ISSN: 2710-0170

# Research Progress on the Relationship between Carbon Emissions and Socio-economic Growth in China

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## Abstract

**Climate change has become a great threat and challenge to human survival and development, as the largest developing country and the largest carbon emitter in the world, China is facing the double test of high-quality economic development and effective response to climate change. Therefore, exploring the relationship between carbon emissions and social and economic growth is of great theoretical and practical significance for effectively carrying out carbon emission reduction and achieving the carbon peak and neutrality targets. This paper deeply discusses the research progress of the socio-economic influencing factors of carbon emissions in China and the decoupling relationship between carbon emissions and socio-economic growth, in order to provide a useful reference for China to achieve the carbon emission reduction goal as soon as possible.**

## Keywords

**Carbon Emission; Socio-economic Factors; Decoupling Theory.**

## 1. Introduction

Since the new century, the problem of global warming has become increasingly prominent, and heavy natural disasters and extreme weather occur frequently. As the main cause of the greenhouse effect, carbon emissions have attracted more and more attention from experts and scholars. as the world's largest carbon emitter and the world's second largest economy, China has an arduous task to independently explore and achieve carbon peak and neutrality targets at the stage of high-quality economic development. Therefore, sorting out the relationship between carbon emissions and socio-economic growth is of great significance to achieve China's carbon emission reduction.

## 2. Research on Social and Economic Influencing Factors of Carbon Emissions in China

The analysis of academic research literature shows that China's carbon emissions are mainly affected by the coupling of many socio-economic factors, such as economic scale, industrial structure, population size, energy structure, technology research and development. For the convenience of induction and analysis, economic scale, population size and energy consumption are classified as scale factors, technological research and development as technical factors, energy structure, industrial structure and urbanization level as structural factors, and policy regulation as policy factors [1] (Table 1).

ISSN: 2710-0170

**Table 1.** Summary of socio-economic influencing factors of carbon emissions in China

| | Primary factor | Secondary factor | Research conclusion |
|---|---|---|---|
| Carbon emission | Scale factor | Economic scale | Mo Huibin and Wang Shaojian (2021) (positive effect) [2], Yang Shiping and He Yongjian (positive effect) [3], Zhou Yannan et al. (2020) (positive effect) [4], Fan Jianshuang and Zhou Lin (2019) (positive effect) [5] |
| | | Population size | Song Fulin et al. (2022) (positive effect) [6], Guo Chenglong and Xu Weilan (2022) (positive effect) [7] |
| | | Energy consumption | Huang Junxin and Jiao Fangtai (2021) (positive effect) [8], Zhao Mingxuan et al. (2021) (significant impact) [9], Zhou Min et al. (2018) (significant impact) [10] |
| | Technical factors | Technology research and development | He Yong et al. (2021) (significant impact) [11], Ma Hailiang and Zhang Gelin (2021) (significant impact) [12], Zang Mengmeng and Wu Juan (2021) (negative effect) [13], Cheng C et al. (2021) (negative effect) [14], Wang Shaojian et al. (2018) (negative effect) [15] |
| | Structural factors | Energy-resource structure | Song Fulin et al. (2022) (negative effect) [6], Xu Guoquan et al. (2021) (significant impact) [16] |
| | | Industrial structure | Guo Chenglong and Xu Weilan (2022) (negative effect) [7], Yu Zhiwei et al. (2022) (negative effect) [17], Mo Huibin and Wang Shaojian (2021) (negative effect) [2], Fan Jianshuang and Zhou Lin (2019) (no impact) [5] |
| | | Urbanization level | Yang Meicheng (2022) (positive effect) [18], Guo Chenglong and Xu Weilan (2022) (positive effect) [7], Fan Jianshuang and Zhou Lin (2019) (positive effect) [5] |
| | Policy factors | Policy regulation | Guo Yi et al. (2022) (negative effect) [19], Song Guojun et al. (2021) (negative effect) [20], Zhuo Jun (2018) (negative effect) [21] |

Note: the promotion effect of influencing factors on carbon emissions is positive, and vice versa; "Significant influence" refers to the concept of non statistical sample test with great influence.

The results of literature research show that scale factors have a positive effect on China's carbon emissions, which shows that the continuous increase of China's economic scale, population size and energy consumption will promote China's carbon emissions; The influence of technical factors on carbon emissions is different by industry type and urban carbon emission level; Structural factors have differences on carbon emissions. It is generally believed that the energy structure and industrial structure have a positive effect on carbon emissions, that is, the improvement of China's energy structure and industrial structure can effectively curb carbon emissions, while the level of urbanization has a negative effect on carbon emissions, indicating that the improvement of urbanization level will aggravate the level of carbon emissions; Policy factors have a negative effect on carbon emissions, showing a restraining effect on carbon emissions.

Scale and technology are the leading effects of China's provincial carbon emissions [4]. Many studies have shown that economic development is the main factor leading to China's carbon emissions [2, 22-24], There are significant U-shaped [25], U-shaped [26] and inverted U-shaped [27] curve relationships between China's carbon emissions and income gap, per capita GDP and

ISSN: 2710-0170

economic development level, respectively. The relationship between per capita carbon emissions and economic agglomeration and economic growth presents inverted n-shaped [28] and inverted U-shaped [15] curves. However, Tian Chengshi and Liu Yi (2021) found that there is no inverted U-shaped relationship between China's carbon emissions and economic development [29].Zhang Yunhui, Hao Shiyu (2022), Xu Weixiang, et al. (2022), Xie Yunfei (2022), Yang Linjing and Liao Zhigao (2021) found that economic agglomeration [25], digital economic development [30-31] and green financial development [32] have a significant inhibitory effect on carbon emissions, which also shows that China should accelerate the transformation of economic development mode and promote the regionalization and agglomeration of economic industries. Population size has a positive n-shaped impact on Provincial carbon emissions [33], and population size can promote carbon emissions, but its total emission promotion is far smaller than the economic scale. For example, Song Fulin et al. (2022) made an empirical analysis of the driving factors of carbon emissions from energy consumption in the Yangtze River Delta and found that economic output and population size contributed to 1862.1576 million tons and 144.2171 million tons of carbon emissions respectively, with a difference of nearly 13 times, However, for every 1% increase in economic output and population size, carbon dioxide emissions will increase by 0.8454% and 2.2935% respectively [6]. The growth rate of population size is significantly higher than that of economic output, which also shows that the role of population size in promoting carbon emissions cannot be underestimated. China's energy consumption and carbon emissions are highly coupled in the long run, and are mutually important factors with economic growth, which still have a great impact on carbon emissions in a short time [8-9].It is generally believed that technological progress can effectively inhibit carbon emissions [11-14], but in-depth research and analysis found that there are differences in the impact of technological factors on carbon emissions. In cities with low carbon emission intensity, technological progress plays an important role in carbon emission reduction, while in cities with high carbon density, technological progress has no significant impact on carbon emission reduction [34]. He Yong et al. (2021) showed that R & D investment in heavy and medium industrial industries has a significant impact on carbon emission reduction, while R & D investment in light industrial industries will increase carbon emissions [11].

Structural factors are important influencing factors of China's carbon emissions. Yang Linjing and Liao Zhigao (2021) have shown that the optimization and adjustment of energy structure and industrial structure can significantly inhibit carbon emissions, and the unreasonable energy structure will also have a negative impact on the optimization and upgrading of industrial structure [32].Yuan yuan, Zhou Jie (2021), Yu Zhiwei et al.(2022) believe that the optimization and upgrading of China's industrial structure can significantly inhibit carbon emissions [35], and reduce the intensity of carbon emissions in this region and surrounding areas [17].Fan Jianshuang and Zhou Lin (2019) believe that China's industrial structure has no significant impact on local carbon emissions [5].The impact of structural factors on carbon emissions has certain regional differences. The study found that the energy structure of the Fujian triangle region [24], and the six central provinces [36], had a restraining effect on carbon emissions during the study period, while the industrial structure showed a promoting effect; The industrial structure of Jiangsu Province [7], the central and western regions [37] and the three northeastern provinces [27] has an inhibitory effect on carbon emissions, while the energy structure and industrial structure of Beijing Tianjin Hebei region have little impact on their carbon emissions [38]. Although the main factor of carbon emission reduction in Shanghai is still the optimization of industrial structure, the inhibitory effect of industrial structure adjustment is constantly reducing [39].At this stage, the level of urbanization has a promoting effect on carbon emissions, and the two show a significant U-shaped curve relationship during

ISSN: 2710-0170

the study period [5], and there is an inverted n-shaped relationship between population urbanization and carbon emissions from residents' living consumption [40].

Policy factors can play an effective role in promoting China's carbon emission reduction. Guo Yi et al. (2022) studied that the Yangtze River Delta integration policy effectively suppressed carbon emissions, but found that the policy has a certain time lag on carbon emissions, and the effect of emission reduction on high-grade cities is greater than that of general cities [19].He Miao (2021) found that mandatory environmental regulation can directly and significantly inhibit provincial carbon emissions, while market-based environmental regulation may have time lag, resulting in its insignificant inhibitory effect [41].

Carbon emission is a systematic and complex problem, which is often driven by multi factor coupling and superposition. Du Haibo et al. (2021) and Aimaitikali Wumaieraili et al. (2021) have studied the Yellow River Basin and Poyang Lake Ecological Urban Agglomeration, and proved that the interaction of multiple factors such as economic scale, population scale, urbanization level, industrial structure and energy structure can significantly enhance regional carbon emission reduction [42-43].

## 3. Decoupling Relationship between Carbon Emissions and Social and Economic Growth

Decoupling originally refers to the process from existence to nonexistence of the interaction relationship between two or more physical quantities in the physical field. In the environmental field, it refers to the rupture of the relationship between environmental impact coupling and economic growth, that is, "decoupling" in this paper refers to the fact that carbon emissions will not increase with the continuous economic growth. Pan Jinghu and Zhang Yongnian (2021) found that China's carbon load and economic growth showed a weak decoupling relationship as a whole, and the expansion connection and expansion negative decoupling relationship gathered and distributed to the central and western regions and Northeast China [44].Han Mengyao et al. (2021) studied that carbon emissions and economic growth in most regions of China show a trend of negative decoupling from expansion, and expansion is linked to weak decoupling, among which Shanghai, Tianjin, Chongqing, Zhejiang, Shandong, etc. are approaching strong decoupling [45].Zhou Yannan et al. (2020) studied that the relationship between economic development and carbon emissions in different provinces in China presents absolute decoupling, relative decoupling and expansionary negative decoupling, and its coupling relationship changes over time [4].Wang Fengting et al. (2019), Wu Na et al. (2019), Jiang Bo and Ma Shengli (2020), Gong Weifeng et al. (2021) studied the decoupling relationship between carbon emissions and economic growth in Beijing Tianjin Hebei region, Shanxi Shaanxi Inner Mongolia region, the three eastern provinces and the yellow River Basin, and found that during the study period, the decoupling relationships were weak decoupling strong decoupling [38], weak decoupling expansion connection expansion negative decoupling weak decoupling [46] The evolution process of weak decoupling [27] and weak decoupling strong decoupling [47].There is also a decoupling effect between carbon emissions and economic growth in different industries in China, and the decoupling relationship is different. Taking Fujian Province during the 13th Five Year Plan period as an example, agriculture, forestry, animal husbandry, fisheries, water conservancy and economic growth show a negative decoupling relationship of expansion, while the production of electricity, supply and heat shows a weak negative decoupling relationship [48].

Carbon emission is not a simple single factor problem, but a highly systematic and complex multi factor coupling problem. Through sorting out the relationship between China's carbon emissions and social and economic growth, it can be concluded that scale and technology are the leading effects of China's provincial carbon emissions, scale factors have a positive effect on

ISSN: 2710-0170

China's carbon emissions, technological progress generally has an effective inhibition on carbon emissions, but there are differences due to low-carbon emission intensity; Structural factors are important influencing factors of China's carbon emissions; Policy factors can play an effective role in promoting China's carbon emission reduction. There is a general decoupling relationship between carbon emissions and social and economic growth, but the state of this relationship in different time periods and spaces is different, which further illustrates the systematicness and complexity of carbon emissions, which requires more in-depth, comprehensive and systematic research.

## Acknowledgments

Supported by Humanities and Social Sciences Project of the Ministry of Education "Relationship between Haze Pollution and Socio-economic Growth: Research on Three Dimensions Spatial-temporal Feature, Decoupling Effect and Collaborative Governance" (21YJCZH016).

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