12 Reducing Parking Pressure by Sharing Resources

YAOLI WANG

Abstract

This chapter describes a scenario where ridesharing is introduced in urban parking to relieve the pressure of finding a parking site in the city center. A significant amount of time is wasted in cruising for a parking lot according to both life experience and research findings. Although a few policies and strategies have been tested, the middle ground between individual flexibility and reduced travel demand is not yet well accommodated. Therefore, I report of a joint model of ridesharing and parking: people drive from their front doors to a satellite parking site to share rides, and travel to a similar destination in the city center so that parking demand is reduced.

Keywords

Ridesharing, smart parking, travel behavior

12.1 Current Situation and Issues of Urban Parking

Cities are confronted with serious parking problems. Especially in countries with high population density, for example, in the metropolises of China, India, and Japan parking is always a challenge. In the past decades, a couple of countries, especially in Asia, with a swift growth of economy, have gone through a surge of cars on the roads. In India, the amount of cars grew from 55 millions to 210 millions within the time period between 2001 and 2015 (Parmar et al., 2020). The policy to encourage car purchasing in Beijing after the SARS outbreak in 2003 has changed the travel behaviors of Beijing residents, which triggered the world-known challenge of Beijing's traffic congestion. People started to chase after private transport afterwards, which is also assumed as a label of higher social status and as higher travel flexibility.

At least two issues emerge with higher car ownership: limited parking space and wasted cost in searching for parking. Crowded parking space is normal in Chinese neighborhoods. Sometimes roads may be so occupied and narrow that a driver cannot park the car without scratching other cars if no second person is helping to guide the driver's operation. If coming back home late, residents may have to call their neighbors to make some space for their cars. To avoid

https://doi.org/10.34727/2021/isbn.978-3-85448-045-7_12

the trouble, some people place scooters, bikes, or miscellaneous stuff to take a parking space. Within neighborhoods of higher parking demand people have to pay about 200,000 CNY (30,000 USD) for private parking permits in addition to the parking fee. In Australia, parking space in a city center for a whole day can be as expensive as a parking fine[1]. Hence, globally households are taking increasing resources from public parking space.

For the other issue, cruising for a parking lot is time-consuming. The time searching for parking at the urban center can increase exponentially with the occupancy rate of parking spaces (Millard-Ball et al., 2014). The wasted time and fuel adds significantly to the costs of travel (Shoup, 2006). On the other hand, even though people are aware of the risk of prolonged cruising, they still cruise for on-street parking at the expense of marginal fuel cost to avoid the definitive high fees for off-street parking, which essentially is a trade-off between money and time (Shoup, 2006; Van Ommeren et al., 2012). If a driver is lucky enough to quickly find an empty parking spot, the driver saves. However, if parking space is saturated, even paying for parking cannot solve the issue.

12.2 Exploration for Parking Solutions

The battle against the parking issue continues worldwide. Amongst the mutually related parking management strategies mentioned by Litman (2008), three strategies are remote parking, mobility management (e.g., change of transportation mode), and parking pricing, which together yield 10 %–30 % parking demand reduction.

Mobility management aims to control the amount of cars on the road. To make up for overselling of cars as well as the related issues, the Chinese government carried out innovative policies. Beijing launched car plate restrictions based on the last digit of car plate in 2009, aiming to relieve its notorious traffic congestion[2]. Some households hence decided to buy two cars with different last digits so that they could drive everyday. Then Beijing rolled out a car plate lottery in 2011 which demands that car purchasers join a pool to win a chance of obtaining a car plate. The policy now is inclined to families with no car[3]. If a person buys a new energy car, the buyer does not need to join the lottery but has to queue for it. While the game between general public and policies to some extent retards the growth of car occupancy, the policies cannot solve the issue of parking, and still may deteriorate the situation.

Another strategy explores new technologies to solve the difficulty in sourcing for parking. For example, there are applications on the market that find and

[1] `https://bit.ly/3vMl2Xb` – Sydney Morning Herald, 8 September 2015
[2] `https://bit.ly/2P1gZWj` – Global Times, 17 April 2018
[3] `https://bit.ly/393jHBd` – China Daily, 3 June 2020

navigate to available parking spaces [4], that track availability of parking lots on the fly [5] (Lin et al., 2017), that assist drivers to reserve or retrieve parking spots in real time (e.g., Yan et al., 2008), and that customize the price of parking to vehicles (Ayala et al., 2012). Crowd sensing offers another information source for real-time parking information (Bock and Di Martino, 2017). Dynamic dissemination of parking resources reduces the competition for parking spots (Chai et al., 2017). However, when parking demand is higher than supply, drivers have to wait or cruise for parking anyway.

Accordingly, strategies have been established to mitigate the demand for parking. The extreme case is to take public transport in lieu of driving. Public transport is typically well developed in metropolitan areas. However, if the trip origin and destination differ significantly in population density as well as parking space, e.g., traveling from peripheral suburbs with low public transport accessibility to city center with high parking fee, neither taking public transport nor driving is economic. Therefore, compromises such as Park-and-Ride (P&R) come to the modal mix, where parking is co-located with public transport nodes such as a bus stops or railway stations. It saves time for cruising and relieves the over-saturated space for parking in the city center. P&R, however, is neither feasible where public transit is not conveniently developed, nor necessary where parking space is sufficient. Although P&R reduces parking demand effectively, it brings side effects in the meantime. Flexibility has to be compromised by waiting for public transport and driving to specified parking sites.

A second solution to reduce parking demand is ridesharing. Instead of individuals each driving their own car, they can share rides with each other, no matter whether this is by pre-arranged carpooling or real-time ridesharing. The benefit of ridesharing is that parking demand is reduced while it preserves certain flexibility compared with public transport (Carter and O'Connell, 1982). A couple of drawbacks exist in ridesharing as well. Ridesharing is far less popular in reality (Dubernet et al., 2013) than expected based on its proven potential (Tachet et al., 2017). Privacy and trust are significant factors that obstruct people from joining ridesharing. People are less willing to share rides or detour for strangers, nor would they like to disclose the specific location of their homes. Hence, Wang et al. (2017) argue that social acquaintance should be given sufficient consideration in the matchmaking for ridesharing. To protect privacy, launch pads are proposed by (Rigby and Winter, 2015) to disguise the accurate home location. Sharing rides from a public pickup spot is also driven by such motivation (Stiglic et al., 2015).

[4] `https://bit.ly/3tJcLRS` – Chinese Government, 25 September 2017
[5] `https://bit.ly/3vQmRlE` – China Daily, 1 September 2017

12.3 Vision of a New Mode: Park-and-Ridesharing

As a solution to the above-mentioned issues, this chapter suggests to share rides from a satellite parking lot, named *Park-and-rideSharing* (P&S). The P&S model incorporates remote parking that relieves parking pressure in the city center and preserves home location privacy, and mobility management in the last leg to the final destination for higher flexibility. There are a few advantages:

- Shared rides reduce parking demand in urban central areas;
- Sharing from a satellite parking protects privacy;
- Shared rides increase flexibility compared with P&R.

To validate the benefit of the model, three scenarios have been compared: driving from home to city center, driving to satellite parking and transferring to a public transit (P&R), and the proposed park-and-ridesharing (P&S). The second scenario is seen in daily life and has been studied (Karamychev and Van Reeven, 2011). This chapter focuses on the pros and cons of the third scenario, trying to provide a new idea to the general public and let the readers explore on their own.

12.3.1 The Framework of the Model

The conceptual model considers a simplified theoretical scenario as illustrated by Figure 12.1 with the factors as demonstrated in Table 12.1. The conceptual model can be extended to real-world scenarios. As a validation of the potential of P&S in Beijing, a study of Beijing with trajectories from all over the city to the Olympic Park is ongoing in the time of writing this chapter.

The scenario consists of a *city center* with a *central parking lot* and an inbound road with a *satellite parking lot*. People are assumed to travel to the city center only to stop at one location for a specific period, and leave the city back to the satellite parking. Not considered is trip chaining, i.e., a travel with a sequence of several destinations.

Travelers only make decisions from their egocentric perspective. Whether or not to share a ride is a trade-off between time and money, with influential factors of looking for parking, time of waiting for rides, money spent for parking, petrol, and so on. Some subjective factors also contribute to the decision as a transformed cost in time or money, e.g., the willingness to join ridesharing. There are four types of travelers in this model:

1. a solo driver with private car,
2. a passenger taking public transit,

3. a ridesharing driver with a private car,
4. a ridesharing passenger.

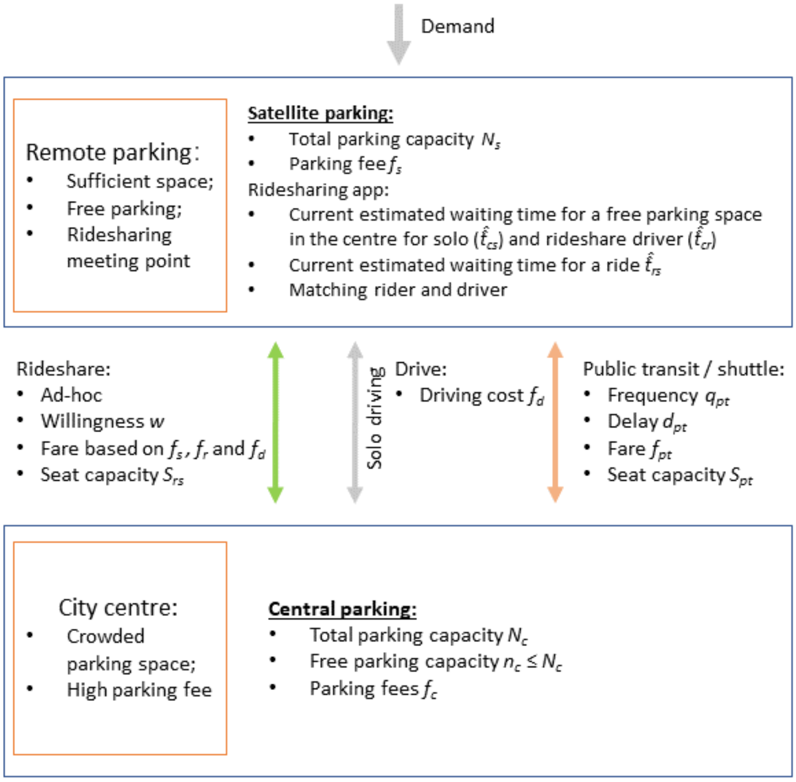

Figure 12.1: The conceptual scenario of the P&S system.

Each type of traveler is associated with a cost function as the utility of being that type. In the baseline scenario where ridesharing is not available, travelers can only choose between being a solo driver or using public transportation to get to the city center.

12.3.1.1 Scenario Setting

The *central parking lot* with a capacity N_c is open for both ridesharing drivers and solo drivers. However, ridesharing drivers are prioritized over solo drivers if queuing for a spot. Ridesharing drivers are rewarded by a reduced central parking fee. The *satellite parking lot* is assumed to be sufficient for the demand. In a real city, any number of satellite parking lots close to the center can be identified, e.g., roadside parking, commercial parking lots, or parking lots at railway or subway stations. Satellite parking lots not only allow people to park but also

Table 12.1: Input and output parameters of the model.

Type	Parameters
Input	Traffic flow distribution by hour of day
	Average parking duration
	Parking fees: central parking for solo-driving and ridesharing, and satellite parking
	Maximum capacity at satellite and central parking lots
	Available parking capacity at satellite and central parking
	Public transit travel fare
	Costs for driving (including gas, car usage, congestion charge)
	Maximum capacity of ridesharing vehicle or public transit
	Subjective willingness to do ridesharing
	Public transit frequency
	Public transit delay compared with driving
	Individual value of time, to convert time to monetary cost
Output	Total travel cost as defined by each case study
	Ratios of each traveler type

function as a meeting point for a ride in this scenario. The satellite parking fee, which is either cheaper than central parking or free of charge, costs the same for ridesharing and solo drivers.

The cost of cruising for parking is highly related to traffic flow volume, the time spent in the city, and the searching time for an empty space in the central parking are input parameters. To facilitate decision making, this model considers a smartphone application that retrieves the parking situation on the fly and broadcasts to travelers. Ridesharing vehicles can use the smartphone application to reserve a parking spot before they actually reach the central parking lot. People at the satellite parking are informed of current estimated waiting time for a ride as well as for the average waiting and searching time for parking at the central parking lot to support their decision making.

In case a traveler cannot find a ride outbound from city, the model assumes a public transit system between satellite and central parking lot. This assumption is pragmatic and is taking place in real life. The efficiency of the public transit system is a parameter that affects travelers' preference to ridesharing. The utility of public transit and also the baseline scenarios with no ridesharing available are studied.

The output of the system – the total travel cost – includes three parts: The total time duration for travel converted into monetary unit, the monetary cost of the travel, and the intrinsic willingness cost to ridesharing converted into monetary unit. The total travel time is calculated from making the mode choice at the satellite parking lot to getting back to the car at the satellite parking lot, excluding the time for activities at the city center. This time includes waiting time for rides or for public transit, travel time for the last leg, and search time for a parking space in the central parking lot (as a solo-driver or as a ridesharing driver). Monetary costs include cost split for ridesharing, cost for solo driving, parking fee and public transit fee. Willingness cost approximates the inconvenience of ridesharing converted to monetary cost, such as psychological uneasiness or time and money spent for cleaning, which only occurs to ridesharing participants.

12.3.1.2 Ridesharing Strategy

Each driver arriving at the satellite parking calculates their utility and decides to be one of the four types of travelers. The drivers who choose to share rides will join the ridesharing population at the satellite parking lot. Ridesharing is assumed to introduce no extra waiting cost for ridesharing drivers at the satellite parking lot. They only pick up passengers if they are queuing at the satellite parking lot instead of waiting for passengers. The driver re-estimates the utility of each travel mode and picks the second best in the case there is no matched passenger. On the other hand, a passenger (ridesharing or public transport) is constantly recalculating the travel mode utility since the lapse of time affects. Hence they may switch mode and become another type of traveler.

12.3.1.3 Deciding the Travel Mode

Travelers' choices of travel modes are based on the estimated utility of each mode. Utility functions are decided according to prior knowledge or theories in behavioral economy or other related fields. As aforementioned, it is a comprehensive factor of the input parameters in Table 12.1 and beyond. A traveler in this scenario always chooses the travel mode of minimal cost. Inbound and outbound travel costs are different. Exact outbound costs are difficult to estimate because ridesharing is not guaranteed on the way back. However, travelers do consider the outbound costs when deciding the overall travel mode in the inbound travel. Public transit thus is provided as a backup choice when estimating the cost. This is not to deny the efficiency of public transit. Sometimes public transit can be more efficient than private driving. It is just applied as a baseline mode. On the way back, passengers split costs with drivers as well. Drivers are supposed to pick up passengers who are waiting in the queue. Solo drivers remain to drive alone on their way back for the sake of their subjective willingness.

12.3.1.4 Results

This P&S scenario has been tested with simulations and is currently being tested by real-world data analysis. A series of simulations with different parameter settings yield indicative findings. Ridesharing has been seen to reduce travel time and travel cost, especially at peak hours when ridesharing is advantageous over other options. Higher volume of travel decreases waiting time for a ride, while it raises the time for cruising if driving alone. Human subjective value of time is converted to money as a factor of behavior utility. There is a sweet spot between spending more time and spending more money. Ostensibly ridesharing also provides resilience to an urban traffic system. The process is a self-adaptive system to mitigate traffic burden when travel demand is high, which brings environmental and social benefits in the meantime. Another issue is the relation between public transit and ridesharing. Although they seem to be competitive at the first glance, they can be supplementary to each other. The decision to do ridesharing is a comprehensive outcome instead of simply travel efficiency. Some people prefer ridesharing intrinsically maybe for a more flexible schedule and maybe for more private space. However, they may hesitate to give up solo driving in the extreme case when a ride cannot be found on the way back. Therefore, a good public transit system ensures travelers to do ridesharing even if the return trip does not have a matched ride.

12.4 Looking Forward to the Future

As I have discussed, the future of urban parking is challenging especially in global cities with high population density and high ratio of private car usage. A solution can solve one aspect of a problem, but sometimes may even make the flip side worse. For example, new energy vehicles indeed exude significantly less pollution and greenhouse gas, but the replacement of petrol cars misleads to a perception that a city can tolerate more cars. Consequently parking is likely to be put into a worse situation, or a city is forced to sprawl even more which in turn stimulates people to buy more cars.

Solving the inner-urban parking problem is essentially a change of travel mode and travel behaviors. This chapter reports a conceptual model called *Park-and-Ridesharing*, showing significant potential by simulations. However, its implementation still requires careful planning and testing. Investigation of real world trajectories is conducted as a proof of concept. The empirical analysis has confirmed a significant ratio of trajectories matched for ridesharing. A next step could be to carry out tests in partnership with local governments. For that purpose, many interwoven technical and social challenges should be addressed, e.g., dynamic ridesharing strategies and techniques, social adoption of ridesharing, and real-time parking information updates. Researchers, engineers, and policy makers from multiple fields need to sit together and work that through.

Bibliography

Ayala, D., Wolfson, O., Xu, B., DasGupta, B., and Lin, J. (2012). Pricing of parking for congestion reduction. In *Proceedings of the 20th ACM SIGSPATIAL*, page 43.

Bock, F. and Di Martino, S. (2017). How many probe vehicles do we need to collect on-street parking information? In *International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS)*. IEEE.

Carter, E. C. and O'Connell, K. (1982). Ridesharing element of parking facilities for industrial employment centers. Report DTFH61-80-C-00057, Federal Highway Administration, U.S. Department of Transportation.

Chai, H., Ma, R., and Zhang, H. M. (2017). Search for parking: A dynamic parking and route guidance system for efficient parking and traffic management. Technical report.

Dubernet, T., Rieser-Schüssler, N., and Axhausen, K. W. (2013). Using a multi-agent simulation tool to estimate the car-pooling potential. In *92nd Annual Meeting of the Transportation Research Board*, pages 13–0866, Washington, DC.

Karamychev, V. and Van Reeven, P. (2011). Park-and-ride: Good for the city, good for the region? *Regional Science and Urban Economics*, 41:455–464.

Lin, T., Rivano, H., and Le Mouel, F. (2017). A survey of smart parking solutions. *IEEE Transactions on Intelligent Transportation Systems*, pages 1–25.

Litman, T. (2008). Parking management best practices. *ITE Journal on the Web*, 78(September):69–73.

Millard-Ball, A., Weinberger, R. R., and Hampshire, R. C. (2014). Is the curb 80% full or 20% empty? Assessing the impacts of san francisco's parking pricing experiment. *Transportation Research Part A: Policy and Practice*, 63:76–92.

Parmar, J., Das, P., and Dave, S. M. (2020). Study on demand and characteristics of parking system in urban areas: A review. *Journal of Traffic and Transportation Engineering (English Edition)*, 7(1):111–124.

Rigby, M. and Winter, S. (2015). Enhancing launch pads for decision-making in intelligent mobility on-demand. *Journal of Location Based Services*, 9:77–92.

Shoup, D. C. (2006). Cruising for parking. *Transport Policy*, 13(6):479–486.

Stiglic, M., Agatz, N., Savelsbergh, M., and Gradisar, M. (2015). The benefits of meeting points in ride-sharing systems. *Transportation Research Part B: Methodological*, 82:36–53.

Tachet, R., Sagarra, O., Santi, P., Resta, G., Szell, M., Strogatz, S. H., and Ratti, C. (2017). Scaling law of urban ride sharing. *Scientific Reports*, 7:42868.

Van Ommeren, J. N., Wentink, D., and Rietveld, P. (2012). Empirical evidence on cruising for parking. *Transportation Research Part A: Policy and Practice*, 46:123–130.

Wang, Y., Winter, S., and Ronald, N. (2017). How much is trust: The cost and benefit of ridesharing with friends. *Computers, Environment and Urban Systems*, 65:103–112.

Yan, G., Olariu, S., Weigle, M. C., and Abuelela, M. (2008). SmartParking: A secure and intelligent parking system using NOTICE. In *IEEE Conference on Intelligent Transportation Systems, Proceedings, ITSC*.