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Research Article

Tourism-Related CO_2 Emission and Its Decoupling Effects in China: A Spatiotemporal Perspective

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The rapid development of the tourism industry has been accompanied by an increase in CO_2 emissions and has a certain degree of impact on climate change. This study adopted the bottom-up approach to estimate the spatiotemporal change of CO_2 emissions of the tourism industry in China and its 31 provinces over the period 2000–2015. In addition, the decoupling index was applied to analyze the decoupling effects between tourism-related CO_2 emissions and tourism economy from 2000 to 2015. The results showed that the total CO_2 emissions of the tourism industry rose from 37.95 Mt in 2000 to 100.98 Mt in 2015 with an average annual growth rate of 7.1%. The highest CO_2 emissions from the tourism industry occurred in eastern coastal China, whereas the least CO_2 emissions were in the west of China. Additionally, the decoupling of CO_2 emissions from economic growth in China's tourism industry had mainly gone through the alternations of negative decoupling and weak decoupling. The decoupling states in most of the Chinese provinces were desirable during the study period. This study may serve as a scientific reference regarding decision-making in the sustainable development of the tourism industry in China.

1. Introduction

As one of the largest economic sectors in the world, the tourism industry plays an important role in creating jobs, driving exports, and generating prosperity across the world. According to the WTTC's report, the total contribution of travel and tourism to the global economy was USD7.61 trillion in 2016, rising to a total of 10.2% of the world's GDP. The travel and tourism sector supported 284 million people in employment, equivalent to 1 in 11 jobs on the planet [1]. Compared with other industries, such as metal products manufacturing, chemical industry, power supply, and transportation industries, the tourism industry has less energy consumption and pollution emissions. The direct CO_2 emissions and ecological multipliers from the tourism industry ranked the sixteenth and eleventh in the 23 industrial sectors in 2007 in China, respectively [2, 3]. However, this does not mean that the tourism industry is a "zero emission" or "green" industry. A research from the World Tourism Organization reported that global CO_2 emissions from the tourism industry made up about 4.9 percent of the total global greenhouse gas emissions in 2005 [4], which were mainly originated from tourism transportation (accounting for about 75% of total tourism CO_2 emissions) [5, 6], accommodation and catering (approximately 21%) [7, 8], and tourist activities (approximately 4%) [9–11].

In China, the tourism industry has gained high-speed and unprecedented development since the reform and opening up. Through thirty years of development, China's tourism revenue has jumped to the second place in the world in 2015. China has become the world's largest consumer of outbound tourism for many years and contributes more than 13% to the global tourism revenue. The statistics from China Tourism Academy indicated that, during the year 2016, the number of domestic and inbound tourists in China reached 4.58 billion person-times, and the total domestic and international income from the tourism industry approached CNY4.69 trillion, accounting for 6.3% of the country's GDP [12]. The remarkable development of China's tourism industry has been accompanied by a rapid increase in carbon dioxide emissions. According to the calculations of Wu and Shi, Chinese tourism-related CO_2 emissions approximately amounted to 51.34 Mt in 2008, or about 0.86% of the total CO_2 emissions in China [13]. After the Copenhagen Climate Change Conference, the Chinese government made a commitment in 2009 that tourism industry would reduce water and electricity consumption of star-rated hotels and A-rated scenic areas by 20% in five years [14].

Accordingly, Chinese scholars have paid more attention to CO_2 emissions from the tourism industry. Recent research methods to estimate tourism-related CO_2 emissions include life cycle assessment [15, 16], carbon footprint [17, 18], "bottom-up" approach [13], tourist consuming minus coefficient [19, 20], input-output method [21], and top-down approach [22]. These methods have been applied in tourism traffic [23, 24], accommodation [25–27], scenic areas [28, 29], and some provinces and cities [30–32]. However, there is a lack of systemic research on the dynamic change of CO_2 emissions of the tourism industry in China, especially in regional differences [33]. In the meantime, it is necessary to explore the link between CO_2 emissions and economic growth in the tourism industry. The decoupling index is becoming increasingly popular for measuring the relationship between environment pressure and economic growth [34–38]. In studies of the tourism industry, few literatures focused on the decoupling of CO_2 emissions from economic growth [30, 39–41]. However, a decoupling analysis of tourism-related CO_2 emissions from tourism economy based on the decoupling index has not been reported in the 31 Chinese provinces to date.

In China, the development level of the tourism industry varies from region to region. It is necessary to clarify the current situation and regional differences of tourism-related CO_2 emissions, which plays an important role not only in promoting energy saving and emission reduction in the whole tourism industry, but also in improving the pertinence and operability of carbon reduction policies and measures. In view of the importance of estimating spatiotemporal changes of CO_2 emission of the tourism industry and its decoupling effects as well as the shortage of related research in China, this study served as a preliminary attempt to address this gap in such studies. This paper revealed spatiotemporal dynamics of CO_2 emissions of the tourism industry from 2000 to 2015 and examined the occurrence of decoupling between the growth rates in CO_2 emissions and economic growth in the tourism industry in China and its 31 provinces during 2000–2015 and proposed some suggestions for the tourism industry to mitigate climate change and low-carbon development. The purpose of this paper was to provide reference for the formulation of CO_2 emission reduction strategies that will help the tourism industry adapt to climate change. The remainder of this paper was organized as follows. Section 2 presents the methods and related data used in this paper. Section 3 describes empirical results and discussion. Section 4 summarizes the conclusions and provides some suggestions.

2. Methodology and Data

2.1. Estimation of CO_2 Emissions from the Tourism Industry. Previous studies have shown that CO_2 emissions of the tourism industry were mainly from tourism transport, tourism accommodation, and tourist activities [4, 13, 44, 45]. Therefore, this study estimated CO_2 emissions associated with the tourism industry from the above three aspects using the bottom-up approach by the following equations [39]:

$$Q = Q_T + Q_H + Q_A, \quad (1)$$

where Q is the CO_2 emission of the tourism industry and Q_T, Q_H, and Q_A are CO_2 emissions of tourism transport, tourism accommodation, and tourist activities, respectively;

$$Q_T = \sum_{i=1}^{n} \alpha \cdot N_i \cdot D_i \cdot P_{Ti}, \quad (2)$$

where Q_T is the CO_2 emission of tourism transport; α is the proportion of tourists in passengers; N_i indicates the total number of passengers choosing transport mode i (civil aviation, highways, railways, and waterways); D_i is the trip distance for transport mode i; $N_i \cdot D_i$ denotes passenger turnover volume of transport mode i; P_{Ti} is CO_2 emission per unit for transport mode i (g/pkm); and

$$Q_H = 365 \cdot C \cdot R_k \cdot P_{He} \cdot P_{Hc} \cdot \frac{1}{1000} \cdot \frac{44}{12}, \quad (3)$$

where Q_H is the CO_2 emission of tourism accommodation; C is the scale of accommodation which is expressed by the number of beds; R_k is the annual occupancy rate of accommodation; P_{He} stands for energy consumption factor per bed night; P_{Hc} is CO_2 emissions factor per bed night; 1/1000 is the unit conversion coefficient; 44/12 refers to the ratio of the molecular weight of CO_2 to the atomic weight of C;

$$Q_A = \sum_{i=1}^{n} M_i \cdot w_i \cdot P_{Ai}, \quad (4)$$

where Q_A is the CO_2 emission of tourist activities; M_i is the number of tourists choosing activity type i; w_i is the proportion of activity type i; P_{Ai} is the CO_2 emission per unit for of activity type i.

2.2. Decoupling Index. Originally derived from physics, decoupling presents the separation and independent operation of two previously linked factors [46]. In 2002, OECD introduced decoupling into the research of agricultural policy, which then gradually expanded to the environment and other fields [34–37, 47]. Decoupling analysis is the significant method to characterize the relationship between environmental pressure or energy use and economic growth [48, 49]. Referring to the available literatures on decoupling index (DI) approach [35, 39, 42, 43], this study constructed DI for decoupling CO_2 emissions from tourism economy using the following equation:

$$\mathrm{DI} = \frac{\%\ \Delta Q}{\%\ \Delta G} = \frac{\left(Q_i/Q_{i-1} - 1\right)}{\left(G_i/G_{i-1} - 1\right)}, \quad (5)$$

where % ΔQ is the change rate of tourism-related CO_2 emissions between the last phase and the base period; % ΔG is the change rate of tourism economy from the last phase to

Table 1: Decoupling states on CO_2 emission from economic growth in the tourism industry.

Decoupling state	Relationship between tourism-related CO_2 emissions and tourism economy
↑ Strong decoupling	$\% \Delta Q < 0$, $\% \Delta G > 0$, $DI < 0$
Weak decoupling	$\% \Delta Q > 0$, $\% \Delta G > 0$, $0 < DI < 1$
Negative decoupling	$\% \Delta Q > 0$, $\% \Delta G > 0$, $DI > 1$
Recessive decoupling	$\% \Delta Q < 0$, $\% \Delta G < 0$, $DI > 1$
Weak negative decoupling	$\% \Delta Q < 0$, $\% \Delta G < 0$, $0 < DI < 1$
Strong negative decoupling	$\% \Delta Q > 0$, $\% \Delta G < 0$, $DI < 0$

Source. Revised by [35, 39, 42, 43].

the base period, which is represented by the tourism revenue in this study; Q_i and Q_{i-1} represent tourism-related CO_2 emissions in the last phase and the base period, respectively; similarly, G_i and G_{i-1} represent tourism economy in the last phase and the base period, respectively.

In order to distinguish the decoupling state, Tapio defined eight logical possibilities [35]. However, Tapio's division is too elaborate and cannot be simply applied to reflect the decoupling relationship between energy use or environmental pressure and economic growth [46]. The decision on decoupling criterion often requires to be comprehensively determined by practical situations. For the above reasons, this paper gave six possible decoupling states between tourism-related CO_2 emissions and tourism economy, which can be interpreted as different degrees of the decoupling process (Table 1). The six possible decoupling states were given the following interpretation:

(1) Strong decoupling: it represents the case when the change rate of tourism-related CO_2 emissions is negative and that of the tourism economy is positive, and the relationship is optimal.

(2) Weak decoupling: it represents the case when the growth rate of tourism-related CO_2 emissions is less than that of the tourism economy, and the relationship is desirable.

(3) Negative decoupling: it represents the case when the growth rate of tourism-related CO_2 emissions is greater than that of the tourism economy.

(4) Recessive decoupling: it represents the case when the decline rate of tourism-related CO_2 emissions is greater than that of the tourism economy.

(5) Weak negative decoupling: it represents the case when the decline rate of tourism-related CO_2 emissions is less than that of the tourism economy.

(6) Strong negative decoupling: it represents the case when the growth rate of tourism-related CO_2 emissions is positive and that of the tourism economy is negative, and the relationship is the most unfavorable.

2.3. Data Sources and Processing. The research period in this study ranged from 2000 to 2015. All statistical data were collected from China Statistical Yearbook series for the period 2001–2016, the Yearbook of China Tourism Statistics series for the period 2001–2016, Tourism Sample Survey Information series for the period 2001–2016, and the relevant statistical yearbooks of the 31 Chinese provinces (autonomous regions and municipalities) [50–52]. Hong Kong, Macau, and Taiwan were not analyzed because of the lack of data. In addition, this paper adjusted the total income of the tourism industry on the basis of 2000 constant prices in order to remove the factor of price changes among different years.

Some parameters were obtained based on a full reference of the previous empirical studies. For tourism transportation, according to the *Reputation Report for China Tourism Cites on Network*, *Development Report of China Civil Aviation*, and the researches of Wu and Shi [13] and Wei et al. [23], the value of α was 32.7%, 27.9%, 10.6%, and 36.7% for railways, highways, waterways, and civil aviation, respectively. CO_2 emission per unit for different transport modes was, respectively, set as 27 g/pkm, 133 g/pkm, 106 g/pkm, and 137 g/pkm for railways, highways, waterways, and civil aviation, respectively [4, 15, 23, 53]. For tourism accommodation, P_{He} were severally allocated as 155 MJ, 130 MJ, 110 MJ, 70 MJ, and 40 MJ for five-star hotels, four-star hotels, three-star hotels, two-star hotels, and one-star hotels, respectively [5, 13, 54]. In light of the conversion coefficient of the World Power Organization in 1990, P_{Hc} was set as 43.2 gC/MJ [5]. For tourist activities, there were five types, that is, sightseeing, leisure vacation, business conference, visiting relatives and friends, and other activities in the *Tourism Sample Survey Information*, and the corresponding CO_2 emission per unit was, respectively, 417 g/visitor, 1670 g/visitor, 786 g/visitor, 591 g/visitor, and 172 g/visitor [13]. Furthermore, this paper assumed the above-mentioned parameters to be constant due to the relatively short study span of 2000 to 2015.

3. Results and Discussion

3.1. Spatiotemporal Dynamics of CO_2 Emission of the Tourism Industry. Figure 1 presents the temporal dynamics of the total amount and the shares of CO_2 emissions from the tourism industry in China from 2000 to 2015. It can be seen from Figure 1 that the total CO_2 emissions of the tourism industry in China increased from 2000 to 2015, except for a decline in 2013. China's overall CO_2 emissions of the tourism industry increased from 37.95 Mt in 2000 to 100.98 Mt in 2015, an average annual growth rate of 7.1% during this time span. It was also observed that tourism transport was the primary contributor to CO_2 emissions of the tourism

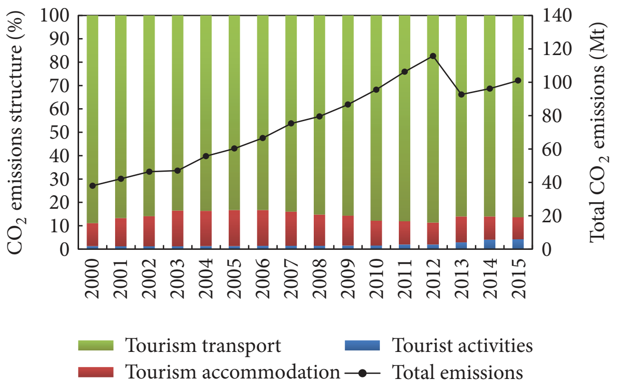

Figure 1: Total CO_2 emission and its shares of the tourism industry in China during 2000–2015.

industry, accounting for averagely more than 83% from 2000 to 2015. It can be concluded that tourism transport had the greatest impact on the tourism industry in CO_2 emissions. Comparatively, CO_2 emissions of tourism accommodation and tourist activities showed slight changes, which indicated that they only made rather small impacts on the changes in CO_2 emissions of the tourism industry during this period.

As shown in Figure 1, the share of tourism accommodation in total emissions appeared to be increased firstly and then decreased from 2000 to 2015. One possible explanation was that some hotels introduced a package of low-carbon measures since the Chinese government published plans to reduce CO_2 emissions of star-rated hotels in 2009 [14]. The share of tourist activities in total emissions took on a rising trend in this period of time, which indicated that some measures should be adopted for raising tourists' low-carbon sense in order to reduce their CO_2 emissions. As for the share of tourism transport, it declined firstly and then increased gradually before being reduced within the study period. Statistics released by the China Ministry of Public Security showed that the number of car owners and vehicle drivers in China increases every year, reaching 217 million and 342 million, respectively, in 2017, which promotes the development of self-driving tours, thus contributing to the growth of CO_2 emissions of tourism transport. But at the same time, the number of new energy vehicles is increasing year by year, with 1.53 million vehicles in 2017, accounting for 0.7 percent of the total number of vehicles [55]. In addition, with the increase of operation mileage around the country, the G-Series High-Speed Train has become the first choice of more and more tourists for the way of their journey. Being a low-carbon, environment-friendly, and green transport means, CO_2 emissions per passenger on the G-Series High-Speed Train are about one-fourth of those generated by flying or driving [56]. It is concluded that the CO_2 emissions of tourism transportation and total tourism industry have decreased in recent years.

Figure 2 shows the CO_2 emissions from the tourism industry of each province in 2000 and 2015, as well as their average growth rates. As shown in Figure 2, the amounts and average growth rates of CO_2 emissions from the tourism industry were different among the 31 provinces of China. Guangdong produced the most CO_2 emissions of the tourism industry in both 2000 and 2015. The listed emissions in Guangdong ranged from 4.59 Mt in 2000 to 17.89 Mt in 2015. Rounding up the top 10 were Guangdong, Jiangsu, Zhejiang, Sichuan, Hebei, Beijing, Henan, Hunan, Hubei, and Shandong in 2000 and Guangdong, Beijing, Shanghai, Sichuan, Jiangsu, Hunan, Henan, Hubei, Zhejiang, and Anhui in 2015. By contrast, Tibet recorded the lowest emissions, emitting only 0.29 Mt in 2015, which was 1.62% that of Guangdong. Qinghai and Ningxia also ranked last.

The average growth rates of the 31 provinces varied from one another even though the emissions of all provinces in 2015 are higher than those in 2000 (Figure 2). The emissions of Tibet, Tianjin, Shanghai, Qinghai, and Beijing, respectively, had the fastest average growth rates of 43.20%, 38.76%, 31.31%, 25.17%, and 24.57%. Hebei had the lowest average growth rate of 1.64%, followed by Guangxi and Zhejiang with average growth rates of 3.52% and 4.40%, respectively.

3.2. Spatiotemporal Change of Decoupling State. Table 2 lists the decoupling state of CO_2 emissions from economic growth in the tourism industry. The most common state was weak decoupling that occurred in 9 years of the study period, and the decoupling indexes were 0.13, 0.72, 0.82, 0.92, 0.58, 0.95, 0.97, 0.52, and 0.73, whose corresponding years were, respectively, 2003, 2005, 2006, 2007, 2008, 2009, 2010, 2014, and 2015. The CO_2 emissions presented negative decoupling with tourism economy in the following periods: 2001, 2002, 2004, 2011, and 2012. And the decoupling indexes were 1.32, 1.11, 1.83, 1.18, and 1.13, respectively. Strong decoupling only appeared in 2013 and the decoupling index was −2.57. Generally speaking, the decoupling relationship indicated that "weak decoupling" and "negative decoupling" were the main states during the study period. Over the period of 2000 to 2015, China's tourism industry had experienced a clear tendency toward decoupling, moving from negative decoupling in 2001–2004, accompanied by weak decoupling in 2003, to a long period of weak decoupling in the period 2005–2010, next into short-term negative decoupling in 2011-2012, followed by strong decoupling in 2013 and then weak decoupling in 2014-2015. In general, the decoupling state of CO_2 emissions from economic growth in the tourism industry in China was desirable.

The decoupling state for the tourism industry of the 31 provinces of China from 2000 to 2015 is shown in Figure 3. According to the decoupling index defined in Section 2.3, only two decoupling states, negative decoupling and weak decoupling, occurred during the study period. The occurrence of negative decoupling only appeared in Shanghai, Tibet, and Beijing, and the decoupling indexes were 1.53, 1.51, and 1.17, respectively, which indicated that CO_2 emissions from the tourism industry increased more rapidly than tourism economy in the three provinces. The development in the remaining provinces showed weak decoupling and the decoupling indexes were less than 1, as both tourism-related CO_2 emissions and tourism economy increased. However, the growth rates of tourism-related CO_2 emissions were lower than that of tourism economy over the study period.

Table 2: The decoupling state in China for the period 2000–2015.

	% ΔQ	% ΔG	DI	Decoupling state
2000-2001	11.03	8.34	1.32	Negative decoupling
2001-2002	10.09	9.13	1.11	Negative decoupling
2002-2003	1.28	10.04	0.13	Weak decoupling
2003-2004	18.52	10.11	1.83	Negative decoupling
2004-2005	8.22	11.40	0.72	Weak decoupling
2005-2006	10.47	12.72	0.82	Weak decoupling
2006-2007	13.08	14.23	0.92	Weak decoupling
2007-2008	5.58	9.65	0.58	Weak decoupling
2008-2009	8.96	9.40	0.95	Weak decoupling
2009-2010	10.28	10.64	0.97	Weak decoupling
2010-2011	11.23	9.54	1.18	Negative decoupling
2011-2012	8.88	7.86	1.13	Negative decoupling
2012-2013	−19.95	7.76	−2.57	Strong decoupling
2013-2014	3.81	7.30	0.52	Weak decoupling
2014-2015	5.04	6.91	0.73	Weak decoupling

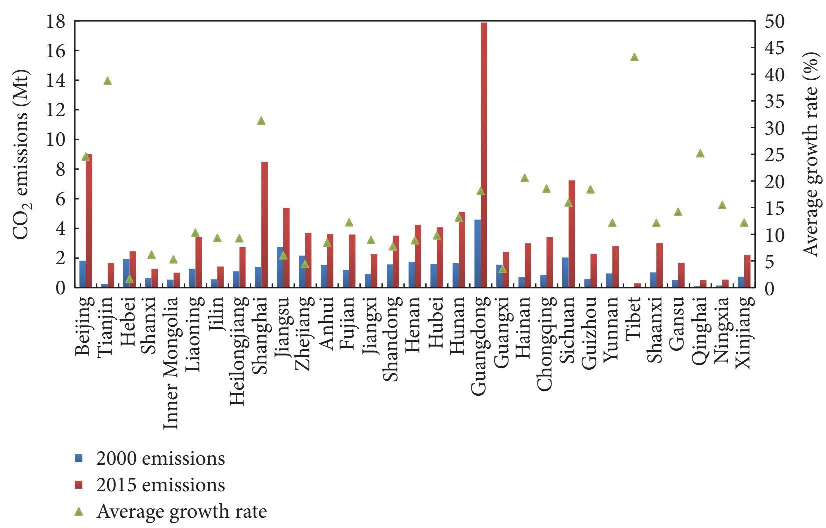

Figure 2: CO_2 emissions and average growth rates of the tourism industry for the 31 Chinese provinces in 2000 and 2015.

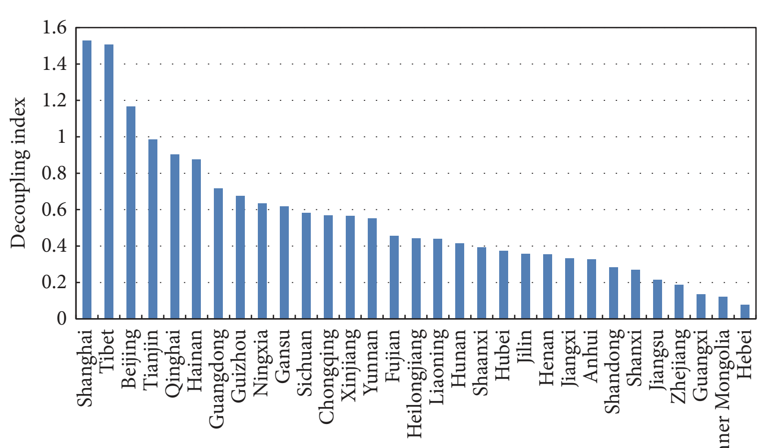

Figure 3: The decoupling index of the 31 provinces of China from 2000 to 2015.

Generally speaking, the decoupling statuses of CO_2 emissions from economic growth in tourism industry were on the level of sustainable development in the vast majority of Chinese provinces.

3.3. Discussion. Because the tourism industry rapidly expands and has high relevance with other industries, there are huge amounts of CO_2 emissions from the tourism industry. Therefore, the negative influence of the tourism development on climate change and ecological environment cannot be ignored. Since the adoption of a strategy of reform and opening up in China, the tourism industry has experienced a remarkable growth and has become an important sector of the Chinese economy. Economic growth in tourism industry was accompanied by increasing CO_2 emission levels. In China, the number of tourists increased from 0.79 billion in 2000 to 4.13 billion in 2015. In addition, the total tourism revenue reached CNY4.13 trillion in 2015, which was further improved from CNY0.45 trillion in 2000. The rapid increase of tourists brought about a large amount of carbon dioxide in the process of travel by choosing different types of transportation, accommodations, and activities. At the provincial level, the highest CO_2 emissions from the tourism industry occurred in eastern coastal China such as Guangdong, Beijing, Shanghai, Shandong, Zhejiang, and Jiangsu. Abounding in tourism resources, these regions' tourism industry was highly developed, which attracted a large number of domestic and foreign tourists. The least carbon dioxide emissions were in the west of China, consisting of Tibet, Qinghai, and Ningxia. In these areas, the tourism industry was on the rise along with the improvement of transport facilities and enhancement of reception capacity. Especially in Tibet, the opening of Qinghai-Tibet railway has attracted many tourists from around the world since 2006, which caused the highest average growth rates of CO_2 emissions from tourism industry among all provinces.

This study primarily showed an understanding of spatiotemporal change of CO_2 emissions from the tourism industry in China. More importantly, as an exploratory study, the findings discovered dynamic change in the relationship between CO_2 emissions and economic growth of the tourism industry. At the national level, the trend of weak decoupling occurred for 9 years, and negative decoupling appeared for 5 years during the period 2000–2015. Furthermore, the average value of decoupling index was 0.69 over the study period, which indicated that tourism economy presented weak decoupling as a whole. In addition, viewed from the decoupling index of various provinces, negative decoupling mainly occurred in the most developed tourism areas and quickly developing tourism regions. The reason for negative decoupling may be attributed to the percentage change of tourism-related CO_2 emission which was higher than that of tourism economy. Hence, these provinces should take steps to curb tourism-related CO_2 emissions while ensuring the long-term stable growth of tourism economy in the future development.

The tourism industry is strongly related to other industries. It is very complicated to determine CO_2 emissions of the tourism industry due to the lack of complete statistics. Owing to the restriction of analysis conditions, the study on the calculation of CO_2 emissions of tourism transport, tourism accommodation, and tourist activities is still to be perfected. For example, some parameters were selected by referring to other scholars' research results. An in-depth investigation of the coefficients will further improve the accuracy of the estimates. This paper is a rough relative estimate of CO_2 emissions from the tourism industry in China, which can reflect the time change trend and regional differences to a certain extent. In addition, the study period is from 2000 to 2015. During this period, new energy and low-carbon technologies have been used in transport, hotels, and scenic spots, which can cause per-unit parameters of carbon emissions to decrease. But these parameters are not fast enough to deviate greatly from the total amount and the estimations [13]. As a development trend, technological innovation, clean energy, energy conservation, and emission reduction will promote the transformation and upgrade and the low-carbon development of the tourism industry. With the Paris Agreement on Climate Change coming into effect, promoting green and low-carbon development has constituted an important part of ecological civilization construction in China. Future changes of tourism-related CO_2 emission and its decoupling effects in China are also worth paying attention to.

4. Conclusions and Suggestions

4.1. Conclusions. This study calculated the spatiotemporal change of CO_2 emissions of the tourism industry based on a bottom-up approach from 2000 to 2015. Then, the relationship between CO_2 emission and economic growth in the tourism industry was analyzed by the decoupling index. The conclusions were as follows.

(1) At the national level, the total CO_2 emissions of the tourism industry increased from 37.95 Mt in 2000 to 100.98 Mt in 2015 with an average annual growth rate of 7.1%. The results also showed that CO_2 emissions of the tourism industry in China were dominated by tourism transport, which accounts for over 83% of total CO_2 emissions. At the provincial level, the highest CO_2 emissions from the tourism industry occurred in eastern coastal China such as Guangdong, Beijing, Shanghai, Shandong, Zhejiang, and Jiangsu. The least carbon dioxide emissions were in the west of China, consisting of Tibet, Qinghai, and Ningxia.

(2) From 2000 to 2015, the decoupling of CO_2 emissions from economic growth in the tourism industry mainly experienced the alternations of negative decoupling and weak decoupling. By examining the historical evolution of decoupling analysis during 2000–2015, this study can obtain the fact that tourism economy grew faster than tourism-related CO_2 emissions in China. Generally speaking, the decoupling states of CO_2 emissions from economic growth in the tourism industry in the 31 Chinese provinces were desirable, except for Shanghai, Tibet, and Beijing.

(3) Future studies should pay more attention to the changes of CO_2 emissions from the tourism industry accompanied by the broad application of the energy-saving technology. Some key parameters demand more accurate findings

and further investigations. Furthermore, comparative studies using different estimating methods, such as life cycle assessment, carbon footprint, tourist consuming minus coefficient, and input-output method, can give more valuable information of the spatiotemporal change of tourism-related CO_2 emissions in China.

4.2. Suggestions. According to the above results, this study puts forward some suggestions in order to slow down the impact of the tourism industry on climate change.

(1) Relevant tourism administrations should set up low-carbon tourism standards and action plans, give a systematic guarantee of policies funds and technology for low-carbon tourism development, strengthen the publicity and marketing efforts of green tourism and low-carbon tourism, expand international exchanges and cooperation, and introduce an international advanced management model of low-carbon tourism.

(2) Tourism enterprises should supply low-carbon routes and products. As the guider of low-carbon tourism, travel agencies can design low-carbon routes and methods depending on vast forests, lakes, and wetlands. Tourism attraction should build the closed-loop feedback cycle process of "resource-product-recycling-resource" in the process of tourism resources development and tourism activities. Tourism traffic should improve the energy efficiency, optimize the energy structure, demand, and supply, and actively explore the application of new clean energy [57]. Hotels and restaurants should use low-carbon technology in building, heating, air conditioning, lighting, electrical appliances, and water resources utilization and make full use of solar energy, biological energy, organic energy, and other clean energy sources.

(3) Tourists with low-carbon demand will lead to low-carbon supply in tourism. Tourists should develop strong low-carbon and environmental awareness and then shift to actual action. Green and low-carbon behaviors should run through the entire travel process, such as catering, lodging, transportation, sightseeing, shopping, and entertainment, in order to really implement the consumption patterns of low-carbon tourism [58].

(4) Policy measures of low-carbon tourism should be formulated considering the social and economic development degree and tourism resources endowment of different provinces. The economically developed eastern China should further promote the transformation and upgrading of the tourism industry, increase investment and R&D efforts in energy saving and emission reduction technology, and improve the energy efficiency and optimize the energy structure of the tourism industry by means of science and technology. The central and western regions of China should improve the energy efficiency of the tourism industry, reduce the carbon intensity of the tourism industry, and vigorously develop clean energy, such as wind energy, solar energy, and biomass energy. In addition, clean development mechanisms or cooperation projects, such as carbon compensation, carbon neutralization, and carbon trading, can also be carried out among different provinces.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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