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Factor decomposition analysis and causal mechanism investigation on urban transport CO_2 emissions: Comparative study on Shanghai and Tokyo

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ABSTRACT

Low-carbon urban development has been regarded as a promising pathway for mitigating climate change, and the transportation sector makes a key contribution to a significant proportion of all CO_2 emissions. Investigating the driving factors and analysing the causal mechanism on urban transport CO_2 emissions is critical for stakeholders and policy-makers to draft appropriate policies for low-carbon transport, and conducting a comparative study on developed and developing countries' experiences will provide beneficial insights from an evolving perspective. To date, many emerging case studies have analysed urban transport CO_2 emissions in China; however, they lack an in-depth decomposition and causal mechanism analyses as well as a comparative study. To fill this gap, this study aims to conduct a decomposition analysis and causal mechanism investigation study on the urban transport sector with comparative studies on two Asian mega cities, Tokyo and Shanghai. We illustrate the driving forces of the urban transport sector and the causal mechanism of each factor and provide critical policy insights through comparative studies. The outcomes of this study provide critical insights to recent practices in Shanghai as well as practical guidance to low-carbon urban planning in developing countries.

1. Introduction

City development has become the key driver to global GHG-emissions increases; therefore, low-carbon urban development has become a point of focus to mitigate global climate change. It is reported that urban land use contributes to 80% of world CO_2 emissions while only occupying 2% of the earth's surface (Grimm et al., 2008; Wu, 2008). With economic growth and urbanization, the transport sector has become an important driving force for CO_2 emissions (Nakamura and Hayashi, 2013): the sector emits a significant proportion of total emissions, at 32.9% in United States, 17.7% in Japan, and 8.6% in China in 2012 (IEA, 2014).

Various low-carbon strategies and instruments are designed and implemented to mitigate urban transport CO_2 emissions (Feng et al., 2013; Hao et al., 2014, 2011; Hickman and Banister, 2007; Jie and van Zuylen, 2014; Lehmann, 2013). As a mixed-use urban design methodology, the Transit-oriented Development (TOD) strategy, which promotes sustainable urban transport by integrating transport infrastructures with surrounding land uses (Cervero, 1998; Curtis et al., 2009; Dittmar and Ohland, 2004; Loo et al., 2010; Sung and Oh, 2011) provides a novel methodology for low-carbon urban planning (Nakamura and Hayashi, 2013).

China, which has become the highest CO_2 emitter in the world, faces significant pressure regarding CO_2 mitigation. China is under pressure due to its responsibility for climate change and criticism from the international community; thus, China's administration had been

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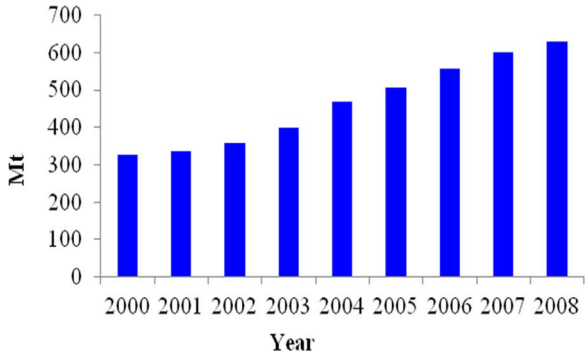

Fig. 1. China transport sector CO_2 emissions.
Source: Annual review of low-carbon development in China.

planning various measures for the mitigation of CO_2 emissions. In 2009, the Chinese government declared that it would reduce its CO_2 emission intensity by 40–45% by 2020. It was reported (Fig. 1) that the transport sector's CO_2 emissions in China increased by 8.6% annually, reaching 630 million tons in 2008. Compared to sector energy consumption in 2000, transport-related energy consumption increased by 93.2% in 2008 (Chen and Yang; Hao et al., 2014). Especially in some mega cities of China, as economic growth and migration increases, the trend of motorization also increases quickly; as a result, transport sector-related emissions are still surging (Feng et al., 2013; Wang et al., 2012; Wei et al., 2013).

Many developing cities in China promote urbanization, and they face a conflict of increasing travel demand and limited transport supply as well as corresponding problems, e.g., traffic congestion, increasing traffic-related injuries and increasing transport-related air pollution, such as $PM_{2.5}$, and significant transport energy consumption. The experiences of other cities can offer valuable lessons to cities in developing countries (Mittal et al., 2016a, 2016b). For instance, the experience of Tokyo, Japan is critical for some mega cities in China to learn about low-carbon urban development. From this perspective, it is beneficial to learn and analyse the lessons and experiences (both positive and negative) of developed cities to help developing cities achieve major advances with early and proper policy making. Given such circumstances, identifying the key factors affecting urban transport emissions (D'Agosto et al., 2013; Hickman et al., 2011; Liu et al., 2013; Makido et al., 2012; Ribeiro and Balassiano, 1997) and investigating the causal mechanisms in cities in both developing and developed countries is necessary to promote a sustainable and low-carbon urban transport system for a TOD strategy (Dou et al., 2016; Mitric, 2013; Nicolas and David, 2009).

To date, there have been emerging studies on urban transport CO_2 emissions, both domestically (Feng et al., 2013; Jie and van Zuylen, 2014; Wang et al., 2012; Wei et al., 2013) and internationally (Hickman et al., 2011; Hickman and Banister, 2007; Makido et al., 2012; Pérez et al., 2009; Ribeiro and Balassiano, 1997). As a powerful tool to trace the driving forces of emissions (Jiang et al., 2015; Wu and Xu, 2014; Zucaro et al., 2014), an increasing number of decomposition analysis methods have been applied in the transport sector (Wu and Xu, 2014). However, to our best knowledge, research on the combination of decomposition analysis and the urban transport sector has not yet been carried out. In addition, research on the follow-up causality mechanism investigation has not yet been done. A number of studies have focused on enumerating these features and making a full causality map for the driving forces of the urban transport CO_2 emissions in developing cities.

This paper aims to fill this gap with a decomposition analysis and causal mechanism investigation study on the urban transport sector with comparative studies on a developed city — Tokyo — and one developing city in China. We aim to not only illustrate the driving forces of the urban transport sector and the causal mechanism of each factor but also provide critical policy insights from an evolving perspective through the comparative studies. Our results will be critical to finding the causality of urban transport CO_2 emissions and the inter-factor mechanisms in Asian cities and supporting the design of a policy framework to achieve urban transport CO_2 mitigation targets towards a TOD strategy.

The rest of this paper is organized as follows. After this introduction, Section 2 presents details on the methodology; Section 3 introduces the case city and its urban transport development; Section 4 presents and discusses the analytical results; and finally, Section 5 presents the conclusions and addresses the policy implications.

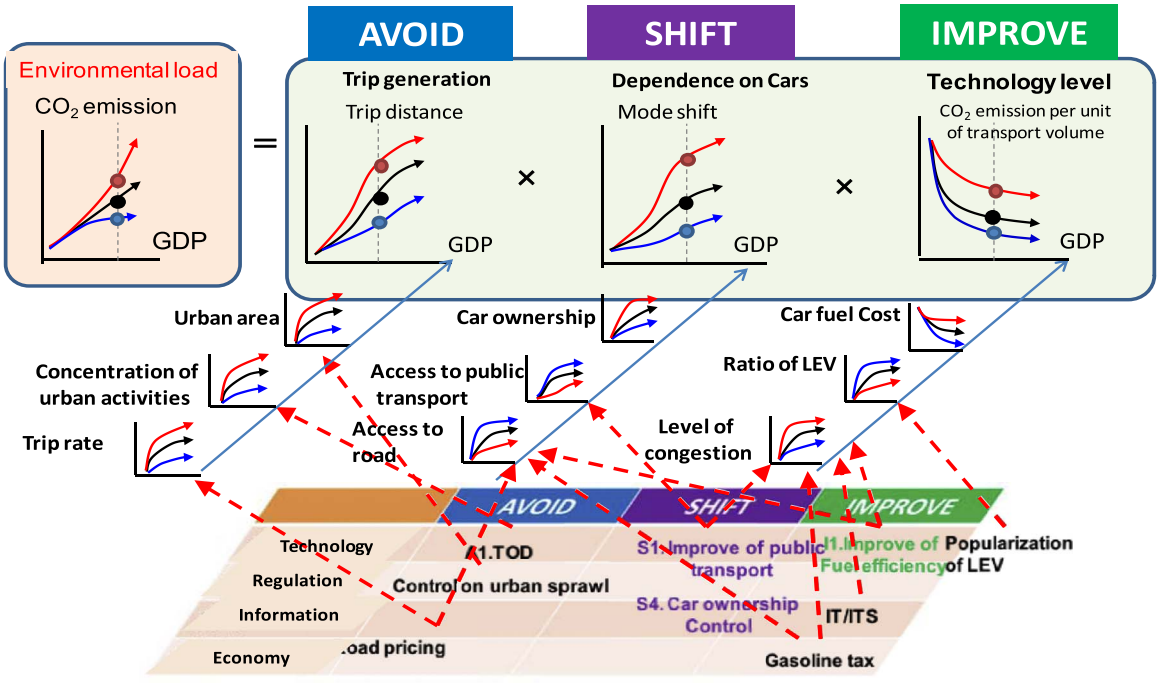

Fig. 2. Dynamic tracking of transport-related emission mechanism.

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