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Evaluating the effect of enforcement on speed distributions using probe vehicle data

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ABSTRACT

Collecting driving speed data is a crucial element in road safety research. Recent technological developments enable a wide range of alternative traffic monitoring possibilities. In particular, the availability of cellular and GPS devices creates the opportunity to utilize probe vehicle data. To date, most studies using probe vehicle data focused on operational purposes such as congestion identification, relying primarily on average speeds.

Probe vehicle data can also be useful for safety studies. The data is often collected continuously (24/7, 365 days a year). It can therefore enable detailed analyses of the continuous changes in speed over time. In addition, the spatial coverage of the data enables continuous evaluation of the halo effect of speed enforcement installation, compared with a relatively small number of measurement sites (e.g. 3–5) in traditional methods.

Probe vehicle data offer one more advantage: When performing a before-after study, the before measurements have to be performed before camera installation. However, installation plans may change, and therefore conducting the before measurements may be administratively challenging. Probe vehicle data, especially if collected continuously, regardless of research needs, enable researchers to choose the desired sites and times for analysis in retrospect, after the cameras have been installed.

The purpose of this paper is to describe the results obtained from analysis of probe vehicle data on the effect of speed enforcement cameras that were installed at non-urban roads in Israel during 2011–2013. In addition to the contribution regarding the impact of enforcement cameras, the paper demonstrates the potential (as well as the challenges) of using probe vehicle data for safety studies. The analyses in this paper consider 22 installation sites and 12 comparison sites. The results show that at the installation sites (within 100 m), the 85th percentile speeds exhibited a short-term (two months) reduction of 2.92 km/h (SD = 2.37) and a long-term (one year) reduction of 6.48 km/h (SD = 3.5). An a-symmetric double exponential model is presented to depict the halo effect up to 1.5 km from the installation location.

1. Introduction

Enforcement is a critical component in any speed management scheme. Automatic cameras have been in use for speed enforcement since the 1960s. Digital enforcement cameras, introduced in 1997 (GATSO, 2014), have been gradually

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implemented during recent years. Digital cameras offer important operational advantages over traditional (wet-film) cameras, such as higher violation recording capacity, continuity of operation, as well as statistical information on all passing vehicles.

A number of previous studies examined the impact of enforcement cameras on speed and safety. Most of these studies relied on speed measurements using equipment installed specifically for the purpose of the research. Such measurement techniques have an important advantage, as (nearly) all passing vehicles are measured. However, the cost of equipment installation often limits the temporal and spatial scope of analysis.

Recent technological developments enable a wide range of alternative traffic monitoring possibilities. In particular, the pervasive availability of cellular and GPS devices creates the opportunity to utilize probe vehicle data. To date, most studies using probe vehicle data focused on operational purposes, such as congestion identification, relying primarily on average speeds.

Probe vehicle data can also be useful for safety studies. The data is often collected continuously (24/7, 365 days a year). It can therefore enable a detailed analysis of the continuous changes in speed over time, which may be much more meaningful than the comparison of one day before camera installation vs. one day after the installation, even if these days are carefully chosen to be as representative as possible. In addition, the spatial coverage of the data enables continuous evaluation of the halo effect of speed enforcement installation, compared with a relatively small number of measurement sites (e.g. 3–5) in traditional methods.

Probe vehicle data offer one more advantage, which may seem benign, but could in fact prove rather useful from a practical research management perspective. In order to perform before-after study, the before measurements have to be performed before camera installation. Installation plans may change. As a result, measurements taken at a site where camera installation was planned but not implemented might be wasted. In addition, time constraints due to plan changes complicate the ability of completing a proper set of measurements before the installation. Probe vehicle data, especially when collected continuously regardless of research needs, enable researchers to choose the desired sites and times for analysis in retrospect, after the cameras have been installed.

This paper describes probe vehicle data analyses pertaining the effect of speed enforcement cameras that were installed at non-urban[1] roads in Israel during 2011–2013. In addition to the contribution regarding the understanding of the impact of enforcement cameras, the objective of this paper is to demonstrate the potential (as well as the challenges) of using probe vehicle data for safety studies.

The research reported here is part of a larger study that evaluated the overall impacts of digital enforcement camera installation in Israel on driver behavior and on safety. Other components of the study included: analysis of changes in accident patterns; point speed measurements with pneumatic tubes; violation record trends; gas-station survey regarding drivers' opinions (Schechtman, Bar-Gera, & Musicant, 2016); and traffic signal behaviors as measured by the loop detectors of the enforcement system (Bar-Gera, Musicant, Schechtman, & Ze'evi, 2016). To place the research reported here in context, a brief description of the overall digital camera enforcement program, as well as a summary of key results from the other components of the larger study are presented in Section 2.4.

The remainder of the paper is organized as follows. Section 2 provides background for the research. Description of the dataset is given in Section 3. The results are presented and discussed in Section 4. Conclusions and suggestions for future research are presented in Section 5.

2. Background

2.1. Speed and safety

The importance of speed and its distribution as factors affecting traffic safety is well recognized. In particular, the connection between mean driving speed and safety was demonstrated in numerous studies (e.g. Elvik, 2009, 2013; Elvik, Christensen, & Amundsen, 2004; Hauer & Bonneson, 2008; Nilsson, 1984). It is difficult to know whether speed affects just accidents' severity (Joksch, 1993) or also accident probability, as the ability to distinguish the impact on severity from the impact on accident probability is problematic (e.g. Hauer, 2009; Shinar, 1998).

Until recently, documentation of speeds, speed distributions, and their evolution in time was fairly sparse (Hauer, 2009). This information limitation has a detrimental impact on the ability of the research community to address other important questions, such as the impact of speed variance and other parameters of the speed distribution on safety. In recent years more information is collected on a regular basis (e.g. Choe, Skabardonis, & Varaiya, 2002; Pack, 2014). Yet there is still a lot to be done using probe vehicle data, as illustrated here or otherwise.

2.2. Probe vehicle data

Traditionally most traffic measurements relied on out-of-vehicle equipment. In principle, measurements can be made by equipment installed in vehicles, as they travel along the roads. The vehicles may be travelling for the sole purpose of con-

[1] In Israel, roads are characterized as either urban or non-urban. The latter often cross metropolitan areas, but typically offer limited direct access (if at all) to businesses and residences. In these respects they are somewhat similar to state routes in the US.