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Investigation on Regional Decomposition Mechanism of Carbon Emission Control Target: China 2021-2030

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Abstract
China already set up national target for carbon emission control before 2030. Based on experience of former target allocation, the way of both local voluntary commitments and negotiation between the central government and local governments to allocate the targets would help local governments set up energy conservation and carbon emission control initiatives. A target decomposition scheme is thus developed in this study. Combining the anticipation for the economic and social development situation during 2021-2030, the initial idea of decomposition mechanism of carbon emission control target is suggested.

Keywords: carbon emission control, target decomposition, index evaluation system, clustering analysis

JEL classification: O13, O38

1. Introduction

China is predicted to face challenges and requirements for green development before 2030. Thanks to the reform and open-door policy, China has undergone a continuous 30 years' economic boom period. From 1978 to 2017, the average annual growth rate of GDP is 9.5% and that of per capita GDP is 8.3%. Since 2010, economic aggregate of China has surpassed that of Japan and become the world's second. The per capita GDP has reached the level of middle-income country and it hits nearly 9000 US dollar in 2017. The *19th CPC National Congress* further proposed that 2020-2035 should basically bring about socialist modernization and by 2035 to the middle of this century, a strong socialist modernization country will be built.

On the other hand, China's industrialization has not yet been completed, urbanization is still rapidly developing, and its economic and social development still has a rigid demand for energy. However, the proportion of industrial added value in the GDP is still too high, and the service industry needs further development. Not only the rapid urbanization will lead to a significant increase in energy demand in the fields of construction, transportation

and residential consumption, but also the expansion of urban infrastructure and public utilities will lead to the expansion of energy consumption.

Data[1] shows that in 2016 China's carbon emissions from fossil fuels and industrial processes account for 28% of global annual emission, surpassing the sum of the United States and the EU. Per capita annual emissions of 7.2 tons of China are also far exceeding the world average of 4.2 tons. The Paris Agreement adopted at the end of 2015 reiterated the goal of a temperature increase of not more than 2 ℃ and has led the world in the direction of low-carbon transition.

In order the meet the above aim, Chinese government has clearly set forth the 2020 and 2030 carbon emission control targets and attached great importance to green and low-carbon development and proposed that by 2020, its carbon dioxide emissions per unit of GDP will drop by 40% to 45% from 2005 and that by 2030, its carbon dioxide emissions per unit of GDP will drop by 60% to 65%. The goal of achieving the peak of carbon dioxide emissions around 2030 is first put forward. China has successively set goals and work plans for the reduction of carbon dioxide emissions per unit of GDP during the 12th Five-Year Plan and 13th Five-Year Plan.

2. Research Objectives

Based on international experience of GHGs emission reduction and China’s experience of energy intensity control target decomposition, **equity** and **efficiency** should be attached equal importance. It is really difficult to evaluate the principle of equity and efficiency scientifically, and it is even widely acknowledged that both equity and efficiency cannot be achieved simultaneously. Therefore, this research takes indirect quantitative method and utilizes available data to establish a decomposition scheme that is pragmatic, effective and easy to evaluate from bottom-up. Drawing on the idea of AHP (Analytic Hierarchy Process) and aiming at meeting the principle of equity and efficiency, it takes into account nearly all factors related to the decomposition of carbon control target, including **responsibilities, rights and abilities** of emission reduction. Different regions (here, provinces or municipalities) are compared and similar regions are incorporated into same

[1] Global Carbon Budget 2017, http://www.globalcarbonproject.org/carbonbudget

classes. A reference and evaluation system for target decomposition is then built up to reach the aim of "**similar regions undertaking similar control targets while different schemes for different classes**".

3. Methodology

3.1 General Idea of Decomposition

A reference and evaluation system for target decomposition is established. Indicators of energy, economy and environment corresponding to different topics (responsibilities, rights and abilities) are then selected. Different weights are assigned to these indicators to reflect the policy orientation and the significance of the indicators. Multiple decision-making requirements are indirectly reflected in this way. By calculating the scores of comprehensive evaluation in different regions, it can provide a quantitative reference for the scientific decomposition of carbon emission control targets.

Specifically, drawing on the idea of AHP and combining the characteristics of carbon emission control, responsibilities, rights and capabilities are firstly taken as the topics of the first level. Then, the specific indices that truly reflect the requirements of each topic are selected and the overall framework of the evaluation indicator system is formed. According to the different topics, the establishment of index system can reflect the requirements of efficiency and equity indirectly, basically covering all aspects involved in the scientific decomposition of carbon emission control target.

3.2 Index System

On account of the recent amount of carbon dioxide emission and fossil energy consumption in all regions, the **responsibility** can be reflected by indices such as per capita carbon dioxide emissions, per capita fossil energy consumption, and GDP proportion to China's total. On account of resources endowment, development expectations and regional development policies in all regions, **right** can be reflected by indices such as per capita energy production, expected speed for regional economic development and the China's strategic guiding for regional development. On account of economic development level, economic structure and carbon productivity, **capability** can

be reflected by targets such as per capita GDP, the proportion of the tertiary industry and carbon dioxide emissions per unit of GDP. Per capita fossil energy consumption, per capita carbon dioxide emissions, GDP proportion to China's total, per capita GDP and the proportion of the tertiary industry are in positive direction, which means that the more the value is, the higher the requirements for control they will have. Per capita energy production, strategic guiding for regional development, speed of regional economic development and carbon emissions per unit of GDP are in negative direction, which means that the larger the value is, the lower the requirements for control they will have.

Table 1: Evaluation indices

Number	Evaluation index	Index connotation（relations with aggregate control）
1	Per capita fossil fuels consumption	The more per capita fossil fuels consumption is, the heavier the responsibility for controlling is（+）
2	Per capita CO_2 emissions	The more per capita CO_2 emissions are，the less space for emissions will be with heavier controlling responsibility（+）
3	GDP proportion to national total	The larger the GDP proportion is, the heavier the responsibility for controlling is（+）
4	Per capita energy production	The more per capita energy production is, the more the rights to pursue development by using energy are（-）
5	Strategic orientation for regional development	Regions encouraged by national strategic orientation for high-speed development can enjoy more rights to pursue development by using energy（-）
6	Development speed of regional economy	The higher the expectations for economic development are, the more the rights to pursue development are（-）
7	Per capita GDP	The more the per capita GDP is, the stronger the economic tolerance is, with stronger controlling ability（+）
8	The tertiary industry proportion	The more the tertiary industry proportion is, the less dependence of economy on energy, with stronger controlling ability（+）
9	CO_2 emissions per unit of GDP	The more CO_2 emissions per unit of GDP are, the more dependence of economy on fossil fuels energy, with weaker controlling ability（-）

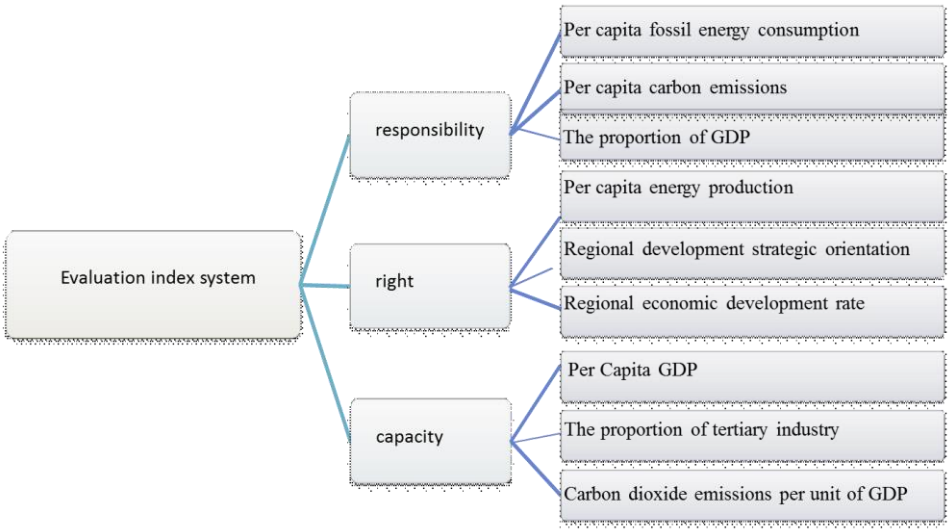

Figure 1: Comprehensive evaluation index system

3.3 Decomposition Methodology

Data Standardization Treatment. First, define the positive index and negative index. Then, standardize these data. In other words, for a certain index X_i (i represents a province or municipality), the system will find out the maximum value X_{max} and the minimum value X_{min} from all provinces or municipalities, and then conduct normalized treatment according to the orientation of this certain index. After value setting and transformation process, indices' values are within the range of 0 to 1. 0 represents the smallest decline target of carbon emission and 1 represents the biggest. Standardized treatment of indices aims at clearing up the differences between orientation and dimension among different indices and ensuring the comparability of them, thus laying a solid foundation for further determining the weights and establishing models.

Weights Setting. Weight is a variable that reflects the degree of difference of each index in the index system and the degree of impact on other indices. The rational weight allocation should proceed from the overall optimization target and objectively reflect the difference in importance of each index. Meanwhile, the weight can also play a guiding role, through different weight assignment to reflect the policy orientation, and guide local government behavior. Taking into account the availability of data and the requirement of

the problem, we can take the method of subjective weighting with experts making assessment. Subjective weighting can simplify complex issues and fully embody the long-accumulated knowledge of various experts. At the same time, different weight assignment can reflect the development priorities of the country and regions at different stages and be rapidly adjusted according to actual conditions and environmental changes with great flexibility and pertinence. On the basis of determining the weight, we use the method of linear weighting to calculate the second-level topic score and further calculate the comprehensive evaluation score. The reason for choosing the linear weighting model is that its weights can highlight the impact of each sub-topic on the decomposition results, as well as the policy focus and other factors, and has the characteristics of simple and practical.

Clustering Analysis. In order to make up for the possible limitation and instability of subjective weighting, this study uses "clustering analysis" method to compare the objective clustering results of secondary indicators with the results of comprehensive evaluation. By comparing each other, the rationality of region sorting in all levels of topics are double-checked. The clustering analysis method can proceed from multiple dimensions, classify similar regions into one class, and eliminate the influence of high correlation between certain indices. Initially each region falls into a class of its own, and then the two most similar classes are combined, and the distance or proximity measure between the new class and other classes are calculated. Continue this procedure until all regions fall into one class. This class combining process can be described by a pedigree cluster graph. Since there are multiple observation indicators for each region, we use WARD method (Error Sum of Squares) and assume that Sum of Squares of Deviations between different classes of regions should be large enough to ensure that the same class of regions have a certain degree of homogeneity, and there are significant differences among different classes, which are reflected in the cluster diagram of pedigree. In other words, the regions with the highest similarities are first classified as one class. The results of clustering analysis can be verified with the results of quantitative analysis of comprehensive evaluation to provide the basis for determining carbon control target decomposition by classifying the regions.

Determination of range of regional carbon control targets. Under the premise of China 2030 national target of reducing carbon intensity and reaching emissions peak, and

according to the results of the comprehensive evaluation and referring to the results of regional clustering analysis, 30 regions in the whole country (the lack of basic data in Tibet needs to be considered separately) are divided into several classes. Regions in the same class can be further subdivided into different sub-classes. Finally regions of different classes and different sub-classes are assigned relative target range (**high target, slightly above the national average target, national average target, slightly below the national average target and low target**).

4. Results

According to the decomposition method of carbon control target mentioned above, this research conducts regional decomposition for 2030 carbon control target based on provincial data in base year of 2016 collected from China Statistical Yearbook, China Energy Statistical Yearbook and Compiling Guide for Provincial GHG Inventory, etc.

4.1 Decomposition Results

The overall scores of all regions after calculation can be seen in figure 2.

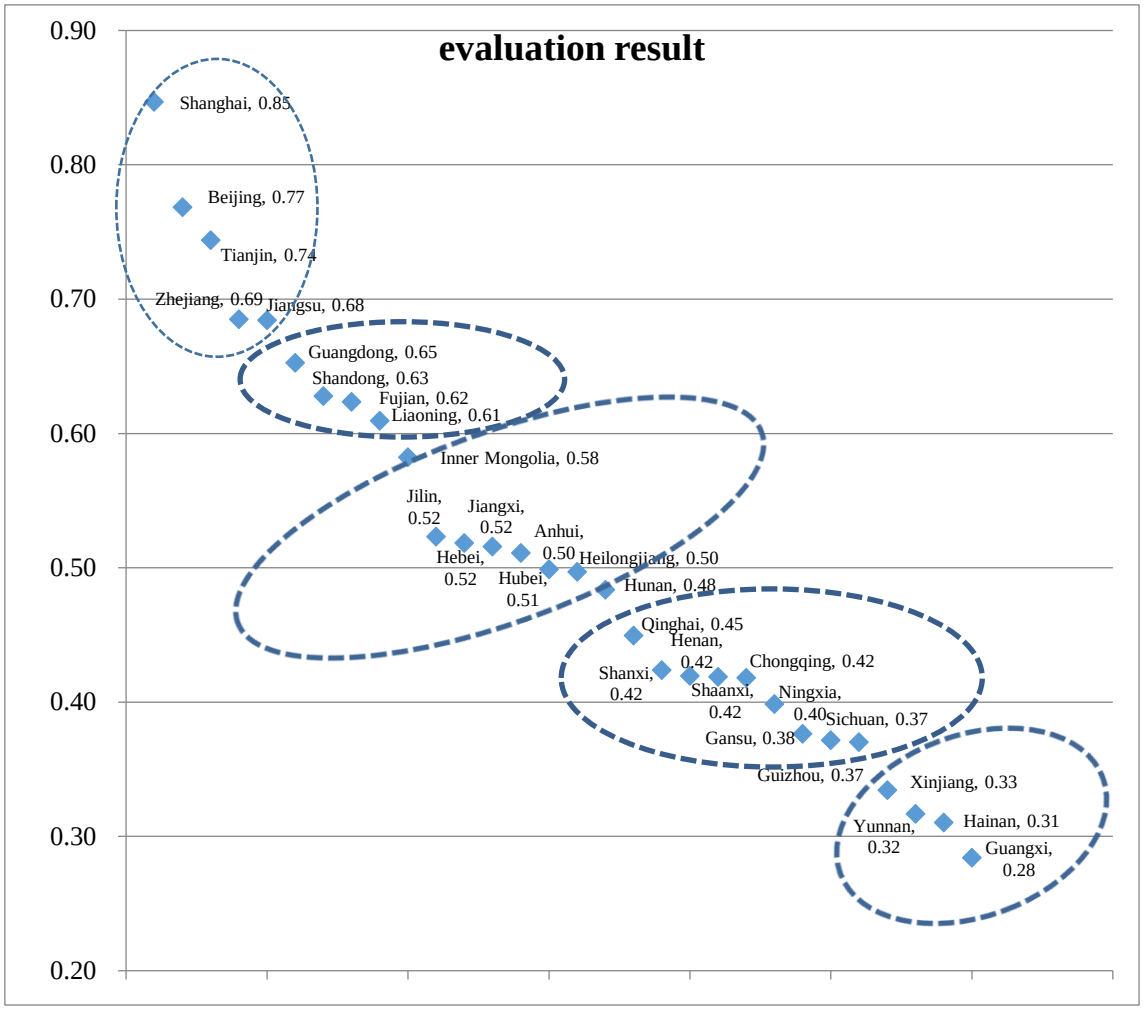

Figure 2: Evaluation result of index system

Regional integrated evaluation results can be verified by clustering analysis (figure 3). According to integrated evaluation indices system, 30 regions of China show relatively good cluster results.

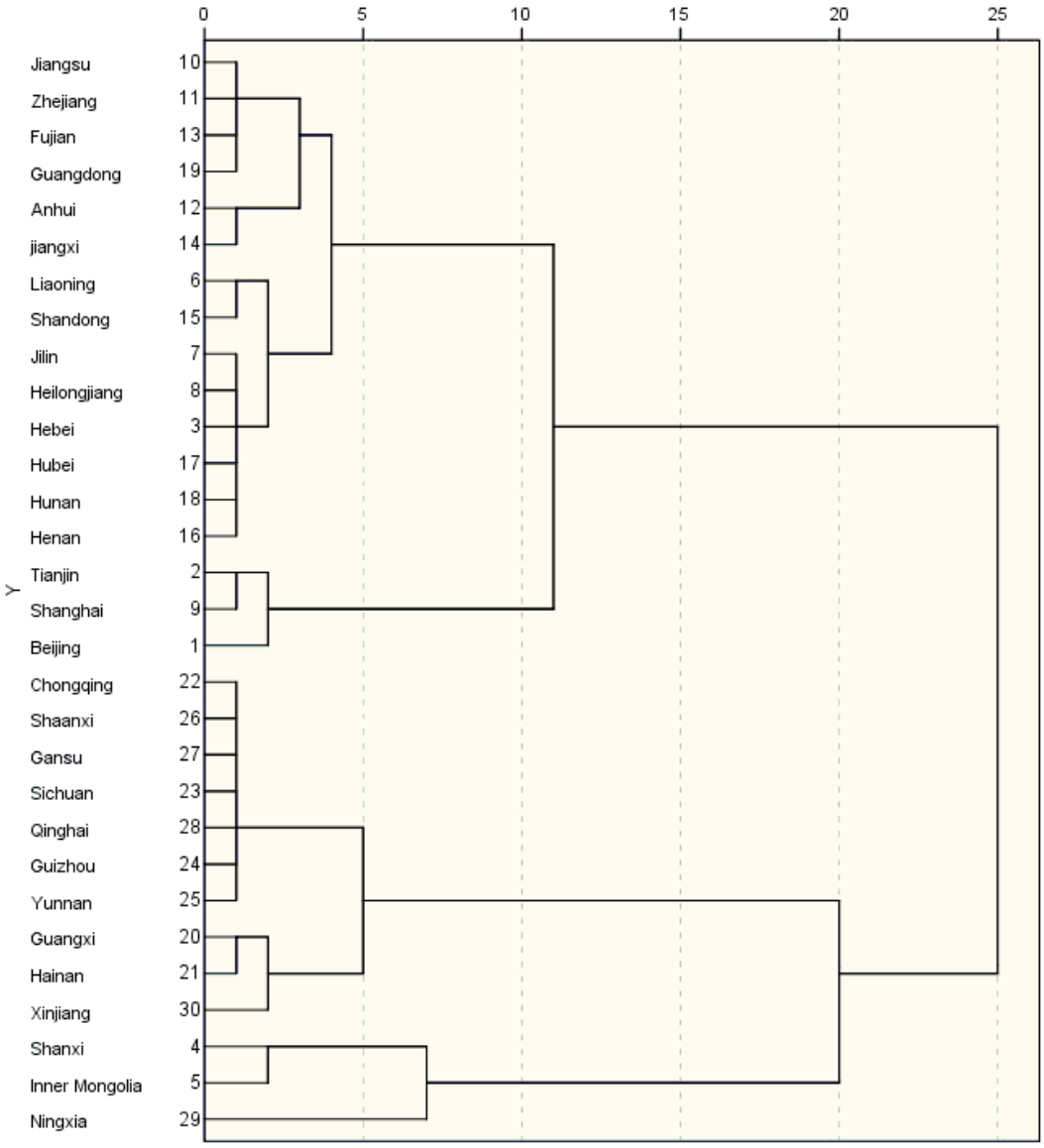

Figure 3: Clustering analysis result: dendrogram

4.2 Suggested Target Decomposition Range

Referring to the results of comprehensive evaluation and cluster analysis, the targets decomposition is suggested as shown in Table 2 below.

Table 2: Decomposition range of decline target of carbon emissions 2021-2030

Regional classes	provinces (with high scores prior to the rank)	Target ranges
1	Shanghai, Beijing, Jiangsu, Guangdong, Zhejiang, Tianjin	Maximum target
2	Liaoning, Fujian, Hebei	Little higher than national average target
3	Heilongjiang, Inner Mongolia, Hubei, Jilin, Hunan, Jiangxi, Ningxia, Anhui, Shanxi, Henan	National average target
4	Qinghai, Xinjiang, Shaanxi, Gansu, Chongqing, Sichuan	Little lower than national average target
5	Guizhou, Hainan, Guangxi, Yunnan	Minimum target

5. Conclusion

5.1 Comparison of Carbon Intensity and Cap Control

Intensity control and cap control are both effective ways to control carbon emissions. The former mainly requires to reduce the intensity of carbon emissions to a specific target, while the latter requires the total carbon emissions cannot exceed a specific cap. Both can promote green development, but there are also differences between them, mainly including:

Different goals. The intensity control of carbon emissions is to emphasize the quality and efficiency of economic growth in order to reduce carbon emissions per unit of GDP. Developing countries have great potential for economic growth. In particular, the process of industrialization and urbanization is inevitably accompanied by the growth of total

energy consumption and carbon emissions. The requirements of green development in the corresponding development stage are to enhance the quality and efficiency of economic development. Therefore, carbon intensity control method is normally preferred. The cap control method emphasizes the absolute amount of carbon emissions control, and could even sacrifice economic growth in some degree to achieve the goal of carbon emissions reduction. The requirements of green development for developed countries with a high proportion of tertiary industry are to take green development as the new economic growth opportunities, decoupling economic growth and carbon emissions, and thus controlling and gradually lowering the total carbon emissions, so cap control method gains more popularity among developed countries.

Different binding force. There are also differences between two kinds of carbon emission control targets in terms of binding force. Adopting the cap control target intensifies the constraints on carbon emissions, thus providing more power in facilitating the reform of the government, adjustment of economic structure, energy mix and innovation in technology, while intensity target means less constraint force because the target can be reached by means of enlarging denominator, i.e. producing more GDP. When there is lack of concrete data, it will be easy for local governments and enterprises to achieve the intensity target through data frauds. As a result, for the regions with relatively great potential of development, there must be due attention to demand of GDP growth which should be incorporated into the target range.

Different relations between regional and national targets. When intensity target is used, regional targets and national target may not be coordinated, because the targets decomposed to all regional governments are the decline target of carbon emissions intensity. Mathematically we can see that on the one hand, it cannot be ensured that all regions' targets of carbon intensity decline can be strictly in line with national target. On the other hand, it could happen that all regions have achieved their targets but national target is unaccomplished. Therefore, further research is needed to address the problem of coordination between national target and regional targets during regional decomposition of national intensity target.

5.2 Remaining problems when regional decomposition

Data quality should be improved as soon as possible. The implementation of national

carbon emissions control target decomposition, whether intensity control or cap control, requires a real and effective data base. The statistical basis of China is still relatively weak. In the future, the basis of data statistics needs to be further strengthened and the quality of statistical data needs to be improved. In particular, the allocation of carbon emissions is based on relatively accurate statistics on population, GDP and energy consumption. Currently, the statistical data of various provinces and municipalities vary greatly from that of the whole country, especially the total energy consumption and its structure. Local and national statistics should be coordinated to solve the problem of relevant data gap as soon as possible to provide solid data support for the regional decomposition of the intensity and cap of carbon emissions.

National carbon emission control target decomposition should be coordinated with other goals. Carbon emissions control targets are directly related to energy-saving targets, non-fossil energy development targets and environmental protection targets. The accomplishment of carbon emissions control targets also needs support from efforts of these areas. In addition, assessment policies need to be adjusted, which means that it is necessary to formulate and issue assessment policies on carbon emissions cap control to coordinate national carbon trading policies and inter-governmental trading that may exist in the future.

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