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An integrated approach to evaluate policies for controlling traffic law violations

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ABSTRACT

Modeling dynamics of the driver behavior is a complex problem. In this paper a system approach is introduced to model and to analyze the driver behavior related to traffic law violations in the Emirate of Abu Dhabi. This paper demonstrates how the theoretical relationships between different factors can be expressed formally, and how the resulting model can assist in evaluating potential benefits of various policies to control the traffic law violations Using system approach, an integrated dynamic simulation model is developed, and model is tested to simulate the driver behavior for violating traffic laws during 2002–2007 in the Emirate of Abu Dhabi. The dynamic simulation model attempts to address the questions: (1) "*what*" interventions should be implemented to reduce and eventually control traffic violations which will lead to improving road safety and (2) "*how*" to justify those interventions will be effective or ineffective to control the violations in different transportation conditions. The simulation results reveal promising capability of applying system approach in the policy evaluation studies.

1. Introduction

It has been recognized that traffic law violations are strongly associated with the likelihood of road crashes. For example, researchers (Rajalin, 1994; Elvik, 1997a; Mäkinen and Wuolijoki, 1999) have explored the relationship between road crashes and violations and reported that traffic violation history is related to an increased likelihood of serious road crashes. Indeed, reducing violations could help lower the number of road crashes and subsequent deaths. Elvik (1997a,b) reported that eliminating 16 of the most frequent traffic law violations in Sweden could reduce 48% of the road crash fatalities and 27% of the road crash injuries. Furthermore, he also reported that by eliminating all traffic violations, the number of road crash fatalities could be reduced by 76% and the number of casualties by 48%. These estimated reductions in fatalities or casualties by reducing violations may vary by country. However, the questions that are more important and need to be answered are (1) "*what*" interventions should be implemented to reduce and eventually control traffic violations which will lead to improving road safety and (2) "*how*" to justify those interventions will be effective or ineffective to control the violations in different transportation conditions.

The main aim of this paper is to introduce the System Dynamics (SD) approach to simulate the driver behavior in relation of law enforcement, traffic monitoring, and education. In this paper, the SD approach is applied to develop an integrated dynamic simulation model. This model provides a platform for evaluating interventions aimed at controlling traffic violations.

The problem of traffic law violations in the Emirate of Abu Dhabi is eminent. This study attempts to use System Dynamics approach to evaluate the road safety and proposes interventions which could control traffic violations. Abu Dhabi is one of the seven emirates that constitute the United Arab Emirates (UAE). Due to the rapid economic growth of the UAE, the number of vehicles on the roads has substantially increased over the past few years. This rapid growth in mobility has significantly increased traffic violations. The statistics obtained from the UAE Ministry of Interior indicate that during the years from 2002 to 2007, the number of reported violations per registered vehicle increased from 6 to 7.2 (i.e., about 20%), shown in Fig. 1.

Based on discussions with traffic police officials, it is noted that traffic violations have become common in the Emirate of Abu Dhabi. The most common violations cited by police officials are speeding, sudden lane change without indicators, flashing, and tailgating, and even disrespecting other drivers is a commonly observed infringement. The reasons for that may include lack of police surveillance and enforcement, lack of awareness and safety education, and lack of scientific research and evaluation in road safety in UAE.

In addition to this introduction, the paper includes the following sections. In Section 2, we discussed the rationale for proposing the system approach for modeling driver behavior. In Section 3, we present the logical framework of the proposed dynamic simulation model. The mathematical equations of the proposed model are described in Section 4, while the calibration and the validation of the model is described in the subsequent section. The simulation results of the policy scenarios are discussed in Sections 6 and 7. Con-

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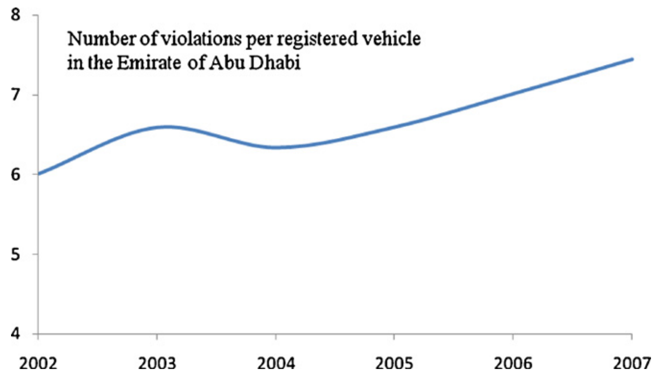

Fig. 1. Number of violations per registered vehicle in the Emirate of Abu Dhabi.

clusions, policy recommendations, and future work are discussed in the last section.

2. Rationale for introducing system approach

A system can be defined as something that maintains its existence and functions as a whole through interaction of its components. Viewing the system as a whole help in understanding how change in one component produces changes in other components of the system that eventually help in finding the leverage points for fundamental change (Oconnor and McDermott, 1997).

The system approach adopted in this research is based on System Dynamics, modeling methodology developed at Massachusetts Institute of Technology as a tool for analyzing complex problems in 1950s. SD method provides ways of viewing the system components together as a whole, as opposed to focus on improving the components only. SD enables a new level of understanding of why things are as they are, and offers insight for breakthrough solutions (Sterman, 2000). The unique features of the SD approach are considering: (1) principles of information–feedback control theory, (2) time delay or lag between action and its outcome, (3) causal relationships between variables, and (4) precise definitions of all system variables. These features ensure that SD based models realistically replicate the problematic situation into a formal computer model to investigate root cause of the problem (Abbas and Bell, 1994 and Sawicka, 2008).

SD has been applied to assess the behavioral characteristics of a number of complex social and economic systems. This type of model has its origins in the 1930s. The theory was refined in the 1950s by Brown and Forrester and applied to the analysis of industrial systems and management (Forrester, 1958, 1961, 1971, 1990). SD was originally rooted in the management and engineering sciences but has gradually developed into a discipline useful in the analysis of social, economic, physical, chemical, biological, and ecological systems. As such, SD has been shown to be useful in exploring possible scenarios to solve complex real world problems, especially those involving human behavior (Sterman, 2000).

The reason SD method is chosen for this research is that modeling dynamics of driver behavior is a complex process including inter-relationships between several factors that influence driver behavior over time. SD has been proven to be useful in exploring possible scenarios to solve complex real world problems, especially those involving human behavior (Sterman, 2000). A few examples of the SD application methodology particularly in the transportation sector are Hobeika et al. (1981), Abbas and Bell (1994), Sang (1997), ASTRA (1998, 1999), Raux (2003), Mehmood et al. (2001a,b, 2002a,b, 2003), Mehmood et al. (2001a,b, 2002a,b, 2003), Mehmood (2006a,b), Haghani et al. (2003), Friedman (2006).

3. Logical framework of the proposed dynamic simulation model

Fig. 2 presents logical assumptions to model interactions among various elements. The purpose of the Fig. 2 is to illustrate a part of

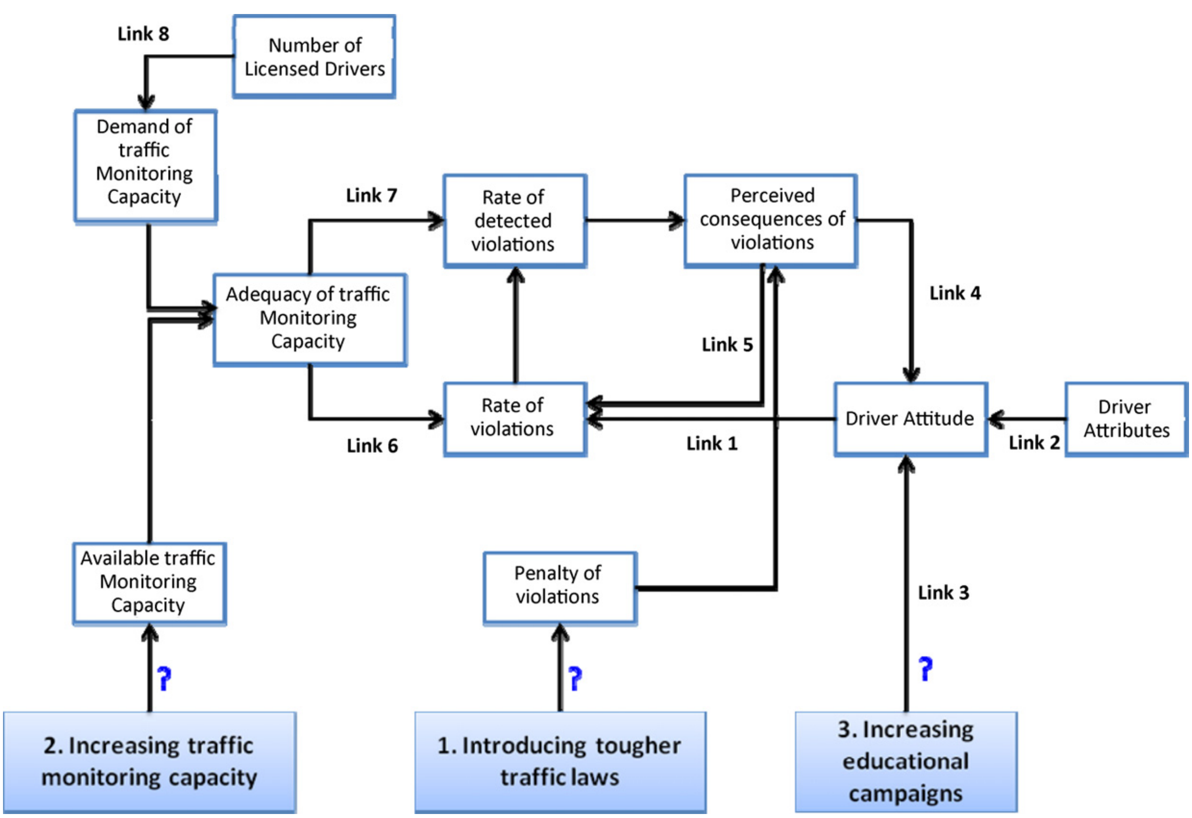

Fig. 2. Logical framework of the proposed dynamic simulation model.