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AGGREGATED MODELING OF URBAN TAXI SERVICES

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Abstract

Models are an indispensable tool for decision makers when defining the principal policy measures of the taxi services, such as fleet size, fares or operational modes of the services within the city. Various models have been developed for calculating the variables that characterize the taxi services in urban regions. This paper presents an extensive review of the presented formulations for the modeling of taxi services in urban areas. The variables of the problem are identified and analyzed, presenting the different formulations proposed in the literature for each one of the three operational modes (hailing, stand and dispatching).

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Keywords: Taxi modeling, aggregated taxi model, taxicab problem, transport on demand, individual public transport

1. Introduction

Public authorities of current cities have the difficult task of providing the necessary infrastructure and services to their citizens in order to satisfy their mobility needs, which are becoming more complex. The provision of taxi services is one of the traditionally adopted solutions, taking advantage of the combination of the positive characteristics of both individual vehicle transport and public transport services. Taxis are cars used for public transport services providing door to door personal transport services. They can be divided into three broad categories: stand, hailing and dispatching markets. Taxi stands are designated places where a taxi can wait for passengers and vice versa. Taxis are forming queues, and served with FIFO rules while passengers take the first taxi

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in the queue. Customers must walk until the nearest taxi stand. In the hail market customers hail a cruising taxi on the street. This case is the most unfavorable situation concerning the information aspects for the customers, due to the uncertainty about the waiting time and the quality/fare of the service they will find. On the other hand, customers don't need to walk until the nearest taxi stand. In the dispatching market customers call a dispatching center requesting for an immediate taxi service. Only in this kind of market consumers can choose between different service providers or companies. At the same time, companies can fidelize customers by providing services of good quality. The market in this case is more competitive since companies with larger fleets can offer lower waiting times.

Nowadays, the global economic situation is promoting the liberalization of traditionally protected professions. That is the case of taxi drivers, a protected market in many cities that has been partially deregulated during the last years (Salanova et al. (2011) present a relation of regulated and deregulated taxi markets) as well as the impacts of both regulation and deregulation. Taxi markets have been traditionally regulated by the cities, controlling the number of issued licenses and the prices of the offered services for protecting both the users and the taxi drivers. This regulation assured a minimum income to taxi drivers while protecting users from abusive tariffs, but created a market for taxi licenses, where prices were controlled by the free market, and not by policy makers.

There is a need for evaluating the taxi services by the decision makers responsible for the regulations and the modeling of the taxi services is a powerful tool for quantifying and helping them in taking the right decisions. In order to evaluate the system in terms of waiting time of users and income of taxi drivers, various models have been developed, providing policy makers with methodologies for estimating the optimum number of licenses for each demand level and city (in terms of size, geometry and congestion levels). Various models have been developed for this purpose; most of them aiming at supporting decisions related to planning issues more than to operational issues. The model proposed in this paper is an aggregated model developed for analyzing the most important variables of the taxi services and optimizing the number of taxis at the planning level. It is a variation from the model presented in Salanova and Estrada (2014) where the demand is considered to be elastic.

The paper is structured as follows: Section 2 reviews the different formulations presented in the literature. Section 3 describes the proposed formulation. Finally, section 4 contains conclusions related to the reviewed formulations and from the results obtained using the new formulation.

2. Review of the formulations presented in the literature

The actors involved in the taxi market are briefly presented below, highlighting their objective and most significant variables. There are several stakeholders involved in the taxi market with different objectives: the taxi users, the taxi drivers or service providers and the city or society in general. This fact crates the necessity of defining a multiobjective problem (Lo and Yip, 2001). The users are trying to minimize their total time or the generalized cost when satisfying their necessity for a trip (utility). The taxi drivers are willing to maximize their benefits (operator revenue), while the city is "paying" the externalities of the congestion and pollution generated by the taxis when circulating (empty or occupied). On one hand, the most relevant variable of the users is the generalized cost, which includes total travel time (composed of access time, waiting time and in-vehicle time). On the other hand, the two important variables for the drivers are the income and the cost, which determine the benefit of the service. The income of the taxi drivers depends on the number of trips, the average length of these trips, the average duration and the applied fee. The operating costs are divided into variable costs (distance cost) and fixed costs (time costs of operation). However, the system cost depends on the mode of operation: if the taxi driver is circulating while waiting for a call the cost can be considered as a fixed cost per hour of circulation (with or without passenger); if the taxi is not circulating while waiting for a call, then the cost is only the cost per hour and, when circulating, per distance.