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Preferences for shared autonomous vehicles

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ABSTRACT

Shared autonomous vehicles (SAVs) could provide inexpensive mobility on-demand services. In addition, the autonomous vehicle technology could facilitate the implementation of dynamic ride-sharing (DRS). The widespread adoption of SAVs could provide benefits to society, but also entail risks. For the design of effective policies aiming to realize the advantages of SAVs, a better understanding of how SAVs may be adopted is necessary. This article intends to advance future research about the travel behavior impacts of SAVs, by identifying the characteristics of users who are likely to adopt SAV services and by eliciting willingness to pay measures for service attributes. For this purpose, a stated choice survey was conducted and analyzed, using a mixed logit model. The results show that service attributes including travel cost, travel time and waiting time may be critical determinants of the use of SAVs and the acceptance of DRS. Differences in willingness to pay for service attributes indicate that SAVs with DRS and SAVs without DRS are perceived as two distinct mobility options. The results imply that the adoption of SAVs may differ across cohorts, whereby young individuals and individuals with multimodal travel patterns may be more likely to adopt SAVs. The methodological limitations of the study are also acknowledged. Despite a potential hypothetical bias, the results capture the directionality and relative importance of the attributes of interest.

1. Introduction

In recent years, car manufacturers and software companies have presented prototypes of self-driving vehicles and have announced that the autonomous vehicle (AV) technology will be available to the market in the near future (Fagnant and Kockelman, 2015a; Wadud et al., 2016). The most striking characteristic of AVs is that in their most advanced stage, the navigation of the vehicle will be fully automated, making driver input obsolete (National Highway Traffic Safety Administration, 2013). The disruptive potential of the AV technology is undeniable; as drivers will not need to pay attention to traffic anymore, the overall driving experience will be altered considerably. Drivers, who in effect may be considered passengers for most of the journey, will be able to pursue activities such as reading, working or sleeping, while traveling in their cars (Le Vine et al., 2015).

Furthermore, the advent of the AV technology may allow for the emergence of novel business models such as shared autonomous vehicles (SAVs), which could provide inexpensive mobility on-demand services and could play a vital role in sustainable transportation systems, by providing convenient last-mile solutions, which could facilitate multimodality. System-wide coordination of SAVs could mitigate congestion and could facilitate the integration of advanced propulsion

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systems (Burns, 2013). Furthermore, SAVs could reduce private car ownership levels substantially (Fagnant et al., 2015; Fagnant and Kockelman, 2014) and dynamic-ride sharing (DRS) schemes could be implemented (Fagnant and Kockelman, 2015b).

However, there are potential downsides to the ubiquity of this low-cost mobility option. The modal shift could be altered in a way so that more kilometers are traveled in small, possibly less energy-efficient vehicles. Inexpensive mobility on-demand services could erode public transit (PT) services, which rely on a sufficiently large number of users to be operated efficiently. Moreover, travelers could walk considerably less due to the convenience of the mobility on-demand services, which could have adverse effects on individuals' health.

The literature suggests that SAVs may be an attractive mobility option for elderly travelers (Fagnant and Kockelman, 2015a) and for individuals, who currently do not have access to private transportation (Anderson et al., 2014). A review of the literature dealing with the mobility behavior of these groups reveals the shortcoming of these presumptions, since there is strong evidence that these groups are in fact highly heterogeneous, which suggests that age and the availability of private transportation are insufficient discriminators of potential SAV use.

The design of effective transport policies, which aim to realize the potential benefits of SAVs, requires an understanding of how users will adopt SAVs. Yet, at this stage, little is known about how SAVs will be employed by travelers. This study intends to advance future research about the travel behavior impacts of SAVs, by exploring the characteristics of users who are likely to adopt SAV services and by eliciting willingness to pay measures for service attributes. For this purpose, a stated choice survey was conducted and analyzed, using a mixed logit model.

Several studies have investigated consumer perception of the AV technology (see Bansal et al. (2016) and the literature referenced therein), but to the best of the authors' knowledge, only two studies have specifically dealt with the adoption of SAVs. Haboucha et al. (2015) draw from stated preference data to investigate car owners' propensity to switch to SAVs on work-related and education-related trips. Furthermore, Bansal et al. (2016) analyze individuals' stated frequencies to use SAVs under different pricing scenarios and identify the characteristics of potential SAV adopters. This current study distinguishes itself from previous studies by explicitly addressing the acceptance of DRS in the context of SAV use.

The remainder of this contribution is structured as follows: In Section 2, the operations of SAV services are explained and existing ideas regarding potential users are discussed. The survey design and the data collection are described in Section 3. In Section 4, the collected data are analyzed both descriptively and inferentially. In Section 5, the results are critically discussed, policy implications are derived, the methodological limitations of the study are acknowledged and a conclusion is drawn.

2. Shared autonomous vehicles

2.1. Overview

The concept of SAVs combines elements of conventional carsharing and taxi services with AVs (Fagnant et al., 2015). SAVs could provide inexpensive and convenient mobility-on demand services (Burns, 2013; Burns et al., 2013), which have been described as driverless taxis (Fagnant et al., 2015).

Carsharing is generally considered to be a flexible mobility option, which complements public and slow modes, by offering the flexibility of the private car without the obligations associated with private car ownership (Shaheen and Cohen, 2012). As such, carsharing could potentially foster more sustainable mobility, by facilitating multi-modal travel behavior (Nobis, 2006) and in the longer run, carsharing could potentially reduce private car ownership levels (Firnkorn and Müller, 2012; Martin et al., 2011).

The AV technology could make carsharing more accessible and affordable. As for conventional carsharing, the walking distance to access shared vehicles is considered to be a key determinant of carsharing usage. Since SAVs will collect their passengers directly at their origin, walking times to access shared vehicles will be reduced to zero. Moreover, the AV technology could resolve the relocation issues of one-way carsharing and reduce the costs of providing one-way carsharing services (Firnkorn and Müller, 2015). In addition, carsharing with AVs could mitigate the availability concerns of users, i.e., users of one-way carsharing fear that a vehicle will not be available nearby after completing the activity at the destination (Fagnant and Kockelman, 2014). The AV technology will also dramatically lower the likelihood of accidents so that the insurance primes contained in current carsharing rates could be reduced.

Moreover, the AV technology could facilitate the implementation of DRS schemes, under which travelers, who travel from a similar origin to a similar destination, are allocated to the same vehicle to travel together for some part of their trip. DRS would allow for better capital utilization and would reduce the environmental impact of mobility on-demand services. In a simulation-based study of an SAV fleet in Austin, USA, it was determined that the excess vehicle kilometers traveled due to empty vehicle relocation could approximately be halved under DRS (Fagnant and Kockelman, 2015b). Ride-sharing with conventional vehicles requires users to incur high transaction costs for searching for ride opportunities, for arranging pick-ups and for cost-sharing agreements. In many cases, transaction costs may offset the benefits of ride-sharing. Even if ride-sharing was supported by information and communication technology (ICT), drivers would still need to navigate to the origin and the destination of the passenger for whom a ride opportunity is provided. Furthermore, the applicability of ride-sharing is restricted to cases, where the route between the driver's origin and destination roughly coincide with the ride-receiving person's origin and destination. In conjunction with a comprehensive ICT integration, the AV technology