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Carpool-Based Parking Assignment Policy

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POLICY BRIEF

BACKGROUND AND OBJECTIVES

Excess demand for parking, and its associated traffic, is commonly a severe problem in cities. Often, increasing parking capacity is physically impossible, economically infeasible, or environmentally undesirable. Even when increasing parking capacity is viable, the long-term benefits of such projects are unclear given latent demand; more parking spaces invites more traffic, pollutant emissions, noise, etc. Increasing parking capacity also decreases space that could be available for other transportation modes or urban uses. Therefore, a more sensible response to parking demand problems in congested road networks is to implement travel demand management (TDM) strategies. The preeminent parking TDM strategy is demand-responsive pricing, which has proven effective in places such as San Francisco. However, parking pricing raises equity concerns, particularly in auto-dependent places, and generally faces strong political opposition. Considering the challenges of implementing parking pricing, the primary objective of this report is to present a novel non-pricing parking control policy, called the Parking Allocation and Ridesharing (PARS) system.

In the PARS policy, parking spaces are allocated, free of out-of-pocket cost, to drivers and riders who are willing to participate in a coordinated carpool going to/from a common venue or area. The basic idea in PARS is as follows:

i. There is a software platform where individuals requiring transportation from a location (e.g., their home) to a specific venue (e.g., the university), and/or vice versa, enter their request. These individuals are referred to as riders.
ii. Similarly, individuals that are interested in driving to that venue would use the software platform to request a reserved parking space at the venue. These individuals are referred to as drivers.
iii. A centralized algorithm combines the riders' and drivers' information to optimize the creation of carpools between drivers and riders, and reserve parking spaces for these carpools at the venue. A carpool would start at the driver's initial location, pick-up the riders specified by the centralized algorithm from their respective locations and complete the trip to the venue. At the venue, the carpool vehicle would have a guaranteed parking space. On the trip back, the carpool includes a potentially different set of riders specified by the algorithm that are to be transported from the venue to their respective locations.

Since not all potential drivers can have a guaranteed parking space, the algorithm ensures that drivers who do not receive a parking reservation are included in a carpool as a rider.

The project's primary objectives were to:

i. Develop mathematical optimization models and heuristics that can be used to implement PARS.
ii. Evaluate the public opinion and preferences associated with the proposed PARM policy through behavioral experiments and surveys.
iii. Create a proof-of-concept application of the policy and models.

METHODOLOGY

The methodology consisted of three separate components. First, an optimization approach was used to develop models for the practical implementation of PARS. Specifically, a linear mixed integer programming (MIP) formulation was developed to determine minimum cost matches between riders and drivers considering their desired arrival and departure times, flexible user roles (e.g., a driver can be assigned as rider), and parking capacity constraints, among other practical issues. Second, a stated-preference survey was developed and distributed to explore people's preferences for PARS vs. parking pricing. The survey was distributed at the University of Puerto Rico at Mayaguez (UPRM) and the University of South Florida (USF). Discrete choice analysis was used to examine the factors correlated with the participants' preferences. Third, a pilot PARS system was launched at UPRM.

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RESEARCH FINDINGS

Two heuristics were developed to solve the proposed MIP model: the Ride Decomposition (RD) heuristic and the Quick Converge (QC) heuristic. A full factorial numerical experiment was performed to compare the solution methods (original MIP formulation, RD, and QC) in terms of solution quality and runtimes under different scenarios. Overall, on average, the RD heuristic yielded solutions within 3.61% of the optimal and QC within 3.49%. It was also determined that the RD heuristic found the optimal solution in 21.49% of the problem instances, whereas QC did so in 60.74%. In terms of average runtimes, RD was faster than the MIP by 42.23% and QC by 86.39%.

Using the stated-preference survey data, a binary logit parking choice model and a multinomial logit mode choice model were estimated. The parking choice model considered two parking alternatives: paying for parking or picking a rider and parking in a free, guaranteed parking space (i.e., PARS). As expected, a higher parking cost was positively correlated with the likelihood of individuals choosing carpooling with guaranteed parking. Conversely, increases in the number of passengers and in travel and wait time were negatively correlated with the probability of individuals selecting carpooling with guaranteed parking. In terms of sociodemographic factors, females had a higher propensity to choose carpooling with guaranteed parking. Also, UPRM participants were more likely to select the PARS alternative. In the mode choice model, three alternatives are considered: paying for parking, traveling as a rider in a carpool, or using transit. The results for the mode choice model were similar to the results of the parking choice model, with some key differences. For example, no statistically significant differences were observed between participants of different genders. Also, graduate students and faculty members displayed a lower preference towards carpooling compared to undergraduate students, but they exhibited a higher probability of selecting transit.

The pilot PARS system was launched at UPRM on March 7, 2024. The main components of the system were the mobile app ROCS Carpool and a mechanical parking barrier that gave access to a 28-space section of the main student parking lot. ROCS Carpool was developed by the team to operationalize the PARS models. UPRM community members could use ROCS Carpool to i) submit parking and/or trip requests, ii) receive notifications of the acceptance or rejection of their requests and information of their carpool partners, and iii) open the parking barrier. The app was downloaded 751 times during the 27-days test period. In total, 98% of the 476 reservations that were submitted were approved by the PARS system. Only 13% of the service requests were submitted by riders, and 17% of ride requests were denied by the system. Only rider requests were denied by the system; driver requests were always accepted as there was always sufficient parking capacity. Ride denials were caused by a lack of drivers within the requested geographic locations and/or time windows. Once the system approved requests, approximately 71% (±22%) of drivers accepted their reservations (i.e., they did not cancel their reservations). On average, each day had 3.5 (±2.7) new users submitting requests. In total, there were 95 unique individuals who submitted parking or trip requests to ROCS. On an average day, around 48% (±17%) of users submitting request to ROCS were female. For comparison, 45% of UPRM undergraduate students for the fall semester of 2023 were female.

POLICY AND PRACTICE RECOMMENDATIONS

Information technologies have enabled the development of novel strategies like PARS that can be used to manage travel demand without the use of pricing mechanisms. Pricing, however, can be used to incentivize participation in carpool-based parking management schemes, as suggested by the survey results. The revenue generated by the pricing component could subsidize the carpool component of the TDM strategy, including the allocation of monetary incentives to increase driver participation, a common challenge in carpooling programs.

The main challenges with the pilot PARS program at UPRM were not technical. The first challenge was developing an effective communication strategy. Prior to the launch of the PARS prototype, the team sent UPRM-wide emails about the service, distributed flyers, and created social media accounts for the service, with some posts viewed more than 50,000 times. However, informal conversations with students revealed that, despite these efforts, there were many misconceptions about the service, the main being that ROCS was an “UBER”-style service were drivers had to pick up multiple strangers during the day or riders had to pay for the service. Future projects should consider designing outreach and marketing activities in parallel with the engineering activities, so that they are tested and ready for publication as soon as the system is operational. The second, and perhaps main, challenge of the UPRM PARS system was student mistrust of unknown people, another common barrier of carpooling programs. Among the strategies that the team is considering to increase trust in the system is to introduce a “friend list” that users can control to indicate which people they are willing to provide transportation to.

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