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Transport demand, harmful emissions, environment and health co-benefits in China

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HIGHLIGHTS

- The changes in travel demand affect both environment and health in China.
- Integrated framework is proposed to analyze environment and health co-benefits.
- Travel demand here includes all travel means: road, rail, water, and air transport.
- Counter-factual scenarios are proposed to estimate environment and health impacts.

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ABSTRACT

The Chinese residents' travel demand has been increasing dramatically. As a result, emissions from motor vehicles have been found as one main source of air pollution in China, which consequently influences the residents' health. To better understand the environmental deterioration and health losses caused by the transport sector in China, in current circumstances, one must know how the changes in residents' travel demand and alternative transport modes affect environment and health co-benefits in China. We first of all calculate the demand from nearly all the residents' travel means, including road, rail, water, and air transport. Besides, based on the results, this paper further makes projections for a business-as-usual scenario for 2050 with several alternative transport scenarios to reduce harmful emissions and improve the welfare of the residents' health in China. Our integrated framework includes the harmful emissions models, the fixed box model and the exposure-response models, to link transport demand with possible environmental and health outcomes. The findings suggest that significant environment and health co-benefits are possible if alternative transport replaces. This research, to the best of our knowledge, is the first attempt to estimate the total resident's travel demand under different scenarios and the consequent environment and health co-benefits in the transitional China.

1. Introduction

The transport pollution has become a serious challenge in China. Motor vehicles have been one main source of air pollution, which directly influences the Chinese residents' health.[2] The last decade has witnessed a dramatic increase of the ownership of personal vehicles (see Fig. 1), causing the rapidly growing travel demand of the Chinese residents. China's passenger turnover has risen from 1746.67 billion passenger-kilometers (pkm) in 2005 to 3009.74 billion pkm in 2014 (National Bureau of Statistics of China,

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[2] Ministry of Environmental Protection of the People's Republic of China: China Vehicle Emission Control Annual Report, 2015. http://www.mep.gov.cn/gkml/hbb/qt/201601/t20160119_326622.htm

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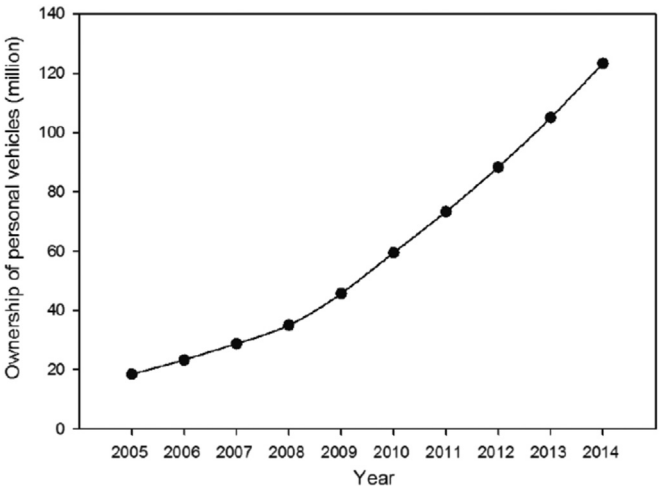

Fig. 1. Ownership of personal vehicles in China, 2005–2014. Data source: National Bureau of Statistics of the People's Republic of China: the ownership of personal vehicles.

2006–2015). In 2013, the China's transport sector consumed 348.19 million tons of coal equivalent (tce),[3] which resulted in serious air pollution. The total vehicle emissions in China reached to 45.71 million tons. Specifically, the emissions of CO, HC, NO_x and PM from passenger vehicles were 18.95, 2.04, 18.89 and 0.12 million tons, respectively.[4] Moreover, empirical evidence shows that traffic-related air pollutants have serious effects on human health, increasing the risk of lung cancer, respiratory and cardiovascular diseases (Kunzli et al., 2000; Hoek et al., 2002; Beelen et al., 2008; Brunekreef et al., 2009; Samet, 2007; Weichenthal et al., 2011). In China, it is estimated that ambient particulate matter has contributed to 1.2 million premature deaths and removing 25 million healthy life years in the year of 2010 alone (Yang et al., 2013). Chen and He (2014) assess the socioeconomic costs of China's air pollution by means of a computable general equilibrium (CGE) framework. According to this study, due to the excess emissions of $PM_{2.5}$, O_3 and $PM_{2.5-10}$ pollutants, China would experience a staggering GDP loss of about 361.468 billion RenMinBi (RMB) Yuan and a welfare loss of about 227.649 billion RMB Yuan.

Chinese government has implemented several transport policies to deal with this challenge and to encourage residents to change their travel behaviours to mitigate severe air pollution. For example, in some megacities (e.g. Beijing and Shanghai), regulatory policies imposed on vehicle usage,[5] as well as car ownership.[6] And, in many Chinese cities, financial policies are implemented to reduce the price of public transportation, and to offer the convenient bicycles rent to encourage residents to travel with a clean mode, etc. But some policies don't achieve the expected goals and some are effective only in a short-term (B.F. Cai and Xie, 2011; H. Cai and Xie, 2011). For example, after imposing so many tight restrictions, Beijing is still facing severe air quality deterioration, and has repeatedly announced the red warnings many times about air pollution in December 2015 alone. The policies which limit the ownership and usage of personal cars, aim to control the growing numbers of personal vehicles to reduce air pollution; however, they would at the same time suppress the resident's travel demand, with a high risk of hurting the development of Chinese economy. Therefore, it is necessary to make a reasonable, feasible and applicable policy on alternative travel modes, which can not only reduce harmful emissions and improve the welfare of residents' health, but also simultaneously satisfy the residents' travel demand and fulfill the development of economy in the transitional China.

In order to find an effective strategy to encourage residents to change their travel behaviours, it is important to quantify and understand the total residents' travel demand and the proportion of different travel modes in China. However, in existing literature, most current studies focused only on one transport mode individually, especially on the road transportation, instead of taking road, air, water and railway transportation as a whole when estimating Chinese residents' travel demand. Han and Hayashi (2008) estimate the private car stock and its regional environmental impacts in China from 2000 to 2020. Yan and Crookes (2010) predict that the rapid growth of road transportation in China will likely continue in the next two to three decades. Hu et al. (2010) provide an overview of the challenges encountered in road transportation development in China. They show that if the current pattern continues, by the year 2030, the vehicle population in China will be 400 million. Zhang et al. (2015) find that the direct rebound effect does exist for road passenger transport in China. Some studies also have attempted to quantify the transport-related harmful gases emissions through different transport modes. He and Li (2010) calculated the historical CO_2 emissions in China's railway transport from 1975 to 2005. He and Xu (2012) calculated the yearly CO_2 emissions of aircrafts during 1960–2009 and analyzed the emissions intensity and its dynamic characteristics in China. Loo and Li (2012) trace the growth trend and spatial disparity of CO_2 emissions from passenger transport in China. He and Chen (2013) attempt to address the possible policy measures to reach both policy goals of energy saving and emission mitigation from China's road transportation. Also several studies focus on the road transport of some big cities in China (H. Wang et al., 2008; Wang and Xie, 2009; Shen et al., 2010; X. Wang et al., 2011). However, the aforementioned studies usually evaluate the emissions and impacts of air pollution based on one transport mode only. At present, there is no study in existing literature investigating the overall demand of residents' travel (including air, road, railway, water, even bicycle, etc.) in China.

Before any attempt to make a feasible and applicable relevant policies, however, policy makers must know the total residents' travel demand and the proportion of different travel modes in light of new policies that aim to reduce harmful emissions from residents' travel transport and also provide a relatively reliable and comprehensive reference for the world to understand China. So this paper first attempts to comprehensively evaluate the Chinese residents' travel demand. In addition, most of the earlier studies focused on CO_2 emissions only (He et al., 2005; He and Li, 2010; H. Cai et al., 2011; B.F. Cai et al., 2011; Liu, 2011; Loo and Li, 2012; He and Xu, 2012; Zhang et al., 2016). A comprehensive research is needed for estimating the harmful emissions from the whole residents' travel demand. Based on the demand from different travel modes, this paper also calculates the corresponding harmful emissions, not only the CO_2 emissions, but also air pollutants emissions, such as SO_2, NO_2 and PM.

Chinese government announced the CPC Central Committee's

[3] Data source: National Bureau of Statistics of the People's Republic of China: Total Energy Consumption of Different Industries. http://www.data.stats.gov.cn/easyquery.htm? cn=C01&zb=A070F&sj=2014

[4] Data source: Ministry of Environmental Protection of the People's Republic of China: China Vehicle Emission Control Annual Report, 2014. http://www.mep.gov.cn

[5] This policy, as known as "plate traffic restriction', imposes a restriction on vehicle usage that vehicles with license plates ending with even numbers can operate on roads only on even-numbered dates, and odd numbers on odd-numbered dates. For more detailed regulations, see the Beijing Traffic Management Bureau. http://www.bjjtgl.gov.cn/publish/portal0/

[6] To give an example, "vehicle purchase limit" policy puts a limit on the quantity of new motor vehicles, and force eligible car buyers, who already meet strict requirements, to apply for car license by network lot drawing. For more details and other regulatory policies imposed on car ownership, see the Beijing Traffic Management Bureau. http://www.bjjtgl.gov.cn/publish/portal0/