ISSN: 2688-9323

Study on Decoupling between Economic Development and Carbon Emission of Nine Provinces Along the Silk Road Economic Belt

Xiaoyu Ju, Jie Wan, Ziwei Zhang

School of Business Administration, China University of Petroleum (Beijing) at Karamay, Karamay, 834000, China

Abstract

Under the cooperation initiative o carbon emissions in the Silk Road Economic Belt is of great practical significance in promoting the construction of the "Green Silk Road Economic Belt". This paper of "Green Silk Road Economic Belt", the understanding of the decoupling of economic development and analyses the relationship between carbon emissions and economic growth in nine provinces along the Silk Road Economic Belt using the Tapio decoupling model based on panel data for the period 2004-2019. The results show that the decoupling state of the Silk Road Economic Belt oscillates between the three states of weak decoupling, expansionary linkage and strong decoupling during the study period, with the weak decoupling state dominating. In a word, the introduction of the Silk Road Economic Belt initiative has indeed contributed to the improvement of energy efficiency in the nine provinces along the Silk Road.

Keywords

Silk Road Economic Belt; Carbon Emissions; Economic Growth; Tapio Decoupling Model.

1. Introduction

The Silk Road Economic Belt, which relies on transportation routes along the route to link various countries, is a new type of cooperation region established between China and Central Asian countries, covering most of the western region of China, with a radiation range encompassing five provinces in the northwest: Shaanxi, Qinghai, Gansu, Ningxia and Xinjiang; and four provinces in the southwest: Sichuan, Chongqing, Guangxi and Yunnan [1, 2].

Firstly, as far as the current state of economic development of the Silk Road Economic Belt is concerned, the rich natural resource abundance of the Silk Road Economic Belt provides an important driver of economic growth; secondly, the Silk Road Economic Belt has a unique location advantage in China, with its central cities having well-developed infrastructure and being important hubs for transportation; furthermore, since 2013, the total trade volume of the Silk Road Economic Belt has been rising and the economic system open to the outside world has been developing and the total volume of foreign trade has been expanding.

Under the international cooperation initiative of "Silk Road Economic Belt", the "Green Silk Road Economic Belt" has also been created, so this paper examines the decoupling relationship between economic development and carbon emissions in the "Silk Road Economic Belt" to promote the construction of the "Green Silk Road Economic Belt". Therefore, this paper examines the decoupling relationship between economic development and carbon emissions in the "Silk Road Economic Belt" in order to promote the construction of the "Green Silk Road Economic Belt" [3].

2. Model Building

2.1. Building a Carbon Emissions Indicator System

Up to now, the vast majority of countries have never published direct data on carbon emissions. Therefore, in order to explore the link between carbon emissions and economic growth, it is inevitable to estimate carbon emissions based on known basic data. The main methods used to measure carbon emissions are the carbon emission factor method, the mass ratio method, the time ratio method and the integrated method. At present, more than 90% of China's carbon emissions come from energy consumption [4], therefore, it is reasonable to calculate carbon emissions based on the consumption of fossil fuels and other energy sources, and this method is more practical and concise, and is more widely used, the specific formula form is as follows:

$$C_t = \Sigma E_{it} X \ u_i \quad (1)$$

Where C_t is the total energy carbon emissions in year t (million tonnes); E_{it} is the consumption of fossil energy i in terms of standard coal equivalent in year t (million tonnes of standard coal equivalent); u_i is the carbon dioxide emission factor of fossil energy source i [5] , as shown in *Table 1*.

Table 1. Carbon emission calculation parameters

Energy type	Coal	Crude oil	Gasoline	Kerosene	Diesel	Fuel oil	Natural gas
CO_2 Emission factor	2.7742	2.1495	2.0324	2.0970	2.1730	2.2699	1.6453

2.2. Construction of Tapio Decoupling Evaluation Model

Decoupling of carbon emissions is a process whereby economic growth and greenhouse gas emissions continue to weaken until they disappear [6, 7]. The elasticity factor is one of the main tools for measuring the low carbon status of each region, and the decoupling elasticity value D is calculated as shown below:

$$D(C, GDP) = \frac{\%\Delta C}{\%\Delta GDP} \quad (2)$$

Table 2. Tapio decoupling type situation

Basic decoupling state	Subdivision decoupling status	$\%\Delta C$	$\%\Delta GDP$	Elastic coefficient
Decoupling	Weak decoupling	>0	>0	0<n<0.8
	Strong decoupling	<0	>0	n<0
	Recessive decoupling	<0	<0	n>1.2
Negative decoupling	Weak negative decoupling	<0	<0	0<n<0.8
	Strong negative decoupling	>0	<0	n<0
	Expansion negative decoupling	>0	>0	n>1.2
Link	Expansion decoupling	>0	>0	0.8<n<1.2
	Recessive decoupling	<0	<0	0.8<n<1.2

ISSN: 2688-9323

Where, $D(C, GDP)$ represents the carbon emissions and economic growth decoupling index, C represents CO2 emissions, and GDP represents the size of the economy, $\%\Delta C$, $\%\Delta GDP$ represent carbon emission growth rate and economic growth rate respectively [8,9].

Based on Tapio, the decoupling elasticity is classified into eight types, as shown in *Table 2*. Among them, strong decoupling is the most desirable state for the economy to achieve decarbonization, while strong negative decoupling is the least favorable state [10].

3. Empirical Analysis

3.1. Carbon Emission Intensity Analysis

As shown in *Figure 1*, from 2001 to 2019, the total carbon dioxide emissions of the nine provinces along the Belt and Road Economic Zone showed a trend of first increasing and then stabilizing, from 104,531,500 tons in 2003 to 236,076,210 tons in 2011, an increase of 225.84%. And from 2012 to 2019, there were slight fluctuations in carbon emissions, but the total amount did not change much, and by 2019 carbon emissions were 3047,485,100 tons; the growth rate of carbon emissions showed a trend of rising first and then fluctuating down, but except for the year 2015, all other years maintained a positive growth rate, with an average annual growth rate of 6.23%. It can be seen that between 2003 and 2011 carbon emissions increased rapidly year by year, especially in 2004, 2005 and 2011, the growth rate reached more than 10%, with a peak of 13.05% in 2011, which was mainly due to the rapid industrialization and urbanization stage, the accelerated development of related heavy industries and infrastructure construction, which inevitably consumed a large amount of resources and fossil fuels. After 2012, the growth rate of carbon emissions began to slow down, but the total amount is still at a high level.

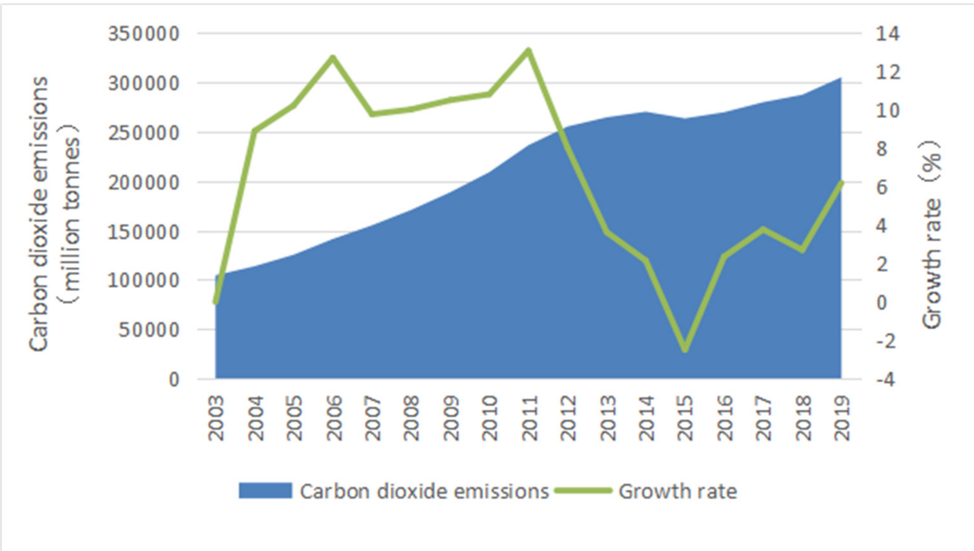

Figure 1. Total Carbon Emissions and Growth Rates of Silk Road Economic Belt Cities

As shown in *Figure 2*, among the nine provinces along the Belt and Road Economic Belt, Shaanxi, Sichuan and Xinjiang are the provinces with the highest carbon dioxide emissions, and these provinces account for a higher share of carbon emissions than other provinces. Prior to 2011, carbon emissions from all three provinces were increasing, with Shaanxi Province showing the fastest growth rate, and after 2011 Sichuan Province's carbon emissions showed a slow decline, while Xinjiang and Shaanxi Provinces continued to rise. The total carbon emissions of Sichuan, Xinjiang and Shaanxi provinces grew from 139,863,300, 106,060,72 and 107,058,400 tonnes in 2001 to 28,398,883, 73,119,79 and 655,681,500 tonnes in 2019, an increase of 612.45%, 203.05% and 685.88% respectively. Therefore, although Sichuan Province is currently doing a good job in reducing emissions, the other two provinces are still growing at a very high rate and carbon emissions are still increasing year by year, making it a key area for energy conservation and emission reduction in the Belt and Road.

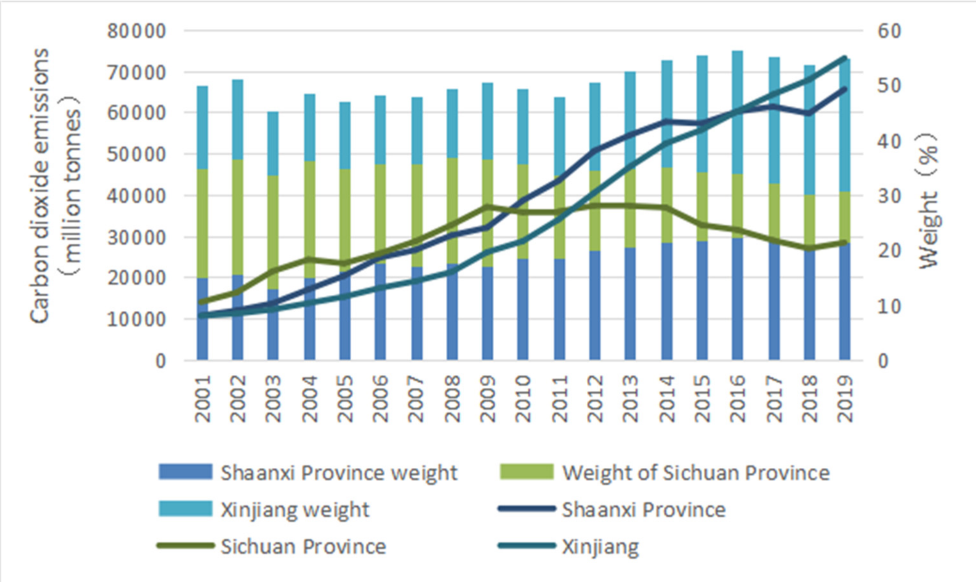

Figure 2. Changes in carbon emissions and share by province and region

3.2. Economy Development Situation Analysis

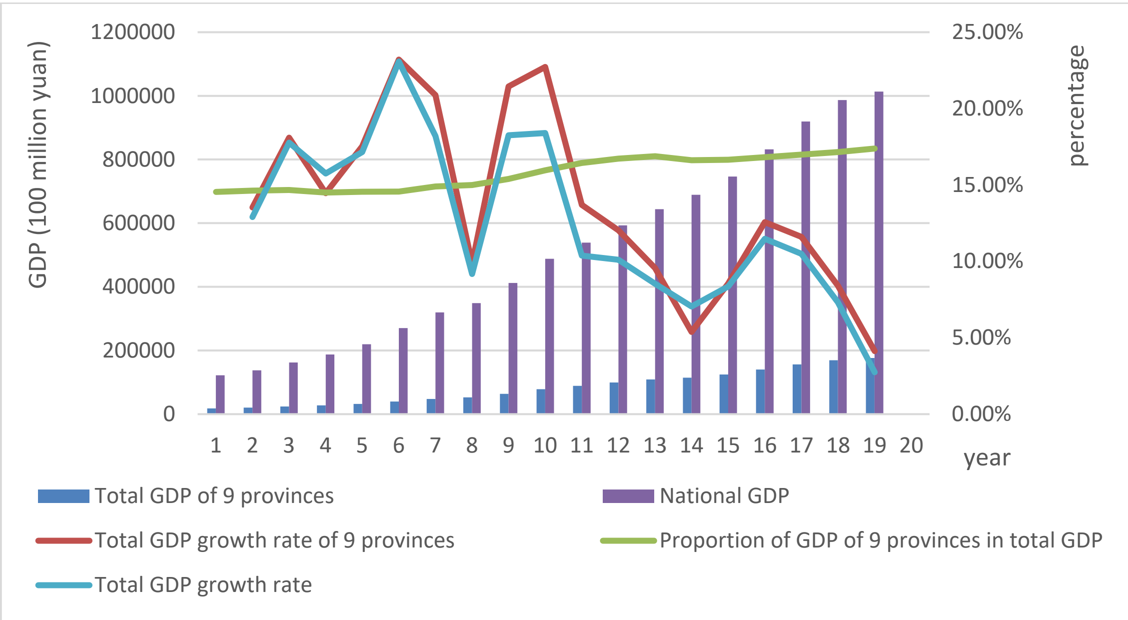

Figure 3. Trends in economic aggregates for the nine provinces along the route

In *Figure 3*, the data shows that since the introduction of the international economic cooperation initiative of the Silk Road Economic Belt, and with the strong support of national policies, the economic growth of the nine provinces along the route has made significant achievements in the past decade, and their economic status in the country has been steadily enhanced. As shown in *Figure 3* , the GDP of the nine provinces along the route maintained a continuous growth trend from 2002 to 2020, from 177.03 billion RMB in 2002 to 176.202.9 billion RMB in 2020, an increase of 9.9 times; the GDP maintained a high growth rate in all years, especially since the official implementation of the Silk Road Economic Belt in 2013, with a growth rate of 12.56% in 2017. After 2010, the Chinese government advocated changing the mode of economic growth, and under the premise of actively responding to the national call, the GDP growth rate has slowed down, but still maintained a high level of growth year after year. In addition to this, from 2002 to 2020, the total GDP growth rate of the nine provinces along the route maintained essentially the same trend as that of the country as a whole, with all years except 05 and 15 being higher than the national level for the same period. In terms of the proportion of the total economic output of the nine provinces along the route to the national level, it increased from 14.54% in 2002 to 17.83% in 2020, an increase of 3.29%. This shows that since the implementation of the Silk Road Economic Belt, the nine provinces along the route have been increasing their economic position in the country, contributing nearly one-fifth of the country's economic output.

3.3. Decoupling Analysis between Carbon Emissions and Economic Growth

By applying the Tapio decoupling model, this paper analyzes the decoupling dynamics of economic development and carbon emissions in the nine provinces along the Silk Road Economic Belt from 2004 to 2019 [11]. As can be seen from *Figure 4*, the decoupling state of the Silk Road Economic Belt oscillates between weak decoupling, expansionary linkage and strong decoupling during the study period, with the weak decoupling (overall decline in the elasticity index) being the main state. The overall decline in the Elasticity Index is a combination of the following.

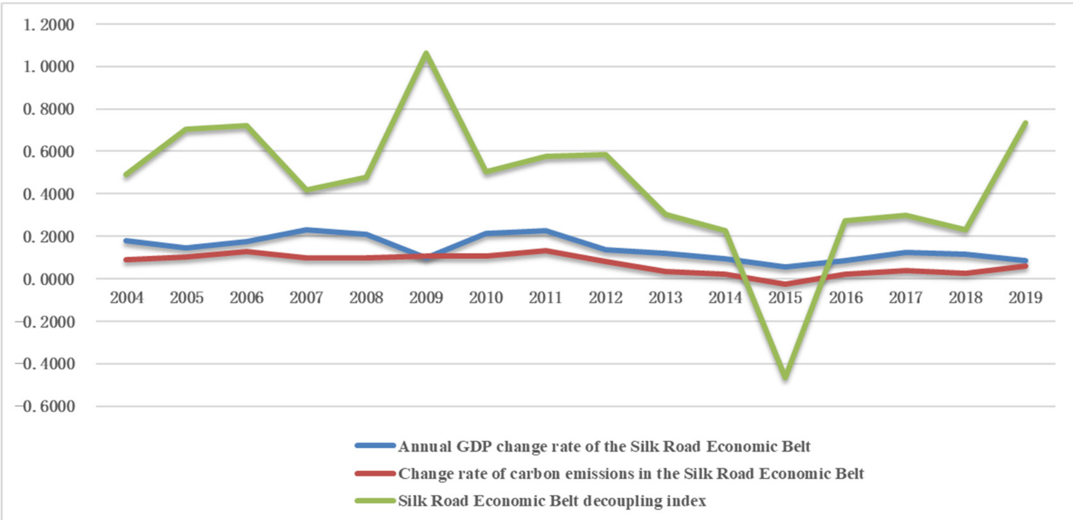

Figure 4. Decoupling of Silk Road Economic Belt cities

Taking the construction of the Silk Road Economic Belt in 2013 as the dividing line, the decoupling of carbon emissions and economic growth in the Silk Road Economic Belt from 2004 to 2019 was divided into two periods: 2004-2013 and 2013-2019 [12]. The results are shown in table 3.

The decoupling elasticity of the Silk Road Economic Belt is 0.416 in 2004-2013, which is higher than that in 2014-2019. This is mainly because since the establishment of the Silk Road Economic Belt, the industrial structure of the nine provinces along the belt has been upgraded and the efficiency of energy use has been improved, and the decoupling elasticity of carbon emissions in 2014-2019 has dropped to 0.217. At present, the total carbon emissions of the Silk Road Economic Belt tend to stagnate, but some provinces in the Silk Road Economic Belt are still in the stage of continuous development, and the urbanisation and industrialisation process is yet to be further accelerated. Therefore, economic growth and carbon emissions in the Silk Road Economic Belt will continue to show a weak decoupling in the long run, or a decoupling index hovering between strong and weak decoupling.

Table 3. Decoupling index and type of carbon emission and economic development

Region	2004-2013		2014-2019	
	Decoupling index	Type	Decoupling index	Type
Silk Road Economic Belt	0.416	Weak decoupling	0.217	Weak decoupling
Shanxi	0.5409	Weak decoupling	0.3281	Weak decoupling
Gansu	0.3034	Weak decoupling	0.0528	Weak decoupling
Qinghai	0.6801	Weak decoupling	-0.2683	Strong decoupling
Chongqing	0.4602	Weak decoupling	-0.3187	Strong decoupling
Sichuan	0.1673	Weak decoupling	-0.3190	Strong decoupling
Ningxia	0.5867	Weak decoupling	0.9558	Expansive coupling
Yunnan	0.2432	Weak decoupling	-0.1329	Strong decoupling
Xinjiang	0.8410	Expansive coupling	0.9062	Expansive coupling
Guangxi	0.4909	Weak decoupling	0.1624	Weak decoupling

During the period 2004-2013, eight of the nine provinces in the Silk Road Economic Belt were weakly decoupled, with only Sichuan Province having a relatively good decoupling elasticity index of 0.1673. In the period 2013-2019, the decoupling elasticity index of all the provinces that were previously weakly decoupled declined, except for Ningxia Hui Autonomous Region, and four provinces - Qinghai, Chongqing, Sichuan and Yunnan - became strongly decoupled, with Chongqing and Sichuan in the best decoupling position, showing negative growth in carbon emissions alongside economic development and shifting to a sustainable development path. In contrast, Ningxia Hui Autonomous Region is a coal-rich province with a large proportion of high energy-carrying industries and low energy-use efficiency in recent years. As a result, the elasticity of decoupling has increased to 0.9558, and the rate of increase in carbon emissions is higher than the rate of economic growth, making decoupling unsatisfactory. In addition, as China's economic strategy advances, the Xinjiang Uygur Autonomous Region's economic construction has achieved greater success under the new opportunities of the Belt and Road, but has also created the dilemma and challenge of declining efficiency levels, slow structural upgrading and insufficient environmental protection, with the decoupling index increasing to 0.9062, indicating that although Xinjiang has maintained high economic growth, its green development path still has a high degree of room for improvement.

3.4. Stability Check

For the sake of avoiding the pseudo-regression problem, we separately test the smoothness in the data characteristics of the variables to determine whether the variables are smooth or not. In this paper, the ADF test is used to test the smoothness of regional GDP and total carbon emissions in nine provinces along the Silk Road Economic Belt [13].

ISSN: 2688-9323

The results of the ADF unit root test in *Table 4* show that: the p-value of the ADF test method statistic is close to zero for both the original data, as well as the first-order difference and second-order difference data, then the data are smooth series data and there is no unit root.

Table 4. Stability check

Variable	GDP	CO2	△GDP	△CO2	$\triangle^2$GDP	$\triangle^2$CO2
ADF value	-2.681	-4.673	-7.880	-9.002	-9.199	-9.584
P value	0.0036**	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
Conclusion	Stable	Stable	Stable	Stable	Stable	Stable

4. Conclusion

This article calculates the carbon emissions of the nine provinces along the Silk Road Economic Belt by constructing a carbon emission index system, and carries out the related carbon emission intensity analysis and economic development analysis, then constructs the Tapio decoupling model to explore the decoupling between carbon emissions and economic growth, and analyzes the results. The results show that the decoupling is weak in the nine provinces along the Silk Road Economic Belt from 2004 to 2019, but with the establishment of the Silk Road Economic Belt proposed in 2013 as the boundary, the decoupling index of the nine provinces along the Silk Road Economic Belt from 2014 to 2019 is smaller than that of 2004. This indicates that the overall decoupling status of the nine provinces has improved, and the overall development towards a sustainable and green economy, but for several provinces and cities, such as Xinjiang, Ningxia, Shaanxi and Gansu, the decoupling status from 2014 to 2019 is expansionary linkage and weak decoupling, and there is still more room for improving their green development path.

Acknowledgments

Thank the China University of Petroleum (Beijing) at Karamay for his research financial support. And we are also grateful to the editor and reviewers for the helpful comments to improve our paper.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References

[1] F.Quan. Analysis of western regional economic development in the context of Silk Road Economic Belt [J]. Western Finance and Accounting, 2016(05):76-78.

[2] C.Q. Lin, T Qu, Z.Z. Yang. "One belt, one road" construction and new opportunities for Zhejiang's development [J]. Zhejiang conomic, 2014 (22): 36-37.

[3] Y.M. Shang, G. Zeng, W. Ni, et al. Characteristics and choices of economic growth patterns in typical Chinese cities[J]. Economic and Management Studies, 2015, 36(2):8.

[4] F. Liu, H.T. Jiang. Study on decomposition of influencing factors of carbon emission from urban energy consumption in Yangtze River Delta Based on LMDI model [J]. Business Exhibition Economy, 2022 (07): 130-132.

[5] X. Hua, R.J. Wu. Research on the intermediary effect of carbon dioxide emission and foreign direct investment -- from the perspective of Eastern, central and Western China [J]. Journal of Tianjin University of Commerce, 2021, 41 (06): 20-27 + 37.

ISSN: 2688-9323

[6] X. Song, JS Jia, C.D. Chen, J.H. Chen. Temporal and spatial characteristics, decoupling relationship and driving factors of energy consumption and carbon emission in Jiangxi Province [J]. Journal of Ecology, 2020,40 (20): 7451-7463.

[7] L.N. Hu, H.Y. Hu. Research on the relationship between carbon emission of tourism and economic growth in Tibet Based on decoupling theory [J]. Journal of Tibet University (SOCIAL SCIENCES EDITION), 2019,34 (04): 185-192 + 208.

[8] L. Gong, H.Z. Tu, C. Gong. Study on Influencing Factors of carbon emission from energy consumption based on STIRPAT model -- Taking the Yangtze River Delta as an example [J]. Industrial technology and economy, 2018, 37 (08): 95-102.

[9] G.F. Zhao, D. Zhao, Y.F. Wang. Analysis of decoupling between economic growth and energy consumption in Heilongjiang Province [J]. Anhui Agricultural Science, 2015,43 (05): 286-287 + 373.

[10] S.N. Wang. Decoupling relationship and driving factors between carbon emissions and economic growth in Shandong Province [J]. Research on science and technology management, 2014,34 (16): 242-248.

[11] J.B. Li, X.J. Huang, X.W. Chuai, S.C. Sun. Temporal and spatial characteristics and influencing factors of carbon emission efficiency in the Yangtze River Delta [J]. Resources and environment in the Yangtze River Basin, 2020, 29 (07): 1486-1496.

[12] Y.M. Hou, C.Z. Liang, X. Tian, D. Pan. Research on carbon footprint and related emission reduction countermeasures of China's iron and steel industry [J]. Ecological economy, 2012 (12): 105-108 + 145.

[13] M. Zhao, W.G. Zhang, L.Z. Yu. Shanghai residents' travel mode and urban traffic CO2 emission and emission reduction countermeasures [J]. Environmental science research, 2009, 22 (06): 747-752.