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Research Article

Decomposition of China's Carbon Emissions Intensity from 1995 to 2010: An Extended Kaya Identity

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This paper employs an extended Kaya identity as the scheme and utilizes the Logarithmic Mean Divisia Index (LMDI II) as the decomposition technique based on analyzing CO_2 emissions trends in China. Change in CO_2 emissions intensity is decomposed from 1995 to 2010 and includes measures of the effect of Industrial structure, energy intensity, energy structure, and carbon emission factors. Results illustrate that changes in energy intensity act to decrease carbon emissions intensity significantly and changes in industrial structure and energy structure do not act to reduce carbon emissions intensity effectively. Policy will need to significantly optimize energy structure and adjust industrial structure if China's emission reduction targets in 2020 are to be reached. This requires a change in China's economic development path and energy consumption path for optimal outcomes.

1. Introduction

Since reform and opening-up, China has become the second largest economy in the world where rapid economic growth was accompanied by rising energy consumption and carbon emissions. From 1995 to 2010, China's primary energy consumption increased sharply from 1.50 to 3.75 billion ton coal equivalents (tec). China's carbon emissions continue to grow rapidly correlating to the level energy consumption. From 331.21 million tons in 1995 to 8782.58 million tons in 2010, China becomes the world's biggest emitter of carbon dioxide [1, 2]. But the country's carbon dioxide emissions per capita are also relatively high compared to other countries. In order to actively respond to climate change and to develop low carbon economy, China has an ambitious goal to reduce carbon intensity by 40–45% by 2020, from 2005 levels [3]. In the Twelfth Five-Year Plan of China, China aims to reduce its energy intensity and carbon emission intensity by as much as 17% and 16% by 2015, respectively, from 2010 levels [4]. How to control carbon emissions in China has become a focus of policy makers. The way to decrease carbon emission intensity has a significant impact on China's economic development, energy security, and environmental protection in the future. Therefore, the analysis of factors affecting carbon emissions intensity constitutes a vital part of low carbon economy. Logarithmic Mean Divisia Index (LMDI) theory was first proposed by Ang and Zhang and has over 10 years of history [5]. Logarithmic Mean Divisia Index (LMDI) theory has been widely used in analysis of energy and carbon emissions because of its perfect decomposition, consistency in aggregation, path independency, and an ability to handle zero values [6–9]. In recently years, LMDI has been adopted to study energy-related carbon emissions in different scale levels based on different types of energy and sectors. Peters and Hertwich, Greening et al., and Pani and Mukhopadhyay study energy consumption and carbon emissions in the world by utilizing LMDI model [10–12]. Greening et al. conduct the secondary decomposition of CO_2 emissions from sectors [13, 14]. Based on completed decomposition technique, many scholars study CO_2 emissions in different countries, such as Thailand [15], India [16], the United Kingdom [17], Turkey [18], South Korea [19], Brazil [20], Greece [21], and Ireland [22]. Completed decomposition technique is also applied to research energy-related CO_2 emissions in China [23–30]. Many of these researches are based on a small number of kinds of energy and sectors, thereby decreasing the accuracy of the accounting.

This paper utilizes LMDI model to study energy-related carbon emissions intensity from 1995 to 2010 based on different types of energy (such as coal, coke, crude oil, gasoline, kerosene, diesel oil, fuel oil, and natural gas) and sectors (such as primary industry, manufacturing industry, electric power, gas and water production and supply industry, construction industry, transportation, storage, postal and telecommunications services industry, wholesale, retail trade and food services industry, and other tertiary sectors). This paper extends further the decomposition literature to China, and aims to identify, quantify, and explain driving forces (such as industrial structure, energy intensity, and energy structure) acting to change carbon emissions intensity.

2. Decomposition Methodology

2.1. Extended Kaya Identity of Carbon Emissions Intensity. Carbon emissions intensity is the carbon dioxide emissions per capita. Kaya identity was first proposed by Professor Yoichi Kaya on IPCC in 1990 [31]. The Kaya identity is as follows:

$$C = \frac{C}{E} \times \frac{E}{\mathrm{GDP}} \times \frac{\mathrm{GDP}}{P} \times P, \tag{1}$$

where C, E, GDP, and P denote carbon emissions, energy consumption, gross domestic product, and population, respectively.

In this paper, carbon emissions intensity is decomposed into predefined factors of industrial structure, energy structure, energy intensity, and other factors based on current theory and literature as following extended Kaya identity:

$$I = \frac{C}{Y} = \sum_{i,j} \frac{C_{ij}}{Y} = \sum_{i,j} \frac{C_{ij}}{E_{ij}} \times \frac{E_{ij}}{E_i} \times \frac{E_i}{Y_i} \times \frac{Y_i}{Y}. \tag{2}$$

The following variables are applied in (2).

I is carbon emissions intensity.

C is total Carbon emissions of all fuel types.

Y is GDP.

Y_i is economic output of sector i.

E_i is total energy consumption in sector i.

E_{ij} is the amount of fossil fuel j consumed in sector i.

C_{ij} is the amount of carbon emissions of fossil fuel j consumed in sector i.

Within this scheme i and j denote sector and fuel type, respectively. The carbon emissions intensity utilizing this way can be rewritten as following extended Kaya identity:

$$I = \frac{C}{Y} = \sum_{i,j} \frac{C_{ij}}{Y} = \sum_{i,j} R_{ij} \times e_{ij} \times Q_i \times S. \tag{3}$$

Within this scheme the following nomenclature is employed.

$R_{ij} = C_{ij}/E_{ij}$ is the carbon emission factors in sector i.

$e_{ij} = E_{ij}/E_i$ is ratio of fossil fuel j to total fossil fuels in sector i.

$Q_i = E_i/Y_i$ is energy intensity of sector i.

$S = Y_i/Y$ is the share of economic output in sector i in total industrial output.

2.2. Decomposition of Carbon Emissions Intensity. Logarithmic Mean Divisia Index (LMDI II) is applied as the method to decompose (2) and (3). According to (2) and (3), the changes in carbon emissions intensity from base year to target year can be expressed as follows:

$$\Delta I_{\mathrm{tot}} = \Delta I_T - \Delta I_0 = \Delta I_{\mathrm{str}} + \Delta I_{\mathrm{int}} + \Delta I_{\mathrm{mix}} + \Delta I_{\mathrm{emf}}, \tag{4}$$

where ΔI_{tot} denotes the total effects of carbon emissions intensity, ΔI_{str} denotes industrial structure effect, ΔI_{int} denotes energy intensity effect, ΔI_{mix} denotes energy consumption structure effect, and ΔI_{emf} denotes carbon emissions factor effect. T and 0 represent the target year and base year, respectively. According to Logarithmic Mean Divisia Index (LMDI) theory [5–9], ΔI_{tot}, ΔI_{str}, ΔI_{int}, ΔI_{mix}, and ΔI_{emf} can be written as

$$\Delta I_{\mathrm{str}} = \sum_{i=1}^{8} \sum_{j=1}^{8} L\left(W_{ij}^t, W_{ij}^0\right) \times \ln\left(\frac{S_i^T}{S_i^0}\right), \tag{5}$$

$$\Delta I_{\mathrm{int}} = \sum_{i=1}^{8} \sum_{j=1}^{8} L\left(W_{ij}^t, W_{ij}^0\right) \times \ln\left(\frac{Q_i^T}{Q_i^0}\right), \tag{6}$$

$$\Delta I_{\mathrm{mix}} = \sum_{i=1}^{8} \sum_{j=1}^{8} L\left(W_{ij}^t, W_{ij}^0\right) \times \ln\left(\frac{e_{ij}^T}{e_{ij}^0}\right), \tag{7}$$

$$\Delta I_{\mathrm{emf}} = \sum_{i=1}^{8} \sum_{j=1}^{8} L\left(W_{ij}^t, W_{ij}^0\right) \times \ln\left(\frac{R_{ij}^T}{R_{ij}^0}\right), \tag{8}$$

where $W_{ij} = R_i \times e_{ij} \times Q_i \times S$ and $L(W_{ij}^t, W_{ij}^0) = (W_{ij}^t - W_{ij}^0)/\ln W_{ij}^t - \ln W_{ij}^0$.

The ΔI_{emf} in (8) is zero because the carbon emissions factors of various types of fossil energy are constant. However, carbon emissions will be affected by the changes in energy consumption structure. Therefore, R_{ij} is replaced by average carbon emissions factor R_i and R_i is written as follows:

$$R_i = \sum_j e_{ij} \times r_j, \tag{9}$$

where r_j represents the carbon emissions factor of fossil fuel j.

3. Data and Decomposition Results

3.1. Data Analysis. This study collected annual data on energy consumption and GDP for 1995–2010 from National Bureau of Statistics of China [1]. The economic output of sectors is measured at 1995 prices. The energy consumption in sectors is measured in ton coal equivalents (tec) according to the standard coal conversion coefficients of Intergovernmental Panel

Table 1: Annual time series of energy consumption in China from 1995 to 2010. (Unit: Mtce).

Year	Coal	Coke	Crude oil	Gasoline	Kerosene	Diesel oil	Fuel oil	Natural gas
1995	983.42	104.19	212.67	42.81	7.54	62.97	52.77	21.54
1996	1033.84	104.89	226.65	46.83	8.17	68.36	50.93	22.45
1997	994.65	106.14	248.11	48.73	10.03	77.10	54.98	23.73
1998	924.96	107.61	248.51	48.98	9.88	76.97	54.70	24.60
1999	902.63	101.58	270.71	49.74	12.13	90.80	56.20	26.10
2000	889.57	101.41	303.32	51.57	12.80	98.71	55.33	29.76
2001	901.53	106.85	304.90	52.94	13.10	103.58	57.37	33.31
2002	975.77	119.91	322.02	55.17	13.52	111.73	55.34	35.44
2003	1169.54	140.89	356.04	59.92	13.56	122.54	60.29	41.17
2004	1382.86	167.73	410.71	69.09	15.61	144.18	68.34	48.17
2005	1546.87	215.71	429.81	71.41	15.84	159.88	60.60	58.18
2006	1708.72	268.03	460.65	77.13	16.55	172.46	62.41	68.17
2007	1847.48	294.69	486.18	81.21	18.30	182.04	58.25	84.42
2008	2007.87	290.45	507.10	90.43	19.04	197.18	46.25	98.72
2009	2113.14	309.39	544.71	90.82	21.18	200.45	40.40	108.70
2010	2230.31	327.24	612.51	101.32	25.66	213.23	53.69	130.63

Table 2: Annual time series of carbon emissions in China from 1995 to 2010.

Year	Agriculture	Excavation	Manufacturing	Electric power, gas, and water production and supply	Construction	Transportation, storage, and postal services	Wholesale, retail trade, and food services	Other
1995	72.79	261.03	1914.41	838.10	12.23	109.18	27.53	76.88
1996	74.30	282.69	1930.55	944.61	16.30	109.24	29.95	85.04
1997	76.09	311.41	1887.09	976.37	15.50	137.69	27.55	65.21
1998	77.37	281.31	1796.32	969.19	19.91	152.60	29.86	60.13
1999	77.72	272.45	1773.15	992.55	19.31	174.17	32.11	66.45
2000	78.36	277.84	1771.92	1041.16	20.26	186.32	30.74	68.97
2001	79.54	285.62	1781.88	1084.75	21.22	190.26	31.62	71.17
2002	83.21	299.87	1887.03	1225.59	22.52	204.15	32.61	71.46
2003	84.50	381.85	2186.53	1464.45	23.61	231.91	36.45	70.25
2004	103.03	276.12	2718.49	1773.06	26.75	274.02	40.57	80.48
2005	105.40	332.75	3038.43	1964.08	28.69	307.13	43.93	78.26
2006	109.93	348.34	3388.65	2225.63	29.94	343.30	46.60	77.74
2007	107.97	390.81	3624.15	2429.97	30.36	382.67	50.38	73.01
2008	66.63	434.50	3914.11	2504.42	29.60	423.03	45.32	104.83
2009	68.73	468.30	4106.32	2655.81	32.43	435.26	51.42	107.02
2010	73.44	522.84	4453.59	2776.81	37.21	477.83	53.24	115.53

on Climate Change (IPCC) [32]. Carbon emissions are measured in metric tons of carbon dioxide based on energy consumption and carbon emissions coefficients of IPCC. The time series data of energy consumption and carbon emissions in China from 1995 to 2010 are presented in Tables 1 and 2, respectively.

Figure 1 shows the changes in China's energy consumption and energy mix based on energy type from 1995 to 2010. The changes in total primary energy consumption were from 72.5% to 68.3% for coal (coal and coke), from 26.7% to 30.3% for oil (crude oil, gasoline, kerosene, diesel oil, and fuel oil), and from 0.8% to 1.4% for natural gas. The ratio of oil and natural gas to total primary energy consumption has increased fast in recent years. However, the energy consumption in China still relies heavily on coal, which has severe implications for carbon emissions. Carbon emissions and environmental problems become increasingly prominent because of increasing coal consumption.

Figure 2 shows the changes in China's carbon emissions and carbon emissions mix based on different sectors from 1995 to 2010. Rapid development in manufacturing and electric power, gas, and water production and supply was accompanied by rising carbon emissions since 2001. Manufacturing is the biggest contributor to China's carbon

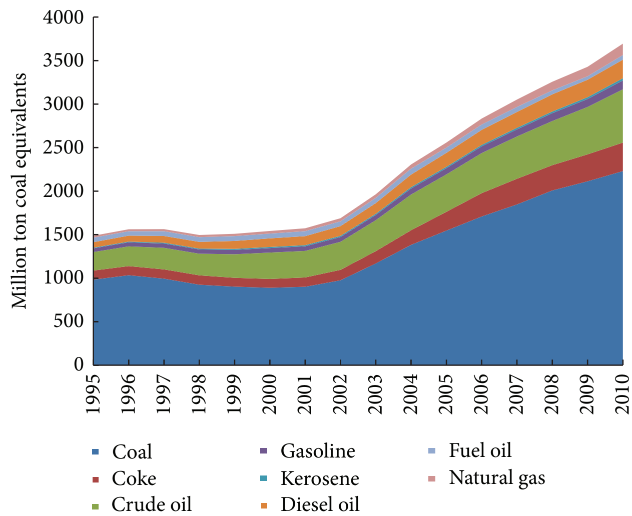

FIGURE 1: Energy consumption in China from 1995 to 2010.

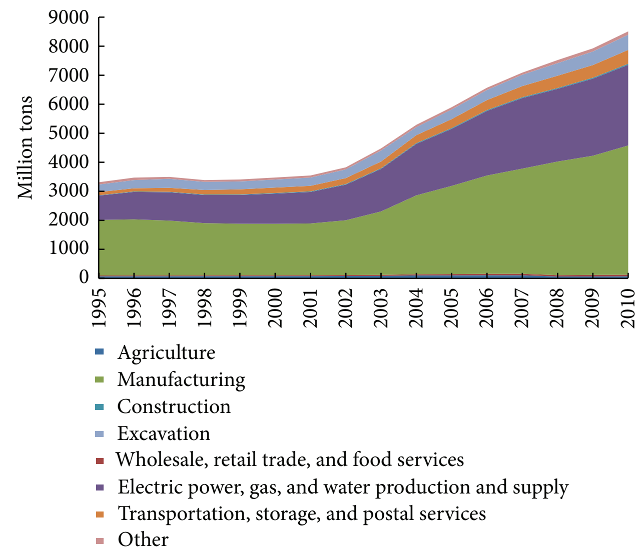

FIGURE 2: Carbon emissions of different sectors in China from 1995 to 2010.

emissions and electric power, gas, and water production and supply are the second contributor. The ratio of carbon emissions in manufacturing and electric power, gas, and water production and supply to total energy-related carbon emissions is more than 60% from 2001 to 2010. Carbon emissions in transportation, storage, and postal services have increased fast due to the rapid development of E-commerce in China since China joined WTO in 2001. In short, the energy-related carbon emissions in China have increased due to the rising of energy consumption and rapid economic development from 1995 to 2010, especially since 2001.

3.2. Decomposition Results

3.2.1. The Changes in Energy-Related Carbon Emissions Intensity in China from 1995 to 2010. From 1995 to 2010, China's GDP increased sharply from 6079.37 to 25000.31 billion Yuan (average annual rate of 19.5%), exceeding the growth in energy-related carbon emissions (average annual rate of 9.81%) from 3312.15 to 8510.5 million tons. China's carbon emissions intensity has decreased sharply from 5.45 to 3.4 tons per 10 thousand Yuan. However, the carbon emissions intensity is higher than many countries (such as USA, Japan, and UK) and the world average.

3.2.2. Decomposition Results of China's Carbon Emissions Intensity from 1995 to 2010. The complete year-by-year decomposition results for the macro-LMDI II (decomposition at macrolevel) are presented in Table 3. The accumulated effects by period are available as index change in Table 4 and Figure 3 and as percentage change in Figure 4.

From Table 4, it is found that although China's carbon emissions intensity increased slightly from 2002 to 2005, it continued to decrease from 1995 to 2010 (total decrease, 2 tons per 10 thousand). The time series decomposition results of China's energy carbon emissions intensity show that industrial structure effect had a great positive effect on China's carbon emissions intensity, followed by energy

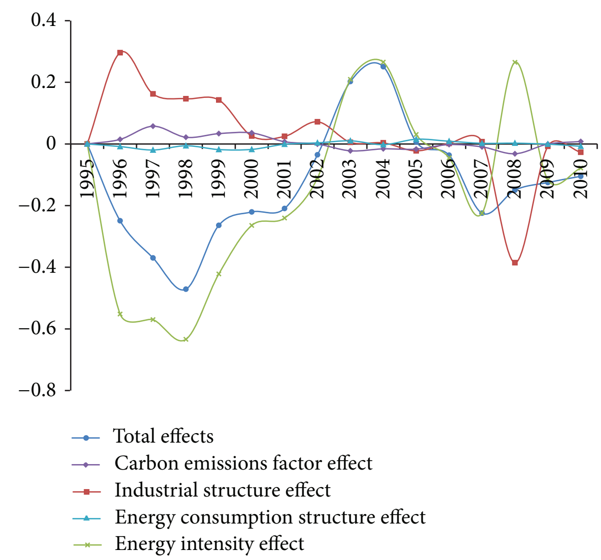

FIGURE 3: Accumulated decomposition of China's energy carbon emissions intensity, 1995–2010.

consumption structure effect. The contribution share of industrial structure effect and energy consumption structure effect was 124.25% and 1.94% (total increase, 2.53 tons per capita), respectively. energy intensity effect had a significant negative effect on China's energy carbon emissions intensity, followed by carbon emission factors effect. The contribution share of Energy intensity effect and carbon emission factor effect was 124.25% and 1.94% (total decrease, 0.53 tons per capita), respectively.

As shown in Figures 3 and 4, the energy intensity effect is the most significant factor in decreasing carbon emissions intensity. The changes in carbon emissions intensity have the similar trend with changes in energy intensity. In studying China, studies such as Song and Lu [23], Sun et al. [24],

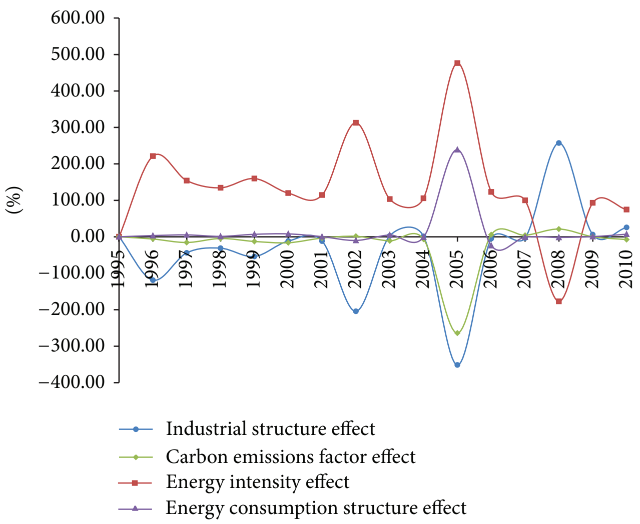

FIGURE 4: Four decompositions of China's energy carbon emissions intensity per capita, 1995–2010.

TABLE 3: Annual time series decomposition results from 1995 to 2010.

Year	ΔI_{tot}	ΔI_{str}	ΔI_{int}	ΔI_{mix}	ΔI_{emf}
1995-1996	−0.2493	0.2960	−0.5517	0.0148	−0.0084
1996-1997	−0.3698	0.1622	−0.5699	0.0575	−0.0196
1997-1998	−0.4713	0.1467	−0.6338	0.0216	−0.0058
1998-1999	−0.2639	0.1426	−0.4218	0.0335	−0.0182
1999-2000	−0.2206	0.0257	−0.2644	0.0358	−0.0177
2000-2001	−0.2094	0.0246	−0.2402	0.0072	−0.0010
2001-2002	−0.0352	0.0719	−0.1101	−0.0005	0.0035
2002-2003	0.2024	0.0052	0.2093	−0.0223	0.0102
2003-2004	0.2506	0.0035	0.2653	−0.0159	−0.0023
2004-2005	0.0064	−0.0225	0.0305	−0.0169	0.0153
2005-2006	−0.0366	0.0018	−0.0451	−0.0021	0.0088
2006-2007	−0.2247	0.0073	−0.2246	−0.0095	0.0021
2007-2008	−0.1497	−0.3852	0.2649	−0.0319	0.0025
2008-2009	−0.125	−0.0075	−0.1165	−0.0003	−0.0007
2009-2010	−0.1049	−0.0269	−0.0784	0.0079	−0.0075
1995–2010	−2.0012	0.4455	−2.4864	0.0786	−0.0389

TABLE 4: Decomposition of China's energy carbon emissions intensity from 1995 to 2010.

Year	ΔI_{tot}	ΔI_{str}	ΔI_{int}	ΔI_{mix}	ΔI_{emf}
1995–1999	−1.3543	0.7475	−2.1772	0.1274	−0.052
1999–2002	−0.4652	0.1222	−0.6147	0.0425	−0.0152
2002–2005	0.4594	−0.0138	0.5051	−0.0551	0.0232
2005–2010	−0.6409	−0.4105	−0.1997	−0.0359	0.0052
1995–2010	−2.0012	0.4455	−2.4864	0.0786	−0.0389

Xu et al. [28], and Zhang et al. [29] attributed changes in carbon emissions to economic development. Changing lifestyle and consumption mode were frequently recorded as the most outstanding positive effect in decomposition analysis study of residential energy consumption in urban China [30]. The energy intensity effect, the significant factor in decreasing carbon emissions intensity, is not the significant factor in changes in carbon emissions. The positive effect of industrial structure effect on carbon emissions intensity had continued to decrease from 1995 to 2010. What is more, the changes in industrial structure effect became a weak negative factor in increasing carbon emissions intensity in recent years. The changes in carbon emissions factor and Energy consumption structure have weak effect on China's carbon emissions intensity. The changes of China's carbon emissions intensity could be divided into three stages: 1995–2002, 2002–2005, and 2005–2010.

Carbon emissions intensity continued to drop in 1995–2002 period. This is attributable to the negative effect of energy intensity and declining positive effect of industrial structure effect. The accumulated effects increasing carbon emissions intensity are more than offset by drivers decreasing carbon emissions intensity, leading to a significant decrease. Adjustment of industrial structure had a positive effect on decreasing carbon emissions intensity from 1995 to 2002.

In 2002–2005 period, carbon emissions intensity began to increase dramatically because energy intensity effect had a positive effect on carbon emissions intensity. This is attributable to the development of high energy-consuming sectors (such as heavy industry and thermal power industry manufacturing). Some high energy-consuming sectors had rapidly recovered since China joined WTO in 2001, which led to rapid increase in energy consumption. The negative effects of energy consumption structure effect, industrial structure effect, and carbon emission factors effect were not significant. The total negative effects are heavily outweighed by the total positive effects, which resulted in the increase in carbon emissions intensity.

Carbon emissions intensity began to drop again in 2005–2010 period. This is attributable to the that fact China's government advocated low carbon economy and green economy in China. China's government encouraged the development of new energy sector, decreasing the ratio of coal in total primary energy consumption, continuing to adjust industrial structure, and promoting technological innovation. The decrease of carbon emissions intensity from 2005 to 2010 is caused by the changes in energy intensity, industrial structure, and energy consumption structure. The decrease of carbon emissions intensity in 2008 is attributable to the Beijing Olympic Games. In order to ensure the success of the Olympic Games, China's government adjusted the industrial structure by shutting down and straightening a large number of high pollution and energy consumption enterprises. With these measures and the effects of Olympic Economy, industrial structure effect had a significant negative effect on carbon emissions intensity.

3.2.3. Sectoral Decomposition Results of China's Carbon Emissions Intensity. In order to study the contribution of changes

Table 5: Sectoral decomposition results of China's carbon emissions intensity from 1995 to 2010.

Sector	1995–2010	1995–1999	1999–2002	2002–2005	2005–2010
Total industrial structure effect	0.4455	0.7475	0.1222	−0.0137	−0.4105
Agriculture	−0.0614	−0.0196	−0.0138	−0.0123	−0.0157
Excavation	0.0133	−0.0365	0.0266	0.0243	−0.0011
Manufacturing	0.3012	0.1062	0.0180	0.0597	0.1173
Electric power, gas, and water production and supply	0.2266	0.6963	0.0814	−0.0800	−0.4711
Construction	0.0001	−0.0022	−0.0009	0.0003	0.0029
Transportation, storage, and postal services	−0.0545	−0.0053	0.0056	−0.0069	−0.0480
Wholesale, retail trade, and food services	−0.0033	−0.0017	−0.0016	−0.0023	0.0023
Other	0.0235	0.0105	0.0068	0.0034	0.0028

in sectors to China's carbon emissions intensity, the accumulated effects of sectors by period are available as index change in Table 5.

From Table 5, it is found that manufacturing sector and electric power, gas, and water production and supply sector are the significant factors in driving China's carbon emissions intensity. The contribution of manufacturing sector and electric power, gas, and water production and supply sector was 0.301 and 0.227 tons per 10 thousand Yuan from 1995 to 2010, respectively. Excavation sector and other sectors have a weak positive effect on China's carbon emissions. Manufacturing sector had rapidly developed since China joined WTO in 2001, which led to increasing positive effect in carbon emissions intensity. In recent years, China's government increased investment in energy sector and encouraged the development of clear-energy. The effect of electric power, gas, and water production and supply sector to carbon emissions intensity had changed from significant positive factor to significant negative factor. Construction sector and wholesale, retail trade, and food services sector had little effects on carbon emissions intensity from 1995 to 2010 according to the sectoral decomposition results. Transportation, storage, and postal services sector and agriculture sector played the positive factors in decreasing China's carbon emissions intensity and the contribution of Transportation, storage and postal services sector and agriculture sector was 0.061 and 0.055 ton per 10 thousand Yuan in the decomposition period, respectively. According to the above analysis, the adjustment of industrial structure is one possible way to decrease China's carbon emissions intensity.

4. Conclusions and Policy Implications

4.1. Conclusions. According to the decomposition of China's carbon emissions intensity from 1995 to 2010, these results are summarized as follows.

(1) China's carbon emissions intensity had continued to decrease since 1995 although China's carbon emissions intensity had a small increase from 2002 to 2005.

(2) In 1995–2010 period, the energy intensity effect was the most significant negative effect on carbon emissions intensity, and the positive effect of industrial structure effect on carbon emissions intensity continued to drop in recent years.

(3) The negative effect of energy intensity effect on China's carbon emissions intensity has continued to decrease from 1995 to 2010. Industrial structure effect and energy consumption structure effect failed to make notable progress in decreasing national carbon emissions intensity over the analysis period. Therefore, China's government should make policies to optimize energy structure and industrial structure to decrease carbon emissions intensity.

4.2. Policy Implications. As shown in the decomposition results, decrease in carbon emissions intensity is a hard and complex project, related to different factors such as energy intensity, industrial structure, energy consumption structure, and carbon emissions factors. The following policy recommendations for decreasing China's carbon emissions intensity are presented in the paper.

Firstly, the industrial structure should be further adjusted and optimized. According to the decomposition in this paper, industrial structure effect was not significant effect on decreasing carbon emissions intensity. China should accelerate the pace of industrial restructuring, increase investment in scientific and technological innovation, and advocate the development of high-tech sectors to improve the quality of economic growth.

Furthermore, Scientific and technological progress and innovation are needed to improve efficiency of energy use and optimize energy consumption structure. China should increase the investment in new energy sectors and carbon emissions reduction technology research. New energy and carbon reduction technology should be implemented to improve energy structure, increase efficiency of energy use and decrease carbon emissions.

In the third place, it is necessary to establish and complete carbon emissions laws and regulations, entry threshold for firms of carbon emissions and carbon finance, technical standards and energy conservation and carbon emissions decreasing and other measures for decreasing carbon emissions.

Finally, China should strengthen international cooperation of energy technology and carbon emissions reduction research with developed countries. What's more, a green lifestyle should be advocated to slow down global warming and decrease carbon emissions intensity.

Therefore, enduring policies are needed to be utilized to convert China's values for a low-carbon economic development way, which is an effective way to achieve the targets of reducing carbon intensity by 16% by 2015, from 2010 levels and by 40–45% by 2020, from 2005 levels.

Conflict of Interests

The authors declare no conflict of interests.

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