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CASE STUDY

Carbon emission allocation standards in China: A case study of Shanghai city

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ABSTRACT

Defining carbon emission allocation standards is becoming increasingly important for China to achieve its emission reduction targets, and support global climate change mitigation and energy constraints. This paper defines and adopts the principle of equal historical cumulative emissions per capita, and uses Shanghai as a case study to build an allocation standard for carbon emissions. First, using China's emission reduction targets, we established the carbon emission space for 2020, then constructed an allocation standard for Shanghai carbon emissions for 2020. We found that Shanghai's total carbon emissions between 2000 and 2013 had exceeded China's average carbon emissions, driven by a traditional economic development model. These results point to the necessity of reducing carbon emissions from 2011 levels effectively. The carbon emission per capita has become increasingly faster since 2012. Finally, we provide policy suggestions for low-carbon development, from the perspectives of industry structure, institutional innovation, low-carbon technology, incentive mechanisms, and new energy supplies. This study's methods can be applied to other regions to build an allocation standard for carbon emissions.

1. Introduction

Industrialization offers daily life conveniences and improves human welfare; however, it also brings serious environmental problems. In the face of increasingly prominent climate change and energy crises, there is considerable motivation to develop a low-carbon economy to address long-term economic and social issues. China is one of the largest developing countries, and is in the process of rapid industrialization and urbanization. The current high-carbon energy structure and economic growth model have introduced a bottleneck for China's economic development. In 2006, China's CO_2 emissions exceeded those in the United States, and ranked first in the world (Vida and Adam [1]). Prediction suggests that China's CO_2 emissions will account for 20–25% of the world's total emissions by 2020 (Wang et al. [2]; Liang et al. [3]; United Nations Development Programme, UNDP [4]). Therefore, the international community has asked for China to commit to quantified emission reduction commitment (Energy Information Administration, EIA [5]). Given these variables, China has the opportunity to explore low-carbon development as a new path of economic development.

1.1. Literature review

The concept of a low-carbon economy was first proposed by the British government, the Department of Trade and Industry (DTI [6]); the European Union, Japan, and the United States also committed to this path. Specialists have proposed different measures for a low-carbon economy from different perspectives. For instance, a British economist studied the economic impact of climate change (Stern [7]), using an econometric method to estimate a CO_2 emissions general equilibrium model (Kainuma et al. [8]). Bahn et al. [9] addressed measures to reduce CO_2 emissions through the trade economy. Experts have also discussed applying CO_2 emission reduction technologies to the electric power industry (Gelmini et al. [10]). Developed countries have mature policies and technologies related to low-carbon economic development; however, an international allocation standard for carbon emissions has not yet been promulgated.

There is a gap between China and developed countries because of China's late start in low-carbon economy research and development.

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China's research has mainly focused on the technology and policy measures associated with low-carbon economy development. For example, Ni [11] and Liu et al. [12] described methods for developing a low-carbon economy from the perspectives of biomass use and green coal power, respectively.

Quantitative research has mainly focused on the relative models and empirical studies of carbon emissions. For example, Liang [13] developed a carbon emission coefficient formula for energy consumption per capita, empirically analyzing the features of historical carbon emissions in Shanghai. This study predicted Shanghai's total carbon emissions across multiple years according to the energy structure under different contexts. Based on gross carbon emissions calculations in eastern, central, and western China, Tan and Huang [14] researched carbon emission differences and characteristics across the three major regions. Xu et al. [15] used a logarithmic mean weight division (LMWD) method to construct a basic equation of carbon emissions and develop a decomposition model of China's carbon emissions per capita. Using data from 1995 to 2004, they quantitatively analyzed the effects of energy structure, efficiency, and economic development on China's carbon emissions per capita.

All these studies include information that could significantly inform China's low-carbon economic development. These studies, however, focus primarily on industry, technology, and policy mechanisms. What is needed now is a macroscopic quantitative analysis that could lead to a commonly accepted and authoritative allocation standard for carbon emissions.

1.2. Low carbon policies in China

Environmental equity exchange agencies have steadily emerged and operated in China since 2008. Despite being one of the largest carbon emission markets in the world, China currently lacks a standard construction of carbon emissions. There have been a series of setbacks with China's Clean Development Mechanism (CDM) projects in the CDM Executive Board of the United Nations. As a result, some carbon trading and property transaction experts have urged China to establish its own carbon trading market and a uniform transaction standard for carbon emissions (Cong et al. [16,17]; Cong et al. [18]).

To address the need for a China-based carbon market, the Panda Standard version 1.0[1] was launched at the Copenhagen Climate Summit in December 2009. The Panda Standard version 1.0 is a reference document describing a project certification scheme and procedures intended to provide transparency and credibility in the nascent China's carbon market (China Beijing Environment Exchange [19]). The program was organized by the Panda Standard Association.

The *China Voluntary Carbon Emission Reduction Standard* was officially presented at the UN Pavilion, Shanghai Expo on October 19, 2010. It was the first complete standard system referencing international rules, and was jointly developed by Shanghai RDR Scientific Research & Development Institute and Shanghai Environment & Energy Exchange [20]. This standards system included a constitution, carbon emission reduction standard, carbon trading standard, registration and verification procedures, and mediation and arbitration regulations.

Different agencies have presented their own reduction standards for carbon emissions; each has worked independently with a different focus. Consequently, a unified allocation standard for carbon emissions has not been established. There remain significant differences in calculation methods and quantification criteria for the spatial allocation of carbon emissions (Energy Research Institute of National Development and Reform Commission of China [21,22]; Wei et al. [23]); as such, an in-depth study on carbon emission allocation standards is needed.

1.3. Aim of this study

Within a fixed emissions space, developing a carbon emissions allocation standard essentially requires a shared definition of reduction targets or allocation of emission rights, which are highly related concepts. The economic theory behind carbon emission allocation standards is primarily the "Contraction and Convergence" theory (Global Commons Institute, GCI [24]). The convergence hypothesis proposes that economies will converge as time passes: economic growth in rich countries will be slower than in poor countries, and income levels between countries will become more consistent over time. The convergence theory can be applied to sharing carbon emission rights among different regions. Although each region's carbon emission per capita may be different to begin with, emissions will eventually become the same. This is achieved by setting different schedules of mandatory emission reductions; on this basis, each region will implement emission reduction in accordance with the requirement of reduction space of carbon emission.

Allocation methods are derived from the principle of "equal rights per capita of historical cumulative emission".[2] This principle emphasizes that citizens have equivalent opportunities and rights to access public goods, including the environment. As such, carbon emission space allocations should align with the principle that each region has an equal chance, and equal rights should be reflected in both horizontal and longitudinal dimensions. This means that some regions have discharged more carbon to the atmosphere than others, so their subsequent share of carbon emission rights should be reduced, to maintain equilibrium.

This distribution method of emission rights not only emphasizes responsibility, but also traces the historical footprint. Moreover, it considers normal population growth, setting a specified year after which no more emission rights will be granted, if the population grows past a certain rate. This discourages regional procreation policies, in favor of greater emissions allocations. This method could promote carbon emission trade, improve market efficiency, and increase fairness. All of these benefits are consistent with the current needs of low-carbon economy development in China.

As noted above, low-carbon economy research is still in its infancy in China, with most studies focusing on qualitative analysis. Although the Chinese government announced emission reduction targets at the Copenhagen Climate Change Conference in 2009, accurate quantitative analysis is needed to define a carbon emissions allocation standard. Unfortunately, consensus has not been reached on such a measurable standard. As such, research in the development of a carbon emissions allocation standard could have great theoretical and practical significance for China. Research indicates that the total carbon emissions in Shanghai between the years 2000 and 2013 exceeded China's carbon emissions per capita, because of impacts of traditional economic development models. These carbon emissions must be reduced, starting now.

2. Methodology

For this study, we consulted and amended the "Contraction and Convergence" approach (GCI [24]), and adopted the principle of equal historical cumulative emission per capita (Tan

[1] The Panda Standard is a Chinese domestic standard for project activities reducing GHG emissions. It bases its core structure on the international standard for greenhouse gas (GHG) management activities developed by the International Organization for Standardization.

[2] The equal rights per capita of historical cumulative emission allocates emission rights to countries in proportion to their population, but only for the remaining portion of the global "carbon budget" — that is, for the amount that can still be emitted between now and 2050, without causing dangerous, irreversible climate change. It combines responsibility for past emissions and equal per capita rights. It allocates an equal share of the overall global carbon budget, taking into account the portion that has already been consumed. For an extended discussion of the allocation principle, please see Tan and Huang [14], Pan and Chen [25].