Exploring the impact of social economic variables on traffic safety performance in Hong Kong: A time series analysis

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ABSTRACT

Using time series data over the period of 1984–2015, this paper applies the combined autoregressive distributed lag (ARDL) and vector error correction model (VECM) approach to identify short- and long-run causal relationships between the number of road accidents and social economic development, including increase of GDP, growth of population, expansion of road infrastructure, and growth of private car ownership. The results confirm a long run relationship between those four social economic variables and road accidents frequency in which growth of population and private car ownership lead to long-run increases in the number of road accidents while road network expansion leads to a long-run decrease in road accidents number in Hong Kong. Additionally, the correlation inside of social economic variables are examined and reported. Insights that obtained from this study are expected to help with evaluating new policies and programs currently being implemented for verifying if they could contribute to a major improvement of road safety in Hong Kong.

1. Introduction

Nearly 1.25 million people die in road crashes every year, on average about 3200 deaths per day, and an additional 20–50 million are injured or disabled across the whole world. Those accidents cause considerable economic losses that cost countries approximately 3% of their gross national product, and further increase to 5% in some low- and middle-income countries (WHO, 2017). Given the seriousness and relevance of this issue, road safety turns to be a global issue significantly linked to health and development which requires government to take effective actions to improve the situation in a holistic manner. This thus arises an important research topic, "What are risk factors of impacting road safety?", that attracts broader attentions from both transportation researchers and practitioners.

Under such a circumstance, many efforts have been carried out to identify and analyze the factors that affect road crashes and severity, among which environment, road factors (Noland, 2003), vehicle characteristics (Jovanis and Chang, 1986; Ritter and Vance 2013), and human factors (Wang et al., 2002; Dissanayake, 2004; Yannis et al., 2005; Clarke et al., 2006; Tractinsky et al., 2013) have been widely reported to be closely related with road safety (Wang et al., 2002). In addition to those studies that are mainly designed to explore factors of affecting road safety at micro-level, some other scholars discussed how macroeconomic conditions can impact road traffic accidents. In the past

years, the social economic variables have been proved to significantly impact various aspects of society. The economic growth, demographic changes and financial development have an intertemporal causal relationship with energy consumption (Odhiambo, 2009; Zhang and Cheng, 2009; Asafu-Adjaye, 2000). Social factors, economic development and trade are closely associated with CO_2 emissions (Baiocchi and Hubacek, 2010; Shahbaz et al., 2013; Kasman and Duman; 2015; Li et al., 2017). Socio-economic factors have been widely found to be in a tight connection with health status (Adler et al., 1994; Gerdtham and Johannesson, 2001; Pickett and Pearl, 2001). In terms of road safety, since per capita GDP will increase when an economy grows faster than population growth, an increase in the number of vehicles purchased by citizens is expected, especially for developing regions (Iwata, 2010). This observation and would easily arise a hypothesis that more road accidents will be accompanied along with car ownership increase. Thus, it may imply a relationship between socio-economic variables and road safety. Actually, such the discussion can date back to 1980s when Wagenaar (1984) investigated the effects of macroeconomic conditions, as reflected by the indicator of unemployment rate, on the incidence of motor vehicles accidents in USA. The results revealed a significant concurrent inverse relationship between the rate of unemployment and the frequency of crash involvement, and a significant positive relationship between unemployment and crash involvement. In case of developing countries, Iwata (2010) built up a relationship between

traffic accidents and economic growth in China. With this relationship, the study estimated that the rate of traffic fatality and injury in China will reach to peak when GDP arrives to $1500 and $4000, respectively. Apparao et al. (2013) identified that road accidents negatively affect economic growth in developing countries because of a high economic loss and human-power loss that easily drain potential economic growth. Apart from the academic evidences, World Bank also concluded that economic development of regions and nations positively correlates with the number of injuries and deaths from road traffic crashes (Kopits and Copper, 2005). With the expectation that a variety of social economic variables will exert influences on road safety performance at macro-level, there is an imminent need to identify how the revolution of those variables may have different long- and short-term effects on road accidents.

Note that despite significant contributions in exploring the relationship between socio-economic variables with road accidents at the macro-level, the exploration was largely based on single factor that is used to represent macroeconomic conditions. Moreover, all relationships are captured statically which implies a neglect of dynamic change, carefully including both short- and long-term impacts, among different time periods, and some findings may only work by case. Therefore, these issues further generate two main research gaps:

- No study has explored the dynamic relationships between number of road accidents and multiple macroeconomic variables using more than three decades of time series data, by separating long- and short-run relationships and capturing both direct and indirect effects. The longer-term time series data are important because some short-run effects may be easy to observe while those long-run and indirect impacts could take decades to manifest. In addition, ignoring dynamic features among time series could easily lead to a biased estimation and inferences when dealing with non-stationary time series (Nkoro and Uko, 2016);
- No study has discussed casual relationships between number of road accidents and multiple macroeconomic variables from a time series prospective. Such the absence could bring the difficulty in evaluating the effects of different economic and transportation police on road safety performance.

1.1. Case of Hong Kong

As one of the most famous world-class metropolitans, Hong Kong has a population of over 7.3 million. By 2016, there were about 2017 km length of public road serving 748,518 licensed vehicles (371 licensed vehicles/km). Every day, about 12.6 million passenger journeys (more than 90%) are made on a public transport system which includes railways, trams, buses, minibuses, taxis and ferries (Transport Department, 2015).

In 2015, the number of reported traffic accidents increased by 2.4% from 15,790 in the previous year to 16,170. Those accidents resulted in 20,381 casualties in total which experienced a 2.7% increase compared with year 2014. Although the total number of traffic accidents slightly increase, the causality rate, fatality rate and accident rate decreased from 32.2, 2.74 and 1.24 per 1000 licensed vehicles in year 2010 to 28.5, 2.61 and 1.22 per 1000 licensed vehicles (Transport Department, 2015). Those figures suggest a steady improvement of road safety over past 5 years due to a series of effective actions, such as changes in legislation, road safety education, and road safety publicity. Certainly, the research efforts of assisting government in developing the road safety improvement programs can't be neglected. In consistent with the main stream of traffic accident studies across the world, most previous works that focused on road safety issues in Hong Kong tried to explore the main contributory factors to traffic crashes and their corresponding impacts on road network (Ng et al., 2002; Wong et al., 2005; Yau, 2006; Yau et al., 2006; Wong et al., 2007; Pei et al., 2016). There subsequently lacks a comprehensive study to discuss the relationship

between social economic conditions, such as GDP, population, expansion of road network, and the road accidents in case of Hong Kong from a time series prospective. The generated findings should be of immediate interests to policy makers and program managers attempting to reduce the incidence of traffic accidents. Meanwhile, the findings are also expected to wipe off some wrong cognitions in traditional road accidents research, for example, does more roads mean more accidents (Couto and Ferreira, 2011)? Therefore, without detailed information on the nature of the potentially confounding effects of economic conditions, new policies and programs currently being implemented may not contribute to a major improvement of road safety in Hong Kong.

1.2. Research motivation

To make a direct response to the reviewed literature gaps, by using five time series over the period of 1984–2015, this study examines the long- and short-run relationships as well as capturing dynamic relationships between the number of road accidents and macro-level social economic variables of Hong Kong. In our study, GDP, population, the number of licensed vehicles, and operated miles of road network have been carefully selected to represent social economic variables due to the following considerations:

- Each of these four variables has already been evaluated to be closely related with road safety performance at macro-level while they are the most popular cited socio-economic variables when discussing the relationship between road accidents and social economic conditions (Wagenaar, 1984; Hauer, 1997; Lamm et al., 1999; Noland and Oh, 2004; Kopits and Copper, 2005; Iwata, 2010; Apparao et al., 2013; Peden, 2004). However, the literature review reveals an absence of testing the impacts of these four variables in combination on road safety performance;
- The availability of dataset in Hong Kong, especially for such a longer-term period data, is another issue;

Advanced statistical approaches are further applied to examine the casual relationships among those five time series.

To summarize, this paper tries to answer the following critical questions:

- Does the development of economic and social status, i.e., GDP, population, road network length and private car ownership, have a long-run relationship with the number of road accidents in Hong Kong?
- What kind of short-run relationship will exist between the change of socio-economic conditions and road safety performance?
- What kind of short-run and long-run casual relationships will exist between the development of socio-economic variables and number of road accidents?

Due to the rising importance of road safety, the inter-temporal relationship in socioeconomic variables-road safety nexus we examined in this study is expected to reveal more policy-oriented implications, as well as to identify those variables associated with effective policies, for Hong Kong to verify the effects of local economic and transportation polices on road safety performance and further to improve the level of road safety. Moreover, the adopted statistical methods in this study are capable of applying to other regions so as to help the local decision makers better understand how the change of socio-economic conditions would impact the road safety from both long- and short-run perspective in their own cases.

2. Data

In this study, five time series over the period of 1984–2015 are adopted: