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Is China's carbon reduction target allocation reasonable? An analysis based on carbon intensity convergence

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HIGHLIGHTS

- The reasonability of Chinese government's CO_2 emissions reduction allocation plan is examined.
- The stochastic convergence and β-convergence are tested using the provincial panel data.
- Both fixed effects and Generalized Method of Moments (GMM) estimators are utilized.
- The provinces with high carbon intensity tend to experience faster reduction in carbon intensity, and vise versa.

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ABSTRACT

To curb CO_2 emissions, the Chinese government has announced ambitious goals to reduce the CO_2 intensity of GDP, and the total target has been allocated to all Chinese provinces during the twelfth "Five-year Plan" period (2011–2015). Although setting the target allocation plan is an efficient way to achieve this goal, some key questions, including how the plan is designed, remained unanswered. From an economic perspective, this requires us to test for the existence of convergence in the CO_2 intensity of GDP because the convergence is one of the most important intrinsic economic characteristics that policy makers should take into account: if the convergence exists, the provinces with a higher CO_2 intensity of GDP tend to experience a more rapid reduction in the intensity and therefore could share a heavier burden of the intensity reduction. The existence of stochastic convergence and β-convergence is verified by employing different estimation methods and using various estimation specifications. As a result, the direct policy implication is that provinces with high CO_2 intensity should be assigned tougher reduction targets to cut CO_2 intensity at higher speeds, while the provinces with low carbon intensity should be allowed to reduce the CO_2 intensity at a relatively lower speed. Because some social and economic indicators such as GDP per capita, industrial structure and population density may influence CO_2 intensity, the policy makers should take all these factors into consideration to design reasonable reduction target allocation plan.

1. Introduction

In recent years, as China's economy developed rapidly, China's carbon dioxide (CO_2) emissions have boomed. According to the statistics of Carbon Dioxide Information Analysis Center (CDIAC), since 2007, China has overtaken the U.S. to become the largest CO_2 emitter in the world, and in 2010, China's CO_2 emissions contributed as much as one-quarter of global emissions. The huge amount and rapid growth of CO_2 emissions have drawn increasing attention from the international community and have brought increasing pressure to the Chinese government, especially at this critical time when global warming has become a serious threat to human beings.

The Chinese government has indeed heeded the mounting pressure and taken action. In recent years, the Chinese government has set several carbon control targets. However, partly due to worries that economic growth would be severely affected, China's carbon control targets address the carbon intensity of GDP. For instance, in 2009, China's central government announced an ambitious

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target to reduce its CO_2 intensity of GDP (the ratio of total CO_2 emissions to GDP) by 40–45% of its 2005 level by 2020.[1] In 2011, the State Council of China drew up a plan for CO_2 emissions reduction during the twelfth "Five-Year Plan" period (2011–2015). In this plan, China vowed to decrease its CO_2 intensity by 17% of its 2010 level by the year 2015. Additionally, this plan for the first time disaggregates the national target into separate targets for each province.[2] According to the official target, Guangdong, a wealthy southeast coastal province with an average CO_2 intensity of GDP of 1.45 ton/10,000 yuan (at 2000 constant price) between 2009 and 2011 should cut its CO_2 intensity of GDP by 19.5%, the highest target of all the provinces. In contrast, Qinghai, a less-developed western province with an average CO_2 intensity of GDP of more than three times of Guangdong's level for the same period, only needs to cut its CO_2 intensity of GDP by 10%, the lowest target among all the provinces.[3]

Although the State Council of China did not reveal the reasons for or the basis of calculation for the provincial disaggregated target, some pilot studies have been made on the reasonability and feasibility of provincial allowance allocation [1–3]. Yi et al. [1] developed a factor model to explore the importance of several key factors that determine the provincial deduction ability, and they designed a reduction target allocation plan based on the model's estimation results. Wei et al. [2] and Wang et al. [3] utilized a Data Envelopment Analysis (DEA) approach to estimate each province's efficiency of the CO_2 intensity of GDP, which determines the deduction allowance for each province. The basic principle of the DEA approach is that provinces with higher carbon emissions efficiency should shoulder a heavier burden of the carbon intensity cuts. For instance, according to Wang et al. [3] calculation, the more economically developed provinces, such as Beijing, Tianjin, Shanghai and Jiangsu, also generally have higher carbon emission efficiency. Therefore, these provinces should undertake more reduction tasks in reducing carbon intensity.

One important potential flaw of previous studies is that an innate principle of economic development might be simply ignored: there may be convergence in the CO_2 intensity of GDP across provinces. In economic studies, the original concept of convergence indicates that the poor economies have a tendency to catch up with rich economies in terms of per capita income. This concept was first raised in Solow [4] seminal study on neoclassical growth theory. There are three main notions of convergence: β-convergence, σ-convergence and stochastic convergence. In the context of this study, β-convergence implies that the provinces with higher CO_2 intensity of GDP would experience a more rapid decrease in carbon intensity compared with the provinces with lower carbon intensity; σ-convergence means that the dispersion of the CO_2 intensity of GDP diminishes over time. Both β-convergence and σ-convergence could be further classified into two types: conditional convergence and absolute (unconditional) convergence. If the convergence takes place after controlling for province-specific characteristics other than the targeted indicator (in our case, the CO_2 intensity of GDP), the convergence is conditional; otherwise, it is absolute (unconditional). On the contrary, stochastic convergence indicates that the shocks in CO_2 intensity of GDP relative to the sample average are only temporary. The most common method used to examine the stochastic convergence is the unit root test.[4]

To date, there has been a growing body of research on the topic of convergence in pollutant emissions across different countries. Carbon dioxide is the pollutant that has received the most attention, partly because global warming is generally considered to be an increasing concern to the international community. After Strazicich and List [6] pioneering work, there is a growing body of literature on the existence of convergence in per capita CO_2 emissions across different groups of countries. The representative studies include Ezcurra [7], Romero-Ávila [5], Westerlund and Basher [8], Jobert et al. [9], Ordás Criado and Grether [10], and Camarero et al. [11]. Strazicich and List [6] and Ezcurra [7] utilized panel unit root tests and cross-sectional/panel regressions to test for stochastic and conditional convergence. Ezcurra [7] employed non-parametric techniques (stochastic kernels) to examine cross-country convergence in per capita CO_2 emissions by estimating the dynamic distribution of CO_2 emissions; Jobert et al. [9] utilized the Bayesian shrinkage estimation approach to estimate the speed of convergence of per capita CO_2 emissions for each of 22 European countries. Using a long-run panel data of OECD countries between 1960 and 2008, Camarero et al. [11] studied convergence in CO_2 emission intensity based on its determinants, and their results indicate that differences in emission intensity convergence are more determined by differences in convergence of the carbonisation index rather than by differences in the dynamic convergence of energy intensity. Recently, Pettersson et al. [12] reviewed research on convergence of carbon dioxide emissions among countries. They found that the existing estimation results are sensitive to the choice of econometric approach and data set. Two very recent studies have focused on the convergence of CO_2 emissions in China. Huang and Meng [13] utilized a specification of the panel regression model with full consideration of spatial–temporal dependency to verify the convergence of per capita CO_2 emissions across Chinese provinces. Wang and Zhang [14] employed panel unit root tests and a panel regression model to find evidence for the existence of stochastic convergence and β-convergence.

Besides, given the important policy implications, in recent years an increasing number of researches have investigated the convergence in energy intensity across countries or within a specific country. The representative researches include Markandya et al. [15], Liddle [16], Liddle [17], Le Pen and Sévi [18], Stern [19], Herrerias [20], Herrerias and Liu [21], and Adhikari and Chen [22]. Markandya et al. [15] verified the existence of β-convergence in energy intensity toward the EU average across transition countries. Liddle [16,17] found evidence for σ-convergence and γ-convergence among different groups of countries. Contrarily, Le Pen and Sévi [18] utilized relatively newly developed pair-wise econometric approach to reject the hypothesis of global stochastic convergence in energy intensity among 97 countries during the period 1971–2003. Using a stochastic production frontier, Stern [19] modeled energy efficiency trends and verified its convergence in 85 countries over a 37-year period. Herrerias [20] utilized a distribution dynamics approach to find evidence for the convergence in the intensity of various energy sources in a group of countries. Adhikari and Chen [22] employed spatial panel data approach to examine the convergence in Asian countries. They found weak evidence of σ-convergence for all sample countries, while their

[1] As a reference, see http://www.chinafaqs.org/library/chinafaqs-chinas-carbon-intensity-goal-guide-perplexed. It should be noted that carbon intensity targets are less binding compared with the total emissions targets because carbon intensity would decrease as long as GDP grows more rapidly than absolute emissions.

[2] There are at present 23 provinces, four Centrally Administered Municipalities, and five autonomous regions in China. For simplicity and consistency, throughout this study, the term "province" is used to represent all of these sub-national administrative entities that are administratively equal.

[3] The detailed reduction targets for all provinces and each province's average CO_2 intensity of GDP between 2009 and 2011 are presented in Table A1 in Appendix A.

[4] To date, various types of unit root test have been developed for stochastic convergence. In recent years, the unit root tests for panel data and tests incorporating structural breaks have attracted increasing attention. For instance, in a recent study, Romero-Ávila [5] reviewed the unit root tests used to test for the stochastic convergence of CO_2 emissions per capita and utilized a bootstrap method that allows for an unknown number of structure breaks to investigate the stochastic and deterministic convergence of CO_2 per capita across industrialized countries.