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Original Paper

The Green Effects of DIF: Corporate Green Production's Stimulation of Residents' Low-Carbon Consumption

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Abstract

Against the background of full implement of China's "dual-carbon" strategy and the rapid expansion of the digital economy, clarifying the mechanisms through which digital inclusive finance (DIF) contributes to green consumption is of both theoretical and practical importance. Using a matched panel dataset of Chinese prefecture-level cities and listed firms from 2011 to 2019, this study develops an integrated analytical framework linking DIF, corporate green production, and residents' low-carbon consumption preferences. Two-way fixed-effects models and firm-level mediation regressions are employed to examine the green effects of DIF. The results indicate that: (1) DIF significantly enhances residents' low-carbon consumption preferences, and this effect remains robust after controlling for socioeconomic characteristics; (2) DIF strengthens corporate green production by increasing green total factor productivity, stimulating green technological innovation, and alleviating financing constraints; (3) Corporate green production further reinforces residents' low-carbon consumption preferences through supply-side channels such as the expansion and upgrading of green products, as well as demand-side channels including environmental improvement and green information spillovers; (4) DIF exhibits a clear chain transmission mechanism, operating through the pathway "DIF → corporate green production → residents' low-carbon consumption preferences." The innovation of this paper lies in: constructing a green transmission mechanism identification framework covering both the urban and enterprise dimensions, and for the first time systematically verifying the path through which DIF influences residents' preference for low-carbon consumption by promoting green production of enterprises, and revealing the formation logic of green consumption from both the supply and demand sides. The research conclusions provide empirical evidence for the coordinated design of digital finance and green development policies.

Keywords

DIF(DIF), corporate green production, green technological innovation, low-carbon consumption

preferences, green development

1. Introduction

Under the global transition toward climate governance and China's accelerated implementation of the "dual-carbon" strategy, fostering and transforming residents' low-carbon consumption preferences has become a critical component of building a green and low-carbon circular economy system. Traditional consumption patterns mainly characterized by high energy consumption and high emissions impose increasing pressure on the ecological system. Meanwhile, Chinese residential consumption is accelerating the transition from quantity-oriented to quality-oriented, with green, low-carbon, and healthy lifestyles gradually emerging as new consumption norms. Promoting low-carbon consumption preferences is therefore essential for sustainable development and for extending ecological civilization into everyday life.

With the deep integration of digital technology and economic activities, the digital economy has become a key driver of economic structural transformation and green development promotion. (Wang, 2025) As a core component of the digital economy, DIF -characterized by broad coverage of services, low transaction costs, high efficiency, and high accessibility-has effectively broken through the limitations of traditional financial services in terms of time and space, reducing the barriers for both firms and households to access financial services. In the context of green transformation, DIF not only optimization the efficiency of financial resource allocation but also reshapes the connection between green production and green consumption, which will become an important driving force for promoting the expansion of green production and stimulating residents' demand for low-carbon consumption.

From the supply side, DIF mitigates firms' financing constraints and reduces uncertainty in green R&D, thereby promoting green technological innovation, improving green total factor productivity, and expanding the scale and quality of green products. From the demand side, DIF improves households' income expectations and wealth accumulation while enhancing environmental information dissemination through digital platforms, which facilitates the upgrading of residents' consumption structure from "subsistence consumption" to "green quality consumption", thereby facilitating the formation and strengthening of the preference for low-carbon consumption.

Although existing studies have examined the positive roles of the digital economy, green finance, and consumption upgrading, little attention has been paid to how DIF affects residents' low-carbon consumption preferences through corporate green production. There is still no clear evidence of a verifiable transmission mechanism linking residents' micro-level green consumption preferences to the expansion of firms' green capabilities on the production side, nor is there a unified analytical framework to capture this relationship. Against this backdrop, this study takes DIF as the analytical entry point and develops an integrated theoretical and empirical framework linking DIF, corporate green production, and residents' low-carbon consumption preferences. From both the supply side and the demand side, we identify the underlying transmission mechanisms and conduct systematic

empirical tests using panel data at the prefecture-level city and listed-firm levels, thereby providing robust empirical evidence and policy-relevant insights for promoting low-carbon consumption transitions in the digital economy.

2. Policy Background and Theoretical Mechanisms

2.1 Policy Background

Against the backdrop of the comprehensive advancement of China's "dual-carbon" strategy and the deepening implementation of high-quality development objectives, China's policy system is simultaneously exerting force on both the supply and demand sides to guide economic social transformation toward a green, low-carbon, and sustainable development path. In this context, the accelerated development of the digital economy and the construction of a green consumption system have become key components of national policy, providing an institutional foundation and realistic background for this study.

From the perspective of national strategies, China has successively issued policy documents such as the "Comprehensive Work Plan for Energy Conservation and Emission Reduction during the 14th Five-Year Plan" and the "Action Plan for Carbon Peaking before 2030", which explicitly propose promoting the green transformation of residents' lifestyles and building a green development system that covers the entire chain of production, circulation, and consumption. Within this framework, green consumption is positioned as a critical link in the societal green transition and has become an important policy objective within the national governance system.

From the perspective of market development and the supply system, the "Outline for Quality Development (2011-2020)" and its subsequent policies emphasize improving the quality of products and services to meet residents' increasingly quality-oriented and green consumption demands. The "Implementation Plan for Promoting Green Consumption" further proposes expanding the supply of energy-efficient, water-saving, and environmentally friendly products and building green supply-chain systems. This series of policies has promoted enterprises to accelerate green technological innovation and green production transformation, forming a green and high-quality supply structure and providing a material basis for the formation of residents' low-carbon consumption preferences.

From the perspective of the digital economy and the development of DIF, policy documents such as the "Overall Layout Plan for the Construction of Digital China" and the "Guidelines for the Construction of the National Integrated Government Big Data System" continuously strengthen China's digital economy development strategy and promote the rapid development of digital infrastructure, digital governance, and digital finance. As an important component of the digital economy, DIF plays a significant role in improving financial accessibility, reducing financing costs, and narrowing the urban-rural digital divide, thereby providing new driving forces for enterprise green transformation and resident consumption upgrading.

China's policy system is thus exerting coordinated efforts across multiple dimensions, forming a green

development policy chain that links the production, circulation, and consumption ends. Based on this policy background, this study investigates how DIF influences residents' low-carbon consumption preferences through enterprise green production.

2.2 Theoretical Mechanisms

The formation of residents' low-carbon consumption preferences is not the result of a single factor, but rather a systematic process jointly driven by the supply side and the demand side. As a key linkage between enterprise production and household consumption, DIF exerts bidirectional empowerment through two pathways-enterprise green production on the supply side and residents' consumption behavior on the demand side-thereby constructing a complete mechanism for the transformation of low-carbon consumption preferences.

2.1.1 Supply-side mechanism: DIF Empowering Enterprise Green Production and Hypothesis Development

From the supply-side perspective, relying on digital technologies such as big data and artificial intelligence, DIF improves the efficiency of financial resource allocation and fundamentally alleviates the financing constraints faced by enterprises in green production, thereby providing a solid material foundation for residents' low-carbon consumption. (Dai & Huang, 2025) Under the traditional financial system, green production projects generally have the inherent attributes such as long investment cycles and high risk-assessment difficulties. Small and medium-sized enterprises, constrained by insufficient credit qualifications and information asymmetry, face particularly severe green financing difficulties. DIF, through precise risk-control models and data-based credit evaluation systems, effectively reduces information asymmetry between financial institutions and enterprises, shortens financing processes, and lowers financing costs, thus providing stable financial support for enterprises to continuously invest in green technology R&D, environmental equipment upgrading, and green transformation of production processes. (He & Li, 2024) This empowerment effect is directly reflected in three dimensions of enterprise green production capability. First, green efficiency is improved: the alleviation of financial constraints encourages enterprises to actively adopt energy-saving and emission-reduction technologies and optimize green production processes, thereby significantly enhancing green total factor productivity. Second, green innovation increases: reductions in financing costs and the expansion of financing channels stimulate enterprises to increase green R&D investment, accelerate the output of green patents, and promote the iterative upgrading of green products. Third, financing constraints are continuously eased, enabling enterprises to allocate more funds to green transformation and environmental governance, forming a virtuous cycle of green production. Based on the above supply-side mechanism, the following hypotheses are proposed:

H1: DIF can significantly enhance enterprise green production capacity. (Wang & Wu, 2024) By alleviating financing constraints on green production, improving the credit evaluation environment, and reducing the costs and risks of green technological innovation and green equipment investment, DIF enhances enterprises' green total factor productivity and increases green patent output, thereby strengthening green production capacity.

H2: Enterprise green production can significantly promote residents' low-carbon consumption preferences. Improvements in enterprise green production expand the scale of green product supply, improve supply quality, and reduce supply prices, while also enhancing residents' green consumption willingness through environmental quality improvement and green information spillovers, thereby promoting the formation and strengthening of residents' low-carbon consumption preferences.

H3: Enterprise green production plays a mediating role between DIF and residents' low-carbon consumption preferences. DIF indirectly improves the supply conditions for residents' low-carbon consumption by empowering enterprise green production through the supply-side pathway, thereby transmitting its effects to the demand side and enhancing residents' low-carbon consumption preferences.

2.2.2 Demand-side Mechanism: DIF Activating Residents' Low-carbon Consumption and Hypothesis Development

From the demand-side perspective, DIF directly activates residents' low-carbon consumption potential by enhancing consumption capacity, strengthening consumption willingness, and optimizing the consumption environment, forming a bidirectional synergy with the supply-side mechanism and jointly driving the systematic transformation of low-carbon consumption preferences. This process can be decomposed into three core dimensions. First, through inclusive credit, convenient wealth-management products, and payment services, DIF effectively improves residents' financial accessibility, steadily enhances income expectations and wealth accumulation capacity, and breaks the financial barriers to low-carbon consumption, laying a solid economic foundation for residents to participate in green consumption. Second, relying on the extensive reach and penetration of digital platforms, DIF accelerates the dissemination of low-carbon and environmental protection concepts, helping residents establish correct green consumption cognition and improve environmental awareness, thereby strengthening their perceived utility of green products and stimulating their intrinsic willingness to actively participate in low-carbon consumption. Third, the risk-protection systems constructed by DIF effectively reduce residents' consumption concerns and increase their marginal propensity to consume, promoting the transformation of green consumption from "optional consumption" to "routine consumption" and continuously consolidating residents' low-carbon consumption preferences. The sustained growth of low-carbon consumption demand on the demand side further exerts a feedback effect on the supply side, prompting enterprises to further optimize green product supply and forming a virtuous cycle of "demand pulling supply and supply adapting to demand," thereby amplifying the overall empowerment effect of DIF on the transformation of low-carbon consumption preferences. Based on the above demand-side theoretical mechanism, the following hypotheses are proposed:

H4: DIF can directly and significantly enhance residents' low-carbon consumption preferences through the demand-side pathway. At the theoretical level, DIF can activate residents' low-carbon consumption willingness and capacity by improving financial accessibility, strengthening the dissemination of low-carbon concepts, and improving risk-protection mechanisms, thereby promoting residents'

low-carbon consumption preferences.

H5: Residents' environmental awareness plays a moderating role in the demand-side pathway between DIF and residents' low-carbon consumption preferences. According to theoretical logic, the higher residents' environmental awareness, the more accurately they can perceive the low-carbon concepts disseminated by DIF, strengthen their perceived utility of green products, and thus make the effect of DIF in activating low-carbon consumption demand more significant and its impact on residents' low-carbon consumption preferences stronger.

2.2.3 Supply-demand Synergy and Hypothesis Development

The empowerment of DIF on residents' low-carbon consumption preferences does not operate through the supply side or the demand side alone, but rather through the synergistic interaction of both dimensions. Optimized green product supply on the supply side provides material support for the release of consumption potential on the demand side, while growing consumption demand on the demand side provides incentives for the upgrading of green production on the supply side. The two sides thus form a positive feedback loop that amplifies the overall empowerment effect of DIF. Accordingly, the following hypothesis is proposed:

H6: A synergistic effect exists between supply-side enterprise green production and demand-side improvement in residents' consumption capacity, jointly strengthening the empowering effect of DIF on residents' low-carbon consumption preferences. When green product supply is sufficient on the supply side and residents' consumption capacity and willingness are simultaneously enhanced on the demand side, the overall empowering effect of DIF on residents' low-carbon consumption preferences is maximized.

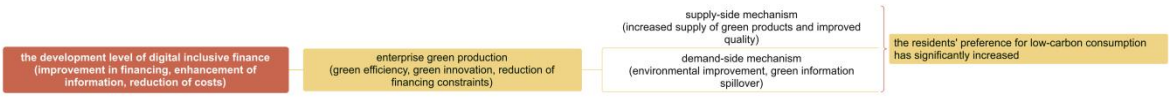

Figure 1. Conceptual Framework of This Study

3. Research Design

3.1 Sample Selection and Data Sources

To systematically examine the mechanisms through which DIF affects residents' low-carbon consumption preferences, this study constructs a research sample based on multidimensional panel data at both the prefecture-level city and listed-company levels, covering the period from 2011 to 2019. This time span is chosen for three main reasons: first, the Peking University DIF Index has been continuously released since 2011; second, data on green patents, corporate financials, and urban environmental statistics are relatively complete during this period; and third, this period witnessed the rapid development of the digital economy, making it highly representative.

Data on residents' low-carbon consumption preferences are obtained from the China City Statistical Yearbook, the China Regional Economic Statistical Yearbook, and statistical bulletins on national

economic and social development published by local governments. DIF data are taken from the Peking University DIF Index. Firm-level data are obtained from the CSMAR database, the Wind database, and the China Environmental Statistics Yearbook, including corporate green patent applications, financial indicators, and corporate governance variables. Control variables are drawn from the corresponding statistical yearbooks and databases. To ensure data accuracy and consistency, missing values are treated and all variables are winsorized at the 1st and 99th percentiles. Based on the registered locations of firms, firm-level data are matched to the corresponding prefecture-level cities by year, thereby achieving a dual-level "firm-city" data integration. Descriptive statistics for all variables are reported in Table 1.

Table 1. Descriptive Statistics

	Observation value	Mean value	Standard deviation	Minimum value	Maximum value
dsc1	1752	0.8405	0.1567	0	1
lnindex_aggregate	2641	5.0034	0.5126	2.8915	5.7766
fiscal_pressure	2566	0.4630	0.2241	0.049	1.541
lnper_capita_regional_GDP (yuan)	2449	10.7010	0.5542	8.8417	12.2807
lneconomic_development_level	1463	9.0184	0.5311	7.8220	10.8294
proportion_of_secondary_industry	2281	47.2110	10.7633	10.68	89.34
proportion_of_tertiary_industry	2281	40.7261	10.0984	10.15	83.52
population_density	2566	4.3816	3.4497	0.013	27.591
financial_development_level	2524	0.9978	0.6459	0.118	9.6221
social_security_level	2560	4.5843	1.7312	1.3513	13.7659

3.2 Variable Definition and Measurement

3.2.1 Dependent Variable: Residents' Low-Carbon Consumption Preference (dsc1)

Existing studies indicate that residents' carbon emissions mainly originate from various types of energy consumption behaviors in daily life, and reductions in carbon emission intensity can directly reflect residents' preference for low-carbon and green consumption (Cao & Gao, 2021). Following the measurement framework of Cao and Gao (2021), this study systematically measures residents' household energy-consumption-related carbon emissions from four dimensions: residential electricity use (Li, Peng, & Wang, 2023), residential gas use, transportation, and residential heating. Electricity-related carbon emissions are calculated based on regional residential electricity consumption and the corresponding regional power-grid emission factors. Gas-related carbon emissions are calculated by comprehensively considering the consumption volumes, calorific values, and emission

factors of liquefied petroleum gas and coal gas. Transportation-related carbon emissions cover the ownership, annual mileage, fuel consumption per 100 kilometers, and emission coefficients of buses, taxis, and private cars. Heating-related carbon emissions are calculated based on household heating area and coal consumption per unit heating area.

The four types of carbon emissions are aggregated to obtain the total household energy-consumption carbon emissions of region c, denoted as Cc. This value is then normalized by the regional population to obtain the carbon-emission-intensity indicator SCct. Since this indicator is a negative measure of low-carbon demand preference, this study further follows Gu Haifeng and Yu Jiajun (2019) by applying range standardization to convert it into a positive indicator dscct with values in the interval [0,1]. The calculation formula is:

$$dsc_{ct} = \frac{\max SC_{ct} - SC_{ct}}{\max SC_{ct} - \min SC_{ct}} \quad (1)$$

A larger value of dscct indicates a stronger preference for green and low-carbon consumption among residents in region c.

3.2.2 Core Explanatory Variable: DIF Index (lnindex_aggregate)

The natural logarithm of the Peking University DIF Index is used to reflect the level of DIF development in each region.

3.2.3 Mediating Variables: Enterprise Green Production(M)

To comprehensively capture the multidimensional characteristics of enterprise green production, this study employs the following three proxy variables: (1) Green total factor productivity (GTFP), measured using the non-radial SBM-ML index, reflecting firms' production efficiency under energy and emission constraints; (2) Green technological innovation (lnnumber_of_green_patents), measured as the natural logarithm of the number of green patents authorized in year t plus one to capture firms' green innovation capability; (3) Financing constraints (SA_index), which measures the degree of firms' financing constraints; a smaller value indicates lower financing constraints and indirectly reflects the level of financial support available for green production. (Fan, 2023)

3.2.4 Control Variables

Following existing studies, the following control variables are included: (1) City-level variables: fiscal pressure; GDP per capita (lnGDP_per_capita); level of economic development (lneconomic_development); share of secondary industry; share of tertiary industry; population density; level of financial development; and level of social security. (2) Firm-level variables: Financial indicators include firm size (lnassets), measured as the natural logarithm of total assets; profitability (roa), measured by return on total assets; firm growth (growth), measured by the growth rate of operating revenue; firm leverage (leverage), measured by the ratio of total liabilities to total assets; cash flow (cash), measured by the ratio of net operating cash flow to total assets; and the proportion of fixed assets (fixed_assets). Corporate governance indicators include firm age (age), measured by the number of years since establishment; ownership concentration (con), measured by the shareholding ratio of the

largest shareholder; board size (dsh_size), measured as the natural logarithm of the number of board members; proportion of independent directors (ind_ds); and executive compensation (ggxc), measured as the natural logarithm of the compensation of the top three executives. (Ma, 2022)

3.3 Model Specification

To test the direct impact of DIF on residents' low-carbon consumption preferences, a two-way fixed-effects model is constructed:

$$dsc_{jt}=\alpha_0+\beta_1 lnindex\_aggregate_{jt}+\gamma X_{jt}+\mu_j+\lambda_t+\varepsilon_{jt} \quad (2)$$

where j denotes cities and t denotes years; dsc1jt represents the low-carbon consumption preference of residents in city j in year t; ln index aggregatejt is the core explanatory variable; Xjt denotes the vector of city-level control variables; represents city fixed effects; represents year fixed effects; and is the random disturbance term.

Table 2. Variable Definitions

	Variable	Definition	Expected sign
Dependent variable	dsc1	residents' low-carbon consumption preference	-
Explanatory variable	lnindex_aggregate	DIF index	+
Mediating variable	GTFP	enterprise green efficiency	+
Mediating variable	lngreen_patents	green technological innovation capacity	+
Mediating variable	SA_index	financing constraints	-
Control variables	Firm-level_controls and city-level_controls	see main text	±

4. Empirical Analysis

Table 3 reports the baseline regression results of the impact of DIF on residents' low-carbon consumption preferences. Column (1) includes only the core explanatory variable and fixed effects. The results show that the coefficient of the DIF index (lnindex_aggregate) is 0.0725 and is significantly positive at the 1% level, indicating that the development of DIF has initially exhibited a role in promoting residents' low-carbon consumption preferences. By facilitating the expansion of green supply and enhancing residents' consumption capacity, DIF helps guide residents toward low-carbon and green consumption patterns. After adding city-level control variables in Column (2), the coefficient of the core explanatory variable becomes 0.0772 and remains significantly positive at the 1% level, suggesting that after controlling for fiscal pressure, the level of economic development, industrial

structure, and other factors, the positive effect of DIF on residents' low-carbon consumption preferences remains robust.

Regarding the control variables, only the level of social security is statistically significant: its coefficient is −0.0095 and is significantly negative at the 5% level (t-value = −2.14). In regions with a higher level of social security, residents' basic "safety-net" needs in medical care, pensions, and unemployment protection have been more fully satisfied, which reduces the short-term urgency of upgrading living quality through low-carbon consumption, thereby leading to a significant negative relationship between social security and residents' low-carbon consumption preferences. Other control variables, such as fiscal pressure and GDP per capita, do not pass significance tests, indicating that their effects on residents' low-carbon consumption preferences are relatively limited. The adjusted R^2 of the model is 0.329, which is higher than the value of 0.308 in Column (1), indicating that the inclusion of control variables improves the model's explanatory power for variations in residents' low-carbon consumption preferences. This level of explanatory power is relatively high in the field of resident behavior research, suggesting that the selected core explanatory variable, control variables, and fixed-effects specification are reasonable and can effectively capture the key factors influencing residents' low-carbon consumption preferences. Overall, the model specification is both scientifically sound and reliable.

Table 3. Baseline Regression Results of DIF on Residents' Low-Carbon Consumption Preferences

	(1)	(2)
	dsc1	dsc1
lnindex_aggregate	0.0725***	0.0772***
	(2.84)	(2.80)
fiscal_pressure		-0.0326
		(-1.03)
lnGDP_per_capita (RMB)		-0.0829
		(-0.71)
lneconomic_development_level		0.1604
		(1.12)
share_of_secondary_industry		-0.0005
		(-0.23)
share_of_tertiary_industry		0.0008
		(0.33)
population_density		0.0205
		(1.59)

financial_development_level		-0.0238 (-0.90)
social_security_level		-0.0095** (-2.14)
year_fixed_effects	yes	yes
city_fixed_effects	yes	yes
N	1714	834
Adj-R²	0.308	0.329

Notes. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. t-statistics are reported in parentheses.

5. Further Analysis

5.1 Mechanism Test

The baseline regression results in the previous section indicate that DIF significantly enhances residents' low-carbon consumption preferences, yet the underlying mechanism of action remain to be further explored. Based on the theoretical analysis, DIF improves the allocation of financial resources and promotes firms' green production, thereby indirectly strengthening residents' low-carbon consumption tendencies. To further verify this logical chain, this section conducts a two-stage mechanism test. In the first stage, an empirical strategy is employed to test the effect of "DIF → corporate green production". In the second stage, theoretical analysis is used to explain the mechanism of "corporate green production → residents' low-carbon consumption preferences", thereby constructing a complete logical pathway from both the supply-side and demand-side perspectives.

5.1.1 First Stage: The Impact of DIF on Corporate Green Production

To identify whether DIF can influence residents' low-carbon consumption preferences by promoting corporate green production, this paper first establishes firm-level mediation models. Green total factor productivity (GTFP), green patent output (lnnumber_of_green_patents), and the degree of financing constraints (SA_index) are employed as proxies for corporate green production.

(1) Empirical Design

A panel fixed-effects model is applied, in which green total factor productivity (GTFP), ln number of green patents, and the SA index serve as dependent variables, and the DIF index is the core explanatory variable. Firm-level financial and governance characteristics are included as control variables. The firm-level mediation model is specified as follows:

$$M_{ijt}=\alpha_1+\beta_2 lnindex\_aggregate_{jt}+\delta Controls_{ijt}+\mu_i+\lambda_t+\varepsilon_{ijt} \quad (3)$$

where i denotes firms; Mijt represents the proxy variables for corporate green production; Controlsijt are firm-level control variables; and other variables are defined as before.

(2) Results Analysis

Table 4 reports the regression results on the impact of DIF on corporate green production. Column (1)

shows that the coefficient of the DIF index (lnindex_aggregate) on green total factor productivity (GTFP) is 0.142 and is significantly positive at the 1% level, indicating that the development of DIF effectively enhances firms' green production efficiency and provides efficiency support for the supply of green products. In column (2), the coefficient of the core explanatory variable on ln number of green patents is 0.325 and is significant at the 1% level, suggesting that DIF significantly promotes corporate green technological innovation by alleviating financing constraints and reducing innovation costs, thereby improving the supply capacity of green products. In column (3), the coefficient of the DIF index on the SA index is −0.180 and is significantly negative at the 1% level. Since a smaller SA index indicates lower financing constraints, this result confirms that DIF effectively alleviates firms' financing constraints and provides sufficient financial support for corporate green production.

Regarding the control variables, firm size (lnassets) is significantly positive in all three models, indicating that larger firms have advantages in green production, technological innovation, and financing capacity. Return on assets (roa) is significantly positive only in the SA index model, implying that more profitable firms face relatively lower financing constraints. The ratio of fixed assets (fixed_assets) is significantly negative in the GTFP model, possibly because asset-heavy firms face greater difficulties in transforming their production modes, resulting in relatively lower green production efficiency. The significant effects of corporate governance variables such as the proportion of independent directors (ind_ds) indicate that sound corporate governance structures facilitate firms' green transformation.

Table 4. Regression Results on the Impact of DIF on Corporate Green Production

	(1)	(2)	(3)
	GTFP	lnnumber_of_green_patents	SA_index
lnindex_aggregate	0.142***	0.325***	-0.180***
	(0.001)	(0.023)	(0.005)
lnassets	0.013***	0.319***	-0.077***
	(0.001)	(0.025)	(0.008)
roa	0.000	-0.004	0.008***
	(0.000)	(0.013)	(0.003)
growth	-0.000*	0.000**	-0.000***
	(0.000)	(0.000)	(0.000)
leverage	0.002*	0.016	0.023***
	(0.001)	(0.017)	(0.006)
cash	-0.001	-0.019	-0.065***
	(0.004)	(0.095)	(0.024)
fixed_assets	-0.012***	0.079	-0.008

	(0.004)	(0.108)	(0.018)
age	0.000	0.000	0.000
	(.)	(.)	(.)
con	-0.073***	-0.522***	0.105***
	(0.005)	(0.159)	(0.024)
dsh_size	-0.020***	-0.004	0.010
	(0.003)	(0.065)	(0.009)
ind_ds	0.007***	0.039***	-0.009***
	(0.001)	(0.013)	(0.002)
ggxc	0.000	0.000	0.000
	(.)	(.)	(.)
_cons	-0.095***	-8.148***	-1.071***
	(0.018)	(0.542)	(0.150)
N	20672	20672	20672
R2	0.7282	0.2199	0.0410

5.1.2 Second Stage: The Impact of Corporate Green Production on Residents' Low-Carbon Consumption Preferences

Based on the first-stage empirical results confirming that DIF significantly promotes corporate green production, this subsection further analyzes, from a theoretical perspective, how corporate green production affects residents' low-carbon consumption preferences. Since firm-level green production behavior is transmitted to residents through multi-layered market mechanisms and social mechanisms, its influence on residents' green consumption willingness and preferences is characterized by a complex systemic nature, which can be explained mainly from both the supply-side and the demand-side dimensions.

From the supply-side perspective, the improvement in corporate green production not only expands the market supply scale of green products and services, but also promotes a shift in the green supply structure from quantity expansion to quality upgrading. On the one hand, green production enriches the variety of green goods, reduces the acquisition cost and choice cost of green products, and enhances residents' accessibility, thereby transforming green consumption from a niche behavior into a more universal practice. On the other hand, corporate green technological innovation leads to improvements in product performance, enhanced environmental friendliness, and lower usage costs, which increase consumers' perceived utility of green products and make them more competitive among substitutes. The upgrading of the green supply system can effectively reduce consumers' risk perception and quality concerns regarding green products, thereby strengthening their green consumption preferences.

From the demand-side perspective, corporate green production affects residents' consumption capacity and willingness by improving environmental quality and reducing negative environmental externalities.

As firms promote emission reduction, energy conservation, and green production processes, regional environmental quality improves, residents' health risks and environmental governance expenditures decline, and real disposable income rises, enabling greater purchasing power for quality-oriented green consumption. In addition, environmental information disclosure, green labeling, and social feedback generated in the green production process produce significant information spillover effects, making it easier for consumers to perceive firms' green behavior, thereby deepening their environmental protection values and green lifestyle concepts at the cognitive level and ultimately strengthening green consumption willingness. The combined effects of information spillovers and social demonstration cause residents to gradually internalize green consumption from a "rational choice" into a "value-oriented" behavior, thus forming stable low-carbon consumption preferences.

5.1.3 Conclusions of the Mechanism Test

Based on the above two-stage mechanism test, a relatively complete transmission pathway can be identified. The first-stage empirical results show that DIF significantly promotes corporate green production by improving green production efficiency, enhancing green technological innovation capacity, and alleviating financing constraints, thereby laying the foundation for the expansion and quality upgrading of the green production system. The second-stage theoretical analysis further indicates that corporate green production influences residents' low-carbon consumption preferences through dual mechanisms on both the supply side and the demand side: the simultaneous improvement in the quantity and quality of green supply reduces consumers' green switching costs, while environmental improvement and green information spillovers enhance residents' green consumption capacity and willingness.

Therefore, the impact of DIF on residents' low-carbon consumption preferences does not occur directly, but is gradually transmitted through the key intermediary of corporate green production. DIF is not only a digital tool in the financial sector, but also an important force in promoting the construction of a green supply system and the formation of a green consumption culture, providing both theoretical and empirical support for achieving coordinated green collaborative transformation across production, circulation, and consumption.

5.2 Heterogeneity Tests

5.2.1 Regional Heterogeneity (Eastern / Central / Western Cities)

Taking western cities as the benchmark group, the differences in the impact of DIF on residents' low-carbon consumption preferences across regions are examined. As shown in column (1) of Table 5, the results exhibit a pattern of "significant in the West, insignificant in the East and Central regions," indicating that differences in regional development foundations lead to heterogeneous policy effects.

For western cities, the coefficient of DIF on residents' low-carbon consumption preferences is 0.0621 and is significantly positive at the 10% level ($p < 0.1$), indicating that in western regions DIF plays a significant role in promoting residents' low-carbon consumption preferences. This is related to the relatively late start and large development potential of DIF in western regions. Its marginal effects in

alleviating insufficient financial services and promoting the diffusion of green products are more pronounced, thereby effectively stimulating residents' low-carbon consumption demand.

The interaction term for eastern cities is −0.0156 and fails to pass the significance test ($p > 0.1$), implying that compared with western regions, the additional promoting effect of DIF on residents' low-carbon consumption preferences in eastern regions is not significant. The eastern region has a higher level of economic development and a relatively mature financial system, and residents' low-carbon consumption preferences may already be at a relatively high level, so the incremental effect of DIF is relatively limited. At the same time, the supply of green products in the eastern region is already relatively sufficient, and the marginal effect of DIF transmitted through the supply side is partially diluted.

The interaction term for central cities is −0.000523 and also fails to pass the significance test ($p > 0.1$), indicating that there is no significant difference between the central and western regions in the effect of DIF on residents' low-carbon consumption preferences. This result may be due to the role of the central region as a hub linking the eastern, central, and western economies, where the development level of DIF and the foundational conditions for green production and consumption lie between those of the eastern and western regions, and no differentiated transmission mechanism has yet been formed.

5.2.2 Urban Type Heterogeneity (Old Resource-Based / Old Industrial Cities vs. Other Cities)

Taking "other cities" as the benchmark group, the differences in the impact of DIF on residents' low-carbon consumption preferences across different types of cities are examined. As shown in column (2) of Table 5, the promoting effect of DIF on residents' low-carbon consumption preferences is significantly stronger in old resource-based cities than in other cities, while there is no significant difference between old industrial cities and other cities. Differences in industrial foundations and transformation paths lead to different heterogeneous outcomes.

The interaction term for old resource-based cities is 0.0225 and is significantly positive at the 10% level ($p < 0.1$), indicating that compared with other cities, DIF has a stronger promoting effect on residents' low-carbon consumption preferences in old resource-based cities. These cities have long relied on traditional high-energy-consuming industries such as resource extraction, and residents' consumption patterns are deeply influenced by traditional production modes. DIF, by supporting the substitution of green industries and promoting corporate green transformation, can more significantly change residents' consumption environment and consumption cognition, thereby strengthening low-carbon consumption preferences. At the same time, during the transformation process, such cities have a more urgent demand for green financial support, making the marginal role of DIF more prominent.

The interaction term for old industrial cities is −0.0075 and fails to pass the significance test ($p > 0.1$), indicating that the effect of DIF on residents' low-carbon consumption preferences in old industrial cities is not significantly different from that in other cities. This may be because the industrial transformation of old industrial cities focuses on the green upgrading of traditional industries, where

structural improvements in the supply of green products are relatively slow, and residents' consumption path dependence on traditional industrial products remains strong. As a result, the transmission effect of DIF is partially offset, leading to no clear differentiation in policy effects compared with ordinary cities.

For other cities, the coefficient of DIF on residents' low-carbon consumption preferences is 0.0475 and is significantly positive at the 10% level ($p < 0.1$), confirming the general promoting effect of DIF on low-carbon consumption preferences in ordinary cities. These cities have relatively balanced industrial structures and lower resistance to green transformation, enabling DIF to effectively stimulate low-carbon consumption demand by promoting corporate green production and enhancing residents' consumption capacity.

Table 5. Heterogeneity Tests

	(1)	(2)
	dsc1	dsc1
Western region (baseline group)	0.0621*	
	(0.0331)	
Eastern region (baseline + interaction)	-0.0156	
	(0.0174)	
Central region (baseline + interaction)	-0.000523	
	(0.0137)	
Other cities (baseline group)		0.0475*
		(0.0270)
Interaction term for old resource-based cities		0.0225*
		(0.01238)
Interaction term for old industrial cities		-0.0075
		(0.0089)
Interaction term for other cities		0
Control variables	Controlled	Controlled
Time fixed effects	Controlled	Controlled
City fixed effects	Controlled	Controlled
N	834	834
adj. R2	0.317	0.3414

F	8.957	9.11

5.3 Moderating Effect Analysis

5.3.1 The Moderating Effect of Environmental Regulation

As an important policy instrument for guiding corporate green transformation and regulating the green development of markets, differences in the intensity of environmental regulation may affect the transmission efficiency of DIF on residents' low-carbon consumption preferences. To test this moderating effect, this paper introduces environmental regulation intensity as a moderating variable and incorporates the interaction term between DIF and environmental regulation into the baseline regression model. The results are reported in column (1) of Table 6.

From the regression results, the main effect coefficient of environmental regulation is 0.0112, but it does not pass the 10% significance level ($p > 0.1$), indicating that without considering DIF, environmental regulation itself does not have a significant direct promoting effect on residents' low-carbon consumption preferences. This may be because environmental regulation mainly operates by constraining firms' production behavior and promoting industrial green upgrading, and its impact on residents' consumption preferences is indirect and lagged, making it difficult to be reflected directly in the short term.

The coefficient of the interaction term between DIF and environmental regulation is −0.00207. Although it does not pass the 10% significance level ($p > 0.1$), the negative sign suggests that environmental regulation may to some extent weaken the promoting effect of DIF on residents' low-carbon consumption preferences. The potential logic behind this result is that strict environmental regulation increases compliance costs for firms' green production, which may cause some small and medium-sized enterprises to face short-term pressure during green transformation, thereby affecting the stability and cost-effectiveness of green product supply. Although DIF can alleviate firms' financing constraints, under high-intensity environmental regulation, corporate funds are more likely to be allocated to compliance-related expenditures such as environmental equipment upgrades and pollution treatment, leaving relatively fewer resources for green technological innovation and product quality upgrading. This indirectly weakens the stimulating effect of green supply on residents' consumption preferences. In addition, overly stringent environmental regulation may lead the market to expect price increases in green products, weakening residents' willingness to engage in green consumption and further offsetting the positive effect of DIF.

The moderating effect of environmental regulation on the relationship between DIF and residents' low-carbon consumption preferences is relatively weak and exhibits a negative tendency. This implies that policy design should emphasize coordination between environmental regulation and DIF: while strengthening environmental regulation, DIF should be used to provide more targeted support for firms' green technological innovation, reducing the conflict between compliance costs and innovation costs, and avoiding short-term shocks of environmental regulation on green supply, so as to better realize their synergistic effect in promoting residents' low-carbon consumption preferences.

5.3.2 The Moderating Effect of Regional Financial Development Level

The level of regional financial development reflects the maturity of financial markets, the efficiency of resource allocation, and service coverage capability. It may generate heterogeneous moderating effects on residents' low-carbon consumption preferences by influencing the scope and transmission efficiency of DIF. This section takes regional financial development level as a moderating variable and constructs an interaction term between DIF and financial development level to test its moderating effect. The results are reported in column (2) of Table 6.

The regression results show that the main effect coefficient of financial development level is 0.1261 and is significantly positive at the 1% level ($p < 0.01$), indicating that regional financial development level itself has a significant positive effect on residents' low-carbon consumption preferences. This is because in regions with higher financial development levels, financial services are more diversified and capital allocation is more efficient, which can provide diversified financing support for corporate green production and complementary services such as credit and wealth management for residents' green consumption, thereby directly or indirectly promoting the formation of low-carbon consumption preferences.

The coefficient of the interaction term between DIF and financial development level is −0.02438 and is significantly negative at the 1% level ($p < 0.01$), indicating that regional financial development level exerts a significant negative moderating effect on the relationship between DIF and residents' low-carbon consumption preferences. As the level of regional financial development increases, the promoting effect of DIF on residents' low-carbon consumption preferences gradually weakens. The underlying mechanism of this result can be explained from two perspectives. On the one hand, in regions with higher levels of financial development, traditional financial institutions have already established relatively well-developed green finance systems, with wide coverage of products such as green credit and green bonds. Firms have more diversified financing channels for green production, and residents also enjoy sufficient financial support for green consumption. Under such circumstances, the "inclusiveness" advantage of DIF is difficult to fully manifest, and its marginal contribution is diluted by existing traditional financial services. On the other hand, in regions with higher financial development levels, residents have accumulated more wealth and their consumption structures are already relatively optimized. Low-carbon consumption preferences may already be at a relatively high level, so the incremental impact of DIF through improving consumption capacity and spreading green information is relatively limited. In contrast, in regions with lower financial development levels, traditional financial services suffer from insufficient supply and high access barriers. DIF can effectively fill these gaps by leveraging its low-cost and wide-coverage advantages to activate the potential of green production and consumption, resulting in a more pronounced promoting effect.

This moderating effect indicates that the role of DIF in promoting residents' low-carbon consumption preferences exhibits a clear "complementary" characteristic: in regions with relatively underdeveloped financial systems, DIF is an important driving force for green consumption transformation; whereas in

regions with mature financial systems, it is necessary to further strengthen the coordinated innovation between DIF and traditional green finance, focusing on segmented areas such as the expansion of green consumption scenarios and the precise matching of green products, in order to maintain its positive impact on low-carbon consumption preferences.

Table 6. Moderating Effect Results

	(1)	(2)
	dsc1	dsc1
DIF	0.0641**	0.0096
	(0.0259)	(0.0365)
Environmental regulation	0.0112	
	(0.00936)	
DIF × Environmental regulation	-0.00207	
	(0.00187)	
Financial development level		0.1261***
		(0.0474)
DIF × Financial development level		-0.02438***
		(0.0079)
Control variables	Controlled	Controlled
Time fixed effects	Controlled	Controlled
City fixed effects	Controlled	Controlled
N	795	826
adj. R2	0.293	0.3439
F	8.741	9.42

6. Conclusions and Policy Implications

Against the backdrop of the rapid development of the digital economy and the comprehensive implementation of the "dual-carbon" strategy, how to enhance corporate green production through financial digitalization and thereby stimulate residents' low-carbon consumption preferences is a key issue that urgently needs to be addressed within the green transition system. Based on city-firm two-level panel data from 2011 to 2019, this paper constructs a unified analytical framework of "DIF - corporate green production - residents' low-carbon consumption preferences" and conducts systematic tests using two-way fixed effects models and firm-level mediation models. The main conclusions are as follows. First, DIF significantly enhances residents' low-carbon consumption preferences. Second, DIF significantly strengthens firms' green production capacity. Third, corporate green production promotes residents' low-carbon consumption preferences through both supply-side and demand-side mechanisms.

Fourth, the effect of DIF on residents' low-carbon consumption preferences exhibits a "chain transmission" structure. This paper demonstrates the key bridging role of DIF in the green transition. Its green effects are reflected not only in the improvement of financial accessibility itself, but more importantly in the systematic mechanism through which corporate behavior and the market environment are improved to ultimately influence residents' consumption behavior.

Based on these findings, coordinated efforts should be made from three dimensions-financial digitalization, corporate green transformation, and the cultivation of green consumption-to build a green development system that links the production side with the consumption side. First, the construction of DIF infrastructure should be continuously advanced to improve the accessibility of digital services in underdeveloped regions and narrow the regional "digital divide," thereby laying a foundation for firms and residents to widely participate in green production and green consumption. Second, DIF should be deeply integrated with green finance by establishing a unified green project identification system and a digital credit evaluation system, so as to guide financial resources more efficiently toward energy conservation and environmental protection, low-carbon manufacturing, and the utilization of new energy. At the same time, innovative products such as green credit scores and green consumption installment plans should be encouraged to reduce the cost of residents' use of green products. Third, policy incentives for corporate green technological innovation should be strengthened. Through tax incentives, R&D subsidies, and rewards for green patents, firms' willingness and capacity for green production should be enhanced, while industrial chain coordination and industrial park empowerment should be used to promote the overall upgrading of the green supply system. Meanwhile, a nationally unified certification and labeling system for green products should be accelerated to improve their credibility, transparency, and market accessibility, reduce "greenwashing" behavior, and strengthen consumers' trust in green products. Finally, corporate environmental information disclosure systems should be strengthened, and digital platforms and public media should be used to expand the dissemination of low-carbon lifestyle concepts, making green values more deeply rooted in society. This will help form an integrated green transition pattern of "financial support - corporate transformation - consumption upgrading," thereby comprehensively enhancing the momentum of green development across society.

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