IT and Eco-driving: The Moderating Effect of App usage on Behavior Changing

Abstract

Information technology (IT) is playing an increasingly important role in the Internet of Vehicles. While there is a substantial body of literature that examines factors resulting in fuel consumption and greenhouse gas emissions, including driving behavior, few studies have focused on the impacts of IT on fuel efficiency. The purpose of this study is to examine whether and how much the use of IT could influence the fuel efficiency through impacting individual driving behavior. Based on Cognitive Dissonance Theory, this study investigates whether a mobile app help improve fuel efficiency by helping individuals to improve their driving behavior and attempts to explore the reasons for the phenomenon. An Empirical investigation has been designed to collect drivers’ app usage data and driving data from XXX drivers over a 16-month period. The results of the study will contribute to sustainable development and further enrich the IT application scenario.

Keywords:

1 Introduction

The continuous development of information technology (IT) has created new and immensely complex environments. The world we live in is greatly influenced by these developments, and the use of information technology is gradually penetrating all aspects of life (Stolterman and Fors 2004). Researchers explore from the acceptance to influence of IT (Dede 2000; Lee et al. 2005; Moon and Kim 2001; Wang et al. 2015b), and recently intend to positively directing people's behavior using IT. In the last decade, IT has been proved to be effective in assisting in changing people's behavior, such as advising individuals to exercise and break properly and successfully helping increase work efficiency (Consolvo et al. 2006; Hughes et al. 2010; Kamal et al. 2016; Lin et al. 2006; Short et al. 2014; Sundaram et al. 2007).

In fact, information technology (IT) is widely used for good in various fields, and it is no exception in the field of driving and Internet of Vehicles (IoV). IT has already made a big difference in autonomous driving, improving communication quality of IoV networks and optimizing environmental detection (Guo et al. 2017; Xu et al. 2021; Yu et al. 2018). To date, as the constantly rising green house gases (GHGs) emissions from road transport raises special concern (Gorham 2002), sustainability is being discussed more often and fuel efficiency has become a crucial topic in the fields around driving sustainability (Allison et al. 2022; Barth and Boriboonsomsin 2009; Hua et al. 2022; Huang et al. 2018; Jazairy et al.).

Prior studies indicated that fuel efficiency from road transport will be influenced by several factors, such as driving environment (e.g., roadway and roadside environment), demographic information, driving style, weather, and vehicle/fuel types (Ewing et al. 1997; Fafoutellis et al. 2021; Sivak and Tsimhoni 2009; Wang et al. 2014).

In order to improve fuel efficiency and reduce fuel consumption, several measures have come out. The most popular ones are investing in new vehicle technologies (like advanced engines) and fuels, and promoting a fuel-efficient driving style, i.e. eco-driving (Alam and McNabola 2014; Zhou et al. 2016). Among them, eco-driving can be significantly lower-cost and more immediate. Eco-driving is a new way of driving that has been developed since the mid-1990s and is now a climate change initiative that cannot be ignored (Alessandrini et al. 2012; Barkenbus 2010). It is a multidimensional concept and has different definitions or scope in the literature. The exact descriptions of the definition may vary, nevertheless, the purpose of introducing the concept of eco-driving in this field is to improve fuel efficiency and driver’s driving behavior (Fafoutellis et al. 2021). Thus, in this paper, eco-driving is defined as the adoption of a driving behavior (or a driving style) that aims at saving fuel and reducing harmful emissions of greenhouse gases (GHG) (Andrieu and Saint Pierre 2012b).

In the field of eco-driving, there is the presence of IT as well. IT is often used to collect data and give feedbacks on drivers’ driving behavior (Stillwater et al. 2017; Young et al. 2011). In addition, many studies claim that IT has the potential to improve road safety and fuel efficiency through providing eco-driving advice and in-vehicle feedback to drivers (Andrieu and Saint Pierre 2012a; Barla et al. 2017; Fafoutellis et al. 2021; Gao et al. 2021; Vaezipour et al. 2015). According to Hebden et al., those kinds of IT are a novel technology that can be used to deliver behavior change interventions directly to individuals and have the potential to make a difference (Hebden et al. 2012). However, the effect of IT on specific eco-driving behaviors such as drivng speed, deceleration and acceleration has not been fully explored (Fafoutellis et al. 2021; Vaezipour 2018; Vaezipour et al. 2015).

Thus, to explore the mechanisms of how IT could influence eco-driving behaviors to improve fuel efficiency, this research carries out an empirical investigation, builds regression model based on naturalistic driving data collected using smartphones and on-board devices (OBD).

The rest of the manuscript is organized as follows: In Section 2 the impacts of IT and the notion of eco-driving is presented in detail and in Section 3 theoretical explanations are discussed. In Section 4 research model and hypotheses are presented and, in Section 5, the methodology is elaborated. Section 6 includes a thorough discussion about the relationship between IT and eco-driving behavior. In Section 7 the main conclusions are presented and future research directions are discussed.

5 Methodology

Data collection

This research observed 400 different taxi drivers using a driving-assistant app named “hujiabao” over 16 months. Drivers were asked to register demographic information such as age, gender, permanent address and types of their cars. Their usage behaviors were recorded once they open the app in a given day. Data sets for driving behaviors were collected using on-board devices (OBD). The OBD system is designed to capture detailed driving information such as vehicle speed, engine rpm, engine coolant temperature, diagnostic trouble codes, fuel consumption, etc. (Lin et al. 2009), and it starts to be used in research recently (Chen et al. 2015; Yang et al. 2016; Zaldivar et al. 2011). Then observations with a 0 mile driven on the day are excluded. After merging data sets of app usage behavior and individual driving behavior, we winsorized the quantity of fuel consumed at the 1 percent level (Tukey 1962) to alleviate potential bias caused by outliers in the following regression analysis, resulting in 11187 observations as the initial sample. And then we deleted the observations containing missing demographic information. The final sample dataset consists of 6993 observations.

Measurement

Independent variables

Following Huang et al.’s and Wang et al.’s study (Huang et al. 2018; Wang et al. 2014), this research characterized eco-driving behaviors using two most important driving behavior variables: average speed and speed change, to reduce the complexity of the model. In this study, average speed is collected from the app data, named as Speed\_KMH and Speed\_Change refers to aggressive speed changing behavior. Speed\_Change is measured by the total number of hard acceleration and deceleration.

Moderator variable

Regarding the driving assistant app works automatically when the user has opened it, the check-in records reflect an individual’s usage status. We define App\_Usage as whether a driver uses the app and whether the app runs effectively during a day (Taylor and Levin 2014). It is measured by the drivers’ check-in status (used or not used) in a given day.

Dependent variable

Vaezipour et al. distinguishes the term fuel consumption rate with fuel efficiency. Their research defines fuel consumption rate as total quantity of fuel consumed by a vehicle per unit distance (commonly expressed in liters/100kilometers) (Vaezipour et al. 2015), while fuel efficiency as ratio of the work or energy output of an engine to the work or energy input (Haworth and Symmons 2001). But according to some other literature, fuel efficiency is based on a vehicle’s miles per gallon (Carson 1980; McCarthy and Tay 1998). Considering both definitions, fuel efficiency is measured by the amount of fuel consumed per unit distance (liters/kilometer) in this paper. Thus, we choose Fuel Consumption as dependent variable, and the more the fuel is consumed, the less efficient is it.

Control variables

Control variables are considered to ensure the model robustness. Apart from driving styles and driving skills, other objective factors can affect driving behavior. For example, driving experience, time pressure, driving environment (weather condition, road condition, traffic congestion, etc.) and vehicle states (Bone and Mowen 2006; Cai et al. 2016; Drobot et al. 2007; Ma et al. 2019; Shi et al. 2019; Wang et al. 2015a; Zheng et al. 2014). Thus, we controlled driving time period, vehicle types (Car\_Type\_n), and drivers’ driving experience. Specifically, we categorized the driving time period by weekay or weekend and day or night, generating two control variables: Day\_n and Isnight. Besides, driving experience (Totalm) is measured by the total distance a driver had ever travelled before. According to the definition of fuel efficiency above-mentioned, we controlled the continuous driving time (Time) in the model. We controlled demographic information of drivers, such as Age, Gender and permanent address as well. We also controlled geographical location-related variables such as the country where the participants driving in. All the drivers comes from Anhui province in China and drive cars in Anhui.

alert

As all functions of the app are open to everyone except for alert, which is randomly open to users, we have controlled Alert in the regression model.

Results





