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A Dataset of Provincial Carbon Emissions Reduction Performance in the Process of Carbon Emissions Intensity Reduction in China's Energy Consumption from 2005 to 2016

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Abstract: Based on the energy consumption and economic development data of 30 Chinese provinces (excluding Tibet, Hong Kong, Macao, and Taiwan), a dataset of China's carbon emissions intensity and provincial output share and carbon emissions intensity in China was built. The correction coefficient was applied to measure carbon emissions reduction effectiveness in each Chinese province. According to the carbon emissions intensity of energy consumption and the output value share of each province, the equation of national carbon emissions intensity in China's energy consumption was established from top to bottom, and the contribution rate of the carbon emissions intensity of energy consumption and the output value share in each province to the decline of national carbon emissions intensity in energy consumption was determined using the LMDI-Ⅰ method. Following the idea of "emissions reduction effectiveness-carbon emissions intensity contribution-comprehensive contribution by province-relationship between provincial carbon emissions reduction effectiveness and the comprehensive contribution of each province", the performance of carbon emissions reduction of each province in the process of carbon emissions intensity reduction in China's energy consumption was evaluated. The results of the dataset analysis showed that: (1) The carbon emissions intensity of China' energy consumption followed a downward trend, decreasing by more than 45% in 2016 from 2005 levels. (2) More than half of the provinces of China were evaluated as effectiveness areas for carbon emissions reduction, and this number increased during the study period; most of the provinces that did not meet the carbon emissions reduction standards were located in economically underdeveloped areas, and there were significant differences in carbon emissions reduction paths across provinces. (3) The contribution rate of the carbon emissions intensity of energy consumption in most provinces followed an upward trend, and the regional differences gradually decreased. (4) The

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competing momentum of the comprehensive contribution by provinces was strong, and most provinces contributed to the reduction of the carbon emissions intensity of China's energy consumption. (5) The number of provinces with good carbon emissions reduction performance was the highest; the general areas were scattered in the eastern coastal area and in a few inland areas, while the spatial pattern of the poor areas remained durably in the western region. The dataset built includes the following data: (1) Carbon emissions intensity of energy consumption in China; (2) Correction coefficients of the provincial carbon emissions reduction of energy consumption; (3) Decomposition factors' contribution rate to the reduction of carbon emissions intensity in China; (4) Order of effectiveness and comprehensive contribution of provincial carbon emissions reduction. The dataset consisted in one file in .xlsx format, with a size of 18.8 KB.

Keywords: province; energy consumption; carbon emissions intensity; carbon emissions reduction performance

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Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2022.07.03.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2022.07.03.V1.

1 Introduction

The collaborative reduction of regional carbon emissions is an important means to promote the reduction of national carbon intensity. Current research mainly focuses on two topics: the regional allocation of responsibility of carbon emissions reduction[1–3], and the decline in regional carbon emissions intensity[4–6]. These two strands of research provide a reference for regional low carbon development; however, as the time is currently in the first emissions reduction target completion stages and second emissions reduction target implementation stages, further investigations should focus on the provincial performance evaluation in the process of promoting the national carbon emissions reduction.

The performance of carbon emissions reduction can be evaluated from multiple perspectives; previous studies investigated aspects such as emissions reduction efficiency[7–9], emissions reduction status[10], emissions reduction benefits[11], and emissions reduction potential[12,13]. However, these studies did not address the contribution of emissions reduction units in China's process of carbon emissions intensity reduction. Therefore, the evaluation of the carbon emissions reduction performance of the various provinces of China in the process of the carbon emissions intensity reduction of energy consumption can provide scientific support for the future achievement of provincial carbon emissions reduction and the formulation of carbon emissions reduction policies.

2 Metadata of the Dataset

The metadata of the Carbon emission reduction effectiveness dataset in provinces of China (2005−2016)[14] are shown in Table 1, which include the dataset name, authors, year, data format, data size, data files, data publisher, and data sharing policy, etc.

3 Methods of Data Development

3.1 The Algorithm Principle

For the purpose to select the relevant energy types to measure carbon emissions, the

Table 1 Metadata summary of the Carbon emission reduction effectiveness dataset in provinces of China (2005−2016)

Item	Description
Dataset full name	Carbon emission reduction effectiveness dataset in provinces of China (2005−2016)
Dataset short name	ProvCReducEffectChina_2005-2016
Authors	Cui, P. P. X-9461-2018, College of Geography and Environmental Science, Henan University/Key Laboratory of Geospatial Technology for the Middle and Lower Yellow River Regions (Henan University), cuipan3353@163.com Zhang, L. J. X-9839-2018, College of Geography and Environmental Science, Henan University/ Key Laboratory of Geospatial Technology for the Middle and Lower Yellow River Regions (Henan University), zlj7happy@163.com Qin, Y. C. N-4027-2016, College of Geography and Environmental Science, Henan University/ Key Laboratory of Geospatial Technology for the Middle and Lower Yellow River Regions (Henan University); Key Research Institute of Yellow River Civilization and Sustainable Development & Collaborative Innovation Center on Yellow River Civilization jointly built by Henan Province and Ministry of Education, Henan University, qinyc@henu.edu.cn
Geographical region	30 provinces in China (excluding Hong Kong Macao, Taiwan and Tibet)
Year	2005–2016 Data format .xlsx Data size 18.8 KB
Data files	4 Excel files: (1) energy consumption carbon emissions intensity in china; (2) correction coefficients of provincial energy consumption carbon emissions reduction; (3) decomposition factors' contribution rate to carbon emissions intensity decline in China; (4) ranking of provincial emissions reduction effectiveness and comprehensive contribution
Foundations	National Natural Science Foundation of China (42171295, 42071294, 42101206); Henan Province (2019SJGLX043, 222300420030, 222300420132)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing, 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[15]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

carbon emissions from energy consumption and the output value at national level could be obtained by adding the corresponding values of the 30 Chinese provinces. Moreover, the corresponding carbon emissions intensity could be deduced by the ratio of carbon emissions and output value. The correction coefficient was used to measure whether the magnitude of decline of carbon emissions intensity in various provinces was higher than the national value, thereby reflecting the effectiveness of carbon emissions reduction. On the basis of constructing the carbon emissions intensity formula, the intensity of the change of carbon emissions from national energy consumption was decomposed into the provincial energy consumption-related carbon emissions intensity and the shares of output value were assessed using the LMDI-I method. Superanalysis and positional relationship analysis were used to measure the relationship between the effectiveness and the contribution of carbon emissions reduction to carbon emissions intensity at national level, and to further determine the types of carbon emissions reduction performance.

3.2 Methods

3.2.1 Carbon Emissions Coefficient Method

Coal, coke, crude oil, gasoline, kerosene, diesel, fuel oil, and natural gas were selected as energy types and carbon emissions were calculated based on the default values and

calculation method provided by the "Guidelines for National Greenhouse Gas Inventory" of the United Nations Intergovernmental Panel on Climate Change (IPCC)[16]. The calculation formula employed is as follows:

$$C_i = \sum_{j=1}^{8} E_{ij} \times \beta_j \tag{1}$$

where C_i indicates the carbon emissions of province i, with i=1,2,……30, in ten thousand t CO_2; E_{ij} indicates the energy consumption for each energy type j in province i, with j=1,2,……8, in ten thousand t; and β_j indicates the carbon emissions coefficient for energy type j. The carbon emissions intensity of energy consumption at national and provincial level in China was expressed by the ratio of the corresponding total carbon emissions and GDP, in t CO_2/ten thousand Yuan; the GDP was converted to comparable GDP for 2005 using the GDP index.

3.2.2 The Correction Coefficient Method

Referring to related literature[17,18], and assuming that China's target of reduction of the carbon emissions intensity of energy consumption is consistent with China's 2020 carbon emissions intensity target, we quantitatively evaluated the effectiveness of the reduction of the carbon emissions intensity of energy consumption by constructing the correction coefficient index, which can measure whether the reduction of the carbon emissions intensity of provincial energy consumption is higher than the national average level.

3.2.3 The LMDI-I Method

The formula of carbon emissions intensity in China's energy consumption including provincial carbon emissions intensity and output value was constructed, and the decomposition model was selected following Ang[19]. The LMDI-I method was employed following the specific steps proposed by Cui, *et al*. (2020)[18].

4 Data Results

4.1 Dataset Composition

The dataset was archived in .xlsx format with a size of 18.8 KB. It included data on the carbon emissions intensity of energy consumption in China, the provincial correction coefficient of carbon emissions reduction, the decomposition effect of Chinese carbon emissions intensity change in energy consumption (including the contribution rate of provincial carbon emissions intensity, the output value share and their sum), and the ranking of provincial effectiveness and comprehensive contribution of emissions reduction in China.

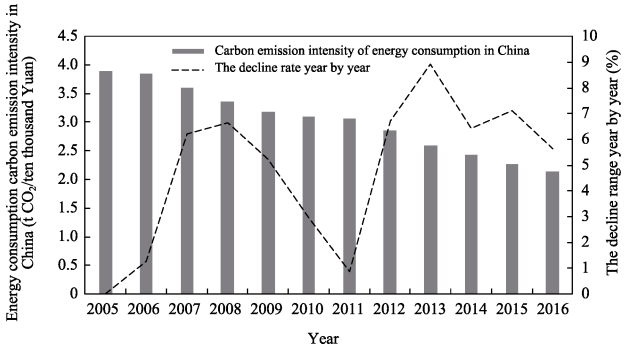


Figure 1 Evolution of the carbon emissions intensity of energy consumption in China from 2005 to 2016

4.2 Data Results

The data results of this study are as follows:

(1) The data of carbon emissions intensity of energy consumption in China from 2005 to 2016 and its decline rate year by year are illustrated in Figure 1.

(2) The correction coefficients of carbon emissions reduction from 2005 to 2016 are presented in Table 2 as divided into two periods, i.e., from

2005 to 2010 and from 2010 to 2016.

(3) The contribution rates of provincial carbon emissions intensity, output value share and their sum to the change of carbon emissions intensity of energy consumption in China from 2005 to 2016 are displayed in Table 3.

(4) The order of effectiveness and the comprehensive contribution of carbon emissions reduction in Chinese provinces from 2005 to 2010 and from 2010 to 2016 are displayed in Figure 2. A positive relationship was observed between the effectiveness and the comprehensive contribution of carbon emissions reduction, that is, the higher the level of the effectiveness and the comprehensive contribution of carbon emissions reduction, the higher the order value of two variables.

Table 2 Correction coefficients of provincial carbon emissions reduction from energy consumption in China

Province	2005–2010	2010–2016	Province	2005–2010	2010–2016	Province	2005–2010	2010–2016
Beijing	1.61	1.53	Zhejiang	0.88	1.15	Hainan	–3.75	0.68
Tianjin	1.45	1.54	Anhui	0.71	1.01	Chongqing	1.31	1.58
Hebei	0.93	1.05	Fujian	0.49	1.20	Sichuan	1.02	1.42
Shanxi	1.49	0.78	Jiangxi	0.99	0.93	Guizhou	1.10	1.16
Neimenggu	0.67	0.79	Shandong	0.86	0.72	Yunnan	1.09	1.76
Liaoning	1.38	0.88	Henan	1.07	1.31	Shaanxi	0.21	0.65
Jilin	1.37	1.33	Hubei	1.07	1.47	Gansu	1.06	1.12
Heilongjiang	1.07	1.01	Hunan	1.43	1.25	Qinghai	0.84	0.45
Shanghai	1.51	1.13	Guangdong	0.76	1.05	Ningxia	0.13	0.26
Jiangsu	1.25	0.79	Guangxi	0.46	0.75	Xinjiang	–0.45	–0.14

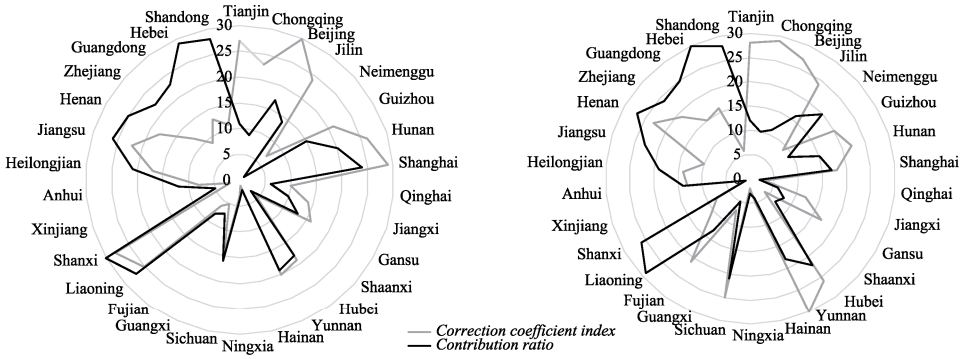
Table 3 Decomposition factors of the contribution rate of the carbon emissions intensity of energy consumption in China from 2005–2016 (%)

Province	2005–2010			2010–2016		
	Provincial carbon emissions intensity contribution	Provincial output value share contribution	Provincial comprehensive contribution	Provincial carbon emissions intensity contribution	Provincial output value share contribution	Provincial comprehensive contribution
Shanxi	11.05	2.42	13.47	4.63	1.62	6.25
Liaoning	9.24	–1.16	8.08	5.01	2.73	7.74
Jiangsu	8.22	–0.59	7.63	4.90	–0.17	4.73
Shanghai	4.48	0.99	5.47	2.68	0.60	3.28
Shandong	8.29	–0.09	8.21	7.23	0.05	7.28
Hunan	4.25	–0.52	3.73	3.45	–0.35	3.10
Beijing	2.51	0.45	2.96	1.85	0.27	2.12
Heilongjiang	3.50	0.65	4.15	3.09	0.54	3.63
Jilin	3.35	–0.83	2.51	3.07	0.06	3.13
Qinghai	0.31	–0.01	0.30	0.18	–0.08	0.10
Jiangxi	1.57	–0.04	1.53	1.53	–0.27	1.26
Gansu	1.77	0.59	2.36	1.82	–0.22	1.60
Ningxia	0.13	0.07	0.20	0.32	–0.10	0.22
Tianjin	2.59	–0.99	1.60	2.79	–0.64	2.15
Guizhou	2.44	0.18	2.62	2.70	–1.00	1.69
Xinjiang	–0.88	1.09	0.21	–0.37	–0.52	–0.89
Chongqing	1.97	–0.53	1.44	2.48	–0.67	1.81

(***To be continued on the next page***)

(***Continued***)

Province	2005–2010			2010–2016		
	Provincial carbon emissions intensity contribution	Provincial output value share contribution	Provincial comprehensive contribution	Provincial carbon emissions intensity contribution	Provincial output value share contribution	Provincial comprehensive contribution
Guangxi	0.63	–0.25	0.38	1.21	–0.12	1.09
Hebei	7.08	1.99	9.07	7.71	1.00	8.71
Zhejiang	3.46	0.89	4.35	4.42	0.59	5.01
Anhui	1.91	–0.19	1.73	3.02	–0.58	2.44
Hainan	–0.82	–0.02	–0.84	0.33	0.00	0.33
Henan	6.12	0.15	6.27	7.39	–0.21	7.18
Neimenggu	3.14	–4.18	–1.04	4.44	–0.38	4.06
Sichuan	3.22	–0.41	2.80	4.66	–0.50	4.15
Hubei	3.58	–0.55	3.03	5.03	–0.53	4.50
Yunnan	2.55	0.57	3.12	4.04	–0.44	3.60
Guangdong	3.89	0.62	4.51	5.47	0.61	6.09
Shaanxi	0.54	–0.96	–0.43	2.13	–0.70	1.44
Fujian	0.88	–0.30	0.58	2.59	–0.37	2.22



(a) Order of provincial carbon emission reduction efficiency and comprehensive contribution from 2005 to 2010 in China

(b) Order of provincial carbon emission reduction efficiency and comprehensive contribution from 2010 to 2016 in China

Figure 2 Order of provincial carbon emissions reduction effectiveness and comprehensive contribution from 2005 to 2016 in China.

5 Discussion and Conclusion

Based on relevant data and methods, this study evaluated the performance of carbon emissions reduction in the context of China's decline of carbon emissions intensity from energy consumption, focusing on its effectiveness and contributors. This study could better reflect provincial carbon emissions reduction efforts and contribution in the process of reduction of the carbon emissions intensity of energy consumption at national level. Differences and interlinkages were found between carbon emissions reduction effectiveness and contributions. Although these two were misplaced in order, they were found to have an overall positive relationship. This illustrates that the provincial comprehensive contributions has some laziness in exerting the effectiveness of carbon emissions reduction. In the future, the theoretical and empirical analysis of the relationship between these two should be further analyzed, so as to lay a foundation to determine the performance type of provincial carbon emissions reduction.

Author Contributions

Cui, P. P. carried out the overall design for the development of the dataset; Cui, P. P. and Zhang, L. J. collected and processed the data of energy consumption and economic output value; Zhang, L. J. and Qin, Y. C. designed the models and algorithms; Cui, P. P. conducted data validation, and wrote the data paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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