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Management of On-demand Transport Services in Urban Contexts. Barcelona Case Study

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Abstract

Urban mobility transport mostly focuses on collective transport based on largely exploited models such as metro, trains or buses. The basis of current public transport is a fix network of both infrastructure and services, presenting a high lack of flexibility, especially regarding geographical issues. Traditional and innovative on-demand transport services, such as taxi and carsharing respectively, can provide the level of flexibility to the public transport needed to provide both a better service while reducing the exploitation costs. In this context, the study aims to improve the efficiency of on-demand transport systems, mainly taxi and carsharing through the development of analytical models and their application to the city of Barcelona. The optimization of the fleet management and the allocation of resources aim to ensure both the level of service of public transport users and the agency's profitability. The decision variables are the fleet size (number of vehicles) as well as the number and capacity of the depots or stands. Two models are presented, one for the provision of taxi stand service and one for the provision of one way carsharing service. Both models are applied to the demand for taxi services of the city of Barcelona, presenting for each model the optimum number of vehicles and depots, the depots' capacity, the system unitary costs and the level of service. Although the results show that the performance of both systems is very similar, the taxi service is up to three times more expensive due to the extra cost from the need for having a driver.

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Keywords: Case study, Barcelona, taxi, carsharing, comparaison, low demand, on-demand, models, one-way, taxi stands

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1. Introduction

Urban mobility transport is usually focused on collective public transport such as metro, train or bus. This is a large exploited model where users have to adapt to the public network offered. Collective public transport has many advantages but flexibility is not one of those. To respond at this drawback, we must talk about on-demand transport services which pursue improving flexibility by adapting the offer to the demand. User's flexibility lead to a complex effectiveness from operator's point of view that have to be smartly managed.

On-demand transport services are a different way to solve mobility issues. Taxis are probably one of the best examples of on-demand transport services, but nowadays sharing systems are arising and increasing its presence in urban scenarios. Sharing systems constitute a collaborative mobility system in which users don't have the ownership of the vehicle, yet they share the use of a vehicle from a fleet. This mobility system can be formed by cars, motorbikes or bikes powered either by electricity or conventional energy systems, thus presenting a wide range of options for users to cover their needs and a large variety of niches for transport operators and companies.

Nevertheless, these on-demand systems present a series of concerns and challenges that policy makers, operators and companies have to deal with to optimize the service and its productivity. On the one hand, the efficiency of the taxi service is crucial to ensure its profitability and reduce its externalities. As an example, real data used in this study shows that 47.4% of the daily mileage of the taxi in Barcelona is made in vacant, and that during the 62.1% of the service time (i.e., 37 min per hour) the taxi has no customer (CENIT 2004). On the other hand, sharing systems are usually less known by citizens, furthermore they present important challenges for operators like the sizing and the managing of the fleet and its costs, the use of public space and the energy consumption.

In this context, the aim of this paper is to propose some models that should be used as smart tools for agencies and police makers to figure out a first approach for a taxi or a carsharing fleet to ensure an optimal and smart performance of its resources. In order to better manage scarcity resources such as public space, vehicles and energy, we proposed two analytical models one performed by taxis and another, by a sharing systems to optimize the fleet offered. The results should be addressed to set optimal guidelines and regulations for taxi and sharing services. Thus the main aspect of this paper is to evaluate in a real case study the difference between performing a taxi service or a carsharing system when demands are homogeneous and affordable for both modes. It is point out how depending on the demand one of the two proposes can perform better than the other one.

The paper is structured as follows. After the introduction a brief state of the art on on-demand transport services is presented, followed by the description of the taxi and carsharing models. The paper concludes with the applications of the two models to the city of Barcelona and the conclusions section.

2. State of the art on transport on-demand models

On-demand transport is characterized by its flexibility in both the spatial route and temporal scheduling dimensions. The traditional and most popular form of on-demand transport is the taxi, with a history of more than 100 years and presenting numerous variants (khattee, jitney, shuttle service…), while new and innovative on-demand transport schemes, such as car-pooling, car-sharing, even Uber, are arising significantly in the last years, especially due to the technological advances. Various on-demand transport modes have been modeled accordingly aiming at optimizing their performance or selecting the most appropriate for each city. The taxi and carsharing models are briefly reviewed below.

2.1. Taxi modeling

Many taxi models have been developed focusing on the profitability of the sector and the Level of Service offered to their customers, the effects of regulation/deregulation on the mentioned metrics as well as the nature and relation of the taxi market most significant variables (demand, waiting time, driver earnings). The main families of models are three: econometric models using aggregated values and continuous variables; equilibrium models taking into account the spatial distribution of both the demand and the offer; simulation-based models based on discrete-events and multi-agent systems. The most important contributions to the modelling of taxi services are the ones of Douglas (1972) and Yang and Wong (1998), developing aggregated and equilibrium models respectively, while the