WANG, HAYASHI, KATO: Proceedings of the 13th International Summer Symposium, JSCE, pp.321-324, 2011.8

THE EVOLUTION OF PASSENGER TRANSPORT CO_2 EMISSIONS AND DRIVING FORCES ANALYSIS IN BEIJING

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INTRODUCTION

Transport accounted for 23% of world energy related GHG emissions (IEA, 2006) and its share in the overall energy consumption is continuously growing, which makes transport sector as one of the most important contributors to global CO_2 emissions. China, the most rapidly growing country and the largest CO_2 emitter in the world, is experiencing rapid and substantial growth in economy and motorized mobility, and transport related energy consumption and pollution problems are poised to soar further, especially in metropolitan areas. Therefore, the identification of key factors driving transport CO_2 emissions growth is essential for formulation of effective CO_2 mitigation policies and strategies.

One of the approaches to identify the key driving factors is to decompose the growth of emissions into possible affecting factors using decomposition methods. In transport sector, a few studies regarding examining factors affecting emissions growth have been conducted over the past decades. Generally, those studies were international comparisons or national level covered one or more transport modes. For example, Scholl et al. (1996) compared the CO_2 emissions growth from passenger transport in some OECD countries between 1973 and 1992 from transport activity, modal structure, and energy intensity perspectives; Kwon (2005) decomposed the factors determining the trends of CO_2 emissions from car travel in Great Britain from 1970 to 2000; Timilsina and Shrestha (2009) analyzed the underlying factors of transport sector CO_2 emissions growth in Asian countries. Taking the urban passenger transport of Beijing as a case, this paper aims to evaluate the evolution of passenger transport CO_2 emission of Beijing from 2000 to 2009 and discusses the contributions of potential driving factors.

DATA AND METHODOLOGY

Data

The data used in this study comes from Beijing Statistical Yearbook (2001-2010) and Beijing Transport Annual Report (2002-2010). The data includes the annual stock of private and public-owned cars, annual operating vehicles, passengers carried and mileage traveled per year on public busses, taxis and metro, as well as annual GDP and population data and the conversion factors to coal equivalent in the Chinese Energy Statistical Yearbook (2010).

Methodology

Eq. (1) is used for estimating CO_2 emissions based on the guidelines for national GHG inventories provided by IPCC (2006) and City's Greenhouse (GHG) Emission Inventory Research (Cai, 2009) in China.

$$\mathrm{CO2_t} = \Sigma_{ij}\mathrm{CO2_{ijt}} = \Sigma_{ij}(EC_{ijt} \times \mu_i \times \sigma \times \theta \times \varphi) \qquad (1)$$

Where subscripts i, j and t refer to energy type (e.g., gasoline, diesel, electricity, Compressed Natural Gas (CNG) and Liquids Petrol Gas (LPG)), transport mode (e.g., public bus, metro, taxi, private car and public-owned car) and year respectively; EC is energy consumption; μ is the conversion factors between different types of energy and coal equivalent; σ is net calorific value of coal equivalent; θ is the effective CO_2 emission factor of coal equivalent when the default carbon oxidation factor φ is estimated at the default value.

Considering the most important dependent factors of passenger transport emissions, the level of passenger transport activity, modal structure and the passenger transport energy consumption and emissions characteristic, Eq. (1) can also be expressed as Eq. (2) and shortened as Eq. (3).

$$\mathrm{CO2_t} = \sum_j \left(\frac{CO2_{jt}}{P_{jt}} \times \frac{P_{jt}}{P_t} \times \frac{P_t}{GDP_t} \times \frac{GDP_t}{POP_t} \times POP_t\right) \qquad (2)$$

$$\mathrm{CO2_t} = \Sigma_j(EF_{jt} \times MS_{jt} \times IT_t \times EA_t \times POP_t) \qquad (3)$$

Where POP is population and P is passengers carried; EF is passenger transport CO_2 emission factor which represents the relationship between the amount of CO_2 produced and the amount of passenger carried (i.e., CO_2 / P); and MS refers to the share of passengers in each mode; IT is the passenger transport intensity which is defined by the ratio of total passengers from all passenger transport modes in an economy to its GDP (i.e., P / GDP); EA is economic activity as captured by GDP per capita.

Based on the detailed explanation and practical guide of LMDI method (Ang, 2005), this study decomposes the total change (D_{tot}) of CO_2 emissions from year t to year 0 (base year) by multiplicative decomposition:

$$\mathrm{D_{tot}} = \frac{CO2_t}{CO2_0} = D_{EF} \times D_{MS} \times D_{IT} \times D_{EA} \times D_{POP} \qquad (4)$$

The factors on the right-hand side of Eq. (4) are Eq. (5) respectively, where F_i refer to the factors of

EF, MS, IT, EA and *POP*.

$$D_{F_i} = \exp\left[\sum_j \frac{(CO2_{jt} - CO2_{j0})/(\ln CO2_{jt} - \ln CO2_{j0})}{(CO2_t - CO2_0)/(\ln CO2_t - \ln CO2_0)} \ln \frac{F_i^t}{F_i^0}\right] \quad (5)$$

RESULTS

Figure 1 presents the evolution of passenger transport CO_2 emissions in Beijing from 2000 to 2009. Aggregate passenger transport CO_2 emissions increased 3.9 times from 4.18 million tons in 2000 to 16.31 million tons in 2009, with a robust average annual growth rate of 16%. Among each mode, although the CO_2 emissions absolutely increased from all modes, the share of each mode was significantly different. Specially, CO_2 emissions from private car increased more than 7 times, and its share reached 66% in 2009 from 34% in 2000. Figure 2 illustrates the estimated contributions of factors relevant to economic activity, population, modal share, passenger transport intensity and passenger transport CO_2 emission factor to the change of passenger transport CO_2 emissions in Beijing based on 2000. All these factors were positive driving factors to passenger transport CO_2 increase in the whole study period except passenger transport intensity which had managed to cancel out the increase effects, although it was too small to offset the whole increasing effects.

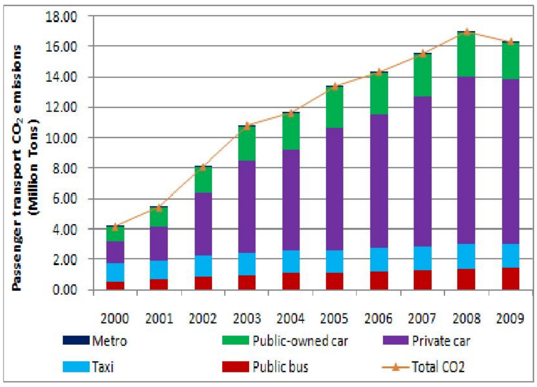

Figure 1 Passenger transport CO_2 emissions evolution in Beijing

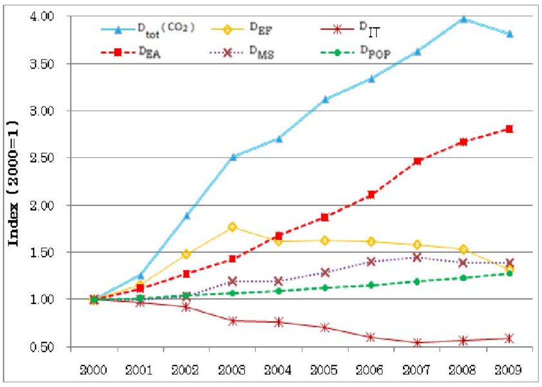

Figure 2 Multiplicative decomposition of passenger transport CO_2 emissions in Beijing

It is notable that the contributions of these variables had not followed a smooth trend except economic activity and population. From 2000 to 2003, CO_2 emissions from the passenger transport of Beijing rapidly increased with average annual growth rate of 37% where EF was the largest contributor because of urban sprawl and the increasing of average travel distance of each mode. Since 2004, the overall growth of CO_2 emissions slowed down and achieved the maximum in 2008. During this period, Beijing government implemented a series of mitigation policies such as the introduction of clean energy in taxis and public busses, ban policy on vehicles with even and odd-numbered license plates and the expansion of metro network to help improve air quality and climate change effects for the Olympic Games which decreased the effect of EF while the effects of EA and MS increased because of rapid economic growth and diffusion of motorized mobility. After 2008, accumulated policies effects and more stringent controlled policies on private cars made the passenger transport CO_2 emissions begin to decrease in 2009.

SUMMARY

From 2000 to 2009, the passenger transport CO_2 emissions in Beijing increased from 4.18 million tons in 2000 to 16.31 million tons in 2009, with a robust average annual growth rate of 16%. Decomposition analysis found that the increase of economic activity and emission factor were the most important factors driving passenger transport CO_2 emission growth. Modal shift to private car also contributed a lot to the passenger transport CO_2 emissions growth in Beijing. While the passenger transport intensity had managed to partly cancel out the increase effects, the effect was too small to offset the whole increase. Mitigation policies slowed down the overall increasing of passenger transport CO_2 emissions since 2004, which achieved the maximum CO_2 emissions from passenger transport of Beijing in 2008 and began to decrease in 2009.

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ACKNOWLEDGMENT

This research was supported by the Environment Research and Technology Development Fund (S-6-5) of the Ministry of the Environment, Japan.