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Spatiotemporal and random parameter panel data models of traffic crash fatalities in Vietnam

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ABSTRACT

This paper investigates factors associated with traffic crash fatalities in 63 provinces of Vietnam during the period from 2012 to 2014. Random effect negative binomial (RENB) and random parameter negative binomial (RPNB) panel data models are adopted to consider spatial heterogeneity across provinces. In addition, a spatiotemporal model with conditional autoregressive priors (ST-CAR) is utilised to account for spatiotemporal autocorrelation in the data. The statistical comparison indicates the ST-CAR model outperforms the RENB and RPNB models. Estimation results provide several significant findings. For example, traffic crash fatalities tend to be higher in provinces with greater numbers of level crossings. Passenger distance travelled and road lengths are also positively associated with fatalities. However, hospital densities are negatively associated with fatalities. The safety impact of the national highway 1A, the main transport corridor of the country, is also highlighted.

1. Introduction

Similar to other developing countries, rapid economic growth in Vietnam has been accompanied by an enormous increase in motorisation and a high level of traffic crashes. Between 2006 and 2014, the number of motorcycles increased with an annual growth rate of 16.1% whereas the number of cars increased with an annual growth rate of 22.6% (JICA, 2009; NTSC, 2015). By 2014, there were 43.3 million registered vehicles, of which 94.6% were motorcycles. Unsurprisingly, the number of traffic crashes increased significantly from 9470 in 1992–27,993 in 2002 while the number of fatalities increased from 3077 in 1992–13,186 in 2002 (NTSC, 2015). Fortunately, since 2007, there has been a small, but steady reduction in the number of fatalities, which would be attributable to stronger traffic safety programs and measures implemented by authorities (Passmore et al., 2010; Ngo et al., 2012; Nguyen et al., 2013a; Nguyen et al., 2013b). In 2014, Vietnam had 25,322 reported traffic crashes and 8996 fatalities (NTSC, 2015). It is not surprised that motorcycles accounted for around 70% of traffic crashes (NTSC, 2015; Truong et al., 2016). The World Health Organisation (WHO) estimated that the traffic fatality rate in Vietnam was nearly 24.5 per 100,000 population, which is 44% higher than the average fatality rate in South East Asia (WHO, 2015).

Traffic crashes are one of the leading causes of deaths and disabilities in Vietnam (Nguyen et al., 2012; Tran et al., 2012). In addition, their economic impact is profound. It was estimated that the cost of traffic crashes is between 2.5% and 2.9% of the country's gross domestic product (GDP) (ADB, 2005; JICA, 2009). Traffic crashes can also cause a significant economic burden at individual and family levels. For example, a study in Thaibinh province found that the average cost of a traffic injury during hospitalisation was greater than 6 months' average salary (Nguyen et al., 2013a).

Forecasting safety impacts of alternative transport planning schemes is essential for proactive safety planning. During the last decade, there has been a growing body of research on macro-level safety analyses. In macro-level safety studies, safety performance measures, e.g. crash counts, spatially aggregated at a certain spatial unit are modelled against area-wide variables. A wide range of spatial units have been investigated, e.g. block groups (Dumbaugh and Rae, 2009), grid structure (Kim et al., 2006), census tracts (Wier et al., 2009), wards (Noland and Quddus, 2004), cantons (Aguero-Valverde, 2013), counties (Traynor, 2008; Huang et al., 2010), provinces (Erdogan, 2009; Tolón-Becerra et al., 2012), cities

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(Moeinaddini et al., 2014; Coruh et al., 2015), multiple provinces (Torre et al., 2007), states (Noland, 2003), countries (Kumara and Chin, 2004), and traffic analysis zones (TAZs) (Ng et al., 2002; Hadayeghi et al., 2003; Lovegrove and Sayed, 2006; Pirdavani et al., 2012; Wang et al., 2013). Effects of spatial units on modelling results have been discussed in few studies (Abdel-Aty et al., 2013; Lee et al., 2014b; Xu et al., 2014).

A variety of area-wide variables have been considered in previous macro-level safety analyses: socioeconomic variables, e.g. population density (Hadayeghi et al., 2003; Noland and Quddus, 2004; Huang et al., 2010; Tolón-Becerra et al., 2012; Lee et al., 2014b), age groups (Noland, 2003; Noland and Oh, 2004; Noland and Quddus, 2004; Aguero-Valverde and Jovanis, 2006; Quddus, 2008; Huang et al., 2010; Aguero-Valverde, 2013; Lee et al., 2014a), income (Noland, 2003; Traynor, 2008; Pirdavani et al., 2012), GDPs (Kumara and Chin, 2004; Tolón-Becerra et al., 2012), and employment (Siddiqui et al., 2012); land use variables (Ng et al., 2002; Lovegrove and Sayed, 2006; Pulugurtha et al., 2013; Wang et al., 2013; Lee et al., 2014b); healthcare variables (Ng et al., 2002; Coruh et al., 2015); road infrastructure variables, e.g. road density, intersection density, road length (Amoros et al., 2003; Hadayeghi et al., 2003; Noland, 2003; Lovegrove and Sayed, 2006; Pirdavani et al., 2012; Tolón-Becerra et al., 2012; Jiang et al., 2016), roads with different functions (Lovegrove and Sayed, 2006; Huang et al., 2010), and road network structures (Wang et al., 2013; Moeinaddini et al., 2014); traffic pattern variables, e.g. vehicle kilometres travelled (VKT) (Dumbaugh and Rae, 2009; Abdel-Aty et al., 2013; Aguero-Valverde, 2013), highway usage (Traynor, 2008), traffic volume (Quddus, 2008; Wier et al., 2009), speed (Quddus, 2008), volume to capacity ratios (Hadayeghi et al., 2003), and trip generation and distribution (Abdel-Aty et al., 2011); and environmental variables, e.g. rainfall (Coruh et al., 2015) and snowfall (Aguero-Valverde and Jovanis, 2006).

Spatial effects, i.e. spatial dependence or correlation and spatial heterogeneity (Anselin, 1988), have been considered in macro-level safety analyses. For example, Bayesian spatial approaches have been used to account for possible spatial correlation between areas (Aguero-Valverde and Jovanis, 2006; Quddus, 2008; Siddiqui et al., 2012; Wang et al., 2013; Xu et al., 2014; Dong et al., 2015; Lee et al., 2015; Song et al., 2015; Siddiqui and Watkins, 2016). To consider spatial heterogeneity, previous macro-level safety studies have adopted the geographically weighted regression (GWR) models (Hadayeghi et al., 2003; Erdogan, 2009; Hadayeghi et al., 2010; Li et al., 2013) and random parameter models (Coruh et al., 2015; Xu and Huang, 2015). Space-time interaction has also been considered by Aguero-Valverde and Jovanis (2006).

A number of studies have focused on macro-level safety analyses, which however is mainly Western-based. There is a need to understand the safety effects of area-wide characteristics in the context of developing countries, including South East Asia countries

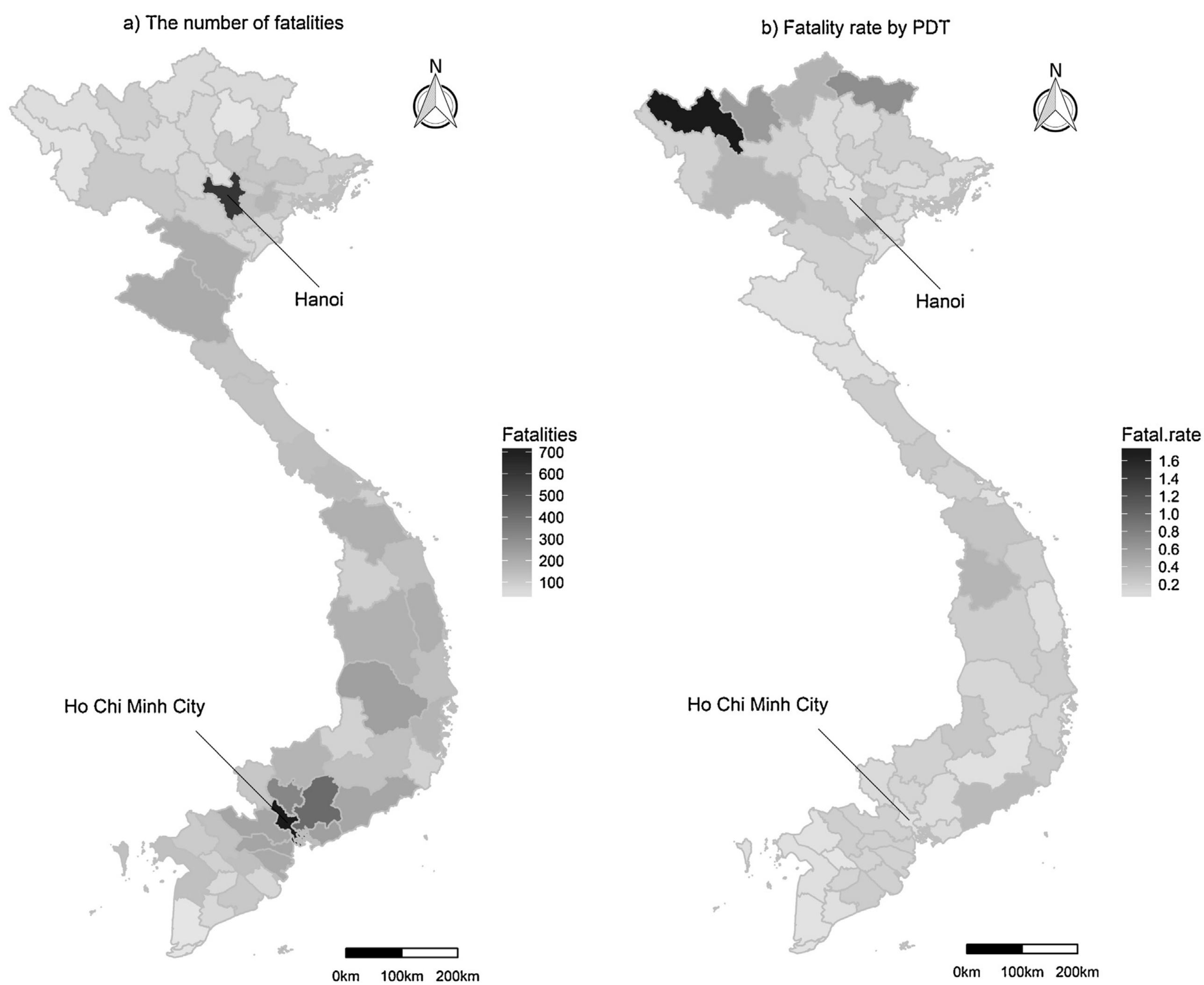

Fig. 1. The number of traffic crash fatalities and fatality rate by million passenger km travelled by province in 2014.