Comprehensive Evaluating the Performance in Green Growth of Chinese Provincial-Level Regions

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Abstract. The concept of green growth has been put forward for many years in China. After years of practice, the performance of green growth in all provinces of China has changed, but it has not been systematically evaluated. Based on OECD's green growth framework, this study develops an indicator system of green growth evaluation suitable for China's provinces, and then evaluates the green growth levels in different regions of China. The result shows that China's regional green growth is uneven. The green growth performances in the eastern coastal provinces are generally higher than that of western provinces. After identifying the advantages and disadvantages of different provinces in green growth, this paper analyses the causes of these differences. This research could offer a valuable reference for regions that adopt green growth as their development mode.

1. Introduction

Since initiating the reform and opening up, China’s economy has been developing at high speed with the boost of industrialization, urbanization and people’s living standards. At the same time, however, many regions in China are facing severe challenges, including environmental pollution, ecological destruction, resource depletion and a sharp decline in biodiversity [1]. Resource and environmental issues seriously restricted the long-term economic development of China. The traditional economic extensive growth pattern, featured with high investment, large consumption, high pollution and low efficiency, is hard to sustain.

Governors, practitioners and researchers all over the world have been always seeking the future pattern of sustainable development. The ecological economy was put forward from the perspective of coordinating the economic and ecological systems. The circular economy was created from the perspective of strengthening material recycling and utilization [2]. The green economy was presented from the perspective of environmental protection [3]. The low carbon economy was invented from the perspective of improving energy efficiency, saving energy consumption and developing new energy [4, 5]. The European Union has imposed “Green New Deal”, “Low-carbon Economy” and a series of national green development strategy to promote green growth. However, the deterioration of ecological environment and resource depletion has not been effectively solved. To explore a way to achieve economic and environmental sustainability, people from all walks of life have carried on the beneficial exploration. Therefore, the concept of green growth was presented.

Green growth, firstly presented in Seoul Green Growth initiative passed on the United Nations Economic and Social Commission for Asia and the Pacific’s 5th Ministerial Level Meeting on the Environment and Development in 2005, was defined as economic growth with environmental sustainability. The Organization for Economic Cooperation and Development (OECD) defined green
growth as that natural resources can be assumed to constantly supply indispensable resources and environment service for human beings as well as promote economic growth and development. Different with sustainable development, green growth requires steady economic growth and development on the basis of natural assets continuing to provide resources and environmental services for human well-being.

Green growth in China has a great application prospect, and it provides tools to foster investment, innovation, and competition in exploring new sources of economic growth. Since 2000, Chinese Government has begun to promote green development. Under the impetus of the central government, the Chinese provincial government has carried out different ways of exploration and practice, such as the development of circular economy, low-carbon economy and so on. After years of development, each province's green growth level has changed, but there has been no systematic evaluation on it. This research can help the central government understand the state of green growth in different provinces, specifically, where do well, which needs to be strengthened, and so as to take proper policy measures to further promote regional green growth.

Many scholars have evaluated the green growth in China, and the related research can be roughly divided into three categories. The first type of research is to evaluate urban green growth. For example, Sun et al. (2015) evaluated the inclusive green growth levels of 285 cities in China [6]. Yi and Liu (2015) measured clean energy economy at the city level in China, by counting green jobs and firms through an analytical approach [7]. The second type of research is to evaluate green growth in countries. For example, Guo et al. (2018) established an evaluation indicator system for green growth based on improving the plan-do-check-action cycle method, and evaluated the green growth practices at the national level in China [8]. Wang and Shao (2019) estimated national green growth level by combining hybrid measure with Global Malmquist-Luenberger index [9]. The third type of research is to evaluate the green growth at the industrial level. For example, Chen and Golley (2014) estimated the changing patterns of ‘green’ total factor productivity growth of 38 Chinese industrial sectors [10]. Li and Lin (2015) measured green productivity growth of Chinese industrial sectors [11].

The existing research has the following deficiencies. There is a lack of research based on OECD framework in the relevant research. Besides, though many researchers evaluated green growth at the level of national, urban and industrial sectors [6-11], there is a lack of studies on evaluation of green growth at the provincial level in the current literature. In addition, in most studies, evaluation indicators are not weighted and lack of differential treatment of the importance of indicators.

The OECD’s index framework is an internationally recognized and universal indicator framework. Scholars can flexibly select OECD indicators for evaluation suitable for the region based on national or regional characteristics. Furthermore, evaluation results based on OECD indicator systems are more comparable across countries. Based on the above considerations, this paper attempts to construct a provincial-level indicator system with weights based on OECD’s framework, and analyse the differences in green growth practices of China's provinces and to identify the effective and efficient ways of green growth among these provinces. This study helps to provide guidance in decision-making for government to promote green growth.

2. Literature Review

Chinese government has made great efforts to promote low-carbon development, such as the development of service industry and strategic emerging industries, renewable energy development, carbon trading, etc. Besides, there are some other green development policies released by the Chinese government, such as The Sustainable Development Plan of the National Resources City, Singapore Tianjin Eco-city etc. The issue of these policies reflects that the Chinese government has attached great importance to green growth. Since 2008, the Chinese government has promoted low-carbon development and accordingly issued related policies to control carbon emissions. These increasingly stringent low carbon policies didn’t diminish economic growth and also didn’t incur significant macroeconomic costs expected [12]. Rather, these policies stimulated green industries and brought improvements in environmental quality and developing quality, including structural change, value
addition, job creation, economic growth, poverty reduction, reduction of vulnerability to climate change and natural disasters, et al. [13, 14].

Many scholars have evaluated the green growth in a certain area of China, and the related research can be roughly divided into three categories. The first type of research is to evaluate urban green growth. For example, Sun et al. (2015) evaluated the inclusive green growth levels of 285 cities in China [6]. Yi and Liu (2015) measured clean energy economy at the city level in China, by counting green jobs and firms through an analytical approach [7]. The second type of research is to evaluate green growth in countries. For example, Guo et al. (2018) established an evaluation indicator system for green growth based on improving the plan-do-check-action cycle method, and evaluated the green growth practices at the national level in China [8]. Wang and Shao (2019) estimated national green growth level by combining hybrid measure with Global Malmquist-Luenberger index [9]. The third type of research is to evaluate the green growth at the industrial level. For example, Chen and Golley (2014) estimated the changing patterns of ‘green’ total factor productivity growth of 38 Chinese industrial sectors [10]. Li and Lin (2015) measured green productivity growth of Chinese industrial sectors [11]. Qu et al. (2017) evaluated the green growth efficiency of Chinese manufacturing industries [15].

In order to evaluate green growth, the international organization has done a lot of valuable research, and several kinds of typical evaluation indicator system have been constructed. OECD’s green growth framework mainly focuses on environmental and natural assets base, resource productivity, environmental quality of life, and economic opportunities and policy responses. This framework has been widely used by some nations to monitor progress towards green growth. Kim selected 12 international indicators to evaluate green growth of 30 countries and these indicators cover GHG emissions per unit of GDP, renewable energy consumption, public transportation, government expenditure on environment, patents in environment-related technology, etc. [16]. The researchers also made a study of the green transformation of economies [17].

UNEP’s green growth indicators cover five aspects of environment, policy, human welfare and equity, which emphasize that well-designed indicators are beneficial to the entire policy process as each stage requires different indicators. Also, World Bank has constructed a framework to measure environmental, economic and social growth benefits. Similarly, GGGI developed an evaluation index system, covering the two aspects of development and sustainability. Its 5 themes cover wellbeing, economy, ecosystem, resources and climate. Besides, some researches on green growth evaluation only considered a single indicator or made comparisons within a single sector [18-21].

The above indicator frameworks can be used to evaluate the performance in green growth, but the focus of each indicator framework is different. Green economy policy making is more emphasized in UNEP indicator framework. The WB framework is more appropriate for evaluating inclusive green growth. GGGI indicator framework is more suitable for assessing country’s sustainable development. OECD framework can comprehensively reflect the concept of green growth as mentioned, so we chose it as a framework to guide the selection of green growth indicators.

OECD’s framework is adaptable and flexible. It has been used by many researchers and research institutions to evaluate the green growth of countries and regions. The strong adaptability of the OECD’s framework to various contexts and interests has always been the key to its wide application. This implies that OECD’ indicators are applicable in the case of the Chinese, despite of differentiating factors in politics, history or geography. Although OECD’s framework provides indicators at the national level, it encourages researchers to select evaluation indicators from the framework according to the situation in different regions. So, OECD’s framework can also be used to evaluate regional green growth.

Scholars and Green growth practitioners have conducted extensive research into green growth, but the research gap is still existed. Under different indicators framework and evaluation method, the research results are not comparable, so they can’t be well compared between regions. Previous researches also failed to tell whether green growth in a certain region is balanced. Since countries vary, the indicator system of green growth suitable for Chinese conditions still needs to be explored.
3. Constructing an Indicator System to Evaluate Green Growth of China

3.1. To Choose an Indicator Framework

To evaluate green growth, a representative indicator framework which can fully reflect the connotation of green growth needs to be selected. OECD presented an indicator framework, which focuses on production and consumption system and includes five indicators of social and economic environment and growth characteristics, environment and resource productivity, living environmental quality, economic opportunity and policy response, natural capital basis.

OECD’s framework and indicators were produced under the Green Growth Knowledge Platform which is a global platform consisted of researchers and experts to address knowledge gaps in green growth theory and practice. The experts and researchers are from OECD, GGGI, UNEP, and WB. Therefore, this study chooses green growth indicators based on OECD’s indicator framework is relatively scientific.

OECD’s framework and indicators is widely used in the evaluation of green growth in different countries and regions. To evaluate green growth in a certain region, researchers can select some applicable indicators or eliminate some non-applicable evaluation indicators from OECD’s framework according to the actual situation of the evaluation regions [22]. To make the constructed indicator system more reasonable and appropriate, this paper made corresponding adjustments on OECD’s indicator system. Specifically, provincial green growth is evaluated from the perspective of output end, thus the input end-natural capital base is left out. International financial capital flow is left out since it is a national evaluation indicator. After adjusting for these indicators, the indicator system contains four types of first-grade indicators, including social and economic environment and growth characteristics, environment and resource productivity, living, environmental quality, economic opportunity and policy response. Among which, social and economic environment and growth characteristics consists of three groups of second-grade indicator, including economic development, productivity, competition, labour market, education and income. First-grade indicator, environment and resource productivity indicator, consist of two groups of second-grade indicators: carbon and energy productivity, resource productivity. First-grade indicator, living, environmental quality indicator, consists of two groups of second-grade indicators, namely environmental health and risk and environment service and facility. First-grade indicator, economic opportunity and policy response indicator consists of one group of second-grade indicator, namely technology and innovation.

3.2. The Principle and Process of Choosing these Indicators

The initially selected indicators must cover the two aspects of green growth-green and growth, and they should be specific, attainable, relevant, dynamic and flexible [22]. Based on the adjusted indicator system above and related literature [22], we collected 57 relevant indicators. The three key principles for indicator simplification provided by OECD are policy relevance, analytical soundness and measurability. We then simplified these initially selected indicators based on its principles.

For selecting these initial indicators, inviting experts to grade the indicators is required. In our study, we used the Delphi Method. Delphi Method is a suitable method for exploratory problem solving, so it is the appropriate method to use. The general process is: after obtaining the expert's opinion on the problem to be predicted, collate, summarize, statistics, and then anonymously feedback to the experts, again soliciting opinions, and then focus, feedback, until the consensus opinion. First, we provided initially selected indicators to the experts for preliminary grading, and then the selected core indicators were further scored through a Delphi procedure to obtain the most reliable consensus of a group of experts. These experts involve seventeen participants. Four people are from the government's economic reform sector and three from the government's green development planning sector. There are 10 researchers in the field of green development research, including 5 university professors and 5 scholars from other research institutions. According to their grades, indicators with low policy relevance, poor analyticity and measurability will be left out. Thus, the evaluation indicator system of green growth is formed. The criteria for indicator selection are shown in table 1.
Table 1. Criteria for indicator selection.

| Criteria             | Classification                                      |
|----------------------|-----------------------------------------------------|
| Policy Relevance     | 1 = to be further reviewed; 2 = medium; 3 = strong  |
| Analytical Soundness | 1 = to be further reviewed; 2 = average; 3 = good   |
| Measurability        | 1 = to be further reviewed; 2 = medium; 3 = good    |

3.3. Method of Data Standardization and the Determination of Index Weight

To facilitate the comparison of those indexes, the original data should be transformed into dimensionless values. Several methods can be used to make the data dimensionless, and they are threshold method, z-score method and extreme standardization method. Compared with other methods, the extremum standardization method has the advantage of processing positive and negative indexes at the same time. Thus, this paper adopts an extremum standardization method to process these original data. The index system constructed in this paper is made up of positive indexes and negative indexes. The extremum standardization equation used in this paper is as follows:

For positive index: $$y_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} (1 \ll i \ll m, 1 \ll j \ll n)$$ (1)

For negative index: $$y_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} (1 \ll i \ll m, 1 \ll j \ll n)$$ (2)

In this equation, $x_{ij}$ is the original index, $y_{ij}$ is standardized index data, $i$ is the evaluation object, and $j$ is the evaluation indicator. After the standardization, the index ranges from 0 to 1, which can facilitate the subsequent processing of the data.

Weighing of indicator should reflect national green development policies, goals and intention so that it can provide guidance for the department and industry in all regions. The indicator weight calculation adopts the expert investigation method. We invited 28 experts to rate the importance of each indicator, 12 from the government’s economic development reform department, and 10 from the government’s green development planning department. There are six experts in the field of green development research, including four university professors and two scholars from other research institutions. In this paper, we use Likert scale to score, the score range is 1 to 5 points. (Very important: 5 points; Important: 4 points; Average: 3 points; Not important: 2 points; Very unimportant: 1 points.) We weighted it by the ratio of the average value of an indicator scored by experts to the average value of all indicators. Finally, we got the evaluation indicator system with weight (see in table 2).

4. Evaluating Green Growth for Provinces of China

The comprehensive index method can be used to standardize the indexes with different units and different properties, and then transform them into a composite index to make an accurate evaluation. Combined with this method, we conducted the evaluation of China’s provincial green growth.

4.1. The Selection of Research Objectives and Data Collection

Considering the availability and validity of the research data, this study only selected 31 regions in China mainland as the evaluation objects. These regions contain 22 provinces, five autonomous regions and four municipalities. The data are collected from China Statistical Yearbook 2014, China’s Environmental Statistical Yearbook 2014, China Energy Statistical Yearbook 2014 and China City Statistical Yearbook 2014. Because there is no released statistics related to carbon dioxide emissions in China, this study employed the estimation method provided by the International Panel on Climate Change (IPCC) to measure the carbon dioxide emissions. Besides, missing data are replaced by the mean value of all the region’s carbon emissions.
### Table 2. Indicator system on green growth of Chinese provincial-level regions.

| Social Economic Environment and Growth Characteristics | Economic growth | Productivity and competitiveness | Labor, education and income | Productivity of carbon and energy | Environment and Resource Productivity | Living Environmental Quality | Environmentally Related Technology and Innovation |
|--------------------------------------------------------|----------------|---------------------------------|-----------------------------|---------------------------------|-------------------------------------|------------------------------|-----------------------------------------------|
| First class                                            | Second class   | Third class                     |                             |                                 |                                     |                              |                                               |
| First class                                            | Second class   | Third class                     |                             |                                 |                                     |                              |                                               |
| First class                                            | Second class   | Third class                     |                             |                                 |                                     |                              |                                               |
| First class                                            | Second class   | Third class                     |                             |                                 |                                     |                              |                                               |
| First class                                            | Second class   | Third class                     |                             |                                 |                                     |                              |                                               |
| First class                                            | Second class   | Third class                     |                             |                                 |                                     |                              |                                               |
| First class                                            | Second class   | Third class                     |                             |                                 |                                     |                              |                                               |
| First class                                            | Second class   | Third class                     |                             |                                 |                                     |                              |                                               |
| First class                                            | Second class   | Third class                     |                             |                                 |                                     |                              |                                               |

#### 4.2. Evaluation Results

On the basis of constructing the indicator system, we get the "green growth index" of each region, reveal the advantages and disadvantages of each region's green growth, and strive to provide a valuable reference for each region to promote the green growth.

#### 4.2.1. Results of Index Evaluation

After determining the weight of each index, the grade and rank of 31 provincial green growth indexes are calculated and then listed in table 3. The green growth index is made up of first-grade index, first-grade index is made up of second-grade index and second-grade index is made up of third-grade index.
### Table 3. Green growth index of Chinese provincial-level regions.

| Regions     | Social Economic Environment and Growth Characteristics | Environment and Resource Productivity | Living Environmental Quality | Economic Opportunity and Policy Response | Green Growth Index |
|-------------|------------------------------------------------------|---------------------------------------|-------------------------------|------------------------------------------|-------------------|
| Beijing     | 0.58                                                 | 0.93                                  | 0.56                          | 0.81                                     | 0.74              |
| Tianjin     | 0.43                                                 | 0.92                                  | 0.44                          | 0.93                                     | 0.69              |
| Hebei       | 0.19                                                 | 0.64                                  | 0.49                          | 0.25                                     | 0.44              |
| Shanxi      | 0.26                                                 | 0.50                                  | 0.54                          | 0.29                                     | 0.42              |
| Neimenggu   | 0.34                                                 | 0.53                                  | 0.61                          | 0.17                                     | 0.46              |
| Liaoning    | 0.30                                                 | 0.68                                  | 0.59                          | 0.43                                     | 0.53              |
| Jilin       | 0.29                                                 | 0.73                                  | 0.27                          | 0.16                                     | 0.46              |
| Heilongjiang| 0.21                                                 | 0.63                                  | 0.36                          | 0.22                                     | 0.42              |
| Shanghai    | 0.52                                                 | 0.91                                  | 0.30                          | 0.95                                     | 0.68              |
| Jiangsu     | 0.40                                                 | 0.77                                  | 0.41                          | 0.99                                     | 0.62              |
| Zhejiang    | 0.28                                                 | 0.86                                  | 0.40                          | 0.99                                     | 0.61              |
| Anhui       | 0.18                                                 | 0.73                                  | 0.48                          | 0.57                                     | 0.50              |
| Fujian      | 0.25                                                 | 0.90                                  | 0.39                          | 0.54                                     | 0.58              |
| Jiangxi     | 0.21                                                 | 0.82                                  | 0.57                          | 0.22                                     | 0.54              |
| Shandong    | 0.25                                                 | 0.67                                  | 0.49                          | 0.71                                     | 0.51              |
| Henan       | 0.18                                                 | 0.74                                  | 0.27                          | 0.31                                     | 0.44              |
| Hubei       | 0.25                                                 | 0.81                                  | 0.37                          | 0.43                                     | 0.53              |
| Hunan       | 0.22                                                 | 0.82                                  | 0.29                          | 0.41                                     | 0.50              |
| Guangdong   | 0.28                                                 | 0.90                                  | 0.31                          | 0.96                                     | 0.60              |
| Guangxi     | 0.17                                                 | 0.82                                  | 0.33                          | 0.17                                     | 0.48              |
| Hainan      | 0.34                                                 | 0.77                                  | 0.44                          | 0.09                                     | 0.52              |
| Chongqing   | 0.27                                                 | 0.86                                  | 0.49                          | 0.46                                     | 0.58              |
| Sichuan     | 0.20                                                 | 0.89                                  | 0.29                          | 0.24                                     | 0.51              |
| Guizhou     | 0.30                                                 | 0.55                                  | 0.27                          | 0.15                                     | 0.39              |
| Yunnan      | 0.21                                                 | 0.75                                  | 0.35                          | 0.11                                     | 0.46              |
| Tibet       | 0.29                                                 | 0.55                                  | 0.14                          | 0.03                                     | 0.35              |
| Shanxi      | 0.24                                                 | 0.76                                  | 0.40                          | 0.30                                     | 0.50              |
| Gansu       | 0.21                                                 | 0.83                                  | 0.40                          | 0.18                                     | 0.51              |
| Qinghai     | 0.20                                                 | 0.55                                  | 0.36                          | 0.13                                     | 0.37              |
| Ningxia     | 0.24                                                 | 0.41                                  | 0.52                          | 0.23                                     | 0.36              |
| Xinjiang    | 0.28                                                 | 0.31                                  | 0.66                          | 0.13                                     | 0.35              |

The mean value on the four first-grade indexes for eastern regions and western regions of China are shown in figure 1. It shows that the green growth level is not balanced in western regions and eastern regions. The mean value of green growth index in eastern regions is 0.54, which is significant higher than the national average 0.5. The western region's green growth index is 0.44, which is lower than the national average. For the secondary indexes, social economic environment and growth characteristics index, environment and resource productivity index and living environmental quality index of the eastern regions, are slightly higher than those of western region. The gap is not great. There are big differences between the western region and the eastern region regarding environmentally related technology and innovation. The numerical gap is 0.35, which shows that the eastern regions did much
better than western regions in technology and innovation. To be specific, its advantage is reflected in terms of R&D expenditure on environment and number of patent applications.

4.2.2. Regional Distribution and Comparison of Green Development Index. Having obtained green growth indexes of all provincial-level regions, the authors classified all regions into groups of similar levels of green growth. A pattern of classification based on the arithmetic mean and standard deviation of the synthetic measures was applied in this study.

- Group I: $U_i \geq \bar{U} + S$, High level
- Group II: $\bar{U} + S > U_i \geq \bar{U}$, Medium-high level
- Group III: $\bar{U} > U_i \geq \bar{U} - S$, Medium-low level
- Group IV: $U_i < \bar{U} - S$, Low level

where $U_i$ is the green growth index in each region and $\bar{U}$ is the mean value of green growth index of all regions and $S$ is the standard deviation.

Table 3 and figure 2 indicate that the performance of green growth in Beijing, Tianjin, Shanghai, Jiangsu and Zhejiang is relatively well, whose green growth index values in 2012 are all over 0.5, higher than the national average. It is worth mentioning that all these areas are located in the eastern coast of China. Beijing’s green growth index ranks top one in the whole country, which benefits from its advantages of higher developing level of service industry and education industry, higher efficiency of energy utilization and lower emissions of carbon dioxide. Tianjin ranks the second because its utilization of water resources and investment in environmental infrastructure rank at the top in the whole country. Shanghai ranks the third for its advantages of comprehensive utilization of industrial waste, the control of pollutant emission and well developed education industry and service industry. Jiangsu province and Zhejiang province rank forward because their labour productivity and expenditure of research and development take the leading position in the whole country.

Regions with lower ranks of green growth index include Tibet, Qinghai, Guizhou, Yunnan, Jilin, Guangxi and so on. Their values of green growth index are lower than the national average of 0.5. The green growth index value of Tibet, which ranks at last in the whole country, is 0.35, far behind other regions. For instance, the Beijing’s is 0.74, three times as the Tibet’s. The values of labour productivity, utilization rate of water resources and waste, infrastructure investment and R&D investment are apparently lower than the others, which have been observed to be the main influencing
indicators on green growth index evaluation in Tibet. However, as for pollution control of sulfur dioxide, chemical oxygen demand, ammonia-nitrogen and nitric oxide, Tibet’s index value is higher than the national average because of its lower industrial development.

Figure 2. Level of green growth of Chinese provincial-level regions.

5. Discussion and Implications
The higher level of green growth in the eastern region may attribute to China’s reform and opening up policy. In order to achieve sustainable economic growth, governments should implement and promote market reforms and gradually slacken regulation and management for factor prices [23]. Reform policies will dictate just how growth is realized [24]. China’s strategic priority is the development of the eastern coastal areas, which means government advocates that the east drives the development of the west. Somewhat similar with South Korea’s green growth policy that is oriented to the central government [25], the reform and opening up policy has extended the local approval right of projects involving foreign investment in the coastal areas. Chinese government has actively supported the import of advanced technology by means of tariff, industrial and commercial consolidated tax and business income taxes. Meanwhile, the government has provided financial support to set up economic and technological development zones to attract foreign investment. Benefiting from the strong support of the central government, the eastern provinces have made great achievements in economic and social development. While the local government was developing its economy vigorously, the eastern region government attached more importance to innovation than the western region. In addition, attaching importance to environmental innovation and technology may fit the concept of innovation-driven development which has been strongly advocated by the government in recent years.

Besides, regional green growth planning, development program and green project are essential to achieve green growth. Beijing and Shanghai began to develop a circular economy earlier in China. In 2006, Beijing made a circular economy development plan as well as environmental protection and ecological construction program. At the same time, Shanghai also put forward a program of environmental protection and ecological construction. These programs reflected that the governments began to pay more attention to the development of circular economy. To achieve these development programs, the two governments not only formulated some related environmental policies but also implemented a series of green projects. For example, Shanghai focused on the implementation of industrial pollution control, recycling economy development projects and ecological protection projects. Beijing stressed to improve the utilization of energy, water and renewable energy. Circular
economy policies and implementation projects can help to improve the productivity of environmental resources, which leads to higher index of environment and resource productivity in Beijing and Shanghai, and this finding is somewhat consistent with Guo et al. [26].

In addition, almost all regions with higher technology and innovation index are located in the eastern coastal areas of China. They are highly open and have the advantage of attracting foreign capital. Technology spillover of foreign investment may help to improve the technological innovation capability. Green innovations can reduce the demand for some materials and energy in certain industries [27]. Technology and innovation can’t be generated without the support of scientists and engineers. Zhejiang, Jiangsu, Shanghai and Tianjin vigorously promote to attract a large number of high-level technical personnel, which is also the focus of local government planning. Green innovation can promote employment [28], and in return the corresponding high employment rate will also contribute to innovation. So, we can infer that aggregation of talent may be the reason for the high technological innovation index. Moreover, these regions with higher green growth indexes have a low index scores in living environmental quality, indicating that these areas still have room for green growth.

After analysing the rank of the green growth index of all provinces and regions in China, it can be found that those provinces with higher green growth index are almost in eastern regions. The green growth indexes of central and western regions generally are lower. This shows that the green growth level is unbalanced and has a regional differentiation, which to some degree also indicates that the more developed the economy and society are, the better the green growth is. More specifically, regions with a higher level of economic development may invest more capital to improve the construction of environmental infrastructure, reduce environmental pollution and purchase production facility for resource conservation. It can be inferred that the government plays a crucial role in pushing the development of green growth. Besides, green growth planning, policies and green projects are essential to achieve green growth. We suggest that regional governments can implement different measures for green growth in light of the actual situation in the region.

China’s green growth is largely relied on its top-down coordination function of the central government. Without central government’s policy support, green growth may be difficult to achieve in local governments. Without the supervision and assessment mechanism of the central government, an originally well-designed strategy process is likely to degenerate into more or less symbolic policy document [29]. Besides, the uneven development of each region should be subject to macro adjustments and controls.

Identifying the bottleneck of green growth in each region will enable the regional government to adopt the most suitable model for the region’s development among low carbon economy, circular economy and eco economy, et al. Besides, local governments should fully consider the basis of the green growth in formulating the annual development targets and environmental indicators of the provinces. Local governments should not stress excessively the growth rate of GDP for these areas with poor green growth. Instead, those governments should give more preferential policies to these areas.

6. Conclusion

Based on the OECD’s indicator framework, this study develops an indicator system of green growth evaluation suitable for China’s provinces and evaluates the status quo of green growth of 31 regions (provinces, autonomous regions and municipalities) in China. The results indicate that the green growth indexes of the eastern provinces are higher than that of middle and western regions and the development level of green growth are unbalanced with regional differentiation. Eastern China, with a higher level of economic and social development, has a relatively higher level of green growth. Nevertheless, this does not mean that green growth can be achieved only by promoting economic growth. Then, this paper discusses the role of the reform and opening-up policy, development programs, green projects and innovation in the implement of green growth, and puts forward some
suggestions. This study could provide valuable reference and guidance for countries and regions that adopt green growth as their development mode.

Because the green growth levels between China’s eastern coastal areas and the central and western regions are quite different, the central government should formulate policies conducive to green growth in the central and western regions, and push forward the implementation of reform and opening up in the central and western provinces. For local governments, due to the significant differences in social and economic development, resource capacity, ecological basis and environmental protection, different provinces have different bases of green growth. Therefore, each region has to choose different growth patterns and adopt different growth approaches in accordance with its own condition. Adjustment of industrial structure, scientific and technical innovation, management innovation and system innovation are also needed to improve the quality of economic growth and reduce the negative effects on resources and the environment caused by economic growth.

Looking into the future, China’s task in promoting green growth is arduous and challenging, and corresponding evaluation is needed to provide evidence for theory analysing and decision-making in practices. However, the measurement of green growth is still a newly emerging research which lacks mature experience. This research has certain scientific significance. First, green growth index framework of OECD is mostly used on the national level, but lacks the provincial evaluation. This study can expand the application of OECD index framework. Second, the OECD index framework is adaptable and can be adjusted [14]. In this paper, the green growth indicators are adjusted reasonably, and the index framework of provincial green growth evaluation is constructed for the first time. Researchers can use this method to construct green growth index framework for other regions in the further. WB, UNEP and GGGI index framework can also be applied to evaluate green growth according to this research method. Besides, future research is still needed to further expand the scale of data to many consecutive years when analysing and predicting the green growth tendency. Furthermore, each evaluation method has its advantages and disadvantages, different evaluation methods can be tried in future research.

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