Research Paper

The Effectiveness of Surveillance Cameras in Reducing Traffic Accidents in Bursa, Turkey

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Abstract

This study examines the impacts of surveillance cameras for the supervision and control of city traffic in Bursa, Turkey over the time period January 2011 to December 2013. A quantitative analysis of city-level traffic data is conducted with the results concluding that the presence of a newly-established traffic surveillance system has not measurably affected the number of injuries in traffic accidents. However, the results also show that there is a significant difference between the number of fatalities before and after the surveillance system was installed.

Keywords: Cameras, Surveillance, Accidents, Fatalities, Technology

Introduction

Traffic accidents are an important social issue in terms of public health management and civil development (Coleman, 2014). According to the World Health Organization (WHO, 2014), about 1.2 million people die and 20 to 50 million people are injured in road traffic accidents worldwide each year. Traffic accidents are also listed as one of the top ten leading causes of deaths (WHO, 2015), and it is predicted that the number of people killed and injured will increase by 65% by the year 2020 if no effective measures for prevention are taken. Although there are limited data regarding costs due to road traffic accidents, it is clear that the economic damage to families and countries is quite significant.

In Turkey, about thirty thousand individuals were killed in road traffic accidents in the decade covering the years 2005 to 2014 (Tuik, 2015). And currently, the road traffic fatality rate is close to three deaths per 100,000 population (WHO, 2015), a figure much greater than the number of people who lost their lives due to terrorist attacks in the over the past three decades in that country (during 1984-2014).

Given this situation, it can be safely concluded that reducing traffic accidents is of crucial importance for the administrative sectors in the government. Thus, the government should put as much emphasis on implemented strategies to reduce traffic violations and maintain traffic order as that put on other major crimes (Findlaw, 2015).

The rapid growth of the use of motor vehicles has resulted in road traffic collisions becoming a serious social problem (Durak, et al., 2007). To address this matter, the government of Turkey installed traffic surveillance systems on major motorways for the purpose of reducing traffic violations and protecting people from being killed and injured. These devices are expected to serve as deterrence to committing violations and saving lives through supervision and control for social safety improvement (Samatas, 2008:354; NG, Wong and Lum, 1997; Fleet Industry News, 2014).

In order to test this hypothesis, we examined data collected for the period January 2011 to December 2013 on the traffic situation in Bursa, the fourth largest city in Turkey with a population of 2.7 million. This city is one of the most industrialized metropolitan centers in the country and functions as the administrative center of Bursa Province. In Bursa, there are altogether fifteen main roads, including the European Boulevard,
The European Boulevard is examined as the investigation target for this study because it is the busiest road in Bursa in terms of traffic volume. In addition, we discuss the issue of traffic-related fatality prevention issue within the framework of relevant theories.

Previous Studies

The extent to which traffic accidents affect society cannot be understated. It is a worldwide phenomenon which often results in death and serious injuries. Traffic accidents bring great property loss to individuals, families and society (Kranz, 2011; ANH et al., 2005). While governments have taken measures to prevent the occurrence of traffic accidents and reduce the number of fatalities, the effect of traffic rules and regulations is subject to debate. “The approach to implement the rules and regulations available to prevent road accidents is often ineffective and half-hearted” (Gopalakrishnan, 2012).

There is also still no consistent conclusion about the causes of traffic violations and the best policy to reduce or stop them. Two general theories, however, can be used to justify the use of surveillance cameras in road accident control.

Beccaria’s Deterrence Theory

Beccaria’s well-known deterrence theory is one of the most studied areas of criminology. According to this approach, individuals desire the least costly method to achieve the best outcome, and this rule applies to criminal behavior, as well. Beccaria believed that criminal behavior could be minimized using the basics of human nature. The core of the deterrence theory is punishment (Harcourt, 2013). Although some researchers argue that “maintenance of societal order can’t be attributed to the efficacy of threats of punishment alone” (Kennedy, 1983-1984), deterrence theory is still considered one of the most effective measures which prevent people from committing crimes. People make judgements examining the trade-off of criminal acts. They are likely to assume the risk from committing the act if the benefit from a criminal act is more profitable than the potential loss (Baker, 1968). Therefore, the amount of penalty functions as the threshold point where people decide whether to risk or to avoid the criminal act. Penalties upon a specific individual warns the public of potential punishment (Paternoster and Piquero, 1995). Because the increase of the amount of penalty is an effective means to stop crimes, governments should impose penalties swiftly, severely, and precisely (Shavel, 1992).

Based on the deterrence theory, governments should impose harsh penalties on people who commit a serious violation of traffic law. Cook (1980) and Nagin (1998) found that the precision of the sanction is the most significant factor in determining deterrence. “The importance of sanction severity is dependent on the perceived certainty of punishment” (Ritchey and Nicholson-Crotty, 2011). It is the perception of the certainty of punishment that truly functions in the prevention of the violation acts by people. Practical studies prove the negative correlation between the perception of the certainty of sanction and recidivism (Waldo and Chiricos, 1972; Horney and Marshall, 1992). This implies that the enhancement of the former
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reversely contributes to the latter. Thanks to progress in technology, it is now much easier to enforce strict discipline among drivers through traffic fines. Thus, fines are confirmed to be effective deterrent in stopping serious violation of traffic laws, such as drunk-driving (Nichols and Ross, 1990).

Routine Activity Theory

Routine activity theory, which is also referred to as lifestyle theory, focuses on “providing information regarding who is more or less likely to be a crime victim” (Tewksbury and Mustaine, 2010). It is “an environmental, place-based explanation of crime, where the behavioral patterns and intersections of people in time and space influence when and where crimes occur” (Branic, 2015). The purpose is to analyze the criminal’s behavior by perceiving the situation in which a crime happens. According to this theory, the consequence of a crime is predictable because time and space are the factors contributing to the behavioral patterns and intersections of people which are involved in a crime. It argues that three conditions are necessary for a crime: (i) availability of a suitable target; (ii) lack of a suitable guardian; (iii) presence of a likely and motivated offender. Missing of any of these three factors can prevent the violation of law (Cohen and Felson, 1979). The routine activity theory offers the best explanation as to why in many countries, people don’t take violations of traffic rules and regulations seriously. The violation act has become a habitual behavior for local people (Olayemi, 2014). They learn from the daily activity of other people in the community that breaking the traffic laws is acceptable.

Although some researchers have reached the conclusion that internal forces, such as traditional beliefs and values, are the causes of crimes (Zimring and Hawkins and Vorenberg, 1974), more and more studies show that crimes happen under the influence of social, technological and economic factors, which are defined as outer forces (Becker, 1974). Therefore, specific interventions are needed to enhance the implementation of the enacted laws and prevent people from committing crimes. “Opportunity makes the thief”, often the factor attributing to a criminal act (Madero-Hernandez and Fisher, 2012). Crimes can be reduced if opportunities are lessened. Thus, it is the responsibility of the government to take necessary precautions to reduce the chances for people to break the laws. The absence of supervision increases the opportunity for people to get involved in illegal actions (Osgood et al., 1996).

Since road traffic is rapidly increasing, supervision is needed to reinforce the implementation of traffic laws. It is not a new finding that over-speeding drivers will slow down if they know they are being monitored. Regulations protect the safety of people and the society. People enjoy more freedom with the management and supervision of law enforcement (Ehrlich, 1996).

Various measures have been taken to stop violations of traffic laws. Cronin (2005) reported that imposing beer taxes is effective in the control of drunk-driving and reducing fatal accidents. Noked (2010) proposed that “a corrective subsidy” should be paid to insurers as a shared social gain from the reduction of traffic accidents. In fact, the purpose of such measures is to improve public understanding about the traffic safety issue. The enhancement of extensive support from people results in less violation of traffic rules and regulations (Zajc, 1996). The application of technological devices for traffic supervision, such as surveillance cameras, proves to be a powerful tool to reduce the occurrence of traffic accidents and the number of fatalities (Carnis and
Blais, 2013). As large percent of traffic crashes with motor vehicles is due to over-speeding (Seckan, 2013; Worley, 2006), Li et al. (2013) reported that vehicles tend to slow down and traffic accidents are significantly reduced near places where surveillance cameras are installed. The effectiveness of cameras in reducing the incidence of traffic accidents is also confirmed in other studies (Utley, 2012; Bochner and Walden, 2010; Perez et al, 2007; Pilkington and Kinra, 2005).

Methodology

The data used in this study were collected by the Traffic Department of the Bursa Police Bureau in Bursa, Turkey. This department is authorized by the Turkish Penal Law and the Highways Traffic Law to gather data for better civil administration. Before the surveillance cameras were introduced in the city, the department was responsible for recording whenever there is a report of a traffic accident. The total number of traffic accidents was obtained by summing up all the numbers from the regional office reports.

A surveillance camera has an automatic system for recording traffic accidents and is a firsthand source of information with detailed information about penalties, number of traffic accidents, injuries and deaths. In this study, the data was collected at the European Boulevard in Bursa, the busiest street in terms of traffic flow in the city and the traffic congestion has made traffic accidents a serious problem for the local people. In this study, the amount of penalties as well as the numbers of the injured and the dead in recorded traffic accidents are used as basic parameters for analysis. The surveillance system functions as the supervisor for keeping traffic order. The violation of traffic laws results in penalties. This study aims to determine whether the continuous recording of the traffic flow through the surveillance camera system has promoted sensible precautions of people to obey the traffic rule and regulations.

This study employs the monthly records kept by the Traffic Department at Bursa Police Bureau, and the amount of penalties and the numbers of the dead and injured in traffic accidents during the 2011-2013 period are subjected to the Kruskal Wallis test. The Kruskal Wallis test is a non-parametric test of one-way analysis of variance in the perception of intergroup conflict. It assesses for significant differences between a continuously dependent variable and groups of independent variables when the data cannot be assumed to be normally distributed. It tests whether the mean ranks are the same in all the groups. The values are organized in order and the implications of the sequential use are reflected through intergroup calculation and comparison. Furthermore, the amount of penalties and the numbers of the dead and injured

<table>
<thead>
<tr>
<th>Year</th>
<th>N</th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Penalty Cases in 2011</td>
<td>12</td>
<td>16.58</td>
</tr>
<tr>
<td>Number of Penalty Cases in 2012</td>
<td>12</td>
<td>19.92</td>
</tr>
<tr>
<td>Number of Penalty Cases in 2013</td>
<td>8</td>
<td>11.25</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>
in traffic accidents during 2008-2010 are also investigated in comparison with the previous group of data. This sequential data are analyzed utilizing the Mann Whitney U Test to examine whether there is a significant difference between the two groups of data. The Mann Whitney U Test is a non-parametric alternative to the t-test for independent samples and does not require the assumption of a normal distribution.

**Findings**

Table 1 shows the numbers of injured, penalties and deaths recorded by the surveillance system on European Boulevard between 2011 and 2012.

As shown in figure 2, the largest number of penalty cases (2971) occurred in July of 2012, but by April 2013 decreased to 989.

In terms of penalty case numbers, for the year 2011, the highest collection of fine revenue took place in November 2011. However, this figure was the relatively low amount of just under 187 thousand lira. During
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Table 2  Mean Rank of Fatalities (2011-2013)

<table>
<thead>
<tr>
<th>Year</th>
<th>N</th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Fatalities in 2011</td>
<td>12</td>
<td>14.38</td>
</tr>
<tr>
<td>Number of Fatalities in 2012</td>
<td>12</td>
<td>19.79</td>
</tr>
<tr>
<td>Number of Fatalities in 2013</td>
<td>12</td>
<td>21.33</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

Table 3  Mean Rank of Injured People (2011-2013)

<table>
<thead>
<tr>
<th>Year</th>
<th>N</th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Injured People in 2011</td>
<td>12</td>
<td>16.54</td>
</tr>
<tr>
<td>Number of Injured People in 2012</td>
<td>12</td>
<td>17.54</td>
</tr>
<tr>
<td>Number of Injured People in 2013</td>
<td>12</td>
<td>21.42</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

the next year the amount of penalties imposed each month expanded sharply from May to July 2012, with approximately 525, 467 and 464 thousand Turkish Lira collected, respectively. This period was also the highest collection period overall. Similarly, the second quarter of the year saw the highest revenue collection for the year 2013.

On European Boulevard in Bursa, a total of nine people was killed in traffic accidents in 2011, while 11 people were injured in the same year. In 2012, 16 people lost their lives and 12 people were injured. In 2013, the number of fatalities in traffic accidents was 20 and 24 people were injured. Based on the time path graph in figure 2, it can be seen that the total number of penalty cases for violation of the traffic law in 2012 is much higher than that of 2011 and 2013. But the data does not indicate a significant difference in terms of numbers of the injured and fatalities during the same period.

The Kruskal-Wallis test was utilized for further analysis and each measurement value in the overall data set is substituted by the mean rank. The number of penalty cases in each month and the number of injured people and fatalities give us a single score on a rating scale. The results are shown in Table 1, Table 2 and Table 3, respectively. Mean rank values indicate the highest rating overall for the number of penalty cases is in 2011-2013. According to the mean rank, the maximum penalty cost is seen in 2012 and the minimum number of penalties can be seen in 2013. The calculation result shows that the critical chi-square value for the number of penalty cases is 4.098, with $p = 0.129$. Because $p > 0.05$, the result shows that this group of data is not statistically significant. In other words, there is no meaningful difference among the monthly means of penalty cases in 2011-2013.

Table 2 shows the mean rank of number of fatalities between 2011-2013. The mean rank of fatalities was highest in year 2013, and the mean rank of fatalities was smallest in 2011. In the Kruskal Wallis test, the value of the chi-square value is 3.121, which is not statistically significant. The probability value of $p = 0.210$
Table 4  Rank of Fatalities in 2011

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Fatalities (2008-2010)</td>
<td>36</td>
<td>43.40</td>
<td>1562.50</td>
</tr>
<tr>
<td>Number of Fatalities (2011-2013)</td>
<td>36</td>
<td>29.60</td>
<td>1065.50</td>
</tr>
<tr>
<td>Total</td>
<td>72</td>
<td></td>
<td></td>
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</tbody>
</table>

Table 5  Ranks of Injuries

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Injuries (2008-2010)</td>
<td>36</td>
<td>38.29</td>
<td>1378.50</td>
</tr>
<tr>
<td>Number of Injuries (2011-2013)</td>
<td>36</td>
<td>34.71</td>
<td>1249.50</td>
</tr>
<tr>
<td>Total</td>
<td>72</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

($p > 0.05$) implies that there is no meaningful difference among the means of fatalities during those three years.

Table 3 shows that the maximum number of people who were injured in traffic accidents occurred in 2013 and the minimum number was in 2011. In the Kruskal-Wallis test, the chi-square value is 1.741, with $p = 0.419$ ($p > 0.05$). Again, it is not statistically significant, which implies that there is no significant difference in the means of injured during 2011-2013.

In order to figure out the changes after the installment of the surveillance cameras in the city traffic control system, a comparison is made between 2011-2013 and 2008-2010. These two groups of data of fatality numbers were subjected to the Mann-Whitney U test to test for a significant difference.

Table 4 shows that the average number of fatalities during 2008-2010 is much higher than that recorded after the surveillance system was installed. In the Mann-Whitney U test, the value of the test statistic was found to be statistically significant: $p = 0.004$ ($p < 0.05$). This indicates that there is a significant difference in the means of fatalities before and after the surveillance camera was installed. Therefore, we can make a conclusion that the surveillance camera was effective in reducing the number of fatalities in traffic accidents.

Table 5 shows changes in the number of injured people after the surveillance system was adopted. There were more injured people before the surveillance system was installed and the situation was improved after the supervision of the camera. But in a Mann-Whitney U test, the test statistic $p = 0.433$ ($p > 0.05$) was not significant. Thus, the conclusion is made that the surveillance camera system is not effective in the reducing the number of injuries in traffic accidents.

**Conclusion**

This study summarizes that the surveillance system installation was effective in preventing fatal traffic accidents. This result is consistent with deterrence theory, because the higher possibility of receiving severe
punishment makes people more cautious in their driving performance. In addition, the camera system has made it possible for the traffic safety administration to take swift action in imposing penalties with the recording as the evidence. This result can be also explained by routine activity theory. People refrain from speeding which is closely related to fatal accidents because there is an ever-functioning safeguard within the surveillance system. Moreover, economic theory also supports the result of this study. People live their daily life based on economic decisions. This fundamental factor leads to the phenomenon that high-level penalties deter people from violating the traffic laws. Surveillance cameras make it possible for the police to gather the evidence of those who exceed the speeding limit. People realize that their speeding behavior may possibly cause them to lose money for punishment and their daily life may be negatively impacted. As a whole, surveillance cameras prove to be effective in traffic safety administration if they are properly deployed and installed at the right locations. The results show that the number of fatal traffic accidents was significantly reduced after the surveillance system was introduced.

The result of the Mann-Whitney U test shows that there is no significant difference in the number of injured people before and after the introduction of the surveillance system. While after the surveillance system was installed, the average number of deaths was reduced, there was no reduction in the number of the injured. Therefore, our expectation that reducing traffic accidents through the supervision of surveillance cameras was only partially met by the data in this study. In other words, the present data does not support the hypothesis that the surveillance cameras are fully effective in the control of traffic accidents. It shows no effect on reducing the average number of injured. A possible explanation is the relatively low-level fine imposed on the drivers who cause minor traffic accidents. What drivers are fearful of is the punishment rather than the camera. Once they know the cameras are installed, they become more cautious to reduce exceeding the speed limit by a significant amount. This may be a major factor in reducing severe traffic accidents that result in fatalities. In addition, there is a huge punishment for drivers involved in fatal accidents. It is the potential cost which keeps on warning the drivers and plays a major role in the control of traffic accidents. Therefore, it is reasonable to assume that drivers will also be more careful if the fine for minor accidents is raised. In sum, although the surveillance camera system has a positive influence on reducing the number of traffic accident fatalities, it should be supported by the higher penalties and regulations in order to better control the traffic situation and minimize the number of death and injuries.

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