Studying the Growth of Heterogeneous Regions in China Based on Trading in Carbon Emissions

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Abstract . This article provides a detailed discussion of the origins of carbon emissions and related pricing mechanisms. Using data, the article analyzes China's critical role in global carbon emission governance and its increasing reliance on carbon trading markets. In 2021, China launched the creation of a carbon emission trading market with the aim of establishing the world's largest carbon trading system that includes tradable performance requirements. This study focuses on the development of the carbon trading mechanism and pricing mechanisms, highlighting the four types of energy structure. It also classifies different regions into four models based on regional differences in carbon emissions in China. Finally, given the current uneven economic development in China, this study emphasizes the importance of designing carbon trading markets that are tailored to regional differences, managing carbon quotas differentially, and customizing price caps and floors, providing a decision-making basis for fine-grained management and realization of carbon emissions mitigation.

Keywords: Carbon Emission; Energy Structure; Carbon Trading System; Regional Heterogeneity

1 Introduction

Climate change resulting from greenhouse gas emissions poses a significant threat to the natural environment that supports human life, as well as the economy and development of nations. As such, addressing the issue of climate warming is of utmost importance. However, economic development often hampers environmental governance, leading to the exploration of ways to reconcile the two objectives. Trading carbon emissions has emerged as a key tool for combating climate change and creating a link between environmental preservation and economic growth. The diversity of China's carbon emissions across its many regions is a result of the varying energy sources, consumption patterns, and economic growth demands. While developed cities have made strides in reducing carbon emissions, less developed provinces still rely on conventional fossil fuels and, therefore, produce more greenhouse emissions. It is essential to develop specific carbon dioxide emission reduction plans for each location based on local conditions during the carbon emissions trading market implementation process.

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China's vast territory means that greenhouse gases are mixed together in the atmosphere, and the location of emissions does not significantly impact climate change[1]. To promote the development of a low-carbon economy, a carbon market is necessary. Regional strategies are required to address market failures beyond greenhouse gas emission externalities, which may render national policies ineffective in some areas. Additionally, local governments may need to supplement national emission reduction plans' flaws, and communities can serve as testing grounds for novel policy approaches. This article will use 2019 carbon emission statistics and China's carbon market structure and regional diversity to explore possibilities for future emission reduction plans.

2 Development of Carbon Emissions Trading System

Based on the Coase theorem of property rights economics, carbon emissions trading is a mechanism for policymakers to address environmental externalities. Based on the work of Coase, American economist Dales first proposed the idea of emissions trading in 1968. Under this system, the government defines the property rights of emitters with respect to emissions and permits trading to transfer these rights in order to maximize resource allocation through market mechanisms[2]. In other words, it creates the legal authority to release pollutants and grants market access for their exchange as commodities. In certain ways, this market-based policy design can better balance efficiency and equity while also being more cost-effective.

Professor Martin Weizmann, the well-known creator of the theory of environmental economics, studied this problem more thoroughly and presented his findings in the scholarly article "Price or Quantity" in 1974[3]. He examined the issue of whether humans should directly regulate the quantity of pollutants released or if a price should be set for the pollutants, i.e., whether the nation should enact laws including carbon emission trading limits or carbon taxes. If the marginal cost curve is relatively smooth, but there are obvious inflection points or abrupt changes in the marginal benefit curve, then controlling the quantity is better than controlling the price. In contrast, controlling the price is preferable than controlling the quantity if there is a major inflection or leap in the marginal cost curve but the marginal benefit curve is smooth. The plan that Professor Weitzman ultimately offered set the theoretical groundwork for the execution of future national carbon trading systems. It utilized carbon emission trading permits as the primary safety valve and was complemented by taxes.

On May 9, 1992, the United Nations Framework Convention on Climate Change was formally adopted by the United Nations Intergovernmental Panel on Climate Change through negotiations, creating a market mechanism for carbon emissions trading to lower global carbon dioxide emissions and support lower global greenhouse gas emissions. Following that, carbon emission trading markets were also formed in the UK, the US, and Australia one after the other. The biggest developing nation in the world, China, is struggling to combat climate change. The Outline of the 12th Five-Year Plan for National Economic and Social Development was published on March 16, 2011, and it makes it clear that a carbon emission trading market would be progressively established[4]. The Chinese government places a high priority on decreasing carbon dioxide emissions. In Shenzhen, Beijing, Tianjin, Shanghai, and Guangdong, pilot trading of carbon emission permits has been going on since the end of 2013[5]. China will legally develop its own carbon emission trading system and conduct voluntary emission reduction trading operations during the 12th Five-Year Plan term in 2021. The policy strategy for this time period demonstrates that China is more devoted to fostering global green development, harmony between people and environment, and achieving carbon neutrality by 2060. China is also more motivated to cut emissions.

3 Trading Performance Criteria for China's Carbon Market

For a long time, the primary and secondary markets have been the inherent division of the carbon market. The primary market is mainly used for initial quota allocation, in which carbon quotas are allocated to enterprises or some government agencies that are required to reduce emissions according to policy, and this policy generally sets an annual upper limit on emissions, thereby reverse driving enterprises to reduce emissions[6]. The secondary market is generally used for trading remaining carbon quotas, for example, enterprises whose actual emissions exceed the initial quota for the year can purchase carbon quotas from companies that have surplus carbon quotas and better pollution control. The carbon credit trading market in the secondary market adopts this trading scheme, achieving price consensus and helping enterprises achieve emission reduction targets through rational resource allocation. In this market, participants who have exceeded their emission allowances can purchase emission allowances from those who have not used their emission allowances. To close the gap between carbon quotas and actual carbon emissions, companies that emit less than their quotas can sell their emission rights on the carbon market[7]. On the one hand, they can earn more profits, and on the other hand, they can balance the supply and demand of carbon emissions and meet the interests of all parties. From another perspective, companies that exceed their quotas need to pay more costs to meet their actual carbon emissions, so these companies, in order to reduce financial pressure, are also inclined to gradually adopt various environmental protection schemes to reduce carbon emissions. Through the secondary market, it is possible to promote low-efficiency enterprises and improve efficiency while providing economic benefits, and also improve environmental benefits.

By adopting the historical intensity technique and the baseline method, China's primary carbon trading market primarily draws on the development experience of the European carbon trading market, according to the country's existing carbon emission market design. The historical intensity method has the advantage of being highly flexible and allowing allowances to be changed in response to changes in product output, which inspires businesses to cut emissions and encourages the technological upgrading of inefficient emission-reducing equipment. With a view on long-term development, the baseline method of allocation is beneficial to enterprises with higher technology levels whose emission intensity is below the industry baseline. Both allocation methods require a comprehensive consideration based on industry-wide input-output and emission data.

Historical intensity method. And the formula is shown in formula (1):

$$y_i = e_i * f * o \quad (1)$$

Where the y_i is the carbon emission. the e_i is the historical emission intensity value of enterprises, f is the emission reduction factor, and the o is the output.

Baseline method, and the formula (2) is the mathematic representation:

$$y_i = I_i * o \quad (2)$$

Where y_i is the carbon emission edit. And the I_i is the industry baseline value, o is the output.

In the secondary market of carbon trading, enterprises sell their surplus carbon emission allowances as a commodity. In this market, the key to giving carbon emission rights a commodity attribute is to define the ownership of the free allowances that enterprises carry over in the current year and the right to dispose of them. Through the observation of foreign carbon markets, it has been found that the price of carbon emission rights will rise with the tightening of free allowances to encourage emission control enterprises to reduce emissions.

On the other hand, the largest CO2 emissions trading scheme in the world will be implemented in China. In essence, the system will be a tradable performance standard (TPS), which is a method of pricing emissions. It distributes allowances in accordance with the actual production (electricity generation) and benchmark rates for the current year. The entire emission rate (emissions per production) is fixed under the TPS. In general, we can illustrate that the marginal cost rises as the quantity of emission reductions grows as mandated emission reduction targets are met. Through one of the price floors used by consignment auctions, the government can somewhat solve this issue in the principal market for carbon emissions. The ETS typically uses this approach by setting a floor price in the permit auction, but the implementation of a price floor in China's carbon trading system may result in a large cost reduction. The price could increase by 50% or more at lower levels, which could result in large gains in the future.

Companies may be forced to assign their allotted permits to an auction with a price floor in order to make up the difference between the low permit price and the price floor. As before, the benchmark determines license distribution based on the output of the business. Then, based on each company's portion of the overall consignment sale, we distribute auction proceeds. The assigned license must be consigned using the consignment mechanism in order for the recipient to receive a share of the auction proceeds based on the consigned license's share. This strategy does not place a substantial financial burden on governments or businesses because, in contrast to other auctions, it is revenue neutral. When we set the price for the emission permits, we should consider this point.

4 Regional Heterogeneity Modes

In general, there are four regional carbon emissions patterns in China, and the explanations as shown following[8]:

One model identified in the study was found to be less sophisticated, but nonetheless represented a significant proportion of the nation with 69.47% falling within this category. This group included almost all provinces within China and was characterized by relatively low carbon dioxide emissions. It is important to highlight, however, that despite the modest nature of these emissions, coal mining and dressing activities accounted for the main of this group's greenhouse gas emissions. In particularly, coal mining and dressing activities in China have been known to produce significant amounts of carbon dioxide, methane, and other greenhouse gases, which can result in disastrous consequences for the environment if appropriate mitigation strategies are not implemented. Therefore, it is essential that this less sophisticated model be studied further to identify opportunities for reducing emissions from coal mining and dressing activities, and to support the development of more sophisticated models that can pave the way towards a cleaner, more sustainable future for China.

A coal-based system. The model under consideration, which accounted for a notable 21.4% the country's total emissions, represented a group with a high level of energy demand that resulted in the most significant amount of carbon dioxide emissions. The emissions structure of this group was dominated by traditional fossil fuels, which were responsible for the main of CO2 emissions. It is noteworthy that the burning of traditional fossil fuels represents a significant contributor to atmospheric concentrations of greenhouse gases and, as such, has been identified as a primary driver of anthropogenic climate change. The prominent position of traditional fossil fuels in the CO2 emission structure of this group is therefore a cause for concern and calls for the development of more sustainable and cleaner energy alternatives that can help mitigate the harmful effects of carbon dioxide emissions on the environment. Overall, addressing the significant carbon emissions associated with this model is a critical step towards achieving sustainable development goals and transitioning to a low-carbon economy in China.

An oil-centric mode. According to the findings of the study, only 3.51% the nation utilizes this mode of transportation. However, despite its relatively low usage rate, this transportation mode was associated with a disproportionately high level of carbon dioxide emissions. Despite this, it is of note that oil-related fuels were identified as the primary contributors to the overall carbon emissions associated with this mode of transportation. The reliance on such fuels presents a significant challenge in terms of mitigating the harmful effects of transportation on the environment, particularly with regards to greenhouse gas emissions. Therefore, it is imperative that policymakers work towards promoting more sustainable transportation alternatives and incentivizing the use of cleaner fuels, such as biofuels and electric energy, in order to mitigate the detrimental environmental impacts of transportation in China. Overall, it is essential that future efforts to reduce carbon emissions associated with this mode of transportation be targeted towards reducing reliance on oil-related fuels and promoting sustainable and environmentally-friendly alternatives.

The mode powered by natural gas. There are only 5.61%, utilized this mode of transportation, which was associated with the smallest carbon dioxide emissions. It is worth noting that clean energy, natural gas, and refined natural gas were identified as significant contributors to the carbon dioxide emissions of this transportation mode, which contrasts with the emission structure of the other three transportation modes. While the usage of clean energy and natural gas undoubtedly presents cleaner and more sustainable alternatives to traditional fossil fuels, the associated carbon emissions should not be overlooked. As such, it is necessary to examine the emissions from clean energy and natural gas within the broader context of reducing carbon emissions across all relevant sectors. Policy efforts in this regard might include incentivizing the use of low-carbon natural gas production methods, as well as promoting the development and deployment of carbon capture and storage technologies. Moves towards a greater reliance on renewable energy sources, such as solar and wind power, also offer significant potential in terms of reducing carbon emissions across this transportation mode. Ultimately, it is essential to explore all available opportunities and technologies to reduce the carbon footprint associated with this mode of transportation while promoting the most efficient use of energy resources in China.

Based on data spanning from 2009 to 2019, almost all of the developed cities and provinces in China have transitioned from the less developed model to other models. However, during the period from 2000 to 2019, twelve provinces continued to remain in the less developed status. Notably, many of these provinces are located in China's relatively underdeveloped western region, which serves as a central hub for coal mining and dressing activities. The transition of eleven provinces from Mode 1 to Mode 2 has significantly contributed to the rise in CO_2 emissions, primarily as a result of the high level of energy demand driven by the region's heavy industrialization. Furthermore, certain provinces that play a critical role in China's coal production and are resource-rich may have lower local mining costs, further exacerbating the situation. However, there have been notable transitions towards cleaner, lower-carbon energy alternatives in certain regions. For instance, Zhejiang Province underwent a two-stage transition process, progressing from Mode I to Mode II before transitioning to Mode III. Similarly, Guangdong Province has continually progressed towards Mode III development. Additionally, a handful of regions, including Beijing, Shanghai, Tianjin, and Fujian, have successfully achieved zero or low emissions in coal mining and dressing activities, leading to their transition from Mode 1 to Mode 4. Overall, these findings underscore the importance of adopting sustainable and low-carbon energy alternatives while promoting concerted efforts to reduce greenhouse gas emissions across all sectors in China.

In 2019, the top 10 provinces in GDP contributed 61.8% of national GDP and 42.5% of CO. The bottom 10 provinces accounted for only 10.9% of GDP but produced 22.0% of emissions. The top 10 provinces in terms of GDP produced 42.5% of CO_2 and 61.8% of the nation's GDP in 2019. While the worst 10 provinces produced only 10.9% of the GDP and 22.0% of the emissions, respectively. The north is mostly home to provinces with high emission intensity and per capita emissions. To get the best results, emission reduction plans should be developed differently in accordance with the region's unique characteristics. The top 10 provinces in terms of GDP produced 42.5% of CO_2 and 61.8% of the nation's GDP in 2019. While the worst 10 provinces produced only 10.9% of the GDP and 22.0% of the emissions, respectively. The north is mostly home to provinces with high emission intensity and per capita emissions. To get the best results, emission reduction plans should be developed differently in accordance with the region's unique characteristics. Two approaches can be taken into consideration: first, the industrial model of these provinces can be changed to Mode 4 given the similarity of

CO_2 emissions between Mode 1 and Mode 4, resulting in the transformation from high-carbon fuel emissions to low-carbon fuel emissions by reshaping and optimizing the energy structure; second, many of these provinces are in western China and are rich in renewable resources, which have good prospects for reusing energy. When drafting regulations, local governments should suitably encourage carbon limits on natural gas or new energy sources to stimulate the transition of energy patterns. They should also quickly implement carbon emission trading systems for renewable resources. These areas want to think about solutions like industrial restructuring for mode 2, which pertains to CO_2 emissions from heavy industries. It is crucial to remember that this policy involves using new environmental technology and replacing equipment, not only shutting down major enterprises. In order to increase energy efficiency, the energy mix is switched from fossil fuels with high carbon emissions to fuels with low carbon emissions. Companies may have to pay more for new technology and equipment during this process. By giving up some of the ability to maintain reserve prices and holding some of the consignment auctions outlined in 4.2, policymakers might lessen the capital burden on regulated polluters.

Model 3 still has a substantial opportunity to reduce emissions even though it has lower CO_2 emissions than Model 2. Only Zhejiang and Guangdong, two developed provinces, are included in Model III. These two provinces can take full advantage of wind and ocean energy and boost the amount of renewable energy use because of their geographic advantages. Each province should consider how the policy would affect the overall development of society while implementing regional heterogeneous carbon emissions trading. Climate change policies should aim for more than simply environmental improvement; they should also aim to reduce poverty and inequality. During the implementation of carbon emission reduction policies, policy makers should provide more support to low-income people and less developed regions through transfer payments and preferential policies, in order to minimize the negative impacts on the poor as much as possible.

5 Conclusion

The article begins by discussing the theory behind carbon emissions trading, followed by an overview of the evolution of the system and the distinctive characteristics of the Chinese carbon market. The focus then shifts to the design of carbon trading for heterogeneous Chinese carbon emission regions, as well as the four emission patterns in those regions. The establishment of accurate and transparent energy statistics data and emission inventories based on the different emission patterns across various provinces is essential for setting and evaluating climate change mitigation goals. Furthermore, in order to establish a carbon trading market with significant regional differences, it is necessary to construct precise and small-scale energy statistics data, while complying with the current conditions of carbon emissions data. Given China's current situation, significant improvements must be made in coordinating national and local level energy statistics data. When designing the trading rules and schemes for carbon markets, it is crucial to be tailored to the unique characteristics of different regions.

Considering China's rapid industrialization period which began in the 1990s, the country has experienced significant increases in carbon emissions, with emissions rising by 1,111%. Drawing on the experiences of Western countries, China has prioritized reducing carbon intensity. Its carbon emission intensity has decreased by 83% from the peak intensity between 1978 and 2020, which is a greater decrease than France, Germany, or India. However, China's carbon intensity in 2019 was still 701% higher than France's, 203% higher than the United States', and 0.6% higher than India's. China has a long way to go to catch up with Western low-carbon economies, which makes it crucial to establish a carbon trading scheme that is tailored to the region's characteristics and fully considers regional differences.

References

1. G. Han, M. Olsson, K. Hallding, and D. Lunsford, "China's carbon emission trading: an overview of current development," 2012.
2. Y. Hu, S. Ren, Y. Wang, and X. Chen, "Can carbon emission trading scheme achieve energy conservation and emission reduction? Evidence from the industrial sector in China," *Energy Econ.*, vol. 85, p. 104590, 2020, doi: 10.1016/j.eneco.2019.104590.
3. H. Wang and X. Yu, "Carbon dioxide emission typology and policy implications: Evidence from machine learning," *China Econ. Rev.*, vol. 78, p. 101941, 2023, doi: 10.1016/j.chieco.2023.101941.
4. S. Basu *et al.*, "Estimating US fossil fuel CO2 emissions from measurements of 14C in atmospheric CO2," *Proc. Natl. Acad. Sci.*, vol. 117, no. 24, pp. 13300–13307, 2020, doi: 10.1073/pnas.1919032117.
5. B. Wang, W. A. Pizer, and C. Munnings, "Price limits in a tradable performance standard," *J. Environ. Econ. Manag.*, vol. 116, p. 102742, 2022, doi: 10.1016/j.jeem.2022.102742.
6. L. Tang, H. Wang, L. Li, K. Yang, and Z. Mi, "Quantitative models in emission trading system research: A literature review," *Renew. Sustain. Energy Rev.*, vol. 132, p. 110052, Oct. 2020, doi: 10.1016/j.rser.2020.110052.
7. Y. Li and W. Chen, "Entropy method of constructing a combined model for improving loan default prediction: A case study in China," *J. Oper. Res. Soc.*, vol. 72, no. 5, pp. 1099–1109, May 2021, doi: 10.1080/01605682.2019.1702905.
8. Y. Zhang, S. Li, T. Luo, and J. Gao, "The effect of emission trading policy on carbon emission reduction: Evidence from an integrated study of pilot regions in China," *J. Clean. Prod.*, vol. 265, p. 121843, 2020, doi: 10.1016/j.jclepro.2020.121843.