

Is Regional Disparity of Material Stock widening in China?

Graduate School of Environmental Studies, Nagoya University Member ○Licheng Zheng, Ji Han, Hiroki Tanikawa

1. Introduction

Because of unbalanced economic development in China, there exists the massive disparity of material stock accumulation of infrastructure in different regions. This study calculated material stock amount of infrastructures including residential buildings and roads and railways as well as water pipeline in 31 provinces from 1978 to 2008, and estimated the regional disparity of material stock by Theil index model. The result implied that total amount of material stock in China increased from 2.3 billion tons in 1978 to 16.1 billion tons in 2008, but the percentage of each type of material stock did not have a clear change during these 30 years. Total regional disparity of 8 unbalanced regions showed by Theil index decreased from 1978 to 1990, and increased from 1990 to 2008. Factor decomposition analysis of regional disparities will be taken, which help us know why regional disparity changed like that, and provide suitable suggestions for lessening regional disparity.

2. Data

Most research data and source as shown in following table 1:

Table 1. Data and material intensity used for calculation

Type	Content	Data Source
Infrastructure	Per capita floor area of residential building newly constructed per year in urban area and rural area; Total floor area of residential building in year-end; Length of road; Length of railway; Length of water pipeline; Material intensity	China Rural Statistical Yearbook (1979~2009) Year Book of China Transportation (1979~2009) Year Book of China Transportation (1979~2009) China Urban Construction Statistical Yearbook Previous reports and papers, etc.
Socio-economic	Urban population, Rural population, GDP	China Statistical Data Collection for 60 Years

3. Methodology

3.1 Material stock account

The material stock of infrastructure was calculated according to the following flow chart:

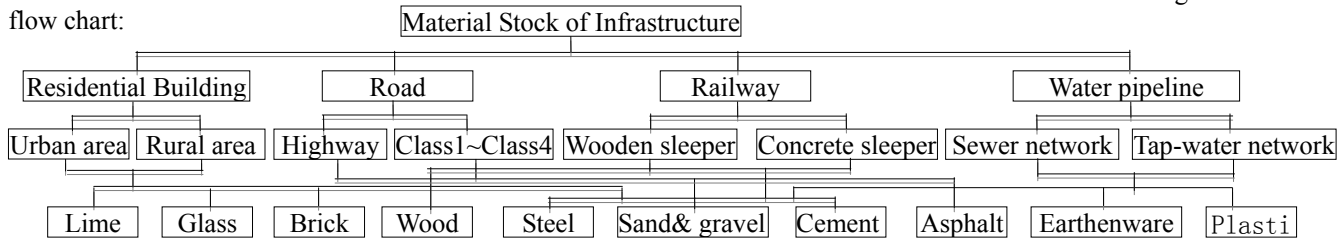


Fig.1 The flow chart for the calculation of material stock of infrastructure

Firstly, We calculated Material stock of residential building by the equation (1):

$$MS_i^t = \sum_{n=1}^N [MS_i^{t-n} \cdot (1 - L^n)] + \Delta A^t \cdot I_i^t \quad (1)$$

where i is material type, n is the year number in which the residential building have been used, N is lifetime of building, MS_i^t is the amount of material i stocked in year t , L^n is the rate of depreciation, ΔA^t is newly constructed area, I_i^t is material intensity. China's residential building was divided into rural residential building and urban residential building, considering the different lifetime and rate of depreciation of residential building in the different regions and different years, we introduce the normal distribution function (2) to calculate the rate of depreciation: L .

$$L = \frac{1}{DEV\sqrt{2\pi}} \cdot e^{-\frac{(t-AVG)^2}{2DEV^2}} \quad (2)$$

Where AVG is the average lifetime of building, the DEV means standard deviation.

Secondly, road was divided into 5 classes, and each class included asphalt pavement road and concrete pavement road. The asphalt pavement road is mainly composed of asphalt, sand and gravel. The concrete pavement road is mainly built of steel, cement, sand and gravel. The material stock of road was calculated by the following equation:

$$MS_{i,j(t)} = A_{j(t)} \times I_{i,j(t)} \quad (3)$$

Where $MS_{i,j(t)}$ is the stock amount of material i stocked in structure j in year t , and $A_{j(t)}$ is the total amount of road for structure j in year t . $I_{i,j(t)}$ is intensity of material i for structure j in year t .

Thirdly, according to different types of sleepers, the railway was divided into two types of railway---wooden sleeper railway and concrete sleeper railway. The wooden sleeper railway is mainly constructed by wood, steel, sand and gravel. The concrete sleeper railway is mainly constructed by cement, steel, sand and gravel.

Then according to the different material intensity of railway, the material stock of different kinds of material of railway can be calculated by equation (3). Where $MS_{i,j(t)}$ is the stock amount of material i stocked in structure j in year t , and $A_{j(t)}$ is the total amount of railway for structure j in year t . $I_{i,j(t)}$ is intensity of material i for structure j in year t .

Finally, Material stock of water pipeline was also calculated by the equation (3) based on the length and material intensity. Where $MS_{i,j(t)}$ is the stock amount of material i stocked in structure j in year t , and $A_{j(t)}$ is the total amount of water pipeline for structure j in year t . $I_{i,j(t)}$ is intensity of material i for structure j in year t .

3.2 Disparity analysis

In order to analyze the disparity, we firstly divided China into 8 regions according to the relative relationship between their GDP and area. Based on Theil model as shown in equation (4), we calculated the Theil index, which could imply disparity of 8 unbalanced development regions in China.

$$T = \sum_i \sum_j \frac{Y_{ij}}{Y} \ln \left(\frac{Y_{ij}/Y}{N_{ij}/N} \right) \quad (4)$$

$$= T_{\text{intra-region}} + T_{\text{inter-region}}$$

Where Y means material stock, N is GDP, and i, j are region and province respectively.

3.3 Factor decomposition analysis

Factor decomposition analysis was taken by the following equations:

$$\Delta Y_{ki} = RS_{ki} + IMS_{ki} + CS_{ki}$$

$$RS_{ki} = Y_{ki}^t \frac{Y_{ki}^{t'} - Y_{ki}^t}{Y_{ki}^t} = Y_{ki}^t \frac{\Delta Y_{ki}}{Y_{ki}^t}$$

$$IMS_{ki} = Y_{ki}^t \left(\frac{Y_{ki}^{t'} - Y_{ki}^t}{Y_{ki}^t} - \frac{Y^t - Y^t}{Y^t} \right) = Y_{ki}^t \left(\frac{\Delta Y_{ki}}{Y_{ki}^t} - \frac{\Delta Y}{Y^t} \right) \quad (5)$$

$$CS_{ki} = Y_{ki}^t \left(\frac{Y_{ki}^{t'} - Y_{ki}^t}{Y_{ki}^t} - \frac{Y_{ki}^t - Y_{ki}^t}{Y_{ki}^t} \right) = Y_{ki}^t \left(\frac{\Delta Y_{ki}}{Y_{ki}^t} - \frac{\Delta Y_{ki}}{Y_{ki}^t} \right)$$

Where, k: infrastructure' type; i: region; t and t': the beginning and end of study period; $\Delta Y/Y^t$: material stock growth rate; $(\Delta Y_{ki}/Y_{ki}^t - \Delta Y/Y^t)$: growth rate gap between stock type k and total stock; $(\Delta Y_{ki}/Y_{ki}^t - Y_{ki}^t / Y_{ki}^t)$: growth rate gap between region i's type k and total sector k.

4. Results

According to this study, we found that the material stock of residential building, road and railway, respectively, grew from 392.8MT, 1.5 BT, and 292.6MT in 1978 to 7.6BT, 7.1BT, and 447MT in 2008. Material stock amounts of 31 provinces all increased by leaps and bounds from 1978 to 2008. Total material stock amount of these 4 kinds of infrastructure increased nearly from 2.2 billion tons in 1978 to 15.2 billion tons in 2008. Especially, the percentage of these 8 kinds of material did not change obviously (Fig. 2). By means of Theil analysis, we knew inter-region disparity was much more than intra-region disparity. Theil index had shown that total regional disparity decreased by average speed 9% per year from 1978 to 1990, and increased by 3% per year from 1990 to 2008. (Fig.3)

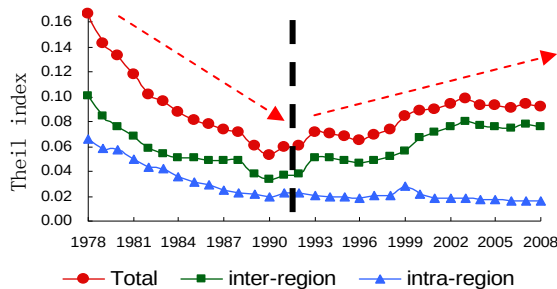


Fig.2 Theil index analysis

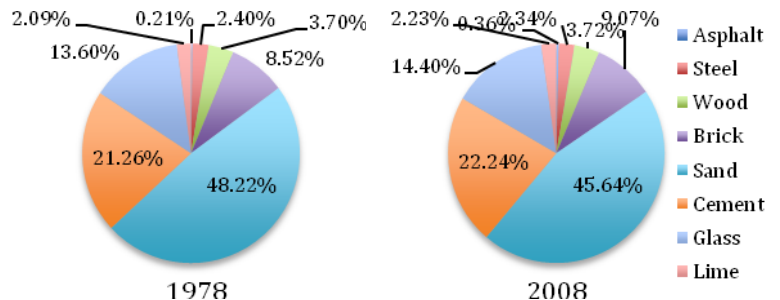


Fig.3 The percentage of material stock

Based on above results, driving factor of China could be analyzed, which could imply the potential waste amount and form of economic development in China. Policy makers can make some suitable policies for building a dematerialization society in China through these results of driving factor analysis.

Acknowledgement

This work was supported by the Global Environment Research Fund (S6-4) of the Ministry of the Environment, Japan.

Reference

- 1) Huang, T.: Study on the material stock of transportation construction associated with the development of infrastructure in China, *Environmental Information Science*, No. 24, pp. 149-154, 2010.
- 2) NBS-National Bureau of Statistics of China: China Statistical Data Collection for 60 Years, *China Statistic Press*, Beijing, 1979-2009.
- 3) Nagaoka, K., Tanikawa, H.: Estimation of surface/subsurface, *Journal of Environmental Systems conference of JSCE*, pp.303-308, 2008.
- 4) Ouyang, J.T.: Studies on life cycle of Chinese city housing 2007.
- 5) Han, J., Hayashi, Y.: Assessment of private car stock and its environmental impacts in china from 2000 to 2020. *Transport and Environment*. 13(7), 471-478, 2008
- 6) Han, J., Zhou, X., Imura, H., A Disparity Analysis of Regional GDP and CO₂ Emissions in China based on Theil and Shift-share Method. *Environmental Science*, 20(6), 449-460, 2007.

Key words: Material stock account, Regional disparity, Theil index, Factor decomposition analysis

Address: Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan. **Tel:** 052-789-3840