Research on the Impact of Green Finance on Industrial Structure Transformation and Upgrading in Zhejiang Province—The mediation effect of Government Fiscal Expenditure

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Abstract： This study empirically examines how green finance drives industrial upgrading in Zhejiang Province (2010-2023) through panel data analysis of 11 prefecture-level cities. Results demonstrate that a one-unit increase in the Green Finance Index (GFI) elevates the Industrial Structure Upgrading Index by 1.429 units, confirming its direct catalytic effect. Crucially, government fiscal expenditure acts as a significant partial mediator, amplifying green finance's impact via low-carbon subsidies and regulatory reinforcement. The findings validate a dual-pathway mechanism where green finance concurrently reshapes industrial structures directly through capital reallocation and indirectly through fiscal policy synergy. Practical implications highlight targeted fiscal incentives and cross-regional governance frameworks to accelerate sustainable transformation.

Key words： Green development; Green finance; Industrial structure; Transformation and upgrading

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1 Research Background

Aligning with national green finance policies, Zhejiang Province actively explores these instruments to support its ecological goals and drive a green, low-carbon economy, integrating this into broader socioeconomic development. With traditional industries urgently needing transformation due to high energy consumption and emissions, green finance targets capital allocation towards clean energy and carbon-neutral tech, aiming to adjust the industrial structure and enable a fundamental shift towards environmentally sustainable development. This paper examines green finance's ability to meet Zhejiang's sustainable industrial development needs and its positive impact on industrial transformation[1].

2 Research Methods

2.1.Research Model and Hypothesis

This study uses the industrial advancement index (third/second industry value-added ratio, per Dang Chenlu 2019) as the dependent variable to measure structural shifts toward cleaner, higher-value sectors. The green finance index (GFI, per Wang 2023) serves as the core independent variable. Four controls—Technological Innovation, Economic Development (ED), Human Capital (HC), and Foreign Investment (FDI)—are included. Government fiscal expenditure is treated as a mediator, as studies show fiscal tools (e.g., subsidies) and policies (e.g., carbon taxes) can directly/indirectly boost green finance and industrial upgrading (Wang et al. 2020; IMF 2021).

Collectively, these variables comprehensively control for innovation, economic, human capital, openness, and governance factors, enhancing robustness[2].

To sum up, this paper builds the following theoretical model.

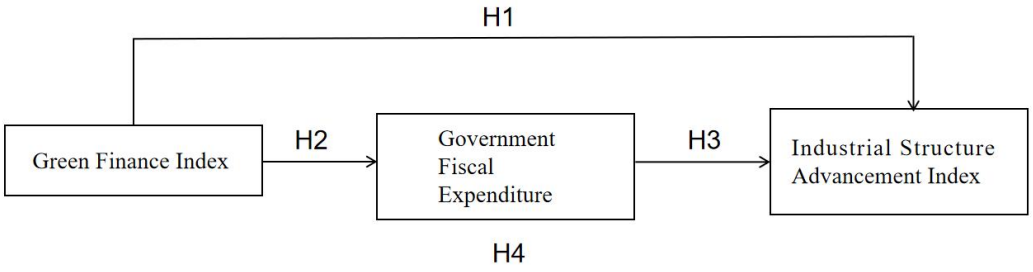

Figure1 Research Model

2.2 The Relationship Between the Green Finance Index and the Upgrading Index of Industrial Structure

Green finance promotes the upgrading of the industrial structure toward high-value-added sectors by optimizing capital allocation efficiency. Existing studies have shown that green financial instruments (e.g., green credit, green bonds) can guide social capital away from high-pollution, high-energy-consuming industries toward low-carbon sectors such as clean energy and energy-saving and environmental protection technologies (Liu Xin et al., 2021). Through differentiated interest rate policies, green credit restricts financing for "two-high-and-one-surplus" industries (high-pollution, high-energy-consuming, and overcapacity industries) while providing low-cost funding support to green enterprises. This mechanism directly facilitates the expansion of the tertiary industry (e.g., the digital economy, modern service industries) and the green transformation of the secondary industry (Wang Yao et al., 2020). Additionally, green finance supports green technological innovation (e.g., carbon capture technology) via its risk diversification function, further driving the industrial structure to upgrade toward a technology-intensive direction (Xie Qiaoxin, 2021). Therefore, based on the above analysis, the following research hypothesis is proposed:

H1: The Green Finance Index has a significant positive impact on the Upgrading Index of Industrial Structure[3].

2.3 The Relationship Between the Green Finance Index and Government Fiscal Expenditure

The development of green finance may, through the policy synergy effect, compel the government to expand green fiscal expenditure. According to the theory of interaction between fiscal policy and financial markets, green finance attracts social capital to participate in environmental protection projects via market-based tools (e.g., carbon tax, green bonds). However, sectors with strong public goods attributes (e.g., ecological restoration, low-carbon technology R&D) still require support from fiscal funds (Stiglitz, 1989). To attract green finance investments, local

governments may reduce the cost of green transformation for enterprises through policies such as fiscal subsidies and tax incentives, thereby forming a virtuous cycle of "green finance leading - fiscal expenditure following." Additionally, in regions with a higher level of green finance development, governments tend to allocate fiscal expenditures toward green infrastructure (e.g., charging pile networks, smart energy systems) to align with the needs of industrial structure upgrading (Liu & Zhu, 2024).Therefore, based on the above analysis, the following research hypothesis is proposed:

H2: The Green Finance Index has a significant positive impact on government fiscal expenditure.

2.4 The Relationship Between Government Fiscal Expenditure and the Upgrading Index of Industrial Structure

Government fiscal expenditure serves as a critical policy tool for the government to intervene in the upgrading of the industrial structure. Keynesian theory posits that fiscal expenditure expands aggregate demand through the multiplier effect, stimulating economic growth and optimizing resource allocation in the short term (Keynes, 1936). In the context of long-term industrial structure upgrading, fiscal expenditure directed toward education, research and development (R&D), and infrastructure sectors (e.g., 5G networks, data centers) can enhance total factor productivity and drive the development of high-tech industries (e.g., artificial intelligence, biopharmaceuticals) (Romer, 1986). Studies by Su Rengang et al. have shown that the Chinese government’s support for enterprise technological transformation via the "Special Fund for Green Manufacturing" has significantly elevated the green transformation level of the manufacturing industry. Furthermore, strategic trade theory emphasizes that governments play a role in cultivating strategic industries through subsidies. For instance, China’s financial subsidies for new energy vehicles (NEVs) have accelerated their marketization process (Brander & Spencer, 1985). Therefore, based on the above analysis, the following research hypothesis is proposed:

H3: Government fiscal expenditure has a significant positive impact on the Upgrading Index of Industrial Structure[4].

2.5 The Mediating Role of Government Fiscal Expenditure Between the Green Finance Index and the Upgrading Index of Industrial Structure

Studies have shown that social capital attracted by green finance may be converted into fiscal expenditure through government tax channels (e.g., carbon tax revenues used for environmental protection projects) or enhance the credibility of government green investment through policy commitments (e.g., green bond issuance) (Musgrave, 1959). Additionally, institutional change theory posits that green finance policies (e.g., the Regulations on Promoting Green Finance) and fiscal expenditure commitments form a stable policy portfolio, reducing the risks of enterprises' green transformation and thereby accelerating industrial upgrading (North, 1990). Wang Xiru’s research has also validated this path. For example, the development of green finance in Zhejiang Province has significantly increased the proportion of local strategic emerging industries through fiscal

subsidies. Therefore, based on the above analysis, the following research hypothesis is proposed:

H4: Government fiscal expenditure plays a mediating role between green finance and the upgrading of the industrial structure[5].

2.6 Data Sources and Scope

The main data for this study are primarily sourced from green finance policy documents issued by government departments, macroeconomic data released by the National Bureau of Statistics, and other relevant sources. These include websites of authoritative institutions such as the Ministry of Science and Technology and the People's Bank of China, as well as various authoritative statistical yearbooks—encompassing national and provincial/municipal statistical yearbooks, environmental status bulletins, and specialized statistical yearbooks (e.g., China Science and Technology Statistical Yearbook, China Energy Statistical Yearbook, China Financial Statistical Yearbook, China Economic Census Yearbook, China Environmental Statistical Yearbook, China Industrial Statistical Yearbook, and China Insurance Statistical Yearbook)—and the Wind database.

3. Research Results

3.1 Descriptive Statistical Analysis

Descriptive statistics of the selected variables are presented in Table 2. For the upgrading index of industrial structure (IS) in Zhejiang Province, the mean value is 1.088, with a significant gap between the minimum value (0.622) and maximum value (2.478). This indirectly indicates substantial disparities in the development of industrial structure among cities at the prefecture level in Zhejiang, suggesting still significant room for improvement in the future. The green finance index (GFI) has an average value of 0.401, with a small gap between its maximum (0.564) and minimum (0.308). This suggests that cities across Zhejiang have actively responded to the national call for environmental protection, strived to enhance green economic development, and emphasized ecological and environmental conservation. The gap between the maximum and minimum values of the technological innovation level (TP) is relatively small, indicating that science and technology expenditure across cities in Zhejiang is generally balanced. For the economic development level (ED), the difference between the maximum and minimum values is 1.98, indirectly reflecting varying driving forces behind economic development among different cities. The gap between the mean and extreme values of both the human capital level (HC) and foreign investment level (FDI) is small. For government fiscal expenditure (GOV), the maximum and minimum values are 0.192 and 0.105, respectively, indicating differences in the intensity of government investment in green finance development across cities.

Variable	N	Mean	p50	SD	Min	Max
IS	154	1.088	1.014	0.338	0.622	2.478
GFI	154	0.401	0.396	0.0500	0.308	0.564
TP	154	0.0370	0.0340	0.0150	0.00400	0.0820

ED	154	11.31	11.33	0.409	10.12	12.10
HC	154	0.0200	0.0160	0.0150	0.00400	0.0700
FDI	154	0.0170	0.0110	0.0140	0.00200	0.0530
GOV	154	0.141	0.134	0.0320	0.105	0.192

Table 2 Descriptive Statistics of Variables

3.2. Correlation analysis

The correlation coefficient matrix results of the variables are presented in Table 3. Empirical findings reveal a significant positive correlation between green finance development and industrial structure transformation and upgrading, which is statistically significant at the 1% level. The coordinated development of the upgrading index of industrial structure (IS) and the green finance index (GFI) suggests that the growth of green finance has, to a certain extent, driven the transformation and upgrading of the industrial structure. The upgrading index of industrial structure (IS) is significantly positively correlated with the technological innovation level (TP), underscoring the critical role of technological innovation in propelling industrial upgrading. Both the human capital level (HC) and economic development level (ED) exhibit strong positive correlations with the green finance index (GFI) and technological innovation level (TP), indicating that human capital and economic foundations are key determinants of industrial structure transformation and upgrading. The negative correlations observed between government policy expenditure (GOV) and indicators such as the technological innovation level (TP) and foreign investment level (FDI) imply that local governments at all levels need to optimize their fiscal structures to balance short-term livelihood needs with long-term innovation objectives.

Variable	IS	GFI	TP	ED	HC	FDI	GOV
IS	1						
GFI	0.413***	1					
TP	0.212***	0.227***	1				
ED	0.336***	0.489***	0.657***	1			
HC	0.480***	0.0650	0.627***	0.610***	1		
FDI	-0.103	-0.109	0.443***	0.457***	0.524***	1	
GOV	0.308***	0.324***	-0.404***	-0.122	-0.207	-0.363***	1

Table 3 Correlation Analysis of Variables

Notes: Standard errors in parentheses. *p<0.1,* ***p<0.05,*** p<0.01.

The benchmark regression results are presented in Table 4:

	(1) IS	(2) IS	(3) IS	(4) IS	(5) IS
GFI	2.919***	2.733***	1.095**	1.472***	1.429***
	(0.321)	(0.356)	(0.548)	(0.522)	(0.516)
TP		2.804	1.718	2.022	0.734
		(2.317)	(2.232)	(2.099)	(2.165)
ED			0.419***	0.438***	0.420***
			(0.110)	(0.103)	(0.102)
HC				-20.774***	-20.910***
				(4.706)	(4.651)
FDI					-6.100**
					(2.944)
_cons	-0.083	-0.111	-4.150***	-4.119***	-3.745***
	(0.130)	(0.132)	(1.067)	(1.003)	(1.007)
N	154.000	154.000	154.000	154.000	154.000
r2	0.368	0.374	0.433	0.503	0.518
r2_a	0.319	0.321	0.380	0.453	0.465

Table 4 Benchmark Regression Results

Notes: Standard errors in parentheses. *p<0.1,* ***p<0.05,*** p<0.01.

The benchmark regression analysis, conducted through the sequential addition of control variables, demonstrates that the Green Finance Index (GFI) exerts a significantly positive impact on the Upgrading Index of Industrial Structure (IS). Across Models (1) to (5), the coefficient of GFI decreases from 2.919 to 1.429 while remaining statistically significant at conventional levels. This result indicates a stable stimulating effect of green finance on industrial structure upgrading. Consequently, H1 is supported: The development of green finance significantly promotes industrial structure upgrading, and this impact demonstrates robustness.

4. Mediation Effect Test

The mediation effect test results are presented in Table 5:

Variable	**Total Effect Model**	**GFI → GOV Path**	**Joint Effect Model**
	IS	GOV	IS
GFI	1.429***	0.066**	1.105**
	(0.516)	(0.032)	(0.500)
TP	0.734	-0.201	1.726
	(2.165)	(0.135)	(2.084)
ED	0.420***	0.029***	0.276***
	(0.102)	(0.006)	(0.105)
HC	-20.910***	-0.365	-19.110***
	(4.651)	(0.290)	(4.467)
FDI	-6.100**	-0.153	-5.345*
	(2.944)	(0.184)	(2.819)
GOV	-	-	4.934***
	-	-	(1.304)
Constant	-3.745***	-0.198***	-2.770***
	(1.007)	(0.063)	(0.996)
N	154.000	154.000	154.000
r2	0.518	0.451	0.563
r2_a	0.465	0.392	0.512

Table 5 Mediation Effect Model Results

Notes: Standard errors in parentheses. *p<0.1,* ***p<0.05,*** p<0.01.

Based on the results presented in Table 4, empirical evidence confirms that the Green Finance Index (GFI) exerts a positive influence on government fiscal expenditure (GOV) with a statistically significant coefficient of 0.066 (p<0.05). This validates H2, indicating that green finance development significantly promotes the expansion of fiscal expenditure. Simultaneously, government fiscal expenditure demonstrates a significantly positive impact on the Upgrading Index of Industrial Structure (IS), evidenced by a coefficient of 4.934 (p<0.01). This supports H3, confirming that fiscal expenditure significantly drives industrial structure upgrading.

Furthermore, in the joint effect model, the direct effect of GFI on IS remains statistically significant at 1.105 (p<0.05). The mediation effect value, calculated as 0.066 × 4.934 ≈ 0.324, accounts for 22.7% of the total effect (1.429). Consequently, H4 is substantiated, demonstrating that government fiscal expenditure plays a partial mediating role between green finance and industrial structure upgrading. This indicates that green finance indirectly promotes industrial upgrading through increasing fiscal expenditure.

Based on the results of these tests, a detailed analysis of the relationships between the paths in the model is presented below.

Hypothesis	Hypothetical content	Results
H1	The Green Finance Index has a significant positive impact on the Upgrading Index of Industrial Structure.	Supported
H2	The Green Finance Index has a significant positive impact on government fiscal expenditure.	Supported
H3	Government fiscal expenditure has a significant positive impact on the Upgrading Index of Industrial Structure.	Supported
H4	Government fiscal expenditure plays a mediating role between green finance and the upgrading of the industrial structure.	Supported

Table6 Research Hypothesis and Hypothesis Test Results

This study synthesizes green finance and industrial transformation literature to construct an analytical framework, utilizing 2010–2023 panel data from Zhejiang's 11 cities. Industrial upgrading is measured by the tertiary/secondary industry value-added ratio, while the Green Finance Index (GFI) integrates seven indicators (e.g., green credit, investment, insurance). Fixed-effects models, mediation testing (government fiscal expenditure as mediator), and endogeneity controls (ED, HC, FDI) were employed. Key findings reveal: (1) GFI significantly drives industrial upgrading—a 1-unit GFI increase raises the Industrial Structure Index by 1.429 units (p<0.01)—through capital reallocation to sustainable sectors and forced optimization of traditional industries; (2) 22.7% of GFI's total effect (mediation effect: 0.324) operates via government fiscal expenditure (β=4.934, p<0.01), amplified by subsidies and environmental regulations, confirming green finance's dual-path promotion of low-carbon, high-value industrial transformation.

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