Omega 59 (2016) 4–14

Contents lists available at ScienceDirect

Omega

journal homepage: www.elsevier.com/locate/omega

In free float: Developing Business Analytics support for carsharing providers☆

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ARTICLE INFO

Article history:
Received 15 July 2014
Accepted 19 February 2015
Available online 30 March 2015

Keywords:
Free-floating carsharing
Decision support
Data analytics
Spatial analysis

ABSTRACT

As a rapidly expanding market, carsharing presents a possible remedy for traffic congestion in urban centers. Especially free-floating carsharing, which allows customers to leave their car anywhere within the operator's business area, provides users with flexibility, and complements public transportation. We present a novel method that provides strategic and operational decision support to companies maneuvering this competitive and constantly changing market environment. Using an extensive set of customer data in a zero-inflated regression model, we explain spatial variation in carsharing activity through the proximity of particular points of interests, such as movie theaters and airports. As an application case, as well as a validation of the model, we use the resulting indicators to predict the number of rentals before an expansion of the business area and compare it to the actual demand post-expansion. We find that our approach correctly identifies areas with a high carsharing activity and can be easily adapted to other cities.

1. Introduction

In the past decade, carsharing as a business model has experienced a tremendous growth. In North America alone, carsharing membership has increased at a compound annual growth rate exceeding 45 percent, from 16,000 in 2002 to more than a million members in early 2013 [1]. Yet, Shaheen and Cohen [2] emphasize that the growing popularity of carsharing is a global phenomenon, with an established market in Europe and increasing interest in Asia and Australia. Furthermore, it is considered to be a possible cure to ailments urban centers around the world are suffering from, such as greenhouse gas emissions, air pollution, and traffic congestion [3]. Carsharing relies on synergies with public transit – busses and trains serve as a reliable infrastructure for daily commutes, with carsharing providing additional flexibility.

This flexibility is maximized by the concept of *free-floating carsharing* (FFC), which disposes of static rental stations and allows customers to end their rentals anywhere within the carsharing provider's operating area [4]. Carsharing members use smartphone applications to locate and reserve the closest available vehicle, RFID cards provide access to the vehicle, and an online payment system handles the billing. However, for the operator FFC concepts are associated with substantially increased complexity – both, with respect to strategic as well as operational decisions. On the strategic level, free-floating carsharing providers need to define their operation area by deciding whether certain parts of the city should be left out, and by determining optimal expansion strategies. These decisions directly translate to the operational level. Vehicle demand and supply vary during the day and across locations, such that operators have to relocate vehicles within the operation area in order to provide a satisfactory service level to members.

In this paper we address the challenges outlined in the previous paragraph, namely the strategic and operational issues arising from a temporal and spatial divergence between vehicle demand and supply, and demonstrate the substantial value Business Analytics methods and applications can bring to emerging business sectors [5,6] such as carsharing. We introduce an innovative analytics tool that aims to relate the spatial variation of vehicle demand to *points of interest* (POIs) in the vicinity, which include, for instance, bus stops, movie theaters, and shopping malls. Through the cooperation with a globally leading carsharing provider, our analysis is based on a dataset spanning more than a million carsharing rentals in the city of Berlin between April 2012 and October 2013. Employing a zero-inflated Poisson model, we relate these observations to more than 180,000 POIs, as well as demographic data, in order to identify POI categories that substantially influence variation in carsharing activity. Furthermore, we illustrate the value of our approach by providing strategic decision support on possible expansion areas, which is validated by comparing the predicted with actual vehicle demand after an expansion of the operating area occurred in 2013.

☆This manuscript was processed by Associate Editor B. Lev.

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http://dx.doi.org/10.1016/j.omega.2015.02.011
0305-0483/

Consequently, the hypotheses investigated during the course of this paper are the following:

Hypothesis 1. Points of interest, as a proxy for the attractiveness of the various areas within a city, can be used to explain the spatial variation in the demand for carsharing.

Hypothesis 2. This relationship can be used to provide decision support regarding expansion strategies.

The paper is structured as follows. In Section 2, we discuss research related to our work. In Section 3, we outline the theoretical argument for a statistical relationship between POIs and carsharing activity, and describe our dataset. In Section 4, the regression analysis is conducted, investigating Hypothesis 1. In Section 5, we analyze the applicability of our results to an expansion of the operation area, which relates to Hypothesis 2. Section 6 concludes.

2. Related work and contribution

In this section, we first present an overview on carsharing and related research. This is followed by a brief summary of geospatial research as it pertains to our work. We conclude this section by positioning our research in a Business Analytics context and specifying our contribution.

2.1. Carsharing

The history of carsharing dates back to 1948 and the SEFAGE ("Selbstfahrgemeinschaft") in Zurich, Switzerland [7]. However, it took until the late 1980s and early 1990s for carsharing to become more common, particularly in central Europe, as well as Great Britain, Italy, and the Scandinavian countries [8]. In the United States carsharing gained popularity following several pilot projects, which aimed to better understand how carsharing can be established and operated [9]. Traditionally, carsharing operators have provided station-based services. Round-trip systems require the customer to return the car to the station where it was originally picked up, while one-way systems afford more flexibility by allowing customers to end their rentals at any station designated by the provider. The novel free-floating concept takes this increased flexibility one step further by allowing customers to return vehicles anywhere within a certain operation area.

Naturally, this evolution in carsharing concepts has been accompanied by a change in the research objectives related to carsharing. Questions regarding the (in)activity of users [10], the lengths and durations of trips [11], and the spatial distribution and determinants of carsharing demand [12,13] concern all carsharing systems. Moreover, the introduction of one-way and free-floating concepts have raised a range of new issues related to the temporal and spatial imbalance between supply of and demand for vehicles. This problem becomes even more pronounced if we take the changing needs of electric vehicles into account [14]. On the other hand, sharing a vehicle can provide benefits from a social and environmental perspective by reducing the overall number of cars on the road [15]. Designing an optimal sharing system regardless of the means of transport remains difficult for station based services [16] and even more difficult in the free-floating model.

Relocation mechanisms that seek to alleviate this imbalance have been investigated by several research groups [17,18]. For instance, Barth et al. [19] introduce a user-based relocation mechanism that encourages users to share or split rides depending on system-wide demand. Kek et al. present event-based relocation techniques validated by real-world data [20]. They implement a complete decision support system that was tested with a carsharing company in Singapore [21], a city that has been at the forefront of rethinking car ownership for more than two decades [22]. The problem of relocating vehicles can also be found in the bike sharing domain. Dell'Amico et al. [23] provide a linear mixed integer programming formulation with the objective to minimize total costs for bike sharing. For FFC systems, Weikl and Bogenberger [4] introduce a relocation system consisting of an offline module that pre-calculates possible relocation strategies based on historical data and an online module, which adjusts these strategies according to the current situation. Critical success factors for carsharing systems have been researched by Millard-Ball [24], as well as Celsor and Millard-Ball [25]. They find that the purposes of rentals are often associated with specific points of interest, such as grocery stores and shops. However, the actual relationship between POIs and carsharing demand has not yet been investigated. Since such an empirical model would provide valuable input to relocation mechanisms, as well as long-term strategic decision-making, the first hypothesis guiding this paper addresses this issue.

2.2. Geospatial research

The emergence of location-based services [26–28] as a growing research field has introduced geospatial analysis [29,30] into the methodological toolbox of Information Systems and Management researchers. One increasingly used method, the geographically-weighted regression (GWR) [31], explores nonstationarity in geographic regression parameters. It calculates local coefficients by distance-weighing observations. This method is purely explanatory and difficult to use for prediction. Hence, it is of limited use in our context, given that one application of our approach is to estimate carsharing activity in locations without any existing carsharing data (expansions). Furthermore, Páez et al. [32] note the flaw of the GWR in its tendency towards an increased amount of false-positives, i.e. a faulty recognition of spatial nonstationarity. Considering these drawbacks, we refrain from using the GWR in favor of a zero-inflated count model (ZINF).

2.3. Business Analytics

Business Analytics is one of the most prominent current research streams in Information Systems, as well as Management research [33,34]. It continues several decades of decision support research and the terms "Decision Support System", "Business Intelligence", and "Business Analytics" are often used interchangeably [35]. However, the core of Business Analytics applications is to unleash the potential of Big Data and substantially transform business operations through data-driven strategies [6]. The breadth of Business Analytics applications is illustrated by the variety of recent publications. Topics include the relationship between advertisements and purchasing decisions [36], resource allocation in emergency response scenarios [37], energy security in a changing world climate [38], as well as decision support for mergers and acquisitions [39].

In our work, we apply the transformative power of Business Analytics methods to carsharing – a business sector that has existed for several decades, but has been invigorated by mobile devices and data-driven business strategies such as FFC. Hence, the objective of our paper is not just to analyze carsharing data, but also to discuss how the insights were used for real-world business decisions. Building upon the second hypothesis guiding this paper, we demonstrate how the empirical results support strategic decision making regarding the expansion of the carsharing provider's operation area, and outline further possible applications to relocation strategies.