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Spatial welfare effects of shared taxi operating policies for first mile airport access

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ABSTRACT

With increasing availability of alternative mobility options for first/last mile, it is necessary to better understand how shared taxis are impacting airport access demand and consumer surplus. However, no study has yet been conducted to evaluate the welfare effects of the range of shared taxi matching and fare allocation policies for airport access. Using several data sources primarily from Port Authority of NY and NJ and The Taxi and Limousine Commission, a mode choice model is estimated for access to John F. Kennedy International Airport in New York City. The baseline model and data show that passengers have a value of time of $101 per hour, consistent with Harvey's study from 1986. Airport taxi travelers are also elastic to cost in a similar manner to public transit. The model is used to evaluate two policies: a first (we call this wait-share policy) where taxis can offer shared rides for two passengers from the same zip code, incorporating an endogenous expected wait time variable; and a second (we call this space-share policy) where taxis match randomly arriving passengers from any zip codes in the city. These two policies reflect extreme ends of a spectrum of policies between waiting and detouring. Findings suggest that having a shared taxi option benefit passengers in NYC going to JFK airport by at least 10% increase in consumer surplus. However, the increase in taxi ridership comes at a cost to transit ridership. Furthermore, the population in NYC that benefits most is highly dependent on the type of shared taxi policy. A wait-share policy benefits passengers from the dense parts of Manhattan most, while a space-share policy distributes the benefits more to other boroughs. These insights can help policymakers set regulations in providing first/last mile ride-sharing taxi options in different cities around the world.

Introduction

First and last mile travel refers to the portions of a trip to access or egress from the main line haul transport (Chang and Schonfeld, 1991; Li and Quadrifoglio, 2010; Djavadian and Chow, 2017a). The quality of last mile trips can significantly impact the main line haul trip, whether it is freight deliveries, public transit, or long distance travel. For example, Bower (1976) found that demand for air travel itself is elastic with respect to access costs to reach the airport. In other words, poor

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access can reduce the demand for air travel itself. And with rising urbanization (WHO, 2010), the importance of first and last mile access to air travel is expected to continue to grow.

In the case of access for air travel, there are a number of modes used. A key mode in addressing this first mile problem is the taxicab. According to the Port Authority of New York and New Jersey (PANYNJ), the proportion of taxi mode of travelers in New York City (NYC) accessing John F. Kennedy (JFK) Airport (PANYNJ, 2014) from 2010 to 2014 was 31%, while other for-hire-vehicles (FHV) were 11%, for a total of 42% share. Considering that JFK is the fifth busiest airport in the U.S. (FAA, 2016), this is indicative of the role of taxi and other FHVs as a first/last mile access mode for air travel.

However, our understanding of the role of taxis in this capacity has changed in recent years because of new mobility services enabled by information and communications technologies (ICTs). Ridesharing and ridesourcing services, such as Uber (Lazo, 2016), Lyft (Hawkins, 2015), and Via (Schifman, 2016), offer new access options to travelers. These operations use mobile devices to hail rides, match rides, and split ride fares in the case of dynamic *shared taxi* trips.

It is therefore important for policymakers to have a better grasp of how taxi sharing options impact the consumer surplus of airport access travelers. By "consumer surplus", we refer to the overall utility gained by travelers to access an airport. Some studies, such as Yang and Yang (2011), consider social welfare for a taxi market which includes the costs of operating the taxi fleet. Since our interest is only on the social impact of different taxi operating policies (as opposed to the equilibration of taxi supply and demand in a taxi market), we ignore costs of operating taxis in this study and focus on consumer surplus. Do policies focusing more on matching at a fixed location lead to higher consumer surplus than policies involving en-route matching? How do welfare impacts differentiate over space and proximity to the destination airport?

In this study, we propose to study these research questions. We use JFK airport access survey data to model the demand and consumer surplus for access modes under a base scenario involving only solo taxis. Two shared taxi policies are then evaluated and compared against this base scenario. The two policies represent extreme cases of shared taxis: one involving matching passengers at the same location with no detour but unconstrained by wait time, and one involving matching simultaneously arriving passengers at random zones in the system. To the best of our knowledge, there is no behavioral study on the impact of shared taxi technology on the consumer surplus of travelers, much less of airport access travelers. Insights from this research can support policies for first and last mile ride-sharing taxi operations in cities around the world.

The remainder of this paper is organized as follows: Section "Literature Review" presents a literature review on taxi evaluation models and shared taxi operational policies; Section "Experimental Design and Data" introduces the experimental design and data; Section "Mode Choice Model" presents a model estimated from the JFK survey data; Section "Policy Analysis" shows the scenario analysis for the two extreme policies, and section "Conclusion" is the conclusion.

Literature review

There are a wide number of studies on evaluating taxi performance. Some of the earliest analytical studies on taxis (Daganzo, 1978; Daganzo et al., 1977) are based on continuous mathematical models to relate system performance to demand and service area. However, the demand is not dependent on that performance. More recent efforts, including Yang and Wong (1998) and Yang et al. (2010), developed economic equilibrium models that capture the costs of matching taxi drivers to customers.

Taxi studies pertaining to airport pickup and drop-off are also abundant. Several studies look at taxi pickups at airports with queueing models to evaluate different operating policies (Curry et al., 1978; da Costa and de Neufville, 2012; Yazici et al., 2016). These studies do not seek to explain access travel behavior.

Harvey (1986) published one of the first explanatory models on airport access mode choice, noting the difference in preference due to different trip purposes. A single generalized cost variable was used with an assumed value of time. Tam et al. (2005) and Choo et al. (2013) estimated mode choice models for Hong Kong and Seoul, respectively. Hess et al. (2013) estimated a joint model of airport, airline, and access mode choice using a stated preference survey of U.S. east coast airports. Yang et al. (2014) focused on a specific subset of origin-destination (OD) pairs and analyzed variations in travel times and cost that arise due to traffic conditions and party size. Yazdanpanah and Hosseinlou (2016) associated personality traits with the access mode choice. None of these studies considered airport access mode choice with shared taxi mode.

There have been a number of studies on social impacts of shared taxis. Rayle et al. (2016) provided a policy study comparing taxi with shared mobility. Paraboschi et al. (2015) evaluated shared taxi as a two-sided market. Several studies have been based on simulation evaluations of system performance (Djavadian and Chow, 2017a,b; Agatz et al., 2011; D'Orey et al., 2012; Maciejewski and Nagel, 2013; Jung and Jayakrishnan, 2014; Jung et al., 2014; Martinez et al., 2015). Al-Ayyash et al. (2016) proposed a demand model for shared taxis for students commuting to University of Beirut in Lebanon. No study has yet been conducted to evaluate the welfare effects of shared taxis' operations to access airports and other similar first or last mile destinations.

In shared taxi operations, several different policies need to be considered by the operator. One is how to match customers together in a shared ride, which is a culmination of decisions on centralized versus distributed operations (d'Orey et al., 2012), ride hailing technology (He and Shen, 2015), and idle vehicle positioning strategy (Yuan et al., 2011). Some services may match only customers within proximity of one another, perhaps waiting up to a threshold time for the passenger requests. Other services may match based on en-route detours of the first pickup, up to a certain maximum detour, to pick up a second passenger. For dynamic ridesharing, pairing typically does not exceed two passenger groups. On the matching