A Review of the Synergistic Mechanism between Green and Low-Carbon Urban Construction and Industrial Structure Adjustment

Yuhan Wang

School of Social Science, The University of Manchester, Manchester, United Kingdom

yuhan.wang-31@student.manchester.ac.uk

Abstract. With the deepening of global climate governance and the promotion of China's "dual carbon" goal, the coordinated development of green low-carbon city construction and industrial restructuring has become an important way to achieve high-quality development, which is of important theoretical and practical significance. Based on the theory of collaboration and sustainable development, this article conducts literature research and case analysis methods, systematically analyses the theoretical logic of its coordinated development, analyses the internal interaction logic, and explores the key influencing factors in the urban practises of typical cities such as Hangzhou, Shenzhen and Ordos. It also assesses development trends and key challenges. The study found that the goal and path of green low-carbon city construction and industrial restructuring are highly consistent. The three core influencing factors are policy coordination, industrial foundation and technical support. Usually, obstacles such as fragmented policies, low synergy efficiency, "relocation" of high-energy-consuming industries and low green financial support still pose challenges. These findings have led to policy proposals, such as the establishment of a multidisciplinary collaborative governance platform and the formulation of a differentiated collaborative strategy, strengthening green technology innovation, and improving the green financial system, to support the coordinated transformation of green and low-carbon cities and industrial structures.

Keywords: Green and low-carbon cities, Industrial structure adjustment, Synergistic mechanism, Policy synergy, Green technology.

1. Introduction

At present, the global climate change situation is serious, and reducing carbon emissions and promoting green development has become an international consensus. China has put forward the goals of "carbon peaking" and "carbon neutrality", and urban green and low-carbon transformation is the key way to realise these agendas. Industrial restructuring is the key to China's high-quality development. The transformation of high-energy-consuming industries and the cultivation of urban green industries are the key ways to improve quality and industrial competitiveness. Against this backdrop, green and low-carbon urban construction and industrial structure adjustment are closely related, and exploring their synergistic mechanism is of great significance [1].

Scholars at home and abroad have conducted extensive discussions on these two aspects. Foreign research often focuses on urban low-carbon governance models and analyzes the role of industrial structure optimization in reducing urban carbon emissions. Domestic research, on the other hand, places more emphasis on combining national conditions to explore the correlation between industrial structure upgrading and urban green development. Some scholars have verified the promoting effect of an increase in the proportion of the tertiary industry on the decline of urban carbon emission intensity, and there are also studies that conduct case analyses of specific cities. However, there are gaps in existing research: most studies only analyze green and low-carbon urban construction or industrial structure adjustment unilaterally, and do not deeply explore their synergistic relationship; there is a lack of differentiated research on the synergistic paths of different types of cities, and the discussion on systemic issues and solutions in synergistic development is not comprehensive enough [2].

In view of this, this paper takes "the synergistic mechanism between green and low-carbon urban construction and industrial structure adjustment" as the theme and adopts a combination of literature and case studies. It first combs through the theoretical foundations of synergistic development to clarify the internal logic and interactive mechanisms. Then, it selects typical urban cases for analysis to extract practical experiences. After that, it checked the important factors and development direction. In a word, it solves problems and obstacles, promotes policies and measures, and provides analytical and pragmatic references for different cities to design coordinated development strategies.

2. Theoretical Foundations of Synergistic Mechanism Research

The coordinated development of green and low-carbon urban construction, as well as industrial restructuring, rely on the comprehensive theoretical combination and integration of various classical theories to support and guide the coordinated progress of the two.

The theory of sustainable development can be regarded as a basic guiding concept. Its method meets contemporary understanding without affecting future generations to meet their own needs. Its core is the coordination and unity of the economic, social and physical environment. In addition, in the coordinated progress, the process of urban planning and progress needs to take into account environmental goals; in addition, industrial restructuring must eliminate intensive energy utilisation and polluting industrial complexes, while advocating the growth of green industries and providing a "win-win" environment for cities and industries.

The synergy theory is a progressive theoretical framework. Haken suggests the interaction correlation of subsystems in systems that produce overall effects. The construction of green and low-carbon cities and the adjustment of industrial structure are closely combined as relevant subsystems; the construction of green and low-carbon cities provides direction in terms of policy, supporting infrastructure and market demand; at the same time, industrial restructuring provides industrial cornerstone, technical momentum and economic guarantee for this, and synergy can create Create positive conditions [3].

Innovative theory provides dynamic support. Schumpeter mentioned that technological innovation and institutional innovation are the core engines of economic development and industrial transformation. In the process of coordinated transformation, technological innovation or technological breakthroughs are prominent [4]. Institutional innovation provides a scientific basis, so that policies, evaluation mechanisms and market mechanisms can support a favourable institutional environment, thus bringing synergistic vitality around the mechanism [4].

3. Internal Logic and Interactive Mechanisms of the Synergistic Relationship

Regarding the goal and the path, both are highly threaded and provide a close synergy.

At the object level, these two goals are very consistent, both of which are committed to achieving high-quality economic and social development, such as providing other high-quality resource insights to reduce carbon emissions, and improving the efficiency of resource utilisation through some improvements and improving the quality of the ecological environment. Green low-carbon construction can create a liveable and commercially supportive environment, and industrial structure or key industrial adjustment can improve the competitiveness of the industry. Obviously, the measurement direction of the two synchronous goals has a unified aspect: "coordinated promotion of economic development and environmental protection" [5].

At the pathway level, they mutually support and interact bidirectionally. Green and low-carbon urban construction promotes the development of infrastructure, generates market demand, guides capital aggregation, and optimizes urban spatial layouts, providing support and opportunities for industrial structure adjustment [6]. Industrial structure adjustment reduces energy consumption and pollutant emissions, cultivates green industries, and is accompanied by breakthroughs in green

technological innovation, offering an industrial foundation and technological support for green and low-carbon urban construction and helping to achieve its goals.

4. Case Analysis of Typical Cities

Against the backdrop of the global wave of green and low-carbon development, Hangzhou, as a benchmark city for digital economy development, relies on its "City Brain" platform to deeply integrate digital technology with green governance and construct a "digital empowerment, multi-domain synergy" model. The "City Brain" integrates data from multiple departments to achieve real-time monitoring and scheduling of urban operations. In the transportation sector, measures such as optimizing signal timing have improved the traffic efficiency of the main urban area by more than 15%, reducing carbon emissions from idling vehicles. In the energy sector, intelligent management of power grids and renewable energy power stations has promoted the low-carbon transformation of the energy structure.

The deep integration of digital technology and green industries has driven the optimization and upgrading of Hangzhou's industrial structure. Relying on the "City Brain," Hangzhou has cultivated a group of green digital enterprises with intelligent transportation as their core business, forming industrial clusters. These industries provide support for green and low-carbon urban construction and have become new engines of economic growth, driving the industrial structure towards a high-end "digital + green" transformation. Hangzhou's practice shows that digital technology can break down departmental barriers, improve synergy efficiency, and provide strong technological empowerment for the synergistic development of the two aspects.

As a frontier of reform and opening up, Shenzhen has achieved a high degree of synergy between the two aspects through the model of "strict policy control + vigorous cultivation of emerging industries." In the early 21st century, Shenzhen restricted the development of high-energy-consuming and high-polluting industries, eliminated traditional industries, and at the same time cultivated high-tech industries and modern service industries, introducing policies to support the rapid development of industries such as electronic information. Today, the added value of high-tech industries in Shenzhen accounts for more than 35% of its GDP, and the proportion of the tertiary industry has exceeded 60%, indicating a highly optimized industrial structure.

The optimization of the industrial structure has laid a foundation for Shenzhen's green and low-carbon urban construction, reducing energy consumption per unit of GDP. Green industries such as new energy have provided support for the construction of green infrastructure, and the scale of new energy vehicle promotion ranks first in the country. Shenzhen's practice proves that policy guidance can drive industrial structure transformation and interact positively with green and low-carbon urban construction, achieving coordinated progress in the economy and ecology.

Ordos is a typical resource-based city that has explored a path of transition from "high-carbon dependence" to "low-carbon transformation" through the strategy of "restricting high-carbon industries + cultivating green industries + improving green infrastructure." In terms of industrial structure, it has restricted the expansion of coal chemical industries and introduced clean energy and new material industries. In terms of green and low-carbon urban construction, it has carried out supporting infrastructure construction and energy system transformation. Ordos's practice provides valuable experience for other resource-based cities. Overall, although the paths of the three cities are different, they have all achieved synergistic development of the two aspects through various means.

5. Analysis of Key Influencing Factors

The synergistic development of green and low-carbon urban construction and industrial structure adjustment is influenced by a combination of key factors, and the interactions among these factors determine the efficiency and effectiveness of synergistic development.

The degree of policy synergy is a fundamental factor. Green and low-carbon urban construction and industrial structure adjustment involve multiple departments. If urban planning, industrial, and environmental protection policies lack unified coordination or even conflict, for example, if industrial encouragement policies do not match strict environmental protection restrictions and there is no support for transformation, it will lead to confusion for enterprises and misallocation of resources, weakening the effectiveness of green transformation. On the contrary, if departments establish a collaborative governance mechanism and formulate a unified set of objectives and policy systems, such as incorporating green and low-carbon indicators into industrial support assessment and reserving space for green industrial development in urban planning, a policy synergy can be formed to provide institutional guarantees [7].

The type of urban industrial foundation affects the synergistic path. Cities with different industrial foundations have different synergistic paths. Shenzhen has a good industrial foundation, mainly consisting of high-tech industries and modern service industries, and its focus is on expanding green industries, promoting technological innovation, and improving the intelligence level of infrastructure. Ordos is classified as a resource-based city. Its core is to promote the transformation of traditional industries into low-carbon sources, develop new green industries, and strengthen ecological restoration and infrastructure improvement. Hangzhou is a comprehensive city, and its core focus is to achieve collaborative optimisation through technological innovation and empowerment. It is necessary to design a differentiated strategy around the industrial foundation [8].

The capacity for green technology support is a crucial link. Efficient green technologies can improve industrial energy efficiency, reduce emissions, drive industrial upgrading and the development of green industries, and can also be applied to urban infrastructure to enhance energy utilization efficiency, improve transportation, and reduce carbon emissions. A lack of core green technologies or low conversion rates will result in a lack of support for industrial structure adjustment and green and low-carbon urban construction, trapping synergistic development in a dilemma.

The rationality of urban functional layouts affects the agglomeration of green industries and the operational efficiency of infrastructure. A scientific layout can achieve the organic integration of functions, provide space for the agglomeration of green industries, and reduce enterprise costs. On the contrary, it will increase costs and exacerbate environmental pressure, hindering the coordinated advancement of the two aspects [9].

6. Data Support and Trend Visualization

To more intuitively reflect the synergistic change trends of green and low-carbon urban construction and industrial structure adjustment in China, this paper has compiled data on the proportion of the tertiary industry and energy consumption per unit of GDP from 2017 to 2024 based on publicly available data from the National Bureau of Statistics and the National Development and Reform Commission (see Figure 1). The proportion of the tertiary industry is one of the core indicators for measuring the degree of industrial structure optimization. An increase in the proportion of the tertiary industry usually indicates a transformation of the industrial structure towards a low-energy-consuming and high-value-added direction. Energy consumption per unit of GDP is a key indicator reflecting the level of green development of the economy. A decrease in energy consumption per unit of GDP indicates an improvement in energy utilization efficiency and a reduction in carbon emission intensity, which is highly consistent with the goals of green and low-carbon urban construction [10].

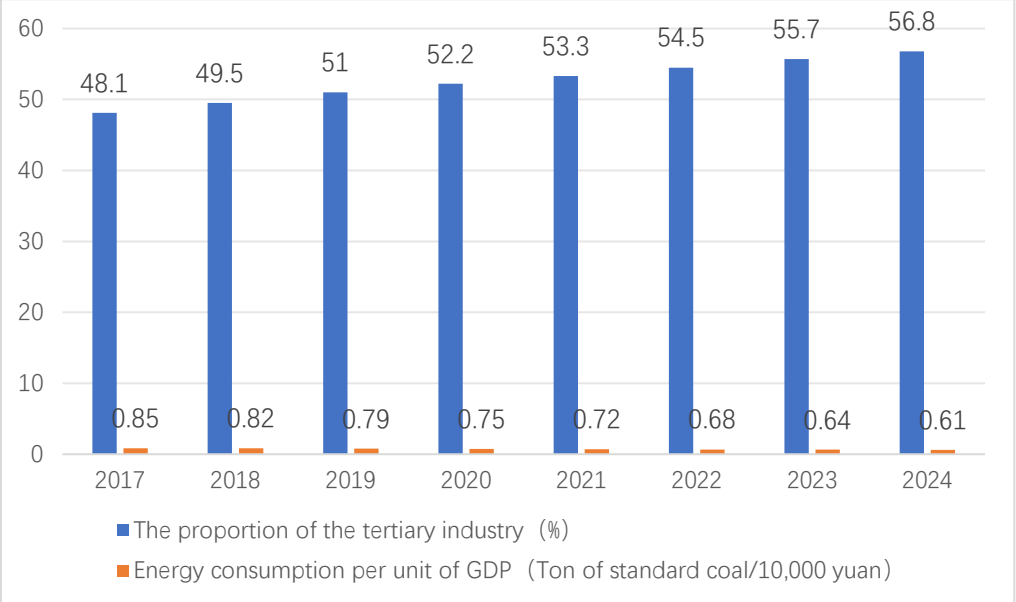

Figure 1. Changes in the proportion of the tertiary industry and energy consumption per unit of GDP in China from 2017 to 2024

From Figure 1, it is clear that from 2017 to 2024, the proportion of the tertiary industry in China has continued to rise steadily, increasing from 51.6% to a predicted 56.8%, an increase of 5.2 percentage points over eight years, indicating significant achievements in industrial structure optimization and upgrading and a reduced dependence on the high-energy-consuming secondary industry. Energy consumption per unit of GDP has decreased year by year, from 0.53 tons of standard coal per 10,000 yuan to a predicted 0.45 tons of standard coal per 10,000 yuan, a decrease of 15.1%, indicating an improvement in energy utilization efficiency and a higher level of green development of the economy.

The two curves show a clear "reverse synergy" characteristic, where for every percentage point increase in the proportion of the tertiary industry, energy consumption per unit of GDP decreases by approximately 0.01-0.02 tons of standard coal per 10,000 yuan. This confirms that green and low-carbon urban construction and industrial structure adjustment promote each other and jointly drive high-quality economic development.

However, the synergistic effects vary across different regions. The proportion of the tertiary industry in eastern coastal areas exceeds 60%, and energy consumption per unit of GDP is low, indicating a high level of synergy. In some resource-based provinces in the central and western regions, the proportion of the tertiary industry is less than 50%, and energy consumption is relatively high, indicating that synergistic development needs to be improved, and differentiated synergistic strategies need to be formulated.

7. Existing Problems and Challenges

Although China has achieved remarkable results in the synergistic development of green and low-carbon urban construction and industrial structure adjustment, it still faces many problems and challenges that restrict the improvement of synergistic efficiency and the promotion of green and low-carbon transformation.

7.1. Fragmented Policies and Implementation Disconnection

Fragmented policies are the primary problem. Green and low-carbon urban construction and industrial structure adjustment involve multiple departments, and each department formulates policies based on its own responsibilities, lacking a unified coordination mechanism and planning objectives. For example, the housing and urban-rural development department promotes the

construction of green buildings but fails to effectively connect with the industrial support policies for green building materials formulated by the Ministry of Industry and Information Technology, resulting in a mismatch between supply and demand. The environmental protection department's carbon emission control policies lack synergy with the development and reform department's industrial layout plans, and some industrial parks have difficulty in landing due to non-compliance with carbon emission indicators. Policy implementation is "enthusiastic at the top but cold at the bottom." Local areas lack implementation details, assessment mechanisms, and financial support, and some policies remain only at the document level, making them difficult to implement, resulting in difficulties in integrating resources and the inability to form policy synergy, thus reducing the efficiency of synergistic development.

7.2. Diverse Local Development Goals and Low Synergy Efficiency

Different regions have different resource endowments, economic foundations, and development stages, and there are significant differences in the priority settings for green and low-carbon development and industrial structure adjustment. Economically developed regions in the east focus on the quality of green and low-carbon development, mainly aiming for "quality improvement and upgrading." Underdeveloped regions in the central and western regions and resource-based cities face greater economic development pressure and place more emphasis on "scale expansion," with a high dependence on high-energy-consuming industries and insufficient investment in green and low-carbon urban construction. Adjacent cities lack coordinated planning, resulting in problems such as industrial homogenization competition and "independent operations" in environmental governance. For example, upstream and downstream cities in a certain river basin all develop high-water-consuming and high-polluting chemical industries, exacerbating the pressure on river basin environmental governance and weakening the synergistic effect.

7.3. Relocation of High-Energy-Consuming Industries to Low-Tier Cities without Effective Reduction

In the process of industrial structure adjustment, some high-energy-consuming industries have been "relocated but not dispersed" and have been transferred to low-tier cities and underdeveloped regions in the central and western regions. On the one hand, some local governments have adopted a "lenient control" approach towards local high-energy-consuming enterprises for short-term interests, resulting in ineffective implementation of policies to eliminate backward production capacity. On the other hand, as eastern regions upgrade their industries, they transfer high-energy-consuming industries to the central and western regions. Some regions in the central and western regions have lowered industrial access thresholds to attract investment and have undertaken a large number of high-energy-consuming and high-polluting projects. This transfer has not reduced the country's total energy consumption and carbon emissions but has instead increased the ecological environmental pressure in the central and western regions and increased the difficulty of green and low-carbon urban construction.

7.4. Inadequate Green Finance Support System and High Cost of Green Transformation

Green and low-carbon development and industrial structure adjustment require a large amount of capital investment, but the current green finance support system is inadequate. First, the types of green financial products are relatively simple, mainly consisting of green credit, which is difficult to cover the financing needs of different entities. Second, the standards for green finance are not unified, resulting in inaccurate capital flows. Third, there is a lack of a risk compensation mechanism, and financial institutions have a low willingness to lend to green projects. High-energy-consuming enterprises face high transformation costs and lack financial support, resulting in insufficient motivation for transformation and hindering the coordinated advancement of the two aspects.

8. Policy Recommendations for Promoting Synergistic Development

In view of the problems in the synergistic development of green and low-carbon urban construction and industrial structure adjustment, combined with relevant analyses, the following policy recommendations are proposed to build an efficient synergistic mechanism and promote their deep integration.

8.1. Build a Multi-Departmental Collaborative Governance Platform to Achieve "Urban-Industrial-Environmental" Integrated Planning

Building a cross-departmental collaborative governance platform is the key to solving the problem of fragmented policies. Synergy theory emphasizes the coordinated interactions among subsystems within a system. Internationally, low-carbon cities such as Copenhagen and Singapore have all established cross-departmental collaborative governance institutions. Specifically, first, establish a leading group at the national level to clarify the responsibilities of each department and establish a policy synergy review mechanism. Second, build a collaborative governance platform at the local level to integrate data resources and establish an information sharing system to achieve full-process policy synergy. Third, improve the implementation guarantee mechanism, formulate detailed rules and timetables, establish a joint supervision and inspection system, include it in performance assessments, and set up a special fund. Through this platform, departments can achieve coordinated operations and improve policy effectiveness.

8.2. Formulate Synergistic Strategies Based on Different City Types to Promote the Coupling of Green Industries and Urban Functions

Different cities have significant differences in industrial foundations and resource endowments. Formulating coordination strategies around different types of cities is the key to improving coordination efficiency. Cities can be divided into three types of cities: comprehensively developed cities (such as Beijing and Shanghai), whose collaborative focus is "technology empowerment and functional optimisation", supporting the integration of green industry and urban governance and digital technology; industrial optimisation cities (such as Shenzhen and Guangzhou), whose collaborative focus is "green industry upgrading and quality improvement", green high The end industry is getting more and more support; and resource-based transformation cities (such as Ordos and Datong), whose coordination focusses on "industrial transformation and ecological restoration", focussing on the transformation of traditional industries, the introduction of new green industries, and the process of ecological restoration projects that pursue sustainability. Formulating strategies to customise different city types can ensure that the collaborative path matches the unique situation of the city.

8.3. Intensify R&D Investment in Green Technologies and Build a Green Technology Innovation Ecosystem

Green technology is the core driving force of coordinated development. Germany, Japan and other countries have achieved coordinated low-carbon development between industry and cities by strengthening R&D investment and creating an innovative ecosystem. More specifically: First, increase the government's investment in research and development, increase the proportion of investment in green science and technology research and development, establish innovation funds, and guide enterprises to increase investment. Second, establish a cooperative innovation ecosystem involving "industry, academic, research and application", establish an innovation alliance, and integrate resources into the closed loop of "R&D-transformation-application". Third, through the establishment of a trading platform, we will optimise the protection of intellectual property rights, strengthen international technical cooperation, and increase the commercialisation mechanism of research results. The innovation ecosystem provides a mechanism for providing technical support and realising opportunities for coordinated development

8.4. Develop Green Finance to Support Green Enterprises, Green Buildings, and Green Transportation

In order to solve the problem of insufficient capital supply, it is crucial to develop a green financial system. The European Union provides sufficient financial support from a set of applicable harmonised standards to provide green bonds to applicable sectors. Specific measures include: First, to be more creative in the financial product system, develop green bonds and funds, and take the test of green insurance as an example. Second, establish unified green financial standards for projects and products at the national level. Third, put forward a risk compensation mechanism, integrate the risk compensation fund, and encourage the price of environmental benefits to have a market basis. Fourth, allow social capital to participate, attract social investment through the public-private partnership (PPP) model, and provide tax incentives. The green financial system can minimise the financial burden through transition and create advantages for other industries involved in green transformation/change.

8.5. Reform the Local Government Assessment Mechanism and Introduce Carbon Emission and Green Performance Indicators

Reforming the assessment mechanism is an institutional guarantee for guiding local governments to prioritize coordinated development. Countries such as Norway and Sweden have promoted regional green development by incorporating green indicators into their assessment systems. Reform paths include: Firstly, optimizing the assessment indicator system by reducing the weight of GDP growth rate and incorporating green indicators such as the carbon emission intensity reduction rate, with a weight of no less than 30%. Secondly, establishing differentiated assessment standards by formulating indicators and target values according to city types. Thirdly, improving the application mechanism of assessment results by linking them to the promotion of responsible persons and fiscal transfer payments, forming an incentive and restraint-oriented approach. Through the reform of the assessment mechanism, local governments can be guided to establish a green development concept and promote coordinated development.

9. Conclusion

This paper takes the coordinated mechanism between green and low-carbon city construction and industrial structure adjustment as the research theme. By comprehensively employing various methods, it has sorted out the theoretical foundations for the coordinated development of the two and drawn the following main conclusions: There is a high degree of inherent coordination logic between the two, with consistent goals and mutually supportive paths. Policy coordination and industrial foundations are key factors. The current coordinated development has achieved remarkable results but faces challenges. Data from China between 2017 and 2024 confirms the effectiveness of the coordination, with some cities having distinctive paths. However, problems such as policy decentralisation have obviously not been solved. The coordination brings a multi-dimensional support system to improve the progress forward. The theoretical significance of this research lies in simply providing a neat possible sequence for coordination logic and expanding the application of coordination theory. The practical significance of this study is to provide a set of actionable reference plans to support the realisation of the "dual carbon" goal and high-quality economic development. However, the limitations outlined in the study exist. The sample size of the case selection is limited, and larger city type samples are not considered. Data analysis will not produce micro-level empirical cases, so it will not deeply reveal quantitative differences. In future research, there is the ability to expand the number of city samples of cases. You can choose to establish a panel data model to measure the degree of impact. There is a prospect of exploring new options and mechanisms, combining new fields, and creating theoretical support for practice in the future.

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