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Exploring urban resident's vehicular PM2.5 reduction behavior intention: An application of the extended theory of planned behavior

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ABSTRACT

Urban transport sector has become an important haze air pollution emitter due to the amplification of the gasoline-based vehicles which release amounts of fine particulate matter (PM2.5). Regulating resident's PM2.5 reduction behaviors related to vehicle use is an effective measure for PM2.5 emission control. The present study focuses on two types of resident vehicular PM2.5 reduction behaviors (taking public transportation and purchasing electric vehicles) and examines their key predictors and influencing mechanism based on the extended Theory of Planned Behavior (TPB). The data was collected from Chinese urban residents who lived in heavy haze areas. The results indicated that attitude, subjective norm and moral norm have positive effects on each vehicular PM2.5 reduction intention. It was highlighted that the differentiated perceived behavioral control components (self-efficacy and perceived control) and their moderating effects were inconsistent across two behaviors. Regarding to the behavior of taking public transportation, self-efficacy affected the intention positively and directly, while perceived control affected intention indirectly by moderating the relationship between subjective norm and intention. For purchasing electric vehicles, self-efficacy and perceived control didn't affect intention directly. Instead, self-efficacy moderated the relationship between moral norm and intention, and perceived control moderated the relationship between subjective norm and intention. The results confirm the appropriateness of the extended TPB model in predicting resident intentions to participate in vehicular PM2.5 reduction behaviors. The conclusions would be helpful for policy makers to take effective measures to reduce PM2.5 emissions and mitigate haze pollution.

1. Introduction

Accompanied with rapid industrialization and urbanization, fine particulate matter (PM2.5, fine particles with an aerodynamic diameter less than 2.5 μm) emission which resulted in haze air pollution has become one of the most severe environmental problems in China. Nearly one seventh of the country is covered by haze weather during heavy haze episodes (MEP China, 2012). According to the report of Asian Development Bank and Tsinghua University, the economic losses from air pollution are estimated to be 1.2%–3.8% of GDP in China (Buntaine, 2011; Zhang and Crooks, 2012). Although there is no unanimous conclusion about the emitter sources of haze pollution due to its complexity, most researchers demonstrate that road transport sector is one of the key PM2.5 emitters, especially in the high-density urban areas (Geelen et al., 2013; Sawyer, 2010; Wang et al., 2014b). Moreover, researchers have validated that the motor vehicles contribute approximately 20%–30% to total PM2.5 emissions (Hasheminassab et al., 2014; Okuda et al., 2011; Pekey et al., 2013). For example, in Beijing, the vehicular PM2.5 emission accounts for 22% in its total PM2.5 emissions in a year, and in Shanghai the percentage is 25% (MEP China, 2015).

In fact, the numerous vehicular PM2.5 emissions attribute to the magnification of the transport sector, since millions of gasoline-based vehicles are running on roads and releasing tailpipe particles (MEP China, 2016). The particles are the main compositions of PM2.5. It is reported that nearly 172 million motor vehicles are owned in China by the end of 2015 and the average growth rate of private car ownership reaches to 20% in recent five years (MPSTMB, 2016). In addition, it is worth noting that approximately 99% of the vehicles are conventional fueled ones of petrol or diesel, which producing much more PM2.5 than electric vehicles (MPSTMB,

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2016). The PM2.5 generation coefficients of petrol and diesel are 0.1 g/km and 0.3 g/km, respectively. While that of liquefied petroleum gas (LPG) and biodiesel are relatively lower compared to petrol and diesel.[1] The European Union also launched Renewable Energy Directive on the promotion of using LPG or biodiesel in transport in 2009 and decreased PM2.5 significantly (Hennecke et al., 2013; Ribeiro et al., 2016). However, they are all quite inferior to electric vehicles which of zero direct PM2.5 emissions. In short, reducing the usage of conventional vehicles is an effective way to alleviate the urban haze air pollution.

In practice, there are two ways to reduce the usage of conventional vehicles. One is to take public transportation for commuting. Public transportation refers to any urban transportation network, such as bus and metro, which can reduce PM2.5 emissions by reducing private car use and lessening total energy consumption quantity (CSC , 2013; Vuchic, 2002). The aim of this measure is to adjust and optimize the structure of the transportation. The other is to adopt electric vehicles instead of conventional fueled cars when purchasing vehicles. Electric vehicles (EVs) refer to the vehicles that derive motive power exclusively from onboard electrical battery packs that can be charged with a plug through an electric outlet (Egbue and Long, 2012; Wu et al., 2015). Compared with conventional vehicles, electric vehicles have advantages in increased fuel efficiency, zero direct PM2.5 emissions and a reduction in fuel dependency (Lieven et al., 2011; Romm, 2006). The aim of this measure is to improve the transportation energy consumption structure.

Like other pro-environmental behaviors, these two PM2.5 reduction measures (taking public transportation for commuting and purchasing electric vehicles) in transport sector are closely bound up with human activities (Abrahamse and Steg, 2009; Castanier et al., 2013; Greaves et al., 2013). The two anthropogenic behaviors were highly discussed in previous PM2.5 reduction literature and related air pollution literature (Donald et al., 2014; Grabow et al., 2012; Okuda et al., 2011; Sawyer, 2010) and also confirmed the efficacy in reducing PM2.5 emissions from technological and legislative perspectives (CSC , 2013; Okuda et al., 2011; Sang and Bekhet, 2015; Sawyer, 2010). However, to date, no research has empirically investigated the two anthropogenic behaviors together under the background of PM2.5 emission reductions and discussed the influencing factors and differences between these two behaviors. Such a void leaves a significant gap between theoretical and empirical research of haze control.

Vehicular PM2.5 reduction is an integrated result of those two kinds of resident behaviors. Researchers have acknowledged that residents would show different attitudes and intentions on different vehicular behaviors, and the different behaviors in turn largely affect the total PM2.5 emissions in the transport sector (Abrahamse and Steg, 2009; Bamberg et al., 2007; Castanier et al., 2013). It turns out to be especially salient in China, who blessed with the vast territory and largest population. So in order to effectively reduce PM2.5 emissions, it is imperative to discriminate between the two vehicular PM2.5 reduction behaviors and encourage resident to engage in each behavior based on corresponding influencing factors. In present paper, as a first systematic introduction of resident vehicular PM2.5 reduction behaviors, the aim is to explore the key influencing factors and explain the influencing mechanisms of each behavior based on the extended Theory of Planned Behavior. Additionally, we also emphasize on exploring their differences in the independent variables and the moderating role of perceived behavioral control components between two behaviors. Then, objective regulations based on the results can be made to encourage more residents to engage in pro-environmental vehicular PM2.5 reduction behaviors. It would be helpful for formulating supportive policies in Chinese transport sector and reducing PM2.5 pollution of urban areas.

The organization of the paper is as follows. An overview of the relevant literature review is provided in Section 2, which allows us to formulate the research model and hypotheses. Section 3 describes the research methodology. Followed is the analysis and main results section. Finally in section 5 and 6, we focus on discussing the results and implications, as well as research issues for further research.

2. Literature review and hypotheses development

This paper aims to persuade residents to adopt pro-environmental public transportation and electric vehicles to reduce PM2.5 emissions in urban transport sector. Thus, we attempt to develop the conceptual model based on the Theory of Planned Behavior (TPB, Ajzen, 1991), which is extensively used in the personal pro-environmental domains. TPB indicates that attitude, subjective norm and perceived behavioral control (PBC) influence behavioral intention, which in turn influences behavior (Ajzen, 1991). In this study, behavioral intention is defined as resident's willingness to participate in vehicular PM2.5 reduction behaviors. TPB has been widely accepted in the context of personal pro-environmental behaviors, including green purchase behavior (Yazdanpanah and Forouzani, 2015), public transportation use (Bamberg et al., 2007; Donald et al., 2014), electricity saving behavior (Zhang et al., 2014) and green traveling behavior (Amaro and Duarte, 2015; Han et al., 2010). However, its role in exploring resident vehicular PM2.5 reduction behavior has not been fully examined. Furthermore, we have extended this theory by incorporating the emotional variable namely moral norm. In addition, we differentiate the PBC components and analyze their moderating effects. The proposed research model is shown in Fig. 1.

2.1. Attitude

Attitude refers to the degree to which an individual has a favorable or unfavorable evaluation or appraisal of a particular behavior (Ajzen, 1991). Most previous researches have concluded that attitude is one of the most significant factors influencing behavioral intention (Yazdanpanah and Forouzani, 2015). An individual with a greatly positive attitude toward a behavior will have a favorable intention to participate in the behavior (Zhang et al., 2014). In current study, attitude toward participating in vehicular PM2.5 reduction behaviors mainly depends on the information the resident holds towards such behaviors and the preference of good air quality which is indirectly affected by their behaviors. Similarly, the paper expects that resident vehicular PM2.5 reduction behavior would possibly be influenced by attitude change and persuasion (Ajzen, 1991; Yazdanpanah and Forouzani, 2015). Therefore, we present the first hypothesis:

H1. Attitude will have a positive effect on resident intention to participate in vehicular PM2.5 reduction behaviors.

2.2. Subjective norm

Subjective norm is defined as individual's perception that most people who are important to him consider he should or should not perform a behavior (Ajzen, 1991). Previous studies have confirmed that the higher pressure received from the significant people the greater intention the individual to perform a behavior (Ajzen, 1991;

[1] See detail at http://www.zhb.gov.cn/gkml/hbb/bgg/201408/t20140828_288364.htm.