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A novel framework for improvement of road accidents considering decision-making styles of drivers in a large metropolitan area

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ABSTRACT

Road accidents can be caused by different factors such as human factors. Quality of the decision-making process of drivers could have a considerable impact on preventing disasters. The main objective of this study is the analysis of factors affecting road accidents by considering the severity of accidents and decision-making styles of drivers. To this end, a novel framework is proposed based on data envelopment analysis (DEA) and statistical methods (SMs) to assess the factors affecting road accidents. In this study, for the first time, dominant decision-making styles of drivers with respect to severity of injuries are identified. To show the applicability of the proposed framework, this research employs actual data of more than 500 samples in Tehran, Iran. The empirical results indicate that the flexible decision style is the dominant style for both minor and severe levels of accident injuries.

Motivation and significance

Decision making is the selection of a procedure to weigh alternatives and find a solution for a problem. Generally, people differ in their approach to making decision, which is named their decision making style. The driver's decision-making style as an important human characteristic could considerably reduce the severity of road accidents. Therefore, the major motivation behind this study is to assess quantitative factors affecting road accidents considering decision-making styles and injury severity. This is achieved through a robust framework based upon mathematical programming models (i.e. DEA) and an efficient technique for making accurate inferences from a collated body of data set (i.e. SMs). Therefore, the main contributions of this study are summarized as follows: (1) a comprehensive approach is proposed to assess and evaluate the risk factors affecting traffic accidents; (2) DEA model which is an optimization linear programming model (to maximize the efficiency of multiple decision-making units (DMUs) when the production process presents a structure of multiple inputs and outputs) together with statistical methods (for making accurate inferences from a collated body of data and for making decisions in the face of uncertainty based on statistical methodology) are used in the approach to achieve reliable and precise results; (3) decision-making styles are taken into account as an important human characteristic of drivers which have a direct impact on the process of decision making process in critical situations such as car accidents; and (4) the model is validated among an independent set of 528 drivers from the Tehran, Iran.

1. Introduction

Injuries of road accidents resulted in 1.4 million deaths in 2013 up from 1.1 million deaths in 1990 (Naghavi et al., 2015). Almost all high-income countries have a reducing death rate, while the majority of low-income countries having increased deaths rates due to road accidents. Middle-income countries have the highest rate with 20 deaths per 100,000 inhabitants, 80% of all road injuries by only 52% of all vehicles (World Health Organization, 2001). In Iran as a developing country, about 19,000 people are died annually in road accidents, and 800,000 are injured (Pakgohar et al., 2011).

The number of traffic accidents and their effects, mainly human injuries and fatalities, validate the importance of investigating the factors which contribute to their occurrence. Principal factors in accident occurrence are including human, vehicle, road and environment factors. Among these factors, human factor has a prominent role and directly or indirectly, can be a cause of undesirable performance during driving (World Health Organization, 2001). A topic of particular interest is how road users collect and process information about the road and its environment, and how to use them to make the suitable decision. The driver's

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Table 1
Four main decision-making styles.

	Low information use (maximizer)	High information use (satisfier)
Single-focus	Decisive	Hierarchical
Multi-focus	Flexible	Integrative

decision-making style as an important human characteristic could reduce injury severity of road accidents.

The human factors that affect the injury severity in road accidents have been analyzed in several studies (Clarke and Adams, 1990; Wang et al., 2002; Dissanayake, 2004; Vaez and Laflamme, 2005; Yannis et al., 2005; Koushki and Bustan, 2006; Vorko-Jović et al., 2006; Gray et al., 2008; Lambert-Bélanger et al., 2012; De Ona et al., 2013; Tractinsky et al., 2013; Zhang et al., 2013; De Oña et al., 2014). Researchers have found that accident risk specifically relies on driving skills (such as license status, term of driving, accident involvement in the last few years, driving distance in mile/km), driver's socio demographic attributes (such as gender, age, marital status, personal or family income, commuter status and educational level), and driving manners (such as the number of traffic accidents in the last few years, physical condition of the driver, use of alcohol and drugs, use of seatbelt, driving beyond speed limit, failure to stay in the proper lane, passing where prohibited by posted signs and use of cell phone).

There are some classifications of the decision-making styles (Drriver et al., 1990, 1998). However, the classification presented by Drriver et al. (1998) is in high agreement with the others. In this study, the decision making styles defined by Drriver et al. (1998) are used for determining drivers' decision making styles. The amount of information and the number of alternatives considered when making decision are identified as the basic effective factors on differences between decision styles. Driver divided decision-making styles into four main types: decisive, flexible, hierarchic, and integrative. These four styles encompass all different models of human decision-making styles. Regarding information usage, people are divided into two groups: maximizers and satisfiers. Maximizers like to take their time and weigh a wide range of options (sometimes every possible one) before choosing. Satisfier would rather be fast than thorough; they prefer to quickly choose the option that fills the minimum criteria. From the focus point of view, they are clustered into two categories, namely, single-focus and multi-focus. Single-focus decision-makers reach a clear solution to overcome the problem while multi-focus ones generate several possible options (Drriver et al., 1990). Mixing focus and information perspectives provide a framework to explain decision-making styles shown in Table 1.

Therefore, people use different styles in different situations. However, most of them use one style more than the others. The style that we use most of the time is our dominant style (Drriver et al., 1990). Taking a rapid action, reliability, stability, loyalty and obey are positive characteristics of decisive people while they are inflexible, regulatory, avoiding from changes and avoiding from complexity. Flexible people have great intuition, flexibility, entrepreneur, communicative, opportunistic and like rapid actions. Whereas, they do not like planning, have short term vision, oppose to structuring, have a minor focus, and they are not reliable people. Hierarchical persons have a great attention on quality. They are logical, exhaustive and good following. Tendency to debating, inflexibility against effects, controlling more than needs and involving in details are negative characteristics of hierarchical style. Integrated people are good auditors. They are creative, aware, charity people that have a long term vision more ever. However, they are non-decisive, slow, unable to respect to the deadline and ambiguous persons (Drriver et al., 1990, 1998; Azadeh et al., 2015a).

In psychology, decision-making is defined as the cognitive process resulting in the selection of a belief or a course of action among several alternative possibilities. Every decision-making process produces a final choice that may or may not prompt action. Decision making style is the selection of a procedure to determine the weight of options and find a solution to a problem based on the amount of information and the number of alternatives considered when making decision. Each decision making style is a different way of weighing alternatives and examining solutions. Furthermore, certain situations will need different methods of decision making in order to be effective. Drivers play the main role in road accidents (Muzheng, 2009). The decision behavior of driver is the vital content of driver behavior modeling (Muzheng, 2009). It will be helpful to design more intelligent driving navigation system and establish more reasonable traffic regulations to decrease the traffic accidents and raise traffic efficiency by going deep into the driving behavior and decision making styles of them. Analyzing and studying from the viewpoint of cognitive science, driving behavior is formed by perception, decision and controlling. The decision course of driver is also affected by psychological characteristic and the personality of driver. Decision-making is the study of classifying and selecting alternatives based on the values and preferences of the decision maker.

As mentioned, identifying the drivers' decision making style can show the personality characteristics of them. Driver personality is taken into account as an effective predictor for accident liability and risky driving behavior. Personality is relatively a stable human characteristic that is not easily malleable by road safety interventions. Furthermore, personality is considered to be a distal predictor of behavior, as compared to other more immediate antecedents of behavioral intention and action initiation (Fishbein and Cappella, 2006). In the literature, relations between personality factors and crash involvement appear to be mixed and vary based on the different personality factors. For example, Yang et al. (2013) explored the effects of personality variables on accident involvement and examined the effects of personality on Chinese drivers' risky driving and accident involvement. The results indicated a significant correlation between personality and risky driving behaviors among Chinese drivers. Mallia et al. (2015) used a personality–attitudes model to evaluate whether personality traits predicted aberrant self-reported driving behaviors, through the effects of attitudes toward traffic safety in a large sample of bus drivers. The results showed that personality traits would relate to aberrant driving behaviors (lapses, violations at the wheel and errors) directly and indirectly, through the effects of attitudes toward road safety.

Driving behavior plays a very important role in accident involvement (Sabey and Taylor, 1980). Various studies conducted in different countries, have explored what can predict drivers' risky driving behaviors and accident involvement. They have found that driver personality is a significant and relevant variable (Elander et al., 1993; Yang et al., 2013; Lucidi et al., 2014). Beirness (1993) showed that personality variables such as hostility/anger, impulsiveness and thrill-seeking explained more than 35% of the variance in risky driving and about 20% of the variance in accidents. A way of looking at improving traffic safety concerns driver characteristics and attributes. Specifically, factors such as work shifts and conditions, experience, speed choice and sleepiness have been studied with respect to crash risk (Vennelle et al., 2010; Kaplan and Prato, 2012; Tseng, 2012). In addition, in the last decade several studies have emphasized the significant role of personality characteristics on risky driving and road safety. Some studies have estimated the risk for traffic accidents on the basis of the multivariate combination of different personality dimensions (for example, Ulleberg, 2001; Lucidi et al., 2010) while others have only focused on the impact of single personality dimensions upon risky driving