policies

A (cab queue): a passenger joins an open cab if destinations are within 4 km; the cab leaves when full or after 10 minutes. *B (window + greedy):* requests are held for W minutes and paired greedily by closeness, with a uniform 10-minute cap. *U (window + optimal, no limits):* pairs are chosen by maximum-weight matching on fare saving and then merged into groups of up to four, with only the seat limit enforced. *C (U + individual limits):* a group is allowed only if every member's waiting, extra ride time, luggage, group-size and minimum-saving limits hold. *D (C + gender preference):* passengers who asked for a same-gender cab travel only with the same gender. Pairs use the NetworkX maximum-weight matching routine [14]; groups of three or four are built by repeatedly merging the two groups with the largest extra saving. This is a heuristic, not an exact optimum.

E. Metrics and experiments

The metrics are the share of passengers matched, fare saving compared with solo cabs, average wait, average extra ride distance, and the share of passengers who waited longer than their own limit. For policy D, the same-gender preference was applied to the 12 respondents who answered "yes, always" (daytime case), to the 19 who answered "always" or "only at night" (night case), and to the 26 who also answered "only if available at no extra cost" (upper case). I varied the holding window (1–15 minutes), the demand (0.3–2.5 passengers per minute), the maximum group size (2, 3, 4), and a uniform minimum-saving threshold (0–50%). Each setting was run 30 times with the same random demand for every policy (seeds 100–129), and means are reported with 95% confidence intervals from these runs. Because the survey is small, I also resampled the 30 respondents with replacement 200 times and reran policy C to see how much the result depends on who answered.

IV. SURVEY RESULTS

Of the 30 respondents, 28 had taken a cab from an airport (15), a railway station (11) or both (2) in the past year. Twenty-two mainly travel in Pune, seven in Mumbai and one elsewhere. Nineteen usually take an app cab and six an auto-rickshaw. Ten respondents were female, nine male, and ten did not state gender; the largest age group was 21–30 (13). Sixteen travel mainly for work or business.

TABLE II. SURVEY RESULTS (n = 30)

Question	Result
Would consider sharing (1–5)	mean 3.6; 17 answered 4–5; 7 answered 1–2
Smallest saving to agree	mean 35.3%, median 40%; 13 need 50%, 19 need ≥40%
Max wait, not in hurry	mean 9.1 min, median 7.5; 11 accept ≤2 min
Max wait, in a hurry	mean 4.9 min, median 5; 11 accept ≤2 min
Extra ride time accepted	mean 7.8 min; 27 accept ≤10 min
Most other passengers	none 1; one 18; two 10; three 1
Destination closeness	same area 13; within 3 km 11; main road 3
Would not share with >1 large bag	15 of 30
Same-gender option	always 12; at night 7; if free 7; unsure 3; no 1
Comfort sharing at night (1–5)	mean 3.0; 11 answered 4–5; 11 answered 1–2
Biggest reason not to share	safety 11; longer journey 6; privacy 5; luggage 4
Fare split	equal 18; by distance 9; app decides 2; no view 1

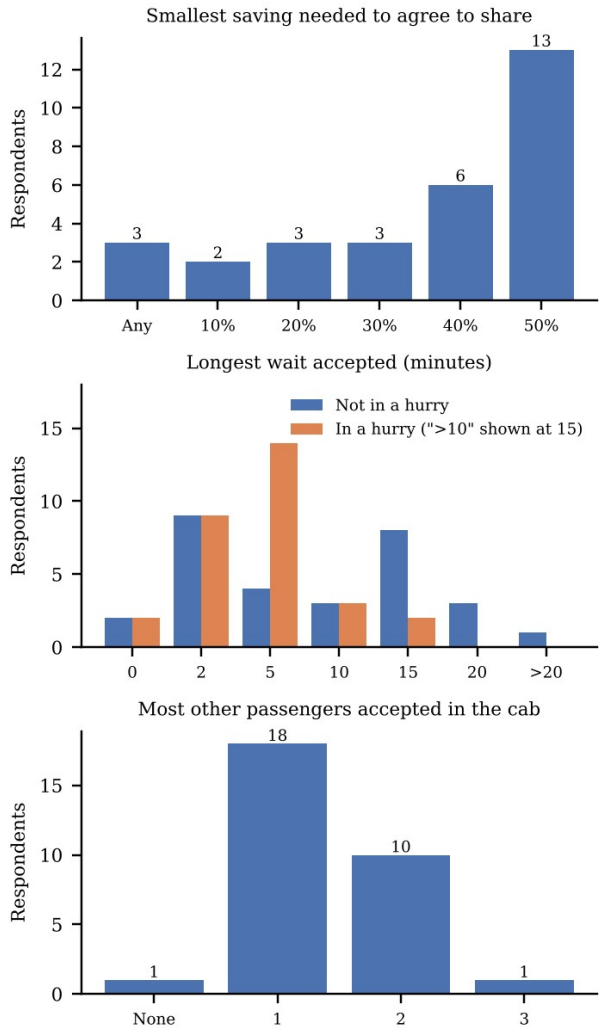


Fig. 1. Survey answers on minimum saving, waiting time and group size (n = 30).

Three results matter most for the simulation. First, 13 of 30 respondents (43%) want a saving of at least 50%, and the median requirement is 40%. Second, patience is short: 11 respondents accept at most 2 minutes of waiting, even when not in a hurry, and the median for a hurry is 5 minutes. Third, 29 of 30 respondents accept at most two other passengers (one of them would not share at all), and only one accepts three. Safety was the most common reason for not sharing (11 of 30). On the safety features, co-passenger name and photo (mean 4.0 of 5), an emergency button (3.9) and a fare guarantee (3.8) were rated highest, and ratings the lowest (3.2). Equal fare splitting was preferred by 18 respondents.

V. SIMULATION RESULTS

A. Policy comparison

TABLE III. POLICY COMPARISON, SURVEY LIMITS (W = 5 MIN, 1.0 PAX/MIN, 30 RUNS)

Policy	Matched %	Saving %	Wait min	Detour %	Over wait %
A cab queue	89.5	54.1 ± 1.3	5.7	9.7	35.0
B greedy	85.8	46.1 ± 1.2	3.9	6.6	29.6
U optimal, no limits	99.3	54.0 ± 0.9	2.7	15.9	22.5
C with limits	35.6	15.5 ± 0.9	6.1	3.6	21.7
D C + gender pref.	30.2	12.7 ± 0.8	6.3	3.9	21.7

Policies A, B and U do not check individual limits, so their high savings are not available to everybody: policy U, for instance, puts passengers in groups of up to four although only one respondent accepts three co-passengers. Policy C respects every limit and gives a saving of 15.5% with 35.6% of passengers matched. Policy D lowers this to 12.7% (a loss of 2.7 percentage points). “Over wait” is the share of passengers who waited longer than their own limit. It is still 21.7% for C because a 5-minute window is longer than the limit of some respondents; this is studied in Section V-D.

B. Effect of using survey limits

TABLE IV. POLICY C UNDER ASSUMED AND SURVEY LIMITS (W = 5, 1.0 PAX/MIN)

Limits used	Matched %	Saving %
Assumed before the survey	97.5	52.3
Survey limits (30 respondents)	35.6	15.5
Survey, but minimum saving 10%	88.3	35.6
Survey, “in a hurry” waiting limit	30.1	12.9

Before the survey I had assumed a mean waiting limit of 10 minutes, a detour limit of 20–60% of the solo ride, a 10% minimum saving and cabs of four. Table IV shows that replacing these with survey limits reduces the saving of policy C from 52.3% to 15.5%. The third row shows where most of the drop comes from: with the survey limits for waiting, detour, luggage and group size, but a 10% minimum saving, the saving is 35.6% and 88.3% of passengers are matched. If passengers are all in a hurry, the saving falls to 12.9%.

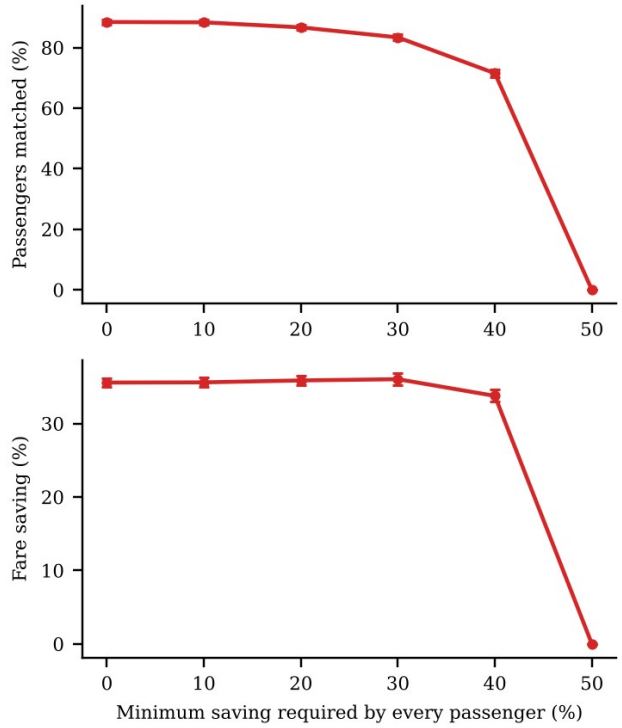


Fig. 2. Policy C when every passenger demands the same minimum saving.

Fig. 2 shows the effect of the threshold. Up to a 30% requirement, 83–88% of passengers are matched and the saving stays near 36%; at 40% the matched share falls to 71.5%; at 50% no group qualified in these runs. A pair can reach a 50% saving only if both passengers go to exactly the same place, and detour limits and spread-out destinations keep most groups below that.

C. Uncertainty from the small survey

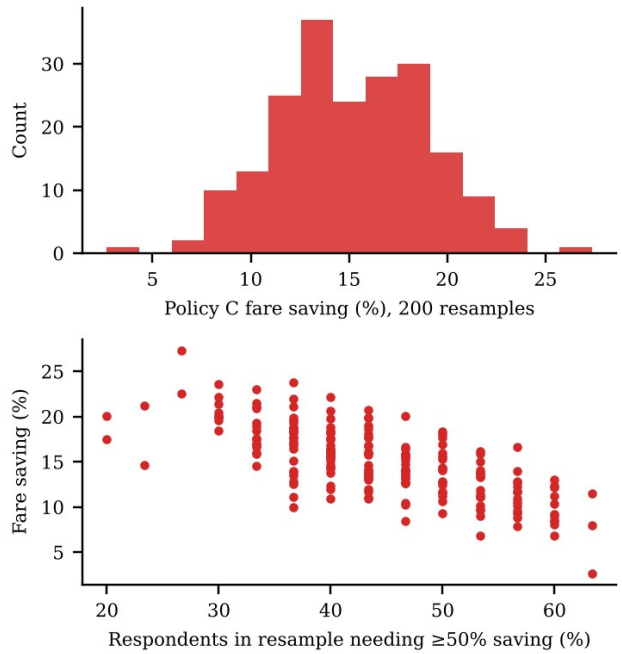


Fig. 3. Policy C saving across 200 resamples of the survey respondents (top) and its link with the share needing at least 50% (bottom).

The 95% confidence interval in Table III (±0.9) only reflects the randomness inside the simulation. To show the effect of a small survey, I resampled the 30 respondents 200 times. Across these resamples the saving of policy C had a mean of 15.1% with a 95% range of 8.1% to 22.2%, and the matched share had a mean of 34.6% with a range of 17.5% to 50.8%. The saving was strongly linked to the share of respondents needing at least 50% (correlation −0.72, Fig. 3). Policy U had a 95% range of 50.3% to 58.6%, because it ignores the limits. The conclusion that limits sharply reduce the saving held in all resamples, but the exact number is uncertain.

D. Holding window

TABLE V. HOLDING WINDOW (SURVEY LIMITS, 1.0 PAX/MIN)

W (min)	C saving %	C matched %	C over wait %	U saving %
1	14.8	35.3	0.0	36.9
2	14.3	34.0	0.0	44.0
3	14.8	34.7	12.5	48.7
5	15.5	35.6	21.7	54.0
8	16.6	37.9	32.5	58.6
10	17.2	38.9	35.3	60.1
15	18.8	41.8	43.4	63.7

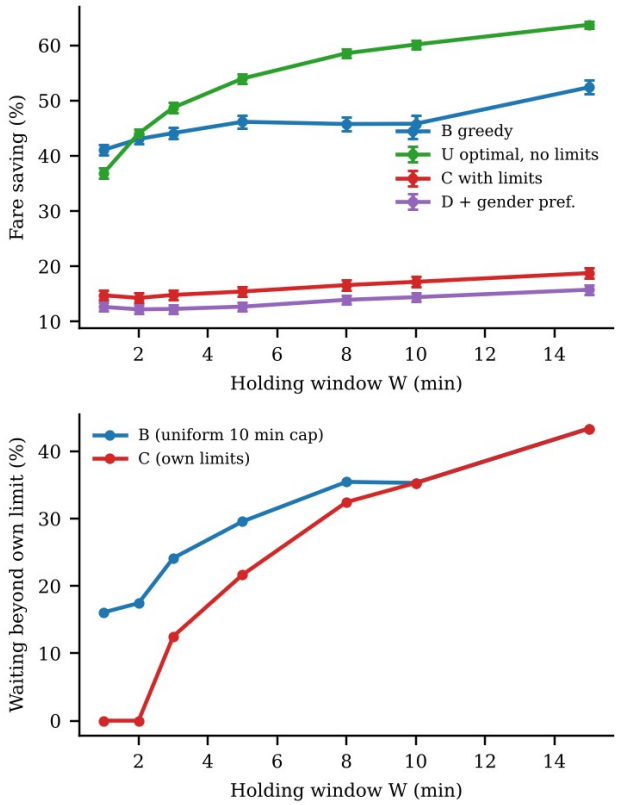


Fig. 4. Effect of the holding window on saving (top) and on passengers who wait beyond their own limit (bottom).

For policy C, a longer window gives only a small gain, from 14.3% at 2 minutes to 18.8% at 15 minutes. The cost is larger: no passenger waits beyond their own limit at 1 or 2 minutes, but 12.5% do at 3 minutes, 21.7% at 5 and 43.4% at 15. The reason is that 11 of 30 respondents accept at most 2 minutes of waiting, and a window longer than a passenger's

limit cannot respect it. For policy U the saving grows much faster with the window (36.9% to 63.7%), but it also ignores the limits, so it overstates what can be offered.

E. Group size and demand

Limiting cabs to two passengers gave a policy C saving of 15.2% and to three or four gave 15.5%; the results for three and four are the same because only one respondent accepts four. The saving of policy U changed from 39.0% (pairs) to 40.3% (three) and 54.0% (four), but the jump to four mainly reflects dividing one cab fare among more people, and only one respondent would accept it. Pairs and groups of three are therefore enough for these respondents, and my grouping heuristic probably understates the benefit of groups of three.

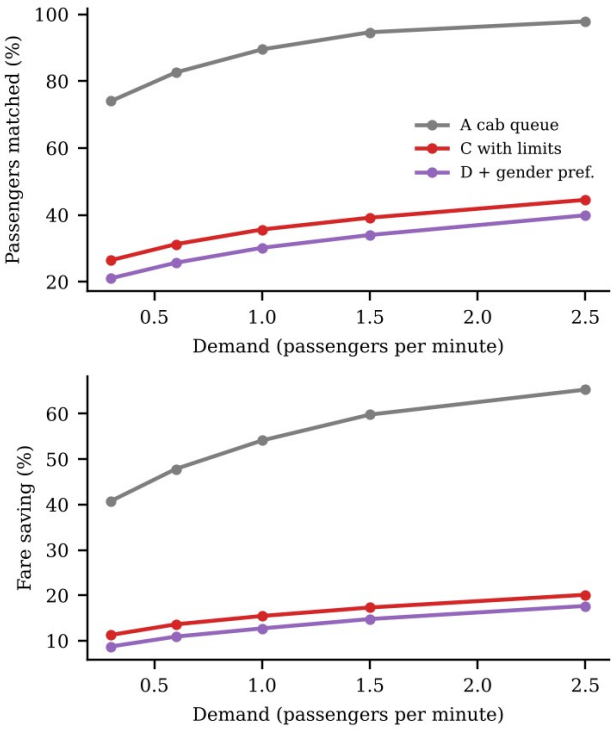


Fig. 5. Effect of demand on matched share (top) and saving (bottom).

More passengers per minute give more possible partners. For policy C the matched share rises from 26.5% at 0.3 passengers per minute to 44.5% at 2.5, and the saving from 11.3% to 20.1%. The cab queue (A) rises from 74.0% to 97.9% matched, but it does not respect individual limits. Shared matching therefore works better at busy times, and quiet hours would need a different design.

F. Same-gender preference

The same-gender option lowers the saving of policy C from 15.5% to 12.7% when applied to the 12 respondents who always want it, to 12.0% for the 19 who want it at least at night, and to 11.3% when the 7 who want it only if free are added. The matched share falls from 35.6% to 30.2%, 28.5% and 27.0% respectively. The cost is therefore 2.7 to 4.1 percentage points. This is a modest cost compared with the effect of the minimum-saving limit.

VI. DISCUSSION

The main result is that the saving passengers demand matters more than how long they wait. With assumed limits, respecting preferences looked inexpensive; with limits from the survey, respecting them reduced the saving to less than a third of the assumed value. A system that wants to serve people who ask for 50% or more would need to tell them honestly what a shared cab can save, or offer them a pair going to the same area.

The results also suggest practical design points: a short holding window of about 2 minutes, or a window set for each passenger, because many respondents are impatient; cabs of two or three passengers; a same-gender option, since 19 of 30 respondents want it at least at night; and safety features such as co-passenger name and photo, an emergency button and a fare guarantee. These points come from simulated results based on 30 responses and have not been tested with real passengers.

VII. LIMITATIONS

The survey has 30 responses from a convenience sample, mostly aged 21–30, so it does not represent travellers in Pune or Mumbai. Ten respondents did not state gender, so simulated gender was assigned at random. Seven respondents mainly travel in Mumbai and two had not taken a cab from a hub in the past year, but all were used, as they are potential users; the destinations in the simulation are Pune zones. Survey answers are stated intentions and not behaviour, and converting ranges to numbers is a simplification. Respondents' rules about luggage (15 would not share with more than one large bag) and destination closeness were not enforced individually. Distances are straight-line distances multiplied by 1.35, the zone coordinates and demand shares are approximate, the tariff is a placeholder, and arrivals are generated and not taken from timetables. The grouping method is a heuristic, and the minimum saving was treated as a strict threshold. The study cannot show that people would adopt such a service. The literature review is limited to papers I could access and verify.

VIII. CONCLUSION AND FUTURE WORK

This paper combined a survey of 30 travellers with a simulation of shared-cab matching for passengers leaving a hub in Pune. When every passenger's limits were respected, the estimated fare saving was 15.5% with 35.6% of passengers matched, compared with 52.3% under assumed limits. The main barrier was the minimum saving that passengers asked for. Holding passengers for no more than 2 minutes kept everyone within their waiting limit, pairs and groups of three were enough, and a same-gender option cost 2.7 to 4.1 percentage points.

Future work is to collect a larger and more varied sample (at least 100 responses, with separate airport and station groups), to replace the placeholder tariff and straight-line distances with the real tariff and road network, to use real arrival data, to test fare-split rules, and to study adaptive windows such as the learning approach of Bao et al. [7]. A prototype with identity checks and trip tracking could then be tested with users.

ACKNOWLEDGMENT

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