A Study on the Impact of Green Finance Development on Industrial Structure Upgrading in Guizhou Province

Mengyue Chen[1, a]

[1]School of Economics and Management, Southwest University of Science and Technology, Sichuan, Mianyang, 621000, China

[a]19162706232@163.com

Abstract. Against the backdrop of global green and low-carbon transformation, green finance is an essential means to achieve carbon neutrality goals, promote industrial structure upgrading, and drive high-quality economic development. Based on this, this paper constructs a green finance indicator system to measure its impact on industrial structure upgrading. The study selects panel data from prefecture-level cities in Guizhou Province from 2017 to 2023 for fixed-effects model analysis, mechanism analysis, and heterogeneity tests. The results show that the development of green finance significantly promotes the upgrading of the industrial structure in Guizhou Province. Mechanism tests reveal that technological innovation has a negative moderating effect on the relationship between green finance development and industrial structure upgrading. Mediation effects indicate that green finance can promote industrial structure upgrading in Guizhou Province by improving the level of urbanization. There are heterogeneous impacts among cities of different sizes, with green finance having a more positive effect on industrial structure upgrading in medium and small cities than in large cities. Finally, based on the research conclusions, suggestions are proposed from five aspects: innovating green finance products, implementing differentiated policies, strictly reviewing standards, strengthening concept promotion, and leveraging coordination and radiation effects, to promote the high-quality development of Guizhou's industries.

Keywords: Green Finance; Technological Innovation; Urbanization Level; Industrial Structure Upgrading.

1. Introduction

Amid the global wave of green and low-carbon transformation, carbon neutrality and green finance have garnered significant attention. Following the introduction of China's "30·60" targets, various industries have accelerated their green and low-carbon transitions. Green finance has emerged as a crucial pathway to achieving carbon neutrality, promoting high-quality development, and contributing to the building of a Beautiful China. Since the launch of green credit policies in 2007 and the preliminary establishment of a green finance system in 2016, the exploration has never ceased. Recently, the People's Bank of China and the National Financial Regulatory Administration jointly issued the "Opinions on Leveraging Green Finance to Serve the Construction of a Beautiful China," proposing 19 measures. Sustained financial investment is imperative.

Guizhou province has a unique geographical location, rich natural resources and excellent ecological environment. The provincial party committee and provincial government held a high-quality development conference for the Gui'an New Area, introduced a series of policies, and vigorously promoted the construction of green finance. Adhering to the new development concept, we insist on "high-end, green, and intensive" development, build a "one pole, one highland, two demonstrations", and strive to create a high-end industrial cluster to promote high-quality economic development.

At present, China is in the critical period of economic structure adjustment and development model transformation. As a pilot of green finance reform and the industrial transfer in eastern China, Guizhou province is faced with the dual pressure of ecological protection and economic growth, and the optimization of industrial structure is imminent. Industrial upgrading and transformation cannot be separated from green and sustainable development and the support of green finance, and green finance ultimately serves the real economy. In this context, it is of both theoretical and practical

significance to explore whether the development of green finance in Guizhou province can drive the industrial upgrading and transformation in the economic circle.

2. Literature Review

Scholars from both domestic and international communities have elaborated on the two related concepts of green finance and industrial structure upgrading from multiple perspectives, as well as their measurements. They have also explored the in-depth correlation mechanisms between the two through constructing diverse models.

2.1. Research on Green Finance.

2.1.1. Concept of Green Finance

Green finance was born against the backdrop of environmental protection and sustainable development. In its early stages, it was nearly synonymous with "environmental finance"[1]. It serves as an important bridge connecting finance and the environmental protection industry, facilitating financing for green enterprises and the green transformation of industries. Chinese scholar Wang Shunan pointed out that the concept and activities of green finance originated in Western countries, aiming to address ecological and environmental issues caused by economic development through financial means and to promote green economic development[2]. The International Development Finance Club (IDFC) defines it as an investment and financing activity related to ecological and environmental protection projects, aimed at achieving the sustainability of industry's green development. Aneja also proposed that green finance is a green investment and financing model that guides investments through various financial instruments to create a green economy, improve the environment, and transfer risks[3].

Green finance in China started late, and scholars have different focuses in their understanding. Yu Luoyao et al. believed that green finance and digital economy can empower each other and promote green coordinated development among regions[4]. Gu Tianrui and Hao Zijing, among others, hold similar views[5]. Gao Jinjie pointed out in the heterogeneous analysis of regional economic growth that green finance can significantly improve the economic growth rate and growth efficiency[6]. Zhu Xiaoying emphasized that industrial transformation and upgrading cannot be separated from green sustainability. The development of green finance ultimately serves the real economy, and the green finance in the Chengdu-Chongqing Economic Circle has strongly promoted industrial transformation and upgrading[7]. Zhou Yujia believes that green finance not only directly affects high-quality economic development but also indirectly plays a role through multiple channels such as stimulating technological innovation and promoting industrial upgrading[8]. In summary, scholars' insights highlight the positive significance and importance of green finance in various aspects.

Therefore, domestic and international communities have provided definitions for green finance. The International Finance Forum defines green finance as a unique investment and financing activity that creates good environmental benefits and continuously promotes the healthy development of a country's economy. The first authoritative definition of green finance in China is an economic activity committed to improving the environment, addressing climate change, and promoting the conservation and efficient use of resources. It covers projects and emission reduction projects in fields such as clean and low-carbon energy, energy saving, and green transportation.

2.1.2. Measurement of Green Finance

With the continuous development of green finance, its evaluation indicators have become a research focus. Foreign scholars mostly comprehensively assess the green products and services of financial institutions, while domestic scholars tend to construct a comprehensive green finance index based on green finance products.

In China, Qu Qiongjing believes that the essence of finance is investment and financing. Selecting only two main components, namely green investment and green insurance, is sufficient to construct

a green finance indicator[9]. Liu Zhaoying et al. used comprehensive indicators such as green credit and green insurance to measure the development level of green finance[10]. In addition, under the "dual carbon" goals, Yang Ying focused on constructing a comprehensive efficiency indicator for the level of low-carbon economic transformation to study the target of green finance's impact[11]. Zhou Shuling and Chen Xueying calculated the green finance development index using the entropy method[12]. Zhao Xunjiao used policy text quantification to divide green finance policies into three categories and quantified the proxy indicators of green finance policies from three dimensions: policy intensity, goals, and safeguard measures. She also proposed optimized policies from the perspectives of government, enterprises, and banks to enhance the quality and efficiency of green finance services[13].

2.2. Research on Industrial Structure Upgrading.

2.2.1. Concept of Industrial Structure Upgrading

Industrial structure upgrading refers to the process of transformation from a lower to a higher form of industrial structure. It is characterized by the shift from low value-added to high value-added activities, from labor-intensive to technology- or knowledge-intensive industries, and the emergence of economies of scale and industrial clusters. It is a key driver of economic growth and social development.

During the stage of high-quality economic development in China, industrial structure upgrading and transformation are crucial for strategic and demand-based structural adjustments to sustain economic growth. Ma Xiaojuan et al. pointed out that the optimization and upgrading of the industrial structure are reflected in the sequential alternation of the three major industries, with the internal structure of each industry continuously optimized through technological advancements[14]. Meng Weifu and Liu Jinghan measured the level of industrial structure upgrading by the increase in the proportion of high-productivity industries, which is manifested in changes in industrial proportions and improvements in labor productivity[15]. Wang Yong and Tang Xuemin argued that industrial upgrading is the concentration of industry resources from low-quality and low-efficiency sectors to high-quality and high-efficiency ones, flowing towards high value-added industries[16]. Finally, scholars Jiang Zehua and Bai Yan emphasized that industrial structure upgrading is distinct from industrial upgrading. It encompasses multiple aspects of a country's economy, including industrialization, socialization, and modernization, and is influenced by social demand and institutions. It is a complex and continuous dynamic process[17].

2.2.2. Measurement of Industrial Structure Upgrading

The measurement indicators of industrial structure upgrading can assess the evolution of industrial structure from multiple perspectives and evaluate changes and development levels in economic structure. In China, a common approach is to construct a measurement system using the indicator method.

Under the new normal of economic development, the optimization and upgrading of the secondary industry is key to becoming a strong manufacturing nation. Zhang Huaxin and Fu Zhanjing constructed a comprehensive index system for new-type industrialization from seven aspects: industrialization, science and technology, economic benefits, environmental benefits, digitalization, human resources, and internationalization level. They used the New-type Industrialization Index (NI) to measure the level of new-type industrialization[18]. Zhu Xiaoying measured industrial structure upgrading with five indicators, including fixed asset investment in the tertiary industry and expenditure on science and technology[7]. Zhou Shuling and Chen Xueying, targeting regional industrial structures, built an evaluation system from the aspects of rationalization and upgrading. They used the entropy method to calculate weights and derive a comprehensive index to support the green transformation of the industrial structure in the Yangtze River Economic Belt[12]. Continuously improving the measurement indicator system for industrial structure upgrading is of great strategic

significance for enhancing national strength, boosting international influence, and promoting high-quality economic development and comprehensive social progress.

2.3. Research on the Impact of Green Finance on Industrial Structure Upgrading

2.3.1. Theoretical Research

The relationship between green finance and industrial structure upgrading is a key topic in the fields of economics and environmental science. Liagreetal pointed out that green finance introduces capital, technology, and other factors through diverse financing methods, helping enterprises integrate production funds. Ye Lin and Deng Ruibin believe that green finance serves as a bridge between finance and the environmental protection industry, playing a significant role in financing for green enterprises, promoting a low-carbon economy, and facilitating corporate transformation[19]. Chu Jingjing, through literature analysis, concluded that green finance promotes the stable growth, high-end development, and integrated development of the primary, secondary, and tertiary industries[20]. Xie Zhi Zhuo, based on the entire industrial chain, indicated that green finance innovation and reform are beneficial for the transformation of small and medium-sized enterprises and the innovation of products and services[21]. Guo Yuchen and Liu Mengyue pointed out at the China Industry and Economy Forum that green finance guides capital allocation and accumulation, steering funds towards green industries to promote industrial structure transformation and upgrading[22]. These theoretical studies provide a foundation and guidance for understanding how green finance can promote industrial upgrading.

2.3.2. Empirical Research

In empirical studies, scholars have used various models to explore the complex relationship between green finance and industrial structure upgrading, confirming that green finance has a significant positive impact on optimizing and upgrading the industrial structure. Zhang Xinyu used the grey correlation model to depict the correlation between the two[23]; Qu Qiongjing employed the coupling coordination degree model to measure the specific interaction between green finance and industrial structure upgrading[9]; Xu T constructed grey correlation and coupling coordination models, concluding that green finance helps upgrade the industrial structure and promotes high-quality economic development in Jiangsu Province[24]; Xie Yu and Long Jing conducted a cumulative impulse response analysis of the development of green finance and industrial structure upgrading in Sichuan Province based on the VAR model[25]; Xu Lu Yuan established a regression model to further empirically analyze that green finance can alleviate the financing constraints of distribution enterprises and support their transformation and upgrading[26]. Hou Lingling and Guo Yun used the autoregressive distributed lag error correction model to systematically analyze the mechanism of green credit in optimizing the industrial structure in Anhui Province in both the short and long terms[27]. Fu Zhanjing et al. adopted the spatial Durbin model and panel threshold model, finding an inverted U-shaped relationship between green finance and new-type industrialization development[18]. Bao Wei Yi assigned different weights and directions to indicators, concluding that green finance has a positive effect on the green transformation of industry in China's western region[28]. Looking ahead, with the increasing global focus on climate change and sustainable development goals, research in this area will continue to deepen and expand.

2.4. Literature Review and Evaluation

Based on the comprehensive review of the relevant academic literature, it is evident that scholars both domestically and internationally have produced a wealth of research on the multifaceted relationship between green finance and industrial structure, providing a solid theoretical foundation for this study. However, existing research predominantly utilizes provincial green finance panel data from China's 33 provinces, focusing on macro-level validation. There is a lack of empirical analysis that combines micro-level perspectives with panel data from prefecture-level cities within a specific

province to explore the impact of green finance development on regional industrial structure optimization and upgrading.

In light of this, this paper innovates while building upon the achievements of predecessors. Firstly, it defines relevant concepts based on the essence of green finance, starting from the connotation of industrial structure upgrading. Secondly, it constructs a comprehensive evaluation indicator system for green finance and industrial structure optimization and upgrading, based on theory. This system is used to measure the development level of green finance and to assess and analyze the degree of industrial structure upgrading. In the empirical research, this paper uses panel data from prefecture-level cities in Guizhou Province and employs a fixed-effects regression model for analysis. It examines the mechanisms through moderation and mediation effects and conducts heterogeneity tests, aiming to comprehensively explore the relationship between green finance development and industrial structure upgrading in Guizhou Province. The goal is to provide targeted suggestions.

3. Research Design

3.1. Theoretical Analysis and Research Hypotheses

Guizhou Province has a lower level of industrial structure compared to the national average, characterized by a "secondary-tertiary-primary"industry structure. This is in stark contrast to Guangdong Province (a pilot zone for green finance innovation and reform established in 2017), which has a "tertiary-secondary-primary" structure, indicating significant potential for industrial upgrading in Guizhou. The specialized sectors in Guizhou are mainly concentrated in heavy chemical industries such as energy and raw materials. The province's abundant coal and mineral resources have led to an over-reliance on resource-based industries, resulting in a slow transformation process. Against the backdrop of coordinated economic and ecological development, green finance aims to support environmental protection, resource conservation, and climate change mitigation through financial means. Its core objective is to guide capital towards green projects, promoting the development of industries in an eco-friendly and sustainable direction, thereby laying a solid foundation for theBenign interaction between high-quality economic development and ecological protection.

Therefore, we propose Hypothesis1 : Green finance can facilitate the industrial structure upgrading and transformation in prefecture-level cities of Guizhou Province.

Green finance integrates technological innovation and policy coordination to vigorously promote the green transformation of the industrial structure in Guizhou Province. In terms of technological innovation effects, policies and market forces guide capital from high-pollution and high-energy-consuming industries such as steel and cement to green industries like energy conservation and environmental protection, and new energy vehicles. These green industries, with ample funding, attract top talent and advanced technologies. For example, the new energy industry leverages technological innovation to drive the green and intelligent transformation of the energy sector. It also encourages high-energy-consuming enterprises to optimize the allocation of production factors, increase research and development, and proactively adjust their production and operation models. In terms of policy coordination effects, preferential green credit policies reduce the costs of green projects and prompt high-pollution and high-energy-consuming enterprises to eliminate outdated production capacities. Financial institutions, through business innovation, guide capital towards green industries, conduct environmental risk assessments, and provide comprehensive support for the green, efficient, and sustainable development of Guizhou's industries, achieving a win-win situation for the economy and the environment.

Therefore, we propose Hypothesis2 : Technological innovation has a moderating effect on the impact of green finance development and industrial structure upgrading and transformation in Guizhou Province.

Urbanization is an inevitable trend in social development. In the 21st century, urbanization in China will inevitably open up new pathways to achieve economic takeoff[29]. The expansion of urban

scale may generate economies of scale, driving technological innovation, cultural exchange, and industrial agglomeration, and promoting the upgrading of products and services as well as the adjustment of industrial structure[30]. Green finance can influence the industrial structure through urbanization as an intermediary variable in multiple dimensions: Urbanization brings population aggregation and consumption upgrades. Green finance supports emerging green industries, pushing the industrial structure towards the tertiary sector and achieving a green transformation. The agglomeration effect of urbanization makes the allocation of green finance resources more efficient, assisting the green and low-carbon transformation of traditional industries and optimizing the industrial structure.

Therefore, we propose Hypothesis3 : Green finance can promote the industrial structure upgrading and transformation in Guizhou Province by enhancing the level of urbanization.

In reality, prefecture-level cities in Guizhou Province differ in terms of city size, GDP, geographical location, and dominant industries. Compared to other prefecture-level cities in Guizhou, the provincial capital, Guiyang, plays a dominant role in Guizhou's green finance development and is an important support for the "Strong Provincial Capital" strategy. Since its pilot program began in June 2017, Gui'an New Area, as one of the first pilot zones for green finance innovation and reform, has achieved significant results in green finance service innovation by combining government and market forces, forging a unique path of reform. In contrast, Liupanshui, an old industrial city that grew and thrived because of coal, ranks first in the province in terms of raw coal and coke production, with the added value of the coal industry accounting for a large proportion of the city's total industrial added value, which may inhibit the development of green finance. Therefore, the impact of green finance on industrial structure optimization and upgrading may also vary among different prefecture-level cities in Guizhou Province.

Therefore, we propose Hypothesis4 : The impact of green finance on industrial structure optimization and upgrading varies across different cities in Guizhou Province.

3.2. Data Sources

This study employs panel data from prefecture-level cities in Guizhou Province, China, covering the period from 2017 to 2023. The sample data are sourced from the following publications and databases: the China City Statistical Yearbook, the China Financial Yearbook, the Bulletin of the Guizhou Provincial Department of Ecology and Environment, the Guizhou Statistical Yearbook, and the People's Bank of China. Additionally, some green finance data are obtained from the WIND database and the ESG (Environmental, Social, and Governance) reports of listed companies in Guizhou Province. During the empirical analysis, the Stata statistical software is used to conduct regression analysis on the sample data.

3.3. Indicator Selection and Variable Description

3.3.1. Indicator System Construction

This paper posits that green finance is an economic activity aimed at improving the environment, addressing climate change, and promoting the conservation and efficient use of resources. Its core objectives are to enhance resource utilization and to facilitate the upgrading of economic structures. In China, a common approach to measuring green finance is to construct a composite index based on green finance products. For instance, Qu Qiongjing constructed an evaluation system using green investment and green insurance as indicators[9], while Liu Zhaoying et al. measured the development level using indicators such as green credit, securities, insurance, and investment[10]. Therefore, considering the availability of data, this paper draws on existing research findings and mainly selects green credit and green bonds as indicators of green financial instruments for the measurement of green finance level[9][10], as shown in Table 1 below.

Table 1. Comprehensive Evaluation System for the Green Finance Index

Green Finance Instrument	Calculation Standard	Calculation Method	Attribute
Green Credit	Proportion of Environmental Protection Project Credit	Total amount of environmental protection project credit in the city / Total credit amount in the province	+
Green Bonds	Degree of Green Bond Development	Total amount of green bonds issued / Total amount of all bonds issued	+

3.3.2. Variable Description

Dependent Variable: Level of Industrial Structure Upgrading (hed). Ma Xiaojuan et al. pointed out that industrial structure upgrading and transformation is a process or trend of moving from a lower to a higher level, often accompanied by a decrease in the proportion of the primary industry (agriculture) and an increase in the proportions of the secondary (industry) and tertiary (services) industries[14]. The domestic academic community commonly measures the degree of industrial structure upgrading by the ratio of the added value of the tertiary industry to that of the secondary industry in a given year. Therefore, this paper also selects the ratio of the total output added value of the tertiary industry to that of the secondary industry as the dependent variable for empirical research.

Independent Variable: Level of Green Finance (gf). Green Credit : Green credit is an important source of funding for green projects, meeting the capital needs of different green projects through flexible loan methods. This paper uses the proportion of the total amount of environmental protection project credit in the city to the total credit amount in the province as a positive indicator. Green Bonds : Green bonds are fixed-income securities issued in the financial market to raise funds for specific green projects. This paper uses the proportion of the total amount of green bonds issued in the city to the total amount of all bonds issued as a positive indicator.

Control Variables : Considering that the optimization and upgrading of the industrial structure in prefecture-level cities in Guizhou Province may be influenced by several macroeconomic indicators, this paper selects two closely related indicators as control variables. Human Capital Level (hcl) : Measured by the ratio of the number of people in each prefecture-level city who have received higher education to the permanent resident population. Government Economic Activity Participation (dgi) : Measured by the ratio of general public fiscal expenditure of local governments to the gross regional product.

Moderating Variable: Level of Technological Innovation (rd) : The ratio of scientific and technological expenditure to the gross regional product in each prefecture-level city is selected as the moderating variable.

Mediating Variable: Level of Urbanization (ul) : The proportion of urban population to the total population in each prefecture-level city is used as the mediating variable.

As shown in Table 2 below:

Table 2. Description of Research Variables

Research Variable	Variable Type	Variable Description	Variable Code
Level of Industrial Structure Upgrading	Dependent Variable	Ratio of the added value of the total output of the tertiary industry to that of the secondary industry	hed
Level of Green Finance	Independent Variable	Ratio of the total amount of environmental protection project credit to the total credit amount in the province; Ratio of the total amount of green bonds issued to the total amount of all bonds issued	gf
Human Capital Level	Control Variable	Ratio of the number of people with higher education to the permanent resident population	hcl

3.3.3. Determination of Indicator Weights

This article uses the entropy method, an objective weighting method, to determine the weights of each indicator and then calculates the green finance index for the 9 prefecture-level cities in Guizhou Province through weighted averaging. (The entropy method is a mathematical statistical method based on information entropy to measure the degree of data dispersion. The more dispersed the data, the greater the information entropy and the less information content.) The specific calculation steps are as follows:

Standardization of Data :

For positive indicators:

$$Y_{ij} = \frac{X_{ij} - \min X_i}{\max X_i - \min X_i} \tag{1}$$

For negative indicators:

$$Y_{ij} = \frac{\max X_i - X_{ij}}{\max X_i - \min X_i} \tag{2}$$

Where " i " is the " i "-th indicator, " j " is the year, " Y_{ij} " is the standardized value, and " X_{ij} "is the initial data value collected for the " i "-th indicator in year " j ".

Normalization :

$$P_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{i=n} Y_{ij}} \tag{3}$$

Calculation of Entropy :

$$E_J = -\frac{1}{ln\ n} \sum_{i=1}^{i=n} P_{j(ij)} \times Ln P_{j(ij)} \tag{4}$$

Calculation of Redundancy of Each Indicator's Entropy :

$$D_j = 1 - E_J \tag{5}$$

Calculation of Objective Weights :

$$w_j = \frac{D_j}{\sum_{j=1}^{m} D_j} \quad (6)$$

Calculation of the Comprehensive Index :

The comprehensive evaluation function for green finance development is:

$$U_j = \sum^{j=m} w_j \times \mathrm{Y_{ij}} \quad (7)$$

Based on the current availability of data and the constructed green finance evaluation indicator system, this paper uses the comprehensive evaluation function to calculate the overall development of green finance in the 9 prefecture-level cities of Guizhou Province from 2017 to 2023. The calculation results are shown in Table 3.

Table 3. Green Finance Index of Prefecture-Level Cities from 2017 to 2023

Year	2017	2018	2019	2020	2021	2022	2023
Anshun City	0.368	0.614	0.697	0.536	0.613	0.766	0.632
Bijie City	0.39	0.831	0.124	0.195	0.435	0.766	0.529
Guiyang City	0.325	0.289	0.363	0.437	0.307	0.653	0.639
Liupanshui City	0.483	0.515	0.239	0.482	0.369	0.384	0.34
Qiandongnan Miao and Dong Autonomous Prefecture	0.352	0.507	0.205	0.308	0.317	0.587	0.414
Qiannan Buyi and Miao Autonomous Prefecture	0.493	0.656	0.481	0.333	0.462	0.433	0.384
Qianxinan Buyi and Miao Autonomous Prefecture	0.161	0.3	0.751	0.222	0.517	0.54	0.518
Tongren City	0.338	0.684	0.283	0.806	0.369	0.443	0.528
Zunyi City	0.428	0.235	0.499	0.772	0.69	0.86	0.619

Based on the data shown in the Table 3 above, the level of green finance development in most sample prefecture-level cities has improved to some extent during the period from 2017 to 2023, such as Anshun City, Guiyang City, Bijie City, and Qiannan Buyi and Miao Autonomous Prefecture. Particularly after the Gui'an New Area (located between Guiyang City and Anshun City) became the only national-level pilot zone for green finance reform in the southwestern region, the surrounding areas have made significant progress in green finance.In terms of city comparisons, high-level cities such as Guiyang City (0.639) and Anshun City (0.632) have relatively high green finance indices. These cities have achieved remarkable results in green credit, bond issuance, and environmental protection investments, leading the development of green finance. Medium-level cities: Tongren City (0.528) and Qiannan Buyi and Miao Autonomous Prefecture (0.414) are at a medium level. Although they have made progress, compared with the leading cities, they may need to further strengthen policy support for green finance, innovate green finance products and services, and so on. Low-level cities: Qiandongnan Miao and Dong Autonomous Prefecture (0.284) has a relatively low green finance index, indicating that it faces many challenges in the development of green finance. There is an urgent need to increase attention, optimize the industrial structure, and guide financial resources towards the green sector.

3.4. Construction of the Benchmark Regression Model

This paper employs panel data from various prefecture-level cities to construct a benchmark regression model (fixed-effects regression model):

$$Hed_{it} = \beta_0 + \beta_1 gf_{it} + \beta_2 hel_{it} + \beta_3 dgi_{it} + \varepsilon_{it}$$

In the model, " i " denotes different prefecture-level cities, and " t " denotes the year. " hed_{it} "is the dependent variable, representing the level of industrial structure upgrading and transformation in city " i " in year " t ". " gf_{it} "is the independent variable, representing the level of green finance in city " i " in year " t ". " hel_{it} " and " dgi_{it} " are selected as control variables in the fixed-effects model. " ε_{it} " represents the random disturbance term.

4. Empirical Analysis

4.1. Descriptive Statistics and Collinearity Analysis.

4.1.1. Descriptive Statistics.

Table 4. Descriptive Statistics of Main Variables

Research Variables	Mean	Sd	Min	Max
hed	1.5851	0.5283	0.8192	2.8343
gf	0.5306	0.1791	0.1892	0.8842
hcl	0.0201	0.0223	0.0049	0.0871
dgi	0.2800	0.0740	0.1448	0.4360
rd	0.0049	0.0017	0.0013	0.0098
ul	0.6474	0.1280	0.4418	0.9138

As shown in Table 4 above, the mean value of the explained variable, industrial structure upgrading level (hed) is 1.5851. This indicates that the efficiency of industrial transformation and upgrading in Guizhou Province is currently not satisfactory. The large gap between the maximum value of 2.8343 and the minimum value of 0.8192 suggests that there is an urgent need to promote balanced development of industrial structure upgrading. The mean value of human capital level (hcl) is only 0.0201, which is relatively low. This indicates that Guizhou Province has a limited talent pool overall. The insufficient human capital may pose challenges in attracting high-end industries and high-quality project investments, making it difficult to meet the demands of industrial upgrading. Moreover, while the relative differences in government fiscal expenditure are smaller, the participation of the government in economic activities still needs to be enhanced. Effective government involvement can play a crucial role in supporting industrial upgrading through targeted policies and investments. Finally, the overall level of technological innovation is relatively low, reflecting insufficient research and development (R&D) investment in scientific and technological innovation in Guizhou Province. In the context of green finance and technological innovation, this may limit the development of innovative green finance products and services, thereby affecting the efficiency and quality of green finance development.

4.1.2. Multicollinearity Analysis

To measure the degree of correlation among variables and avoid the interference of multicollinearity issues on the empirical results, we conducted a multicollinearity test using the Variance Inflation Factor (VIF).

Table 5. Variance Inflation Factor (VIF) Test

Variable	VIF	1/VIF
dgi	2.4	0.415834
hcl	1.73	0.578433
gf	1.58	0.634426
Mean VIF	1.9	

As can be seen from the test results in Table 5 above, the average VIF is 1.9. Since all variance inflation factors are less than 10 and even less than 5, there is no serious multicollinearity problem.

4.2. Empirical Results Analysis.

4.2.1. Hausman Test

Before conducting the regression analysis, it is necessary to select the appropriate model. According to the results of the Hausman test in Table 6, the p-value is 0.0000, which is less than 0.05. The test results indicate that the sample data reject the null hypothesis. Therefore, based on the static panel data, the fixed-effects model is selected.

Table 6. Hausman Test Results

Test	Chi2(3)	P-value	Conclusion
Hausman Test	75.34	0	Fixed-effects model is selected

4.2.2. Benchmark Regression Analysis.

Table 7. Benchmark Regression Results

Variable	hed
gf	1.027463 (0.197802)
hcl	9.226152 (2.936416)
dgi	3.286086 (0.737437)
_cons	-0.659329 (0.6522)
N	63
adg.R^2	0.796

The regression results in Table 7 show that the adjusted R^2 is 0.796, indicating that the model results have a linear relationship. Core Explanatory Variable: The coefficient of green finance is positive and significant at the 1% significance level, strongly confirming that green finance has a significant positive effect on industrial structure upgrading. This supports Hypothesis 1.

Control Variables: Human Capital Level (hcl) : The significant positive effect of human capital level on industrial structure upgrading indicates that the introduction of talent and technology is crucial for optimizing the industrial structure. Therefore, enterprises in Guizhou Province should increase their human capital investment in technological progress to facilitate the transition of their industrial structure towards greener, more rational, and advanced forms. Government Economic Activity Participation (dgi): The regression coefficient for government economic activity participation is 3.286 and significant at the 1% level. This means that for every 1% increase in fiscal expenditure, the level of industrial structure upgrading increases by an average of 3.286 percentage points. This reflects that the Guizhou provincial government can effectively promote the optimization of the industrial structure through increased fiscal expenditure. In recent years, Guizhou Province has further deepened the reform and innovation of green finance, learned from various experiences, accelerated the construction of a green inclusive finance framework, increased tax cuts and fee reductions for environmentally friendly enterprises, and expanded the issuance of green credit and other financial products. It has also actively explored the innovative path of “green and finance,” making certain contributions to the upgrading and transformation of its industrial structure.

4.3. Mechanism Analysis

4.3.1. Moderating Effect

Table 8 shows that the interaction term has a coefficient opposite to that of green finance and industrial structure upgrading in Guizhou Province, indicating that the level of technological innovation has a negative moderating effect on industrial structure upgrading. In cities with weak technological innovation capabilities and traditional industry dominance, there is an urgent need for green transformation, and the moderating effect of green finance on industrial structure upgrading is stronger. Green finance can guide capital towards emerging green industries through the establishment of green industry funds and preferential credit policies. For example, coal enterprises can use green credit to purchase clean coal mining equipment, reducing waste and pollution, and achieving a green transformation of traditional industries. At the same time, green finance provides funding for enterprises to introduce advanced green technologies and equipment. For cities with weak technological innovation capabilities, directly introducing mature green technologies can accelerate industrial upgrading.

Therefore, these cities have great potential for development. The government should formulate green finance policies, such as interest subsidies and tax incentives, to guide financial institutions to support green industries, send positive signals to the market, enhance the confidence of enterprises and investors in the development of green industries, attract enterprises to form industrial clusters, and promote the optimization and upgrading of the industrial structure.

Table 8. Moderating Effect

Variable	(1) hed	(2) hed	(3) hed	(4) hed
gf	(0.52797) 0.18473	(1.41406) 0.63903	(0.17787) 0.63903	(1.692756) 0.60927
rd	(4.11816) 0.18473	(3.24436) 2.0516	(-2.203771) -1.83554	(-1.265896) -0.97632
gf×rd		(-2.5986) -1.1982		(-2.178028) 1.01534
hcl			(18.2149) 7.178132	(20.2118) 7.0589
dgi			(0.43773) 0.29876	(0.08796) 0.63903
_cons	(1.27846) 0.138887	(0.79328) 0.36235	(0.767529) 0.34364	(0.28261) 0.63903
N	63	63	63	63
R^2	0.6318	0.7237	0.7564	0.7657
adg.R^2	0.5864	0.6976	0.7233	0.7428

4.3.2. Mediating Effect

Referring to the approach by Ge Yuanjing [30], this paper selects the level of urbanization as the mediating variable and constructs a mediating variable model:

$$Ul_{it} = \beta_0 + \beta_1 gf_{it} + \beta_2 hel_{it} + \beta_3 dgi_{it} + \varepsilon_{it}$$

$$Hed_{it} = \beta_0 + \beta_1 gf_{it} + \beta_2 ul_{it} + \beta_3 hcl_{it} + \beta_4 dgi_{it} + \varepsilon_{it}$$

The benchmark regression indicates that green finance in Guizhou Province has a direct impact on industrial structure upgrading and transformation, satisfying the first step of the mediating effect test. Table 9 shows that the green finance index has a significant positive effect on the level of urbanization at the 1% level, indicating that the development of green finance can significantly enhance the level of urbanization in Guizhou, meeting the second step of the mediating effect test. Meanwhile, urbanization and industrial structure upgrading are significantly positive at the 1% level, with the

mediating variable acting as a full mediator. Green finance can promote industrial structure upgrading and transformation by enhancing the level of urbanization. By improving the level of urbanization, green finance can drive the construction of urban infrastructure, improve the ecological environment, and leverage the effects of population aggregation, consumption upgrading, and technological innovation brought about by urbanization to promote the upgrading of the industrial structure. Therefore, in the future, it is necessary to further strengthen the construction of the green finance system, play its positive role, and achieve sustainable economic development.

Table 9. Mediating Effect

Variable	(1) ul	(2) hed	(3) ul	(4) hed
gf	(0.1085448) 0.04498	(0.38179) 0.12353	(0.074027) 0.025132	(0.409012) 0.1715414
ul		(1.224243) 0.41867		(1.79882) -0.65572
hcl			(6.883445) 1.428508	(6.03012) 5.86972
dgi			(-0.82971) -0.16012	(2.1122) 0.92639
_cons	(0.09435) 0.138887	(0.58992) 0.26308	(0.70179) 0.06816	(0.50883) 0.46008
N	63	63	63	63
R^2	0.1524	0.5266	0.7004	0.7498
adg.R^2	0.0854	0.4785	0.6732	0.7149

4.4. Robustness Test

Considering that the implementation effect of green finance policies in Guizhou Province's cities on industrial structure upgrading may have a certain degree of lag over time, and to address potential endogeneity issues in the benchmark model, this paper follows the approach of Ge Yuanjing [30] and lags the core explanatory variable, the green finance index (gf), by one period (last) and reconstructs the model for regression analysis. The results remain valid, passing the robustness test.

4.5. Heterogeneity Analysis

Table 10. Results of Heterogeneity Test

Variable	Large Cities	Medium and Small Cities
gf	27.5133 (16.0161)	53.7645 (18.1491)
hcl	20.7754 (6.8897)	27.5133 (16.0161)
dgi	0.0652 (0.0169)	0.0859 (0.0794)
_cons	(0.09435) 0.138887	(0.58992) 0.26308
N	63	63
R^2	0.1524	0.5266

Based on the total GDP scale of cities in Guizhou Province, this paper classifies the nine prefecture-level cities into large cities and medium-small cities. The results of the heterogeneity test are shown in Table 10 above.

From the perspective of human capital level, although the regression coefficient for medium and small cities is positive, it is not significant. The main reasons are the small economic scale and the single industrial structure, which limit the absorption of high-skilled talents. For example, Qianxi City, which is dominated by traditional coal industry, finds it difficult to retain innovative talents, thereby weakening the positive impact of human capital on industrial structure upgrading. Meanwhile, medium and small cities have weak supporting resources such as education and training, and the cultivation of local talents is restricted. Moreover, compared with large cities, the salary treatment and development opportunities in medium and small cities are inferior, leading to serious talent outflow. This further dilutes the positive effect of human capital, ultimately resulting in a positive but insignificant regression coefficient. This indicates that in the process of promoting industrial structure upgrading in medium and small cities, it is not possible to rely solely on the natural growth of human capital. It is necessary to optimize the industrial structure and increase educational investment to enhance the ability to absorb and reserve talents.

Regarding green finance development (gf), although the coefficient of green finance development in large cities is large, it is not significant due to the bottlenecks of market competition, complex risk assessment, and policy transmission during the transformation stage. It is difficult to effectively transform green finance resources, and its impact on industrial structure upgrading and transformation is not significant. In contrast, the role of medium and small cities is more prominent, and it is necessary to optimize the green finance environment and policies in large cities.

The impact of government economic activity participation (dgi) on industrial structure upgrading and transformation varies between large and medium and small cities. Taking Guiyang New Area, a large city, as an example, the government actively formulates industrial support policies, provides tax exemptions for emerging high-tech enterprises, sets up special funds, allocates resources, and cultivates talents. It introduces major projects and improves infrastructure construction, thereby promoting industrial high-end development. The government's participation plays a significant positive role. On the contrary, although the participation of the government in economic activities in medium and small cities has a positive impact, it is not significant. Looking at the industrial basis, the industrial structure of medium and small cities is relatively single, mostly relying on traditional resource-based industries with low technological content and short industrial chains. Their ability to accept new technologies and new industries is limited. Even if the government introduces policies, due to the limitations of the industries themselves, enterprises upgrade slowly due to factors such as funding, technology, and market demand. The policy effect is not good, and it is difficult to quickly achieve industrial structure optimization and upgrading.

The heterogeneity test shows that there are significant differences in the impact of human capital level, government economic activity participation, and green finance development on industrial structure upgrading and transformation between cities of different sizes. Large cities have certain advantages in human capital level and government economic activity participation, but green finance development needs to be optimized. The impact of medium and small cities in various aspects is mostly not significant, and it is necessary to comprehensively strengthen the transformation of economic development model, government economic activity participation, and human capital level investment. At the same time, potential development directions are also revealed, such as increasing the innovative development of green finance and exploring a green finance development path suitable for themselves. The Guizhou provincial government should focus on infrastructure construction, improve the level of education and scientific research, cultivate the basis of green industries, guide financial resources to tilt towards medium and small cities, explore policy reform and market mechanism optimization, narrow the gap, and promote the province's green, sustainable, and high-quality development.

5. Summary

5.1. Conclusions

This paper references literature related to green finance and industrial structure upgrading, selecting panel data of green finance from prefecture-level cities in Guizhou Province from 2017 to 2023 to study the relationship between the two. When constructing the indicator system, a green finance development index was created using green credit and green bonds to measure the development of green finance; the ratio of the added value of the tertiary industry to that of the secondary industry was used to measure industrial structure upgrading. Empirical tests and regression analyses were conducted on the impact relationship between green finance and the upgrading and transformation of Guizhou's industrial structure. A fixed-effects model was used for the basic regression, mechanism moderation and mediating effect tests were carried out, and considering the significant differences in economic levels across different regions in Guizhou Province, heterogeneity tests were further conducted. Finally, the following conclusions were drawn:

1. Overall, the benchmark regression empirically shows that green finance significantly promotes the upgrading of Guizhou Province's industrial structure. As a financial instrument, it tends to invest in low-pollution, environmentally friendly enterprises, guiding capital towards green industries, improving the investment environment, attracting more investors to participate in green industries, expanding their investment base, and effectively promoting industrial structure adjustment to support sustainable economic development.

2. Technological innovation has a moderating effect on the development of green finance and the upgrading and transformation of Guizhou's industrial structure. It helps financial institutions accurately assess the risks of green projects using technologies such as big data and blockchain, optimize services, improve the efficiency of capital allocation, and drive the green and sustainable transformation of Guizhou's industrial structure.

3. Green finance can promote the upgrading and transformation of Guizhou Province's industrial structure by enhancing the level of urbanization. It provides funding for the construction of urban green infrastructure, improves the ecological environment, attracts population aggregation, drives consumption, optimizes resource allocation, and encourages enterprises to develop in a green and high value-added direction, thereby promoting the upgrading of Guizhou's industrial structure.

4. In the process of promoting industrial structure upgrading, the role of green finance shows significant heterogeneity across different city sizes. The positive impact of green finance on promoting industrial structure upgrading in medium and small-sized cities is greater than its positive impact on large cities in Guizhou Province.

5.2. Recommendations

Based on the empirical analysis results, green finance in Guizhou Province has promoted the optimization of the industrial structure but is not yet mature. It is recommended to further improve policies for the development of green finance, promote green technological innovation, guide the optimization and upgrading of the industrial structure, and promote coordinated development in Guizhou Province.

1. Innovate and enrich green finance products to build a diversified green finance system.Promote innovation in green finance products and build a multi-level product structure. Specifically, establish a "green project database" and connect it with financing, optimize and upgrade financial tools such as green credit and bonds, standardize business operations, increase funding for the new energy industry, assist environmental protection enterprises in obtaining financing, and draw on successful experiences from places like Shaoxing to design differentiated credit products and improve the green finance system.

2. Adapt to local conditions and implement differentiated green finance policies. Given the diverse characteristics of prefecture-level cities in Guizhou Province, the implementation of green finance policies should be adapted to local conditions. Considering the differences in economic development

levels and city sizes, there is heterogeneity in the impact of green finance on industrial structure upgrading. It is necessary to combine the actual situation of green industries in each city, appropriately increase fiscal subsidies for green credit in medium-sized cities, allocate fiscal expenditures differentially, and improve the efficiency of resource allocation to promote the optimization and upgrading of the industrial structure.

3. Strictly regulate review standards and establish a sense of responsibility among all parties. The Guizhou provincial government should strictly follow green finance regulations, standardize the operations and reviews of financial institutions, and hold violators accountable primarily through civil liability. Draw on the model of separate management and supervision of commercial banks in China to control green finance projects and avoid risks. Strictly enforce information disclosure and severely punish environmental violations. Financial institutions should also implement guidelines, integrate ESG concepts, establish a sense of social responsibility, and effectively resolve the contradiction between profitability and environmental protection.

4. Strengthen the promotion of green finance concepts and cultivate an environment for green technological innovation. Promote green finance through various media channels, initiate popular topic discussions, and increase public awareness. In addition, the provincial government should create an innovative environment, maximize the guiding role of fiscal funds, support enterprise technological innovation and the transformation of scientific and technological achievements, subsidize innovative enterprises, optimize taxation, assist green and environmentally friendly enterprises in going public, attract high-quality talent, and promote the sustainable development of green finance to support the upgrading of the industrial structure.

5. Enhance collaboration among all parties and leverage radiating effects. Promote coordinated development of green finance among urban clusters in different regions, establish a counterpart support mechanism, create cross-regional cooperation demonstration zones, integrate resources to develop green finance products, and jointly build green and low-carbon industrial clusters. At the same time, strengthen the linkage between the government, enterprises, and banks. The government should build platforms to hold government-enterprise-bank, establish special funds, and leverage the role of capital to guide social capital into green fields.

Literature References

[1] Huang Qian. The Impact of Green Finance on the Optimization and Upgrading of China's Industrial Structure [D]. Lanzhou University of Finance and Economics, 2024.

[2] Wang Shunan. The Impact of Green Finance on Industrial Structure Upgrading [D]. Qi Lu University of Technology, 2024.

[3] Aneja Ranjan, et al. "Does the green finance initiatives transform the world into a green economy? A study of green bond issuing countries." Environmental Science and Pollution Research International 30.14 (2023): 42214-42222.

[4] Yu Luoyao, Liang Ze, Gao Yang. The Mechanism of Green Finance and Digital Economy in Empowering Regional Green Development. Forum on Statistics and Information, 2024, 39(10): 56-71.

[5] Gu Tianrui, Hao Zongjing. A Brief Discussion on Green Finance and Sustainable Financial Development. Business Exhibition Economy, 2024, (03): 85-88.

[6] Gao Jinjie. The Impact of Green Finance on China's Economic Growth and Its Regional Heterogeneity [D]. Jilin University, 2021.

[7] Zhu Xiaoying. The Impact of Green Finance Development on Industrial Upgrading in the Chengdu-Chongqing Economic Circle. Jilin Financial Research, 2023, (12): 20-24.

[8] Zhou Yujia. The Impact of Green Finance on High-Quality Economic Development [D]. Qi Lu University of Technology, 2024.

[9] Qu Qiongjing. The Coupling Coordination of Green Finance, Environmental Quality, and Economic Growth in the Yellow River Basin [D]. Jiangxi University of Finance and Economics, 2023.

[10] Liu Zhaoying, Zhang Xianchang. Green Finance, Technological Innovation, and Industrial Structure Optimization and Upgrading. Science and Industry, 2024, 24(03): 112-118.

[11] Yang Ying. The Impact of Green Finance on Regional Low-Carbon Economic Transformation [D]. Lanzhou University, 2022.

[12] Zhou Shuling, Chen Xueying. The Impact of Green Finance on Regional Industrial Structure Upgrading: A Case Study of the Yangtze River Economic Belt. Journal of Jiaxing University, 2024, 36(05): 41-50.

[13] Zhao Xunjiao. The Impact of Green Finance Policies on the Optimization of Guizhou's Industrial Structure: A Technological Innovation Perspective [D]. Guizhou Minzu University, 2024.

[14] Ma Xiaojuan, Li Yichan, Fu Zhi, et al. The Impact of Digital Economy on Industrial Structure Upgrading from the Perspective of Spatial Effects. Forum on Statistics and Information, 2022, 37(11): 14-25.

[15] Meng Weifu, Liu Jinghan. The Effect and Heterogeneity of Green Finance in Promoting High-Quality Economic Development: A Perspective of Technological Innovation and Industrial Structure Upgrading. Economic Review, 2023, (07): 100-110.

[16] Wang Yong, Tang Xuemin. Structural Transformation and Industrial Upgrading: Quantitative Facts and Theoretical Progress from the Perspective of New Structural Economics. Economic Commentary, 2021, (01): 3-17.

[17] Jiang Zehua, Bai Yan. The Connotation and Influencing Factors of Industrial Structure Upgrading. Contemporary Economic Research, 2006, (10): 53-56.

[18] Zhang Huaxin, Fu Zhanjing. How Does Green Finance Affect the Development of New-Type Industrialization?. Innovation and Technology, 2024, 24(08): 39-57.

[19] Ye Lin, Deng Ruibin. Exploring the Path of Green Finance in Achieving the "Dual Carbon" Goals: An Analysis Based on Policy Tools. Local Governance Research, 2023, (01): 52-64+80.

[20] Chu Jingjing. The Role of Green Finance in Supporting Industrial Upgrading and High-Quality Development. Finance and Economics, 2023, (36): 12-14.

[21] Xie Zhizhuo. Exploring the Innovation and Reform of Green Finance and Regional Industrial Structure Upgrading. Finance and Accounting Learning, 2023, (06): 122-124.

[22] Guo Yuchen, Liu Mengyue. Green Finance in Promoting Industrial Structure Upgrading. China Industry and Economy, 2022, (19): 120-122.

[23] Zhang Xinyu. Grey Correlation Analysis of Green Finance and Industrial Structure Upgrading in Qinghai Province. China Business Review, 2024, (07): 109-112.

[24] Xu T, Zhu Z, Chen T. The Impact of Green Finance on Promoting Industrial Structure Upgrading: An Analysis of Jiangsu Province in China. Sustainability, 2024, 16(17): 7520-7520.

[25] Xie Yu, Deng Hanlin, Long Jing. The Path of Green Finance Development in Promoting Industrial Structure Transformation in Sichuan Province: An Empirical Analysis Based on VAR Model. Modern Business, 2023, (16): 47-50.

[26] Xu Lu Yuan. The Impact Mechanism of Green Finance and Financing Constraints on the Transformation and Upgrading of Distribution Industry. Commercial Economic Research, 2024, (03): 15-19.

[27] Hou Lingling, Guo Yun. The Impact of Green Finance on the Optimization of Industrial Structure in Anhui Province and Empirical Analysis. Journal of Changchun University, 2024, 34(03): 12-19.

[28] Bao Wei Yi. The Impact of Green Finance on the Green Transformation of Industry in China's Western Region. Fortune Today, 2024, (28): 35-37.

[29] Ma Liang. Analyzing the Relationship between Urbanization and Economic Development. China Business Review, 2016, (29): 143+145.

[30] Ge Yuanjing, Ding Qi. The Impact of Green Finance on Industrial Structure Upgrading in the Yellow River Basin. Science and Technology & Economy, 2025, (01): 51-55.