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The impacts of individual behavior on household daily travel carbon emissions in Beijing, China

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Abstract

Recently, the topic of sustainable transport has attracted much scholarly and practical attention. However, few studies have examined the driving forces for household transportation emissions from the perspective of individual behavior. On the basis of daily activity survey conducted in Beijing from 2000 to 2011, this study examines the impacts of individual travel behavior on carbon emissions from urban transport. It first investigates the changes in the inhabitant travel characteristics and carbon emissions, and then discusses the effects of population, per capita economic activity, transportation intensity, transportation mode share, vehicle-use intensity and emission coefficient on carbon emissions based on decomposition analysis. Results shows that: (1) carbon emissions due to urban traffic has increased from 2.99 Mt in 2000 to 16.76 Mt in 2011, following an annual growth rate of 16.95%; (2) the vehicle-use intensity effect, per capita disposable income effect and population effect are found to be the main drivers that increase household daily travel carbon emissions; and (3) both transportation intensity and emission coefficient have significant effects on the reduction of carbon emissions. However, the transportation mode share effect plays a very minor role over the study period.

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Keywords: Sustainable transport; Carbon emission; Individual behavior; Decomposition analysis

1. Introduction

The transport sector plays a curial role in daily activities around the world, and accounts for more than 20% of global energy consumption and 22% of CO_2 emissions [1]. In 2009, Chinese government announced it would reduce its CO_2 emissions per unit of GDP by 40 to 45 percent by 2020 from the 2005 levels. However, with the accelerating process of urbanization and increasing levels of motorization in China, the CO_2 emission from transport sector has dramatically increased in past years, especially in big

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cities, such as Beijing, which brings great pressure on trying to meet its emission reduction target by 2020. At present, as the country is still in the period of optimization of urban traffic structure, a radical change may occur to the transport behavior of urban residents, which will change their transportation mode share and the number of privately owned vehicles. In this context, it is necessary to examine the driving forces for household transportation emissions from the perspective of individual behavior.

Recently, several studies have been interested in analyzing the energy consumption and emission reduction in the transport sector [2-4]. Some studies focus on the specific country and area, such as OECD countries, China, Malaysia and so on [5, 6]. Furthermore, some researches pay attention to different transport modes [7]. In the previous studies of carbon emissions from transport sector, researchers mainly used the decomposition method to investigate the factors influencing energy consumption and emissions, such as the transport activity, population, per capita GDP, transport intensity and density, energy efficiency, transport distance, technical progress and so on [8, 9]. These studies have widely studied the impact of different factors on the increasing of carbon emissions in transport sector. However, few studies have examined the driving forces for household transportation emission from the perspective of individual behavior. Therefore, this study aims to fill this gap and develop a comprehensive picture of the driving forces of the changing carbon emissions related to household daily travel from a systemic point of view. Thus, taking Beijing as an example, the authors first calculate the carbon emissions from household daily transportation from 2000 to 2011. By applying Logarithmic Mean Divisia Index Approach (LMDI), we then construct a structural decomposition model to examine the main factors that influence the changes of emissions comprehensively. At last, we propose suggestions for the purpose of carbon emission reduction. Here, we consider four main transportation modes in Beijing: taxi, city bus, metro and private car.

The remainder of this paper is organized as follows. Section 2 introduces the models and the related data used in this paper. In Section 3, the main results and discussions are reported. Finally, the conclusions and policy implications are given.

2. Methodologies

2.1. Estimation of CO_2 emissions

We use the distance-based method to estimate the emissions from household daily travel in Beijing. The formula can be expressed as follows:

$$C_i = VMT_i * EF_i \tag{1}$$

Where C is CO_2 emissions of household daily travel (in Million tons, Mt), VMT_i is vehicle-miles of travel of different kinds of vehicle (in km), and the indices VMT_i of taxi, city bus and metro are collected from Yearbook of China Transportation and Communications and Annual Reports on Development of Beijing Transport [10, 11]. And EF is CO_2 emission intensity factors (in kg/km), which are given as follows: Taxi, 0.25; City bus, 1.07; Metro, 2.11; Private car, 0.23.

2.2. Decomposition analysis

According to Kaya identity, the carbon emission C can be decomposed in:

$$C = \sum_i P \times \frac{INC}{P} \times \frac{TD}{INC} \times \frac{TD_i}{TD} \times \frac{VP_i}{TD_i} \times \frac{C_i}{VP_i} = \sum_i P \times I \times TI \times TS_i \times TU_i \times EI_i \quad (2)$$

Where P and I is population and per capita disposable income (in yuan), TI is transportation intensity which is calculated as passenger turnover volume (TD , in pkm) divided by residential disposable income, TS is transportation mode share which refers to the passenger turnover volume of transportation mode i (TD_i) to the total passenger turnover volume (TD, in pkm), TU is vehicle-use intensity which is calculated as vehicle number (VP) divided by passenger turnover volume, EI is emission coefficient which is calculated as carbon emission divided by vehicle number.

Then, following the LMDI method, the variation of C in the time period (0, T) can be decomposed as:

$$\Delta C = C^t - C^0 = \Delta C_P + \Delta C_I + \Delta C_{TI} + \Delta C_{TS} + \Delta C_{TU} + \Delta C_{EI}$$
$$= \sum W In(\frac{P^T}{P^0}) + \sum W In(\frac{I^T}{I^0}) + \sum W In(\frac{TI^T}{TI^0}) + \sum W In(\frac{TS^T}{TS^0}) + \sum W In(\frac{TU^T}{TU^0}) + \sum W In(\frac{EI^T}{EI^0}) \quad (3)$$

Where $W = \frac{P^T I^T TI^T TS^T TU^T EI^T - P^0 I^0 TI^0 TS^0 TU^0 EI^0}{In(P^T I^T TI^T TS^T TU^T EI^T) - In(P^0 I^0 TI^0 TS^0 TU^0 EI^0)}$

Where ΔC_P , ΔC_I , ΔC_{TI} , ΔC_{TS} , ΔC_{TU} , ΔC_{EI} refers to the population effect, per capita disposable income effect, the transportation intensity effect, the transportation mode share effect, the vehicle-use intensity effect and the emission coefficient effect, respectively. The ΔC_{TI}, ΔC_{TS} and ΔC_{TU} are used to estimate the impacts of individual behavior on transport emission.

3. Results and discussion

3.1. Analysis of household daily travel carbon emissions in Beijing

Using Eq. (1), we calculate the carbon emissions from household daily travel in Beijing from 2000 to 2011. Results show that carbon emission has increased from 2.99 Mt in 2000 to 16.76 Mt in 2011, with an annual growth rate of 16.95%. In terms of different transport modes, emissions from private car transport have increased dramatically, with an annual growth rate of 22%. The growths of taxi and city bus are relatively slow in the same study period, with an annual growth rate of 7.7% and 5.9%, respectively. Due to the rapid construction and development of Beijing Metro in recent decade years, the emissions from metro increased from 0.017 Mt in 2000 to 0.096 Mt in 2011, with an annual growth rate of 17%. Results also clearly show that private car transport is the biggest CO_2 emitter, with the share increased from 51% in 2000 to 82% in 2011. It is obvious that private car transport is the dominant factor regarding carbon emissions from household daily travel in China.

3.2. Decomposition results

By applying Eq. (3), we analyze the factors affecting change in carbon emissions. Results show that there are three factors exhibiting positive effects on the growth of emissions during the other study periods:

the vehicle-use intensity effect, per capita disposable income effect and population effect. On the contrary, the transportation intensity effect, emission coefficient effect and transportation mode share effect contribute to the decrease of carbon emissions. The accumulated effect makes the carbon emissions to increase by 13.75 Mt.

The vehicle-use intensity effect has the most important positive effect on emissions, which increases emissions by 9.25 Mt, and its contribution ratio reaches to 67.18%. Among the four transport modes, the most significant growth comes from private car, which reaches to 9.95 Mt, while taxi and city bus decrease emissions by 0.35 Mt and 0.36 Mt respectively. From the perspective of private ownership of the four kinds of vehicles, the number of private car in Beijing has grown to more than 15 times from 2000 to 2011, which causes a tremendous change on the residential transport behavior. For one thing, people tend to choose private car instead of public transport modes. The share of private car in total passenger traffic volume increases from 23% in 2000 to 34% in 2011. In addition, behaviors change not only influences what transport modes are chosen, but also the usage efficiency. With the expansion of residents' ability to purchase private cars, the loading rate (passenger load per vehicle) of private car in Beijing is declining, which increases the travel time and travel distance in deed.

Results show that the growth of per capita disposable income generates positive effect on emissions. The accumulated effect is an increase of 8.92 Mt, and the total contribution ratio reaches to 64.77%. The per capita disposable income in Beijing increases from 10003 Yuan in 2000 to 32900 Yuan in 2011. Residential transport demand is closely linked to economic growth. With the increase of personal income, more and more families have the ability to purchase and use of private cars to satisfy their travel demands. Also, as the economic level is enhanced, people might shift from public transportation to fast and comfortable travel modes, for example private car and taxi.

The accumulated effect of transportation intensity effect and emission coefficient effect are decreases of 4.82 Mt and 2.01 Mt respectively, which accounts for 35.00% and 14.60% of the total changed emissions over the period. The contribution value of population effect reaches to 3.02 Mt, which accounts for 21.93% of the total increased emissions. Differ from the results of other studies, we find that although transportation mode share has contributed to some reduction in emissions, its effect is very limited, which contribution ratio is only 4.28%.

4. Conclusions

In Beijing, the transport emissions from household daily travel have growth rapidly from 2000 to 2011. Private car travelling is the leading and most rapidly growth contributor. Also, the decomposition results show that the vehicle-use intensity factor, especially the use intensity of private car, explains the most for the growth of carbon emissions. Moreover, the per capita disposable income effect and the population effect cause the rise of emissions, while the transportation intensity and the emission coefficient exhibit negative effect. However, the transportation mode share effect plays a very minor role over the study period, which is differing from previous researches. The results of this paper strongly suggest that the Chinese government should take measures and instruments to influence household transport behaviors and encourage people to choose environmentally friendly transport mode in order to fulfill the 40-45% carbon intensity reduction target by 2020.

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Biography

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