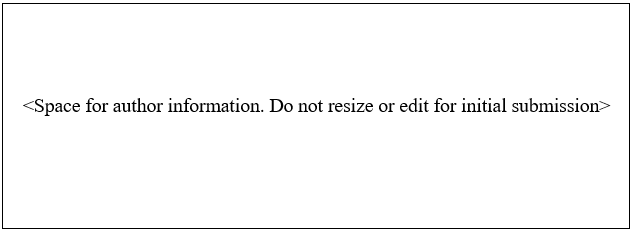
**The Impact of Mobile App Usage on Individual Behavior Changing: An Experimental Study of Driving Behavior**

*Research-in-Progress*

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**Abstract**

*The use of IT products and applications has grown substantially over the past few years and many studies have reported the effects of using these platforms in business, entertainment and public health. However, the relationship between environmental impacts and App usage behavior of drivers have received little attention. Given the lack of a picture of the effects on individuals of using Mobile App, we conducted a natural experiment of 63 taxi drivers from July 2019 to October 2020. The experiment recorded their driving behaviors and monitored their behavior changing by daily CO2 emissions detected by* *On Board Diagnostic (OBD) systems.* *This paper discusses implications of the findings, identifies gaps in the literature and provides a roadmap for future research.*

**Keywords:** Mobile App usage, CO2 emissions, individual behavior changing, natural experiment

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# Introduction

There is a growing emphasis on global effects of various air pollutants, especially for greenhouse gases and notably CO2. Road vehicles are acknowledged to be significant sources of a range of pollutants. In 2018, they were responsible for 25% of total CO2 emissions from fuel combustion[[1]](#footnote-1) (IEA 2020). Among the many causes of road vehicle emissions, bad driving habits are one of them (Alessandrini et al. 2012; Van Mierlo et al. 2004). Then since the mid '90s, eco-driving has been developed as a new approach to driving, and nowadays it is a climate change initiative not to be overlooked (Alessandrini et al. 2012; Barkenbus 2010).

But it is far from enough to be satisfied with the help of initiatives or suggestions. With the development of Internet of vehicles (IOV), increasingly more organizations including government agents and IT companies are paying attention to leverage information technology (IT) to improve driving behaviors and cutting CO2 emissions.

It is acknowledged that the diffusion and deepening of the IT revolution is a hallmark of the emerging ‘information age’ (Castells 1997). And the rapid development of IT brings many gadgets with it, such as smartphones, personal computers, mobile apps and so on (Joorabchi et al. 2013; Mahmood et al. 2001; Nishad and Rana 2016). People use these IT products and applications for different purposes. And not surprisingly, as people use IT more frequently, researchers are studying the effects with growing interest (Greengard 2011).

Early studies have emphasized their positive applications including health promotion, education, business, communication, entertainment, and global connectivity (Chen 2020; Cole-Lewis and Kershaw 2010; Green and Bavelier 2008; Hitt and Brynjolfsson 1996). With the deepening of the research, a few researchers start trying to use IT to change human behaviors (Årsand et al. 2010; Hebden et al. 2012; Hughes et al. 2010; Mattila et al. 2009; Sundaram et al. 2007; Varnfield et al. 2011). However, there is a lack of its application on the purpose of environment protection. Thus, we planned to carry out a natural experiment to prove the drivers’ behavior changing and the environmental value of IT usage.

# Literature Review

## IT Usage and Behavior Changing

A typical objective of most prior IT research is to explain the factors influencing the IT usage or acceptance. In the last decades, researchers built and tested several theorical models of IT usage (Taylor and Todd 1995; Venkatesh et al. 2003). Another major objective of IT research is to assess its value, mainly in business. Studies shows that IT usage is a key driver of organizational performance and can effectively improve productivity (Devaraj and Kohli 2003; Hitt and Brynjolfsson 1996).

Meanwhile, only a few researchers have reported on the use of IT products and applications for individual behavior changing. Researches are usually found in some certain fields like public health and business. Mattila et al. tried to record self-management of weight-related behaviors (Mattila et al. 2009), Hughes et al. developed an app for monitoring energy balance (Hughes et al. 2010), and others have monitored diet or physical activity as part of a program for diabetes (Årsand et al. 2010) or cardiac rehabilitation (Varnfield et al. 2011). Sundaram et al. suggested that the effective and efficient use of technology enhances salesperson performance (Sundaram et al. 2007). According to Hebden et al., software applications (apps) used on mobile devices 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).

Actually, IT can change even more than that. As environment and sustainability have been supposed to become game-changing megatrends in the near future (Lubin and Esty 2010), new thinking and innovation is urgently required. Green IT is put forward in this context. Prior researchers defined Green IT as the systematic application of practices that enable the minimization of the environmental impact of IT and allow for company-wide emission reductions based on technological innovations (Pablos 2012). It essentially covers two goals, including reducing the amount of emissions released by IT systems and infrastructure, and reducing the emissions from business and production processes with the aid of IT. Green IT benefits a lot, with its saving our money, improving energy efficiency, lowering greenhouse gas emissions, and so on (Erek et al. 2011; Loeser et al. 2011; Murugesan 2008).

As little research explored the Green IT in terms of human driving behaviors, this study will investigate the relationship between individual level environmental impacts (CO2 emissions) and App usage behavior of drivers.

## Driving behavior and CO2 emissions

CO2 emissions from road transport are of special concern, as they have been rising constantly (Gorham 2002). Some studies (Idso et al. 1998; Nasrallah et al. 2003) have measured and considered levels of CO2 to be representative of air quality similar to other pollutants that can have significant health effects (e.g. NOX, SO2, CO and PM10 ). In this respect, it is about time researchers researched on how to reduce CO2 emissions from road transport.

Except methods like better transport infrastructure, advances in vehicle technology and management systems (Nejadkoorki et al. 2008), only a few research showed that driving style has influence on greenhouse gas emissions as well. Alessandrini et al. have shown that women tend to consume and emit less than men because they push the accelerator pedal in a steadier way (Alessandrini et al. 2009). Gao et al. analyzed fuel consumption and NOx emission characteristics over various scenarios, and provided the guidance for eco-driving to achieve cleaner travelling (Gao et al. 2021). And Alessandrini et al. proves the influence of driving style on the environment by making an on road campaign, and adopting the tool developed by Centre for Transport and Logistics (CTL) (Alessandrini et al. 2012).

Therefore, one of the possible actions to reduce the environmental impact caused by road transport is to educate drivers to adopt a driving style that is as eco-friendly as possible. And we will use in-car sensor data and a natural experiment to build regression models to see how each contributing factor relates to CO2 emissions.

# Natural experiment design

## Research hypothesis

This study uses CO2 emissions to quantify individual driving behavior, examines the relationship between individual behavior and mobile App usage, and assesses the extent to which App usage correlates with individual behavior.

As discussed earlier, previous studies (e.g. Alessandrini et al. 2012) have highlighted the importance of drivers’ driving style as highly influential variable when studying the total CO2 emitted by cars in a specific experimental setting, while age, gender and driving skills (or driving experience) have been proved to be able to affect drivers’ driving style (Donovan et al. 1988; Gao et al. 2019; Groeger and Brown 1989; Rolison et al. 2018). With this in mind we proposed testing the following hypothesis, while controlling for the variables of age, gender and driving years:

* H1: Under natural circumstances, driving style can also influence CO2 emissions significantly.

The Maslow’s Need Hierarchy Theory (Kaur 2013) shows that as the basic needs are satisfied, an individual seeks to satisfy the higher level needs, such as social, esteem, and self- actualization needs, thus having the intrinsic drive to constantly improve themselves. And the Social Comparison Theory (Festinger 1954) explains that people tend to compare themselves with others in similar situations to get access to those indirect objective cues and standards. The mobile App will alert our drivers when they are engaging in dangerous driving behavior and give a ranking of driving performance at the end of each day. In other words, the mobile App could improve driving performance and then cut down the CO2 emissions by informing drivers of their own driving behavior and comparing that with their colleagues’. Thus, we hypothesize:

* H2: Mobile App usage behavior of drivers is positively correlated with individual level environmental impacts (measured with total daily CO2 emissions amounts).

我在想后续这里加一个age、gender、driving experience、收入、婚姻状况会不会影响app的使用 可不可行(不过目前我们的处理是不行的，一方面那些驾驶员特征缺太多了，另一方面我们现在是把app\_usage当成是二分类变量的。)

## Data collection

The goal of this work is to discover the impact of mobile App usage. Thus, we planned to choose CO2 emissions as dependent variable to show the drivers’ driving behavior changes and the environmental impact of the usage of our app.

*（下面这我用了过去时和现在完成时）*

The sample of vehicles monitored in the experiment has been selected from 63 different taxi drivers in xxx(公司). We obtained their driving data from July 2019 to October 2020 using On Board Diagnostic (OBD) systems, which have been incorporated into the computers on-board new vehicles to monitor vehicle components and driving behaviors in recent years. Meanwhile, we invited these 63 taxi drivers to use our software application, which can send alert to them when it detects risky driving behaviors and can provide a driving behavior ranking at the end of the day. We used the drivers' check-ins in the app to identify whether they had used the software that day.

After deleting all records with zero daily CO2 emissions (which means the driver didn’t use the car that day), we’ve got 11188 observations and 21 variables including app\_usage (whether to check in on the App), tired\_driving (hours of tired driving/day), Speed\_KMH (average driving speed/day), age, gender, driving years of a driver, etc.. The daily CO2 emissions and counts of the total number of the driver’s rapid acceleration, rapid deceleration, sharp turn, driving hours, fuel consumption, night driving hours and total miles travelled per day were remarkably skewed and transformed with logarithmic transformations. We used the mean value of related attributes of each driver to complete the missing values. Some important variables are shown in the table below.



## ***Analytic strategy***

We planned to construct a linear regression model to investigate how the app\_usage and driving behaviors affect the CO2 emissions, as given next:

As described earlier, CO2 emissions(log\_co2) being the dependent variable, is get directly through the OBD systems of a car per day. xxxxxxxx are the independent variables. We use the driver's personal features (gender, age, driving experience) as control variables, and ε is the idiosyncratic error term. Thus, we use the equation above to fit our data.

Significance of the equation, each independent variable and coefficient was assessed using z tests and measured the effects of the presence of each independent variable on the strength of predictive relationships in the model. An α level of 0.05was adopted for our z test on each contributing factor. Analyses were conducted in 2021.

# Preliminary Results（估计加不上去了）

# Conclusion

Future studies may benefit from including multiple traffic conditions of different areas; measuring driving behavior mainly by CO2 emissions; and examining how the usage of App make difference to individual behavior changing. The present study provides evidence that App usage has the potential to positively influence drivers’ driving behavior and their CO2 emissions. The fındings have implications for future environmental protection projects and can assist public officials and IT engineers to develop apps that can help achieve the goal of energy conservation and emission reduction and promote sustainable development.

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