Two Faces of Car Sharing: 
An Exploration on the Effect of Car Sharing 
on Car Accident 

Completed Research

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Abstract
This study investigates the impact of car sharing on urban traffic violence. Conducting differences-in-differences approach, we find that car sharing entry increases the number of urban car accident. Moreover, the effect varies by the types of car accident based on license year of attacking driver. After car sharing entry, the number of car accident by experienced drivers have been increased whereas those by inexperienced drivers didn’t change significantly. According to additional analysis using the number of car sharing zones as an alternative measure, we find that the impact of car sharing on the number of overall car accident and those from experienced driver are still positive and the number of car sharing zones has negative impact on the number of car accident by inexperienced drivers. Our findings contribute to sharing economy literature by focusing on car sharing and its societal impact. Implications for managers and policy makers are also suggested.

Keywords
Sharing economy, car sharing, car accident, differences-in-differences, societal impact of IS

Introduction
Leveraging the benefits from today’s mobile information technology, sharing economy has been changing the way people consume, own, and travel. Airbnb has provided new experiences to travelers by providing diverse options of staying at a travel destination and helped saving accommodation fees. One of the most popular ride-sharing services, Uber, has provided new transportation options. Airbnb and Uber are not the alternatives for traditional accommodations or transportation methods anymore. They have become one type of major means of consumption. It is argued that these services disrupt traditional industries (Eckhardt and Bardhi 2015). In addition, as sharing economies are getting more popularity, scholars are trying to investigate the potential of these services (Botsman and Rogers 2011; Sundararajan 2013) and even regulatory and safety issues of sharing economy are mentioned (Malhotra and Van Alstyne 2014). Just as these services do, car sharing service is taking up a position as another major means of driving vehicles, which may affect diverse areas in society. Since the introduction of car sharing, vast number of population are taking the benefit of driving a car more easily than ever before. With the emergence of smartphones and the development of mobile information technology, it became much easier to use car sharing service and that car sharing has been getting more popularity and becoming more common in recent years. Thus, it is expected that the impact of car sharing service on our society is becoming more significant. However, car sharing has been getting relatively scant attention from IS literature compared to the other sharing economy services such as ride sharing or home sharing services.
Conventionally, as car is an expensive durable asset, driving a car is limited to people who can afford to own a car and are confident enough to drive a car. Therefore, some young, inexperienced drivers didn’t have the opportunities to drive on the road. Car sharing is a service providing flexible car rental service for a short period of time unit. As car sharing lowers people’s entry barriers to drive a car, the service has brought new drivers on the road. Moreover, as one of the representative access-based consumption, it is taking the form of temporary use, accessing public goods rather than using privately owned goods, which can be a factor changing drivers’ driving behavior. In sum, there has been more chance that inexperienced drivers drive on the road and drivers’ behavior can also be changed by driving a shared car, public vehicle. As a result, car sharing service may change the road environment with increased traffic violence. In this regard, we investigate the effect of car sharing on the number of car accidents occurred within urban areas. This study empirically investigates the effect of car sharing service on car accident occurrence. We use car sharing data from a leading car sharing company in South Korea. The data is constituted of information on the car sharing entry into each urban area in South Korea between 2012 and 2016. Then, in order to capture the effect of car sharing entry on car accident occurrence in each urban area, we combined data from multiple sources. We got car accident data from Korean Traffic Accident Analysis System (TAAS) database and other urban area related variables from Korean Statistical Information Service (KOSIS) database. In order to investigate the causal impact of car sharing on car accident, we employ natural experiment approach, differences-in-differences analysis. Examining the impact of car sharing, we also investigate the impact of car sharing on different types of car accidents based on the license year of a driver involved in car accidents. Additionally, as the number of car sharing zone varies across each urban area, we conducted fixed-effect panel regression analysis using the number of car sharing zone as an alternative measure for dependent variable. We examine how car sharing service activeness affect car accident occurrence via additional analysis. Based on the differences-in-differences analysis, we find that car sharing increases the number of overall car accident and accident from inexperienced drivers within urban area. The results also show that car sharing does not have significant impact on car accident occurred by inexperienced drivers. Moreover, our additional analysis results show that the number of car sharing zone also significantly increases the total number of car accident and the accidents from experienced drivers whereas it decreases the number of car accident from inexperienced drivers. That is, as the number of car sharing zone increases, the number of car accident due to inexperienced drivers is decreasing whereas the total number of car accident and the accident from experienced drivers are increasing. This suggests that the effect of car sharing magnitude varies based on the attacking driver’s driving experience. This study contributes to IS and traffic literature by focusing on the impact of car sharing service, which has largely been ignored in both fields. It also contributes to practice by showing the possibility of the bright side of car sharing service.

Related Literature

Societal impact of sharing economy

Sharing economy has been altering the market structure by changing the way people consume and use resources. Sharing platforms help users in demand side to use or get access to assets with a small amount of money and at the same time, help users in the other side to fully utilize unused or infrequently used assets and make economic profit. With the growth of sharing economy platforms, there have been several empirical studies examine the impact of sharing economy on diverse areas. Early researchers started by investigating the impact of sharing economy on related industries. Zervas et al. (2017) investigated the effect of Airbnb on hospitality industry and Wallsten (2015) and Cramer and Krueger (2016) examined the effect of ride-sharing on taxi and public transportation industry. Additionally, Rayle et al. (2014) contrasted taxi and ride-sharing services in terms of the difference in trips and user characteristics between two services. More recently, scholars are paying attention to the role of sharing economy on more diverse social areas and those societal impacts of sharing economy are investigated in a growing number of studies. For example, it is found that Airbnb is related to neighborhood housing fee or gentrification (Barron et al. 2018; Sheppard and Udell 2016; Wachsmuth and Weisler 2018) and affects local restaurant employment by changing the way tourists consume local services at travel destinations (Alyakoob and Rahman 2018). The most widely used representative ride-sharing service, Uber, has been found to affect alcohol-related mortality rate (Greenwood and Wattal 2017), traffic congestion (Li et al. 2017), entrepreneurial activity (Burtch et al. 2018), car purchase (Gong et al. 2017), and even local labor market (Li et al. 2018). As an innovative
business model itself, sharing economy and societal issues are inseparable and scholars argue that there is still much to be studied to explore the role of sharing economy.

**Car sharing**

In this study, car sharing is a service that users access cars owned by a service provider. Car sharing in this study is distinguished from Uber and Lyft, the on-demand ride sharing services that riders take on the driver-owned cars in the same form as taxis, in that each car is owned by car sharing companies and users drive a car on their own. First originated in Europe almost couple of decades ago, car sharing has also been used as a popular alternative to own car or take public transportation (Bardhi and Eckhardt 2012). Zipcar is one of the most famous car sharing services in the U.S. With the growth of car sharing phenomenon and the emergence of the concept of sharing economy, car sharing has been studied in transportation and environmental literature (Hirschl et al. 2003; Huwer 2004). More recently, it is starting to be studied in business literature, investigating the user’s usage intention and attitude (Bardhi and Eckhardt 2012; Hamari et al. 2015) or the business model itself based on consumption pattern (Belk 2014). However, most of the studies are examined in user side and the studies on the societal impact of car sharing service are still limited, especially in IS literature. With the emergence of smartphone and the development in mobile information technology, it became much easier to use car sharing service and thus the impact of car sharing service on human community can be explained as a societal impact of IS along with ride sharing or home sharing services. Especially in South Korea, leveraging the latest information technology, car sharing has been becoming a common phenomenon and getting popularity during last half decade. Also, different from other countries, as South Korean government regulates ride sharing service such as Uber or Lyft, we can find the pure effect of car sharing service on traffic accident. We thus investigate the effect of car sharing in the context of South Korea.

**Car accident and car sharing**

A car accident is a serious concern all over the world. Many policy makers over the world are trying to reduce and avoid bad consequences driven from car accidents and South Korea is not an exception. In 2017, 216,335 car accidents occur and 4,185 people died in traffic accident in South Korea. Also, it is estimated that more than 23 trillion won (about 2 billion USD) was spent on dealing with car accidents in the same year according to Korean Traffic Accident Analysis System (TAAS) report. Therefore, the car accident is an important issue in modern society and changing driver’s behavior or establishing better social systems so as to reduce car accidents is of great interest among scholars. In many cases, car accidents occur due to carelessness or poor driving ability of drivers. Studies find numerous reasons for car accident from driver’s side. Parker et al. (1995) suggested that absent-minded behaviors, errors due to misjudgment and failures of observation, and violations of drivers are three main reasons for car accident. Driver’s cognitive state such as self-regulation (Devlin and McGillivray 2016) or risk perception (Eboli et al. 2017; Turner and McClure 2003) as well as physical condition such as age, gender, or health state (Dellinger et al. 2001; Guo et al. 2017) are other important reasons for car accidents. Likewise, driver’s characteristics as well as physical and psychological state while driving are some of the major reasons for car accident. Hence, many of these studies attempt to address car accidents by findings ways to change driver’s behaviors. Furthermore, systematic or political changes such as change in the speed limit of a road or the number of road lanes are other aspects that change the rate at which car accidents occur (Johansson 2009; Schumaker et al. 2017).

It is thus important to consider those shocks in investigating car accident occurrence. As one of major systematic changes in recent years’ traffic condition, car sharing service entry can be considered as another factor for car accidents.

Anyone having a driver’s license can easily find and rent the available cars real time via mobile application. Specifically, unlike traditional rental car service that can be rented on a daily basis, it is possible to rent a car on a minute-by-minute basis on car sharing platforms. The car sharing service allows users to use the car flexibly in line with their intended use or lifestyle. The car sharing service thus lowers entry barriers of vehicle use while providing more people with the opportunity to drive vehicles on the road than ever before, and creating a different road environment. Specifically, as car sharing is a tech-savvy service operated through mobile application, majority of customers consist of young people, especially 20s. This means that inexperienced drivers and drivers who could not afford to own a car in the past get more chance to drive cars in South Korea (an individual can get a driver’s license since 20 in South Korea). Once inexperienced

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1 http://taas.koroad.or.kr/sta/acs/gus/selectStaInfoGraph.do?menuId=WEB_KMP_IDA_TAI

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drivers get on the road, there might be an increased possibility of car accidents. However, at the same time, since there is now increased chance to practice driving on the road, some serious accidents from these drivers due to lack of driving experience can be eliminated. In addition, the common concern for sharing economy or access based consumption, both of which are based on same form for consumption, rent, is moral hazard from user (Weber 2014). It is often the case that because some of the actions of user cannot be detected, it is likely that even trivial damage to a rented item can occur. Take into account of these facts, driver’s increased violence and absent-mindedness cannot be ignored. For example, unlike the case when driving one’s own car, drivers may show irresponsible behavior, such as reckless driving or traffic signal violation. Given that driver’s state significantly affects car accident and car sharing is significantly related to the changes in driver characteristics and behavior, car sharing and car accident can be related to each other. Current study thus addresses the following research questions:

**RQ1:** How does car sharing service affect car accidents?

**RQ2:** How does the effect vary based on the driver’s driving experience?

### Data

This study aims at investigating the effect of car sharing service on the car accident occurrence, so empirical analyses on the causal relationship between car sharing entry and car accident are conducted. We collected car sharing entry data from the leading car sharing company in South Korea. Founded in 2011 headquartered in Jeju Island, South Korea, the company started service since 2013. In 2016, the company has over 2,500,000 users and provide cars in approximately 2,950 sharing zones to the urban areas in Korea. The service is operated through mobile application that users can rent the car via mobile application. Users should first search for the nearest car sharing zone – the designated parking area for shared cars - and after finding the available cars, users can choose the car to rent by ten-minute unit with minimum of 30 minutes. Finding the car, users can open the door via smart key function on mobile application. After using the car for reserved hours, the user should park the car in the original car sharing zone within the scheduled time, then lock the door and return the car via mobile application.

Car sharing entry data is retrieved directly from the official blog of the company. The data covers entry information in the period between 2012 and 2016. Once the new car sharing zone is launched, the location of the car sharing zone is posted on the blog. The company also notifies the zones that are no more operated. Based on the posted address and posted date, we counted the number of car sharing zones within 227 urban areas in South Korea. In this study, urban areas are defined as districts, the administrative division that composes cities. By counting the number of car sharing zones in each urban area, we determined whether a car sharing service was operated in urban area at each year.

### Dependent variables

We collected the number of car accidents occurred in each urban area between 2012 and 2016 from annual district-level traffic accident database on Traffic Accident Analysis System (TAAS)\(^2\), the website that provides information and data on traffic accidents by each urban area. This study investigates the differential effect of car sharing service on distinct types of car accident based on the attacking driver’s driving experience as well as the effect of car sharing service on the number of overall car accidents. Therefore, we have three dependent variables in this study, the number of overall car accidents within urban area \(i\) in year \(t\) (Total\(_{it}\)), the number of accidents from inexperienced drivers, having attained driver’s license no more than 3 years at the time accident occurred (InExp\(_{it}\)), and experienced drivers, having attained driver’s license for over 3 years at the time accident occurred (Experienced\(_{it}\)). Since the car sharing service is available for the drivers having at least 1 year of driving experience, we excluded the number of car accidents occurred by novice drivers, drivers under a year’s license, from each variable.

### Control variables

We control the effect of a number of variables between 2012 and 2016, which explain area-specific characteristics as well as traffic condition of each urban area. We control for demographic and socio-economic status of each area because these variables may play a role in car sharing service entry decision. These variables include the number of registered cars per capita of urban area \(i\) in year \(t\) (NumCar\(_{it}\)), population density of urban area \(i\) in year \(t\) (Density\(_{it}\)), and to account for the number of potential drivers

\(^2\) http://taas.koroad.or.kr/
within each area, we considered the ratio of the number of people aged over 20, the number of people older than 20 divided by the entire population, in urban area \( i \) in year \( t \) (Over20\(_{it}\)). In South Korea, only the people older than 20 can get a driver's license. Additionally, natural log of gross regional domestic product (GRDP) per capita of urban area \( i \) in year \( t \) (ln(Grdp\(_{it}\))) is controlled. We also control for geographic characteristics, especially those for traffic condition including road area per capita, road area (km\(^2\)) divided by population, of urban area \( i \) in year \( t \) (Road\(_{it}\)), the ratio of train area, train area (km\(^2\)) divided by whole territorial area (km\(^2\)) of urban area \( i \) in year \( t \) (Train\(_{it}\)). These variables have been identified as important variables in the transportation economic literature that explain traffic congestion (Li et al. 2017), which may affect possibility of car accident. We collected these variables from Korean Statistical Information Service (KOSIS), a website providing database and report from National Bureau of Korea. We restrict our empirical focus to the years between 2012 and 2016 as the data for those variables are relatively stable over the urban areas for this time period.

Table 1 summarizes descriptive statistics of each variable and Table 2 shows correlation matrix between control variables. Since none of the variables have correlation of over 0.8 in 5% level, it is ensured that multi-collinearity is not a serious problem in this study (Farrar and Glauber 1967).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs.</th>
<th>Mean</th>
<th>Std.Dev</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total(_{it})</td>
<td>1,098</td>
<td>613.0346</td>
<td>618.1986</td>
<td>5</td>
<td>3,516</td>
</tr>
<tr>
<td>ln(Exp(_{it}))</td>
<td>1,098</td>
<td>41.5146</td>
<td>43.3716</td>
<td>0</td>
<td>268</td>
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<tr>
<td>Experienced(_{it})</td>
<td>1,098</td>
<td>549.1330</td>
<td>553.5173</td>
<td>3</td>
<td>3,156</td>
</tr>
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<td>CarsharingEntry(_i)</td>
<td>1,098</td>
<td>0.5865</td>
<td>0.4927</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>NumCars(_{it})</td>
<td>1,098</td>
<td>0.3066</td>
<td>0.0712</td>
<td>0.1730</td>
<td>1.2751</td>
</tr>
<tr>
<td>Density(_{it})</td>
<td>1,098</td>
<td>0.0037</td>
<td>0.0060</td>
<td>1.97E-05</td>
<td>0.0285</td>
</tr>
<tr>
<td>Over20(_{it})</td>
<td>1,098</td>
<td>0.8589</td>
<td>0.0276</td>
<td>0.7826</td>
<td>0.9263</td>
</tr>
<tr>
<td>ln(Grdp(_{it}))</td>
<td>1,098</td>
<td>3.2270</td>
<td>0.5315</td>
<td>1.8774</td>
<td>5.9826</td>
</tr>
<tr>
<td>Road(_{it})</td>
<td>1,098</td>
<td>166.8409</td>
<td>168.5060</td>
<td>4.6626</td>
<td>690.1865</td>
</tr>
<tr>
<td>Train(_{it})</td>
<td>1,098</td>
<td>0.0039</td>
<td>0.0075</td>
<td>0</td>
<td>0.0582</td>
</tr>
</tbody>
</table>

Table1. Descriptive statistics

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<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
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<tr>
<td>(1)</td>
<td>1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td>0.1269*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3)</td>
<td>0.4268*</td>
<td>-0.2479*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(4)</td>
<td>-0.0903*</td>
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<td></td>
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<tr>
<td>(5)</td>
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<td>-0.0567*</td>
<td>-0.5516*</td>
<td>0.5758*</td>
<td>1</td>
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<tr>
<td>(6)</td>
<td>0.2532*</td>
<td>-0.1113*</td>
<td>0.5205*</td>
<td>-0.0306</td>
<td>-0.3730*</td>
<td>1</td>
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<tr>
<td>(7)</td>
<td>-0.0342</td>
<td>0.3569*</td>
<td>-0.2296*</td>
<td>-0.0856*</td>
<td>0.0516</td>
<td>-0.0147</td>
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</table>

Table2. Correlation matrix

<table>
<thead>
<tr>
<th></th>
<th>(1)CarsharingEntry(_i) × PostEntry(_it)</th>
<th>(2)NumCars(_{it})</th>
<th>(3)Density(_{it})</th>
<th>(4)Over20(_{it})</th>
<th>(5)Road(_{it})</th>
<th>(6)Train(_{it})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(7)ln(Grdp(_{it}))</td>
<td>*p&lt;0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Methods

Differences-in-differences analysis on the effect of car sharing
As the time of car sharing service entry varies across urban areas, we conduct a differences-in-differences method in order to examine the causal impact of car sharing service entry on each urban area’s number of

http://kosis.kr/index/index.do
traffic accidents. Differences-in-differences has been getting an increasing popularity as a way to estimate causal relationship (Bertrand et al. 2004). Following equation specifies our regression model:

\[
\text{CarAccident}_{it} = \alpha + \delta_0 (\text{CarsharingEntry}_{it} \times \text{PostEntry}_{it}) + \delta_1 \text{CarsharingEntry}_{it} + \delta_2 \text{PostEntry}_{it} \\
+ \lambda (\text{Controls}_{it}) + \tau_t + \epsilon_{it}
\]

CarAccident\(_{it}\) represents car accident measures (i.e. Total\(_{it}\), lnExp\(_{it}\), and Experienced\(_{it}\)) and Controls\(_{it}\) represents control variables related to characteristics of urban area \(i\) in year \(t\). CarsharingEntry\(_{it}\) is a binary variable specifying treatment groups in differences-in-differences estimation, which equals to 1 if car sharing service has ever entered in urban area \(i\) within our study period and 0 otherwise. PostEntry\(_{it}\) is a binary variable specifying post car sharing entry period for each urban area. CarsharingEntry\(_{it} \times \text{PostEntry}_{it}\) is a variable of our interest, which represents the differences-in-differences estimator that shows the effect of car sharing service on car accidents in the urban areas that belong to treated group compared to that of urban areas in control group in the same year. \(\tau_t\) specifies year fixed-effects which capture systematic changes over time. \(\epsilon_{it}\) is the error term. Running the regression, we use robust standard errors clustered at the urban areas in order to avoid problems from heteroscedasticity.

**Results**

Table 3 summarizes our main results.

<table>
<thead>
<tr>
<th>DV</th>
<th>(1) Total(_{it})</th>
<th>(2) Total(_{it})</th>
<th>(3) lnExp(_{it})</th>
<th>(4) lnExp(_{it})</th>
<th>(5) Experienced(_{it})</th>
<th>(6) Experienced(_{it})</th>
</tr>
</thead>
<tbody>
<tr>
<td>CarsharingEntry(<em>{it}) \times PostEntry(</em>{it})</td>
<td>42.79* (23.56)</td>
<td>54.76** (22.51)</td>
<td>-4.02 (2.72)</td>
<td>-1.59 (1.22)</td>
<td>51.41** (21.35)</td>
<td>59.84*** (30.90)</td>
</tr>
<tr>
<td>CarsharingEntry(_{it})</td>
<td>746.99*** (58.48)</td>
<td>525.08*** (154.45)</td>
<td>52.87*** (4.39)</td>
<td>32.44*** (7.76)</td>
<td>660.59*** (51.97)</td>
<td>445.31*** (138.23)</td>
</tr>
<tr>
<td>PostEntry(_{it})</td>
<td>-31.51 (19.66)</td>
<td>-41.38** (19.05)</td>
<td>-1.53 (2.53)</td>
<td>-3.37* (1.90)</td>
<td>-27.95 (17.38)</td>
<td>-35.79*** (17.57)</td>
</tr>
<tr>
<td>NumCars(_{it})</td>
<td>116.35 (82.96)</td>
<td>18.58** (8.96)</td>
<td>18.58** (8.96)</td>
<td>99.84 (78.29)</td>
<td>5.576.47 (13,566.64)</td>
<td></td>
</tr>
<tr>
<td>Density(_{it})</td>
<td>6,129.54 (15,218.14)</td>
<td>676.78 (469.06)</td>
<td>676.78 (469.06)</td>
<td>5,576.47 (13,566.64)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over20(_{it})</td>
<td>-2,693.64* (1,445.27)</td>
<td>-428.64*** (100.41)</td>
<td>-428.64*** (100.41)</td>
<td>-1,979.10 (1,304.45)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ln(Grdp(_{it}))</td>
<td>94.84*** (36.03)</td>
<td>7.72*** (2.79)</td>
<td>7.72*** (2.79)</td>
<td>79.82** (32.82)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road(_{it})</td>
<td>-0.47** (0.20)</td>
<td>-0.02 (0.01)</td>
<td>-0.02 (0.01)</td>
<td>-0.54*** (0.19)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Train(_{it})</td>
<td>-4,857.45 (3,487.14)</td>
<td>-488.77** (195.62)</td>
<td>-488.77** (195.62)</td>
<td>-4,714.44 (3,172.09)</td>
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<td></td>
</tr>
<tr>
<td>Constant</td>
<td>22.35*** (3.07)</td>
<td>360.23*** (92.65)</td>
<td>360.23*** (92.65)</td>
<td>1,791.37 (1,180.85)</td>
<td></td>
<td></td>
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<tr>
<td>Time fixed effect</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
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<tr>
<td>Obs.</td>
<td>1,098</td>
<td>1,098</td>
<td>1,098</td>
<td>1,098</td>
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</tr>
<tr>
<td># of urban areas</td>
<td>227</td>
<td>227</td>
<td>227</td>
<td>227</td>
<td>227</td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.36</td>
<td>0.43</td>
<td>0.32</td>
<td>0.43</td>
<td>0.36</td>
<td>0.43</td>
</tr>
</tbody>
</table>

**Table 3. Estimation results of car sharing entry on car accident**

Columns labeled (1) and (2) specify the effect of car sharing entry on the number of overall car accident. The results show that car sharing entry has positive significant effect on the number of car accident occurred in urban area. Columns labeled (3) and (4) indicate the effect of car sharing entry on the number of car accident from inexperienced drivers, having driver’s license less than 3 years. The results suggest that car sharing entry does not have significant effect on the number of car accidents from inexperienced drivers. Columns labeled (5) and (6) show how car sharing entry affects the number of car accidents occurred by
experienced drivers, having driver’s license over 3 years. The results find that car sharing increases the number of car accidents occurred by experienced drivers.

**Additional analysis using an alternative measure**

The main purpose of this study was to investigate the effect of car sharing entry on car accident in urban areas. Based on our data, not only the timing of car sharing entry but also the number of car sharing zones varies across urban areas. Since the number of car sharing zone within area indicates how car sharing is actively operated and that people in the area are having more chance to drive a car, the number of car sharing zone may have more salient effect on road condition, compared to the car sharing entry. Thus, we conduct additional analysis using an alternative measure for our independent variable. We count the number of car sharing zone within an urban area to see if the degree to which car sharing service is active also significantly affects urban traffic violence. We conduct panel regression analysis to investigate the effect of the number of car sharing zone on car accidents in urban areas. In estimating panel regression model, we employ Hausman test (Hausman 1978) to validate the use of a fixed effects model or a random effect model. According to the results from Hausman test, null hypothesis is rejected at the 1% significance, implying fixed effect model is a preferred model to random effect model. We run regression on the following equation:

\[
\text{CarAccident}_{it} = \alpha + \delta(\text{NumZone}_{it}) + \lambda(\text{Controls}_{it}) + \theta_i + \tau_t + \epsilon_{it}
\]

NumZone\(_{it}\) is the number of car sharing zones within an urban area \(i\) in year \(t\). \(\theta_i\) is an urban area fixed effect which captures time invariant characteristics of urban area. Table 4 summarizes the result for the additional analysis.

<table>
<thead>
<tr>
<th>DV</th>
<th>(1) Total(_{it})</th>
<th>(2) InExp(_{it})</th>
<th>(3) Exp(_{it})</th>
</tr>
</thead>
<tbody>
<tr>
<td>NumZone(_{it})</td>
<td>1.84*</td>
<td>-0.33***</td>
<td>2.64**</td>
</tr>
<tr>
<td></td>
<td>(1.04)</td>
<td>(0.11)</td>
<td>(1.03)</td>
</tr>
<tr>
<td>NumCars(_{it})</td>
<td>81.43</td>
<td>10.91</td>
<td>70.84</td>
</tr>
<tr>
<td></td>
<td>(82.18)</td>
<td>(7.08)</td>
<td>(77.56)</td>
</tr>
<tr>
<td>Density(_{it})</td>
<td>-69.344.80</td>
<td>-3.254.03**</td>
<td>-63.189.45</td>
</tr>
<tr>
<td></td>
<td>(66.388.49)</td>
<td>(1.623.54)</td>
<td>(65.819.25)</td>
</tr>
<tr>
<td>Over20(_{it})</td>
<td>-1.702.96</td>
<td>-246.05*</td>
<td>-939.81</td>
</tr>
<tr>
<td></td>
<td>(1.699.40)</td>
<td>(147.62)</td>
<td>(1.580.13)</td>
</tr>
<tr>
<td>ln(Grdp(_{it}))</td>
<td>92.98**</td>
<td>10.32***</td>
<td>77.87**</td>
</tr>
<tr>
<td></td>
<td>(36.33)</td>
<td>(3.87)</td>
<td>(33.21)</td>
</tr>
<tr>
<td>Road(_{it})</td>
<td>0.51</td>
<td>0.10***</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>(0.34)</td>
<td>(0.03)</td>
<td>(0.33)</td>
</tr>
<tr>
<td>Train(_{it})</td>
<td>-127.95</td>
<td>-856.65</td>
<td>803.84</td>
</tr>
<tr>
<td></td>
<td>(7.241.80)</td>
<td>(794.73)</td>
<td>(6.756.93)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.926.73</td>
<td>217.85*</td>
<td>1.268.12</td>
</tr>
<tr>
<td></td>
<td>(1.501.66)</td>
<td>(122.89)</td>
<td>(1.404.47)</td>
</tr>
<tr>
<td>Area fixed effect</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time fixed effect</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Obs.</td>
<td>1,098</td>
<td>1,098</td>
<td>1,098</td>
</tr>
<tr>
<td># of urban areas</td>
<td>227</td>
<td>227</td>
<td>227</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.13</td>
<td>0.10</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses (Clustered on urban area)

| ***p<0.01, **p<0.05, *p<0.1 |

Table 4: Additional analysis using an alternative measure

Column labeled (1) specifies the effect of car sharing on overall traffic accident, column labeled (2) shows the effect on traffic accident due to inexperienced drivers, and column labeled (3) is the result of the car sharing effect on traffic accident occurred by experienced drivers. The results for Total\(_{it}\) and Experienced\(_{it}\) show consistent results that the number of car sharing zones increases urban car accident. However, the result in column (2) shows somewhat different result from the main analysis. The column shows an interesting pattern that car sharing is shown to have negative effect
Discussion

Conclusion
This study investigates the effect of car sharing service on traffic violence – the number of car accidents within urban areas. Using car sharing entry data from a leading car sharing company in South Korea, we empirically examine the impact of car sharing service entry on car accident occurrence in urban areas. In examining the relationship between the entry of car sharing service and the number of car accident, we divided type of car accident by driver’s driving experience, years elapsed an attacking driver got his/her driver’s license. Employing differences-in-differences approach, we find causal relationship between the car sharing entry and the number of car accidents. The results find that car sharing increases the number of car accident in urban area. More specifically, it is shown that car sharing has significant impact on the number of car accidents from experienced drivers whereas the impact on the number of car accidents occurred by inexperienced drivers was not significant. The results indicate that among car sharing users, the experienced users may show irresponsible attitude or enhanced violence when driving a car, whereas inexperienced users’ attitude toward driving are stable regardless of using shared cars. Additionally, as the number of car sharing zones varies across each urban area, we assumed that not only the entry of car sharing service but also the number of car sharing zone may affect car accidents because the larger number of car sharing zone means that there are more opportunities for people within areas to use the car sharing service. We thus conducted additional analysis employing alternative measure for independent variable, the number of car sharing zone in each urban area. Additional analysis results have shown somewhat interesting pattern. The results for car sharing’s impact on the number of overall car accident and accident from experienced drivers are consistent from main results suggesting that the number of accidents increases as car sharing service is more active and more users are using the service. However, it is found that the number of car sharing zone is negatively related to the number of car accidents from inexperienced drivers meaning that car sharing service can lower the possibility of car accidents occurred by inexperienced drivers. A plausible explanation can be that by lowering the entry barrier of driving a car to inexperienced drivers, those drivers might get a chance to drive a car on a real road. Since many of the car accidents from inexperienced drivers are attributed to the lack of confidence and skills for driving a car it is necessary to provide them a chance to drive a car more frequently. However, in the past, unless an individual has one’s own car, an individual could hardly practice driving until he/she gets his/her own vehicle. In contrast, since the introduction of car sharing service, it has been easier to drive a car. Given this fact, car sharing service can be a good aid to practice driving even if a driver does not have a car.

Theoretic implications
Our study provides implications to both theory and practice. From the theoretical perspective, first, the study contributes to sharing economy literature by focusing on the societal impact of car sharing service, one of the commonly used sharing economies that has been getting relatively scant attention compared to home sharing service or ride sharing service. Especially, given that in case of car sharing, the development of mobile application brought more convenience for use, our study contributes by showing how the impact of service on society becomes significant leveraging newly adopted information technologies. Second, according to our main findings, we find that car sharing service has detrimental impact on traffic violence. More specifically, the result exhibits that car sharing service increases the number of car accidents caused by experienced drivers whereas its impact on the number of accidents from inexperienced drivers is insignificant. A plausible explanation might be that since there are more experienced drivers than inexperienced drivers in general, car sharing service play more salient role on experienced drivers. Also, the result can be explained by immoral behavior of the users, which is one of the fundamental issues that both sharing economy and access based consumption entails. Although it is hard to clarify whether our result can be explained by users’ attitudes, due to the observational nature of our data, the study indirectly confirms that the evidence for the phenomenon of user moral hazard exists in real world setting. Researchers can take advantages of finding opportunities for future studies by focusing on investigating the true underlying factors behind this phenomenon. Third, although our main findings suggest that car
sharing has detrimental impact, findings on the additional analysis implies potential positive impact of car sharing on society. The result shows that car sharing can be a double-edged sword in terms of car accident. On the one hand, car sharing may enhance irresponsible behavior of drivers resulting in the increased number of car accident. On the other hand, when it comes to inexperienced drivers’ case, car sharing can rather lower the ratio of car accident. This provides implication that implementing appropriate systems to prevent drivers’ irresponsibility, car sharing will be able to be a good aid for reducing traffic violence.

**Managerial implications**

The study also provides several implications to managers and policy makers interested in understanding the possible side effects of car sharing service and finding ways to brighten the dark sides. First, the study suggests that it is necessary to implement tools to strengthen users’ responsibility. Real time monitoring when cars are in use, self-feedback or feedback on previous users, or automatic driving scoring system using navigators can be examples for the tools that managers can implement to reduce user’s violence. There already exist similar tools within the platform. However, since they are not mandatory and there’s no punishment or reward regardless of using or not using these tools, these tools do not seem to be powerful enough to enhance morality of users. Developing appropriate tools and policies, managers would have to consider ways to encourage users to participate in these policies. Second, drawing upon the additional findings from this study, managers or policy makers might be able to find ways to utilize car sharing service for social purpose. Our additional finding suggests that car sharing can be used to enhance driving ability of inexperienced drivers. That is, car sharing magnitude – the number of car sharing zones – lowers the number of car accidents from less experienced drivers. Applying this fact to the case for education program for inexperienced drivers, car sharing can be a good aid for educating drivers who are not well experienced and confident enough to drive a car but do not have an opportunity to drive frequently. Leveraging these potentials, car sharing can take position as a service that helps these drivers to become well-educated confident drivers and reduces the possibility of car accident occurrence in the end.

**REFERENCES**


