Decomposition and Analysis of CO_2 Emission in Taicang City from 2003-2008 by Kaya Identity

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1. Introduction

Carbon dioxide (CO_2) emissions of human activities are believed to be the main cause of global climate change in recent decades. Much attention has been focused on the total amount of CO_2 emitted by each country, but the city level emission pressures are ignored due to limited data (Davis, S. J. et al., 2010). A decomposition of total CO_2 emission as the main contributing factors in city level can clarify the different major causes of emission in different cities and may provide basic information for formulating climate change policies like carbon tax etc. (Johan Albrechta etc., 2002).

Taicang city, with a population of 466.3 thousands and land area of 822.9km2, is located in the southeast of Jiangsu province and south of the outlet of Yangtze River to the sea. As one of the top 100 developed small cities in the east coast of China, the GDP of Taicang reached 52.8 billion RMB and was rewarded as "State Eco-city" by China Military of Environmental Protection in 2008. Owing to advanced location, economic strength and industrial structure similarity, the city can be regarded as the representative of the whole Yangtze Delta or even the whole coast area of east China, and thus the difference in CO_2 emission patterns between east China and the whole country can be achieved by discussing the CO_2 emission driving forces of this city.

This paper adopts Kaya Identity and Laspeyres Decomposition to decompose the CO_2 emission driving forces of Taicang city into four factors: population, GDP per capita, energy intensity and carbon intensity. But before the decomposition, a simple model is established to estimate the total amount CO_2 emission of the city.

2. Method and Data

As a frequently used discomposion technique to analyze historical evolutions of carbon emissions (IPCC AR4 WGIII, 2007; Lozano, Sebastián etc., 2008), Kaya Identity attempts to measure human activities' impact on CO_2 emission (F) with four variables: population (P), GDP per capita (g), energy consumption per unit GDP (e) and carbon emissions per unit energy consumption (f). The simple form of the equation can be expressed as:

$$F = P*(G/P)*(E/G)*(F/E) = P*g*e*f$$

Where: total CO_2 emission amount(F), population (P), GDP (G) and energy (E).

Laspeyres decomposition attempts to expand above variables to a sum of derivatives and residue, and the residue can be ignored if the year's results are calculated based on the previous year. The equation can be expressed as:

$$\Delta F = \left(\frac{\partial F}{\partial P}\right)_{g,e,f}\Delta P + \left(\frac{\partial F}{\partial g}\right)_{P,e,f}\Delta g + \left(\frac{\partial F}{\partial e}\right)_{P,g,f}\Delta e + \left(\frac{\partial F}{\partial f}\right)_{P,g,e}\Delta f$$
$$= g^i e^i f^i (P^j - P^i) + P^i e^i f^i (g^j - g^i) + P^i g^i f^i (e^j - e^i) + P^i g^i e^i (f^j - f^i)$$

Where: i represents year i or the basic year; j stands year i+1 or any year besides the basic year.

Carbon emission of Taicang city can be divided into carbon sources and carbon sinks. Carbon sources include coal burning, fuel burning, gas burning and cement production, and they are transferred into standard coal based on the heat emitted must be equal (ORNL). Carbon sinks of Taicang city mainly come from forests, cultivated lands, crop and wetland, and the total storage amount of carbon can be achieved by multiplying the respective appropriate parameters.

3. Results

The total amount of CO_2 emission in Taicang city increased dramatically from 2003 to 2008, while the increasing rate reduced to half in 2006 since one of the coal-fired power plant was closed according to the “Energy Conservation and Emission Reduction” policy (Fig.1).

Figures 2-5 show the decomposition results of CO_2 emission both in Taicang city and the whole of China (Feng Xiangzhao, 2008) based on the preceding year or the basic year. The basic year’s decomposition results show that CO2 emission-increasing rate of both Taicang city and China is insignificant and economy contributed the largest amount of emission, but the total amount CO_2 emission increased dramatically and its formed to triple the amount of 2008 in 2030 for Taicang city.

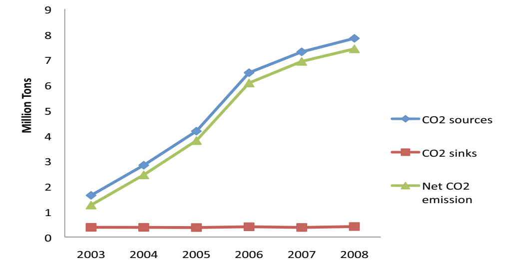

Figure 1. CO2 emission trends of Taicang city in 2003-2008

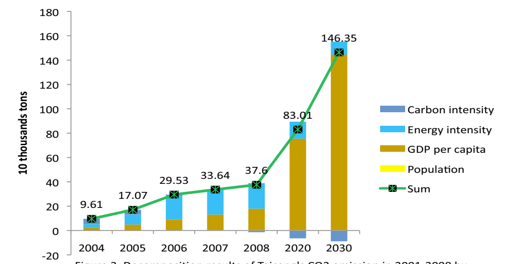

Figure 2. Decomposition results of Taicang's CO2 emission in 2001-2008 by Kaya identity (based on the year of 2003)

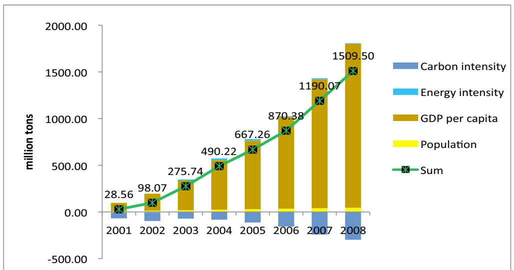

Figure 3. Decomposition results of China's CO2 emission in 2001-2008 by Kaya identity (based on the year of 2001)

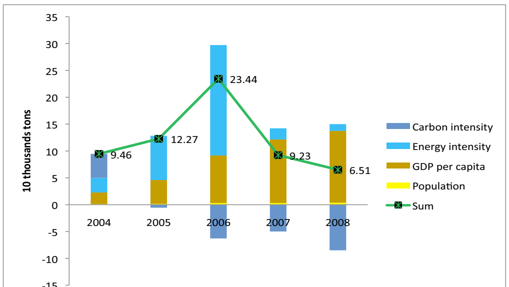

Figure 4. Decomposition results of Taicang's CO2 emission in 2004-2008 by Kaya identity (based on the preceding year)

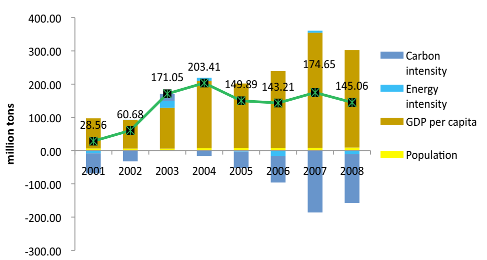

Figure 5. Decomposition results of China's CO2 emission in 2001-2008 by Kaya identity (based on the preceding year)

4. Conclusions

Based on the analysis above, conclusions can be reached as follows: The overall carbon emission of China has increased dramatically in the past decades and the carbon emission-increasing rate for economic developed coast area in China (like Taicang) was a bit larger than the overall level of China; Economic activities ranked the dominant factor for CO_2 emission and population increasing for carbon emission was insignificant, and thus traditional economic structure must be changed for mitigations; Carbon intensity and energy intensity offsite part of the total emission, especially since the implementation of energy conservation and emission reduction plan since 2004, but their effects were consistently shank and only scarce potential left for them to reduce carbon emission now; Carbon tax based on the carbon carrying capacity should be considered as a probably future approach for mitigation of emissions since almost all carbon emissions are driven by economy.

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