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Manuscript 1857

Airport Ground Access Choice Between Transportation Network Companies and Parking: A Case Study of Hartsfield-Jackson Atlanta International Airport

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When commuting to and from commercial airports, passengers can choose different airport ground access modes. Commonly considered ground access modes comprise parking private vehicles at airports, public transport, and commercial operators such as taxis and limos. Compared with these access modes, Transportation Network Companies (TNCs) is a relatively emerging paratransit, that offers door-to-door on-demand ridesharing services. As TNCs became broadly embraced by travelers, more than 90 airports in the United States have officially authorized TNCs to offer ridesharing services to passengers as of December 2016 (Mandle & Box, 2017). These ground access modes improve the commute convenience for passengers traveling from and to commercial airports. Depending upon airports and traveling characteristics, passengers would express different levels of preferences in determining their access mode choices.

Hartsfield-Jackson Atlanta International Airport (ATL) has kept the perch of the busiest airport in the world measured by annual passenger volume between 1998 and 2019. As the headquarter of Delta Air Lines and the focused city for Southwest Airlines, Frontier Airlines, and Spirit Airlines, this mega-hub plays a significant role in serving domestic and international passengers. ATL provides a combination of ground access modes to facilitate its massive passenger flow. With Interstate 85 connecting the domestic terminal and Interstate 75 connecting the international terminal, ATL is easily accessible by motor vehicles. Passengers can choose to drive and park at the airport on-site parking lots. ATL provides various parking services with different parking rates from $10 per day to $36 per day (Hartsfield-Jackson Atlanta International Airport, 2022). TNC services, as an alternative ground access mode, are also allowed to drop off passengers in front of the terminal entrance.

With hundreds of thousands of passengers arriving at and departing from ATL daily, we are intrigued by how these passengers make ground access mode decisions. In particular, we explored how passengers choose between parking and TNC, two of the most commonly used ground access for most airports in the US. To address this issue, a quantitative framework that can measure the overall utility of each access mode became necessary. Also due to the number of potential factors that can influence travelers' decision-making process, a tool that can visualize the effect of individual factors will greatly enhance the acceptance of the quantitative framework. Considering airports' actual authority, we aim to answer this particular question:

How does airports' decision on airport parking rate and TNC surcharge rate affect passengers' ground access mode choices?

Literature Review

Ground access is a frequently addressed topic area in airport-related studies. Many studies use different methods to analyze how passenger determine their ground access choices and explore the factors that passengers would consider.

Panou (2014) conducted questionnaires to analyze the factors impacting the access mode choices of passengers of Athens International Airport (ATH). The results showed that low parking costs and high passenger perceived value made driving more attractive than the use of public transit to travelers flying to and from ATH.

Hermawan and Regan (2017) used a nested logit model to identify how business and leisure passengers make decisions on ground access modes towards the TNCs' fare adjustments. Hermawan and Regan found that both kinds of travelers would give up booking TNC rides when the ridesharing fares equaled the cost of taking a taxi to LAX. Moreover, they found that leisure passengers are more sensitive to the TNCs' fare changes than business travelers while business travelers are more sensitive to travel time.

Gao (2020) concluded that the distance to the airport, daily parking expenses, duration of travel, number of travelers, and type of travelers would affect air travel passengers' decision to use which airport nearby, thus affecting the size of airport catchment areas. Gao utilized the value of travel time saving ($VTTS$) to quantify the travel time cost. Such factors would also affect travelers' selection of ground transportation modes.

Ge et al. (2021) applied a nested multinomial logistic regression model to analyze the ground transportation mode choice of passengers flying out of Dallas/Fort Worth International Airport (DFW). Based on the sensitivity analysis, Ge et al. found that the terminal curb access fee increases with a higher likelihood of selecting remote parking lots.

With the increasing use of TNCs service, ridesharing and its impacts on the operations of other airport ground access modes is another frequently discussed research topic in the field of airport ground access mode choice. Based on the survey responses collected at San Francisco International Airport (SFO) and Oakland International Airport (OAK), Mandle and Box (2017) concluded that the introduction of TNCs can result in a reduction in airport parking and rental car revenues.

Henao and Marshall (2019) analyzed the effect of introducing rideshare service on the parking at San Francisco International Airport (SFO), Denver International Airport (DEN), Portland International Airport (PDX), and Kansas City International Airport (KCI). Through collecting and comparing the parking revenue per passenger before and after the rideshare introduction, Henao and Marshall suggested the parking revenues of all airports consistently declined one or two years after the entry of the rideshare service.

In analyzing how TNCs affect parking demand in three hub airports in Greater New York, EWR, JFK, and LGA, Wadud (2020) conducted a convention analysis to identify the difference in parking demand before and after the entry of ridesharing service. Wadud compared the prediction derived from the Autoregressive Integrated Moving Average model with actual values and

DOI: 10.58940/2374-6793.1857

concludes the introduction of TNCs at focused airports captures a significant portion of travelers who would have otherwise chosen to park.

In examining the impacts of TNCs on the demand of taxi trips to New York LaGuardia Airport (LGA) and John F. Kennedy International Airport (JFK), Dong and Ryerson (2021) compared predicted demands with actual observed data to quantify the impact of TNCs on the other ground access modes. Their study found that in the post-TNC period, taxi operations decreased significantly in contrast with the scenario without TNC services. Meanwhile, they concluded the ridership of AirTrain at JFK maintained a growth trend, and the number of parking transactions at JFK also had a mild decline trend that began before the entry of TNCs.

Reviewing the above studies, it can be summarized that the use of TNC service can lead to significant effects on other ground access modes. Among all reviewed studies, we found only the research by Hermawan and Regan could help answer our research question. However, their research focused solely on examining the one-way effects of adjusting TNC fares on parking and other access modes. It is unknown how the variation in airport parking prices would impact the demand for TNCs. Hence, we are motivated to abridge this research gap.

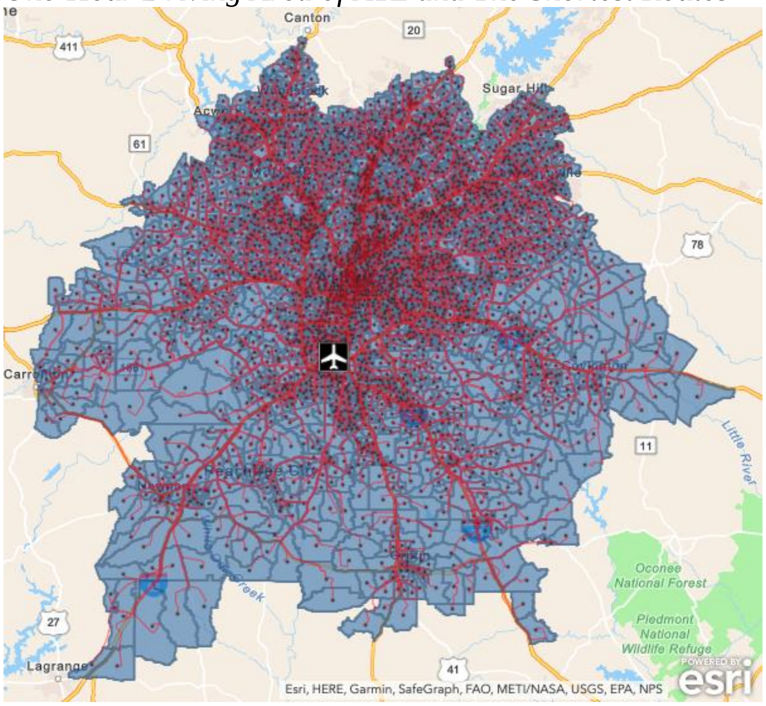
Method

This research is based on the estimation and comparison of the cost of airport parking and using ridesharing services for commuting to and from the airport. The attractiveness of each access mode to passengers can be subject to travel costs and times. If one utility choice costs more or takes more time, the alternative utility will become more economic and efficient. After building the cost estimation models for both utility choices, we exercised control over the parking rate and airport surcharge rate collected by TNCs to identify the variation in the attractiveness of access modes.

As the attractiveness level of using each access mode varies with the distance to the airport, passengers who live far from the airport would choose to park vehicles at the airport as ridesharing services would cost more. It is necessary to define a reasonable service area for both modes. In this study, we focused on the area of one-hour driving distance to ATL, which is derived by ArcGIS. For travelers living out of the one-hour driving area, driving and parking vehicles would be more economical and attractive compared to taking TNCs' rides because the long distance would magnify the cost of taking TNCs rides. In addition, due to the lack of origin and destination address information, we used centroids of all census block groups within the focused area as the substitute inputs. Through utilizing ArcGIS, we identified the fastest routes between ATL and centroids of all census block groups in Atlanta. Refer to Figure 1 for our predetermined area.

Figure 1

One-Hour Driving Area of ATL and The Shortest Routes



Prior to the cost estimation and comparison, we considered three assumptions for our analysis. First, we assumed that these shortest routes are preferred by passengers to and from ATL. Second, we assumed that passengers themselves have no preferred choice between driving-parking and ridesharing services and have sufficient information for decision-making. Third, we only focused on residents within a predetermined driving area and assumed passengers would use the same access mode for their roundtrip. The next two sections detail the cost estimation model for each access mode.

Parking Cost Estimation

The parking cost estimation model consists of both monetary and time costs of a round trip between origins and ATL airport. Based on the previous literature, we considered a few elements for estimating the monetary costs, including the number of passengers, the distance between origins and ATL, the cost for vehicle use, the entire trip duration, and the parking rate. As passengers need to drive vehicles to the airport parking lot, we first built a model for driving cost estimation. We took into account the distance between origins and ATL and the standard mileage rate published by the Internal Revenue Service, which is \$0.585/mile in 2022 (Internal Revenue Service, 2020). The parking cost is only determined by the parking daily on-site price and parking duration. In our analysis, we used the daily long-term parking rate of ATL, which was $10 per day.

Time costs are composed of time spent in the traffic and the commute between the parking lot and the terminal. Dependent upon the traveling purpose, air passengers can be categorized into business and leisure travelers. These two types of passengers have different perceptions about time costs. In addressing the different time value of both kinds of passengers, we utilized the value of travel time saving (VTTS), which refers to the value of time saved by using faster transport. In evaluating the VTTS for both business and leisure passengers, this analysis referred to the latest Value of Travel Time Guidance published by the Department of Transportation in 2016. According to the guidance, VTTS for each kind of traveler is derived by the median hourly wage timed by distinct ratios. 1.46 and 0.5 are the ratios for calculating the VTTS of business travelers and leisure travelers respectively (Office of the Secretary of Transportation, 2016). Based on the Bureau of Labor Statistics, the median hourly wage for all occupations in 2021 was $22.00 (U.S. Bureau of Labor Statistics, 2020). Hence, the VTTS of business passengers and leisure travelers is $32.12 per hour and $11.00 per hour individually. The cost of one-way driving time is the function of driving, the number of passengers, and the traveling purpose. The cost of time spent commuting from parking lot to the ATL terminal includes the time of taking shuttle rides, as parking lots are not directly connected to the ATL terminal. Table 1 details the components of driving and parking costs.

Table 1

Parking Cost Estimation Model

Travel purpose (j)			
Number of passengers (N)			
Travel duration (D)			
Monetary cost		Time cost	
Driving expense	Parking expense	Trip time (t_t)	Time of commuting from parking lot to terminal (t_s)
mileage (r)*distance (d)	price (p)*D	$VTTS_j$*N*t_t	$VTTS_j$*N*t_s

Ridesharing Cost Estimation Model

Due to the limited data of TNCs, we only select Uber as the representative of TNCs service at ATL. Uber ridesharing cost comprises the fare charge and time spent during the entire trip. The monetary cost of the Uber service is composed of several elements. It is noted that all price items of Uber ridesharing cost are effective as of the time of doing this study, which was May 2022.

First, ATL charges Uber an airport surcharge rate for pickup rides. Airport surcharge rate collected by Uber is \$4.35, which is subject to pricing change. Second, travelers are charged a base fare of \$2.69 as well as a predetermined booking fee while ordering their trips on the Uber app. However, the pricing mechanism of booking fees is not disclosed by Uber. In estimating the booking fee, we conducted several experiments, where we selected different locations in Atlanta as destinations, recorded the booking fee for each trip, and estimated the calculation function between the ride-booking fee and trip distance. Our experimental results show that Uber's booking fee is the function of the distance between ATL and origins. Moreover, we observe a threshold distance of 10 and 20 miles. If the trip distance is not greater than 10 miles, \$3.13 is the booking fee Uber charges. Otherwise, the booking fee equals the sum of \$3.13 and the fee on the distance over 10 miles but less than 20 miles. When the distance is over 20 miles, Uber will charge a fixed booking fee of \$10 for the trip.

Travelers need to pay the operating fare which is subject to trip distance and time. This operating fare is based on the minimum fare, per-mile fare, and per-minute fare. If the trip distance does not meet the 10-mile threshold distance, Uber will only charge \$9.03 as the operating fee for the trip. Otherwise, extra fees except \$9.03 will be imposed, which are over-10-mile distance multiplying \$0.46 per mile and whole trip time multiplying \$0.45 per minute. Moreover, actual Uber fare varies with the real-time supply-and-demand relationship. When ridesharing requests exceed the real-time supply, Uber will utilize the surge pricing algorithm. Uber would charge customers a higher fare through multiplying the operating fee by a surge pricing multiplier (e) (Uber, 2022).

While requesting the trip to ATL on the app, travelers usually need to wait for the driver to pick up them. When calculating the time cost, we assume that Uber drivers are available for pick-up orders at the pickup area. Hence, passengers do not have to wait at the pick-up area. t_w denotes the time for waiting for Uber drivers. In addition, the cost of time spent on the whole Uber trip is calculated in the same way as driving and parking. Furthermore, as the TNC pick-up area is not aligned with the terminal entry but north economy parking lot, passengers can take shuttles to get to the pick-up area. For trips ending at ATL, TNC vehicles can drop off passengers directly at the terminal departure level, we only consider the time spent in commuting from ATL terminal to the TNC pickup area. Table 2 itemizes the costs of taking Uber ridesharing service.

DOI: 10.58940/2374-6793.1857

Table 2
Uber Ridesharing Cost Estimation

<table>
<tr><td colspan="7">Travel purpose (j)</td></tr>
<tr><td rowspan="7"></td><td colspan="6">Number of passengers (N)</td></tr>
<tr><td rowspan="6"></td><td colspan="5">Travel duration (D)</td></tr>
<tr><td rowspan="5"></td><td colspan="2">Monetary cost</td><td colspan="2">Time cost</td></tr>
<tr><td>Booking rate (B)</td><td>Base rate (I)</td><td>Waiting for pickup (t_w)</td><td>Trip time (t_t)</td></tr>
<tr><td>max ($3.13, (d - 10)*0.6+$3.13, $10)</td><td>$2.69</td><td>$VTTS_j * N * t_w$</td><td>$VTTS_j * N * t_t$</td></tr>
<tr><td>Operating fare (O)</td><td>Airport surcharge rate (S)</td><td colspan="2">Time of commuting from TNC pickup area to terminal (t_s)</td></tr>
<tr><td>max ($9.03, $9.03 + (d-10)*0.46+$t_d$*60*0.45)*(1+e)</td><td>$4.35</td><td colspan="2">$VTTS_j * N * t_s$</td></tr>
</table>

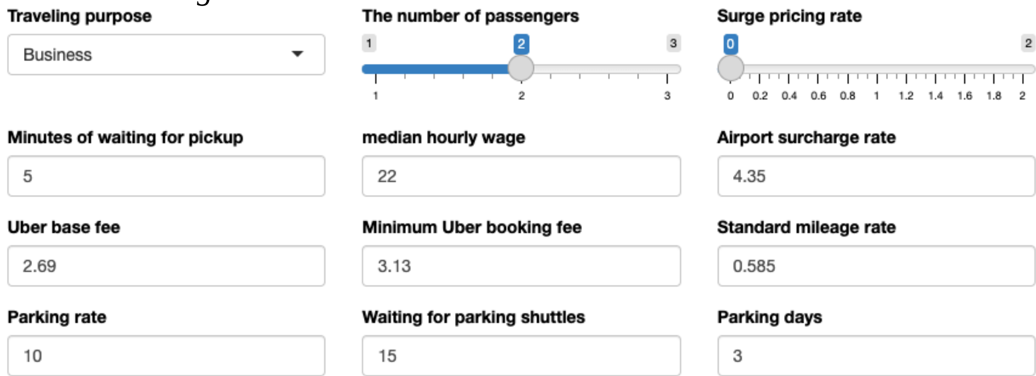
Web Application Design

Through adopting the R Shiny package (Chang et al., 2021), we designed an interactive visualization web application to answer the research question. Airport parking policymakers and air passengers can visit and use our web application via https://avationresearch.shinyapps.io/ATL_Parking_Uber/. Our application is composed of one scenario setting page and one visualization page.

On the scenario setting page, users can modify the inputs for setting up different scenarios, such as raising airport parking rates or changing the parking duration. In demonstrating our proposed web app, we built three scenarios, which were remaining both parking price and airport surcharge rate constant, raising the parking price by 20% and keeping the airport surcharge rate constant, as well as increasing the airport surcharge rate by 20% and remaining parking price constant. For all three scenarios, we set up the number of passengers to two. Also, we use three- and six-days as the trip duration for both business and leisure travel. Figure 2 presents the scenario of keeping both focused rates constant for three-day business travels.

Figure 2

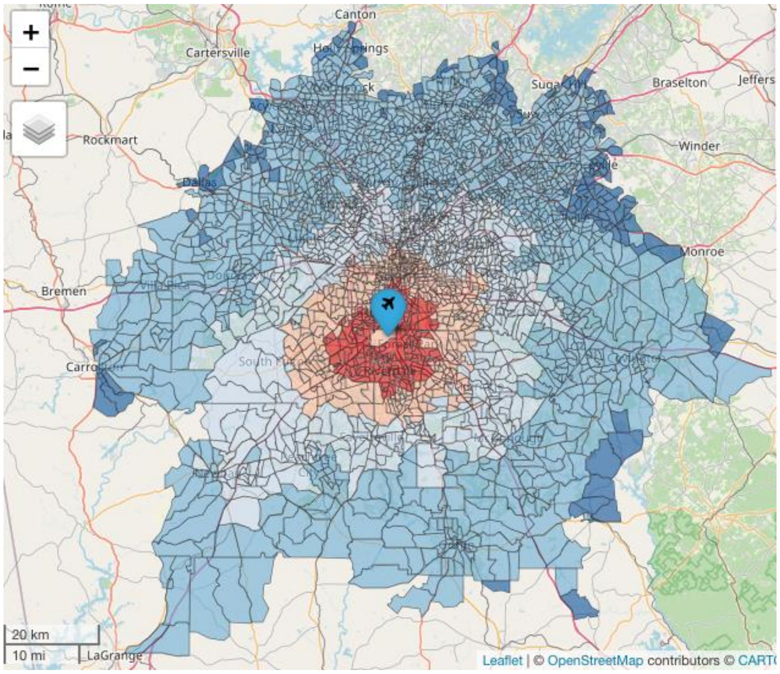
Scenario Setting



Visualization page is designed to present the corresponding outputs for predetermined inputs. Through changing inputs in the scenario setting, our application can calculate the commute cost of parking as well as taking Uber rides to access ATL. Moreover, the cost difference of using two modes is taken as a measure to identify which one is the most economical utility choice within the one-hour driving area. In highlighting the utility advantage of each access mode, we take into account seven numeric limits to mark ranges, which are negative infinity, -30, -15, 0, 15, 30, and positive infinity. We also import U.S. population data on the census block group level through utilizing the U.S. Census Bureau APIs in RStudio. Based on the inputs, our application summarizes the population as well as the number of census block groups within the utility advantage area. We used both demographic indicators to quantify the potential market size of each access mode under different scenarios. It is noted that all results are based on the area of one-hour driving distance to ATL. Refer to Figure 3 for the visualization result of the predetermined scenario setting.

Figure 3

Visualization Results



Note. CBGs are short for census block groups.

Results

By changing the traveling purpose, we derived the results for both business and leisure passengers under the aforementioned three scenarios. Figures 4, 5, and 6 show the utility advantage area and corresponding demographic information for leisure travel. Table 3 shows the demographic information for three- and six-day leisure travels. Based on the results, it can be found that travel duration is essential for passengers to determine utility choices. In other words, more people could utilize Uber services instead of parking in the case of longer trip duration. This finding is consistent with the previous conclusion that trip duration is significant to the travel choice of passengers (Gao, 2020).

Figure 4

Utility Advantage Area of 3-day and 6-day Leisure Travel at the Current Rate

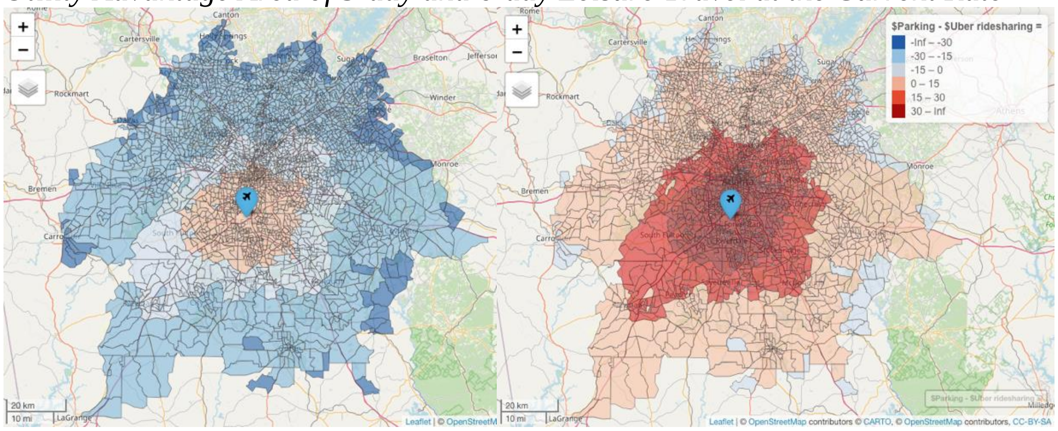
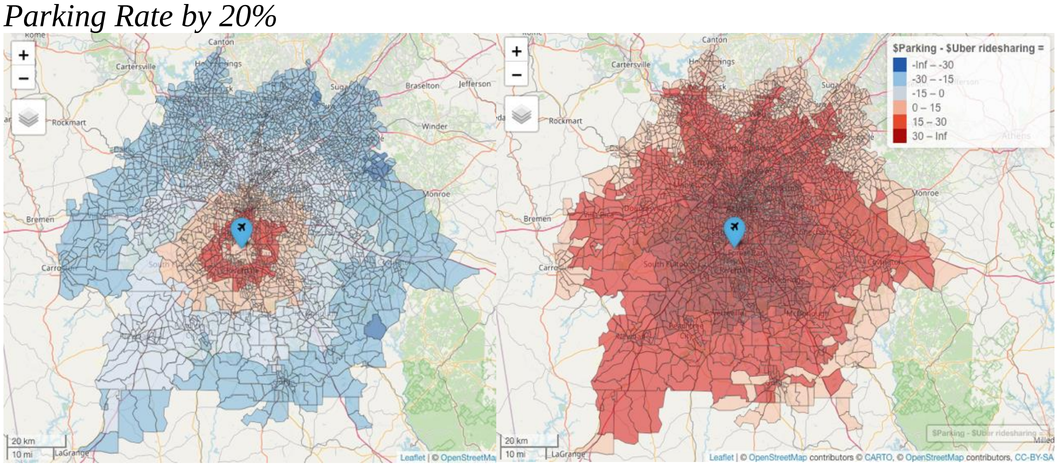


Figure 5

Utility Advantage Area of 3-day and 6-day Leisure Travels When Increasing Parking Rate by 20%



DOI: 10.58940/2374-6793.1857

Figure 6

Utility Advantage Area of 3-day and 6-day Leisure Travels When Increasing Airport Surcharge Rate by 20%

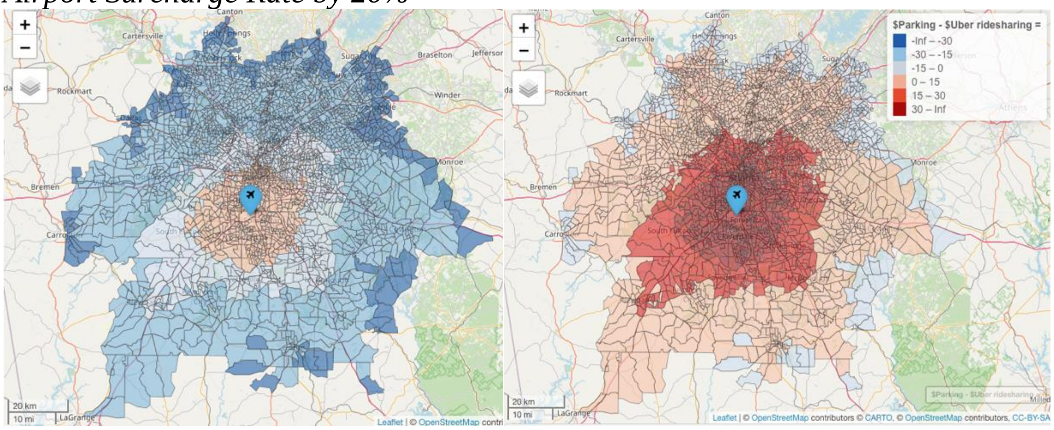


Table 3

Demographic Information of Leisure Travels Under Different Scenarios

Access Choice	Scenarios	3-day		6-day	
		Population	# of CBGs	Population	# of CBGs
Parking	Base rate	4,046,326	2,644	456,449	261
	P raised by 20%	3,751,807	2,438	0	0
	S raised by 20%	4,095,401	2,680	613,311	358
Uber	Base rate	898,497	703	4,488,374	3,086
	P raised by 20%	1,193,016	909	4,944,823	3,347
	S raised by 20%	849,422	667	4,331,512	2,989

Note. CBGs are short for census block groups.

It is noted that as one moves farther from ATL, the difference between parking costs and Uber costs initially increases and then decreases. This phenomenon can be explained by Uber's tiered pricing structure. Within a certain threshold distance, some Uber costs, such as operating fees and booking fees, remain fixed, regardless of the overall trip distance. However, once this threshold distance is surpassed, the incremental cost of using Uber becomes higher than the cost of parking, making parking a more attractive option. This effect is particularly pronounced in scenarios with shorter travel durations.

To analyze how TNC services and airport parking attract business passengers, we followed the same procedures to obtain our results. Figures 7, 8, and 9 present the visualizations of these results, while Table 4 provides a summary of demographic information for the corresponding scenarios.

Figure 7

Utility Advantage Area of 3-Day and 6-Day Business Travels at the Base Rate

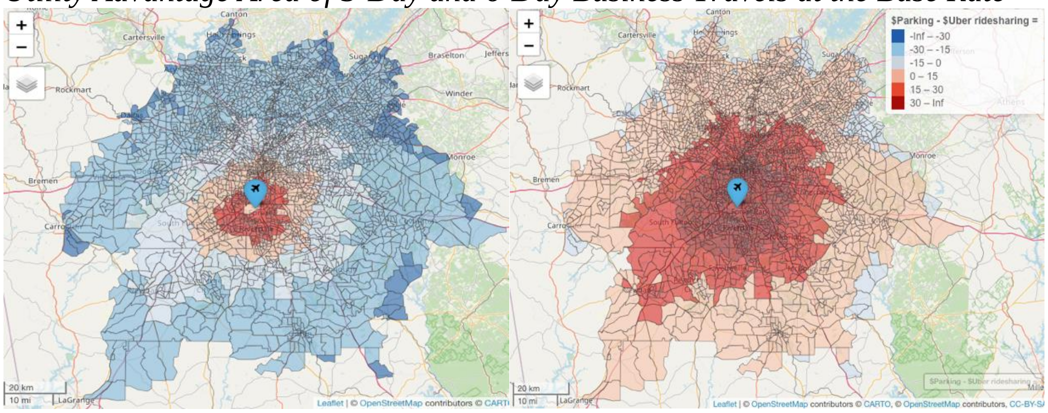


Figure 8

Utility Advantage Area of 3-Day and 6-Day Business Travels When Increasing Parking Rate By 20%

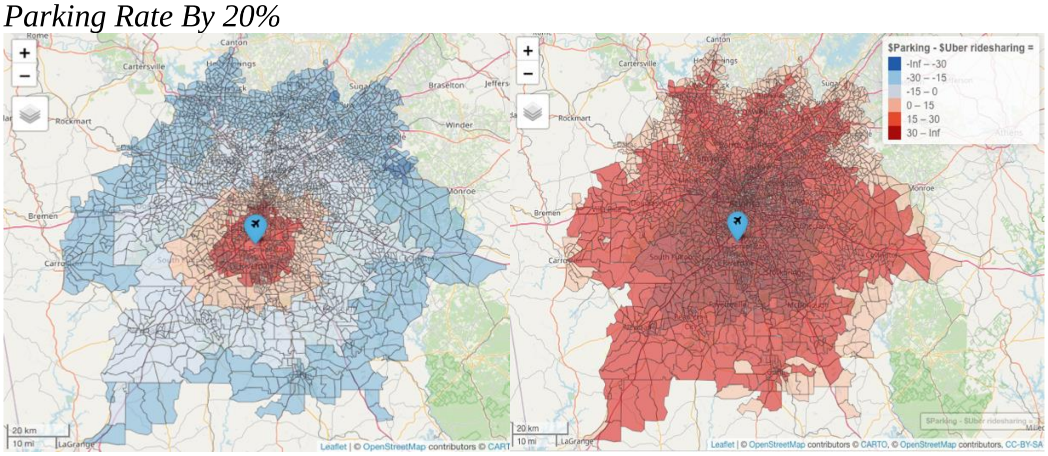


Figure 9

Utility Advantage Area of 3-day and 6-day Business Travels When Increasing Airport Surcharge Rate by 20%

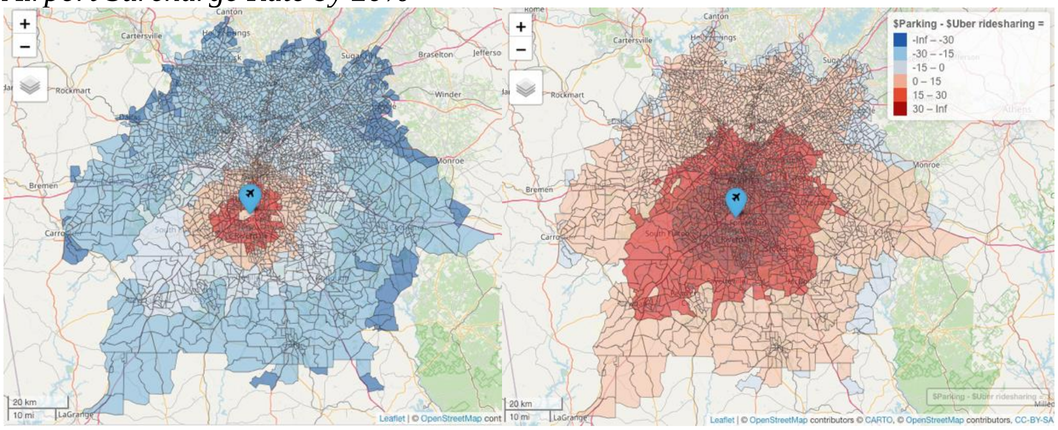


Table 4

Population for Business Travels Under Different Scenarios

Access Choice	Scenarios	3-day		6-day	
		Population	# of CBGs	Population	# of CBGs
Parking	Base rate	3,985,767	2,599	273,658	158
	P raised by 20%	3,709,807	2,405	0	0
	S raised by 20%	4,023,244	2,627	376,047	215
Uber	Base rate	959,056	748	4,671,165	3,189
	P raised by 20%	1,235,016	942	4,944,823	3,347
	S raised by 20%	921,579	720	4,568,776	3132

Conclusions and Implications

In this study, we proposed a cost-based ground access choice model to measure the attractiveness of TNC and parking travelers of different purposes living in the Atlanta Metropolitan Area. Our analysis was based on the assumption that travelers are informed and rational when it comes to choosing the most economical mode to access airports. The calculation of ground access utility (cost) considers both the monetary and time costs to simulate the actual decision-making of everyday travelers. We built an interactive visualization application using the R Shiny package (Chang et al., 2021) to visualize the effect of key parameters on the cost-based utility of airport ground access choices.

Our study has the potential to help airports simulate and predict the impact of rate adjustments for one ground access mode on the other mode. When airports exercise control over parking rates or TNC surcharge rates, they need to be aware of potential tradeoffs between different access modes. Our application can display the number of census blog groups excluded or included by the proposed rate hikes and the corresponding population living within these block groups. This application can benefit TNCs' business as well. TNC operators can simulate how to better compete with the choice of parking at airports or attract passengers to TNC services through providing competitive pricing. Furthermore, our study could help passengers make informed decisions on the airport ground access choice.

It needs to be noted that the cost estimation of Uber trips is the result of reverse engineering based on several sample queries on the Uber mobile app in May 2022. Uber, as a commercial operator, may update their pricing model or parameters used in the model without further notice. When applying the web app, potential users should be aware of this, and update to the latest model for current results. Similarly, users need to refer to relevant government agencies' websites for the current mileage rates and VTTS. Also, this model only applies to the generic scenarios in which both parking and TNC rides are available. In some situations, such as a full parking lot, the model cannot be applied.

In weighing airport ground access choices, we only consider monetary costs and the value of time, which are represented in dollar values. However, travelers' decision-making process can be also affected by other factors, which are subjective and difficult to quantify. For instance, travelers tend to form long-term habits of selecting transportation modes based on their past trip experiences and perceptions regarding each access mode. Travelers tend to have individual opinions towards each mode in terms of comfort, safety, sanitation, punctuality, and other facts that cannot be easily quantified. In certain times and situations, the habits and perceptions would outweigh the monetary costs when making decisions. For example, during the COVID-19 pandemic, people have more concerns on public health risks and are more likely to choose to drive their vehicles instead of taking TNC rides, even though parking could cost more.

There exist some limitations in our analytical model. First, we only take into account Uber business due to the missing data of other ridesharing companies. Hence, the validity of our web application is compromised by the lack of data. Second, we only consider Uber X and private vehicles with a maximum accommodation of three passengers in our model. For a larger group of passengers, they could use Uber XL or a larger full-sized vehicle to commute to and from the airport. As this scenario is not considered in our study, this is another limitation. Moreover, pricing parameters used in the cost calculation model are not always consistent, such as standard mileage rate, airport daily parking rate. They are subject to national inflation, business policies, etc. The fluctuating changes on these factors could compromise the robustness of our web application.

Furthermore, we have recommendations for future researchers. First, we estimate some fare breakdowns in the Uber cost estimation model by conducting experiments on Uber app in May 2022. It is recommended that future researchers utilize other approaches in estimating the fare breakdowns that are not available to the public, which can develop the validity and effectiveness of our application. Second, we suggest future researchers consider the real-time traffic in Atlanta. Traffic jams at different times can lead to extra driving time, thereby increasing the access cost. As one variable fare of Uber is subject to the driving time and distance, traffic congestion during rush hours will increase the cost of taking Uber. Hence, it is likely that passengers would prefer the choice of parking instead of booking Uber rides.

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