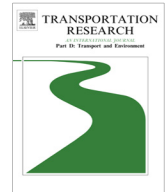




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The effects of eco-driving motivation, knowledge and reward intervention on fuel efficiency



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ABSTRACT

Every year, bus companies consume millions of litres of fuel, and their fuel costs often exceed millions of US dollars. These companies have an obvious interest in reducing their fuel consumption. One way to encourage drivers to engage in eco-driving behaviours, as well as their related beliefs, is to use a monetary reward system. The aim of this study was to explore the incentive effects of such a reward system to encourage better driving behaviours among bus drivers. This study collected fuel-efficiency data before and after the implementation of a reward system. Furthermore, to study the effects that the system had on driver behaviours, this study adopted the theory of Motivation–Opportunity–Ability (MOA) to construct the regression model. The results for the average fuel consumption efficiency for the buses before and after the reward system was introduced showed an improvement of more than 10% and thus a reduction in carbon emissions.

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Introduction

In response to the negative impacts of global warming, many countries are adopting policies to reduce greenhouse gas emissions and fuel consumption. The fuel efficiency of the transportation sector has become a key issue in such actions. According to the United National Framework Convention on Climate Change (UNFCCC) data (UNFCCC, 2007), by 2030, the transportation sector will account for 40% of all new investment in carbon reduction efforts worldwide, the third highest of all sectors considered.

The U.S. Department of Transportation (2010) summarised the strategies for carbon emission reductions in the transportation sector into four main categories: reduced carbon-intensive travel activity (e.g., changes in urban design and land utilisation patterns); improved transportation system efficiency (e.g., increasing the use of public transportation); increased vehicle fuel economy (e.g., popularising eco-driving practices); and development of the use of low-carbon fuels (e.g., promoting the use of electric vehicles). Eco-driving is one way of increasing energy efficiency and has recently attracted considerable research interest (Gense, 2000). It primarily consists of a variety of driving techniques including not driving too fast; not accelerating too quickly; shifting gears earlier to maintain a lower engine speed; keeping a steady speed; and ensuring that vehicles are well-maintained (Barth and Boriboonsomsin, 2009).

Numerous studies have examined the impact of eco-driving training courses on fuel consumption. For example, af Wählberg (2007) monitored fuel consumption in buses and recorded a 2% fuel savings in the 12 months after the drivers had undergone such training. The Centre for Renewable Energy Sources of Greece conducted an eco-driving pilot study to

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assess the effects of changing urban bus drivers' driving style. The training courses were designed to increase the drivers' knowledge with regard to more economical driving techniques. The results indicated an overall 4.35% reduction in fuel consumption per kilometre after training courses (Zarkadoula et al., 2007). However, both studies reported that after a period of time, the fuel savings became lower than the levels originally attributed to the courses. Beusen et al. (2009) provided dynamic advice to drivers in an eco-driving course and analysed the long-term impacts on fuel consumption and on different driving parameters. The results indicated that the mean fuel consumption for all drivers after the course fell by 5.8% and that the effect for the group as a whole was permanent up to 6 months after the course. Bart and Beusen, 2013 re-analysed the data used in a previous paper by Beusen et al. (2009). They indicated that a higher ambient temperature resulted in lower fuel consumption. Additionally, this paper still holds that eco-driving courses can yield significant improvements in fuel economy. However, this effect was gradually lost in the months after the course.

Fuel conservation is especially important to bus companies because it can lower operating costs in addition to reducing environmental pollution. The cost per litre of diesel in Taiwan was NT \$14.4 in 2000. This cost rose to NT \$31.3 by 2013, and fuel accounted for one-fourth of the total operating cost of bus companies. Therefore, the conservation of fuel, in order to lower operating costs, is a vital issue for bus companies. In Taiwan, such companies have adopted a number of fuel use reduction strategies, including vehicle maintenance, vehicle replacement and driver behaviour management. The latter is mainly implemented through training, which can improve drivers' knowledge of eco-driving and encourage them to adopt better behaviours. Therefore, the focus of this study is to examine how to best increase the drivers' willingness to change their practices in this regard.

The approach that this work adopted to promote changes in behaviour was based on behavioural theory. Behavioural theory suggests that an individual's decision-making and behaviours are co-determined by personal characteristics (e.g., motivation and ability) and extrinsic conditions (e.g., opportunities for action) (Lewin, 1951). Rewards are among a number of external structural conditions often used by companies to encourage changes in behaviours and improvements in productivity. Although rewards could be used to encourage eco-driving behaviour, the effectiveness of this approach has not been documented. Therefore, this study used experimental methods to explore the following two issues: (1) the relationship between the eco-driving reward and the driver's motivation and knowledge for eco-driving as a psychological latent variable, as well as the resulting reductions in fuel consumption, and (2) the impacts of eco-driving motivation, knowledge and eco-driving reward on fuel efficiency.

The approach

This study presents a theoretical framework based on the Motivation–Opportunity–Ability (MOA) model (MacInnis et al., 1991) as an explanatory model for understanding the effects of a reward system that correlates the motivation to change driving behaviours, knowledge of eco-driving, and fuel efficiency. The theoretical framework used to evaluate the effectiveness of the reward system is outlined below.

Motivation has been defined as goal-directed arousal (Park and Mittal, 1985) and is commonly viewed as a force that directs individuals toward goals and/or to process information (MacInnis and Jaworski, 1989). Ajzen (1985) theory of planned behaviour (TPB) is one of the most commonly used models to represent an individual's motivation. The TPB model postulates that all motivational factors are determined by three rational determinants: attitude, subjective norm and perceived behavioural control. These three factors combined together lead to the formation of eco-driving intention, which is the immediate determinant of eco-driving behaviour.

Opportunity reflects the extent to which a situation may hamper or facilitate a particular behaviour. An incentive is one of a number of external structural conditions that may mediate the impact of an intervention. Incentives have an active role in pushing an individual's abilities and willingness to take certain action, motivating them to develop skills that can enhance performance in an efficient and effective manner. In the current challenging economic environment, managers require cost-effective ways to motivate employees. Many organisations use non-cash incentives to achieve this motivation. However, academic research has focused primarily on the effectiveness of cash rewards despite the widespread use of non-cash rewards (Dzurainin and Stuart, 2012). Financial incentives can enable individuals to have immediate feedback with regard to their efforts. Therefore, we conducted an experiment to examine how cash incentives can affect fuel-efficiency and the motivation to engage in eco-driving in two bus companies.

Ability is defined as a person's skills or proficiencies (e.g., knowledge, intelligence, and resources) with regard to achieving a specific outcome (Hoyer and MacInnis, 2006). The current study deemed knowledge of eco-driving as the most relevant factor that can affect ability. There is some evidence that suggests that if drivers have more of this knowledge they are better able, and more willing, to carry out the related behaviours.

Data collection

Participants and study design

This study arranged experiments with two bus companies, one with and one without an eco-driving reward system. The experimental group was the company with an eco-driving reward system. This company had 391 standard buses and 85

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