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The Impact of Digital Inclusive Finance on Regional Economic Growth and Environmental Quality

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Abstract: China has prioritized high-quality development as a key goal in building a socialist modernized country. Currently, regional economic development faces challenges such as blocked factor flows, regional disparities, and environmental degradation, highlighting the need for coordinated economic and environmental progress. This paper explores how digital inclusive finance impacts regional economic development and environmental quality. Using panel data from 31 provinces (2012–2022) and a bidirectional fixed-effect regression model, the study finds that digital inclusive finance drives economic growth through technological innovation and enhances environmental quality via industrial upgrading. This research offers empirical evidence on the role of digital finance in regional development and provides policy insights for promoting green transformation and sustainable growth.

Keywords: high-quality development, digital inclusive finance, regional economy, environmental quality

1. Introduction

The Chinese economy has shifted toward high-quality development, with regional economic growth being a key goal [1]. However, regional development faces challenges such as blocked factor flows, regional disparities, low functional specialization, and slow industrial transitions [2]. In December 2023, the Central Economic Work Conference emphasized optimizing regional economic layouts and promoting industrial upgrades. Achieving high-quality regional development requires alignment with environmental protection to meet sustainable development goals. Yet, excessive resource exploitation and reliance on polluting industries in some regions hinder green development and ecological sustainability.

Finance plays a crucial role in driving high-quality development. With the rapid growth of digital finance, China has achieved "leapfrog" progress over developed nations, particularly in fostering inclusive finance. However, the environmental impact of digital finance remains a concern. Financial activities are closely linked to environmental quality, and balancing economic growth with environmental sustainability is an urgent challenge. Therefore, studying the dual impact of digital inclusive finance on regional development and environmental quality is vital for achieving coordinated economic and environmental progress.

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2. Literature Review

The literature extensively explores its economic impact and pathways. Studies show that digital inclusive finance significantly promotes the development of new productivity and fosters common prosperity between urban and rural areas [3]. It eases financing constraints for small and medium-sized enterprises (SMEs), improving investment efficiency, but it also increases financing uncertainty, which heightens financial market risks [4]. By alleviating liquidity constraints and facilitating payments, it boosts consumer spending and significantly enhances residents' well-being [5, 6]. From an urban development perspective, digital inclusive finance aids in upgrading the industrial structure of mature, declining, and resource-based cities, while rationalizing the industrial structure in growing resource-based cities [7]. In agriculture, it encourages farmers' investment in production, thus enhancing the international competitiveness of Chinese agricultural products [8, 9]. Some scholars also argue that digital inclusive finance can reduce carbon emissions [10], improve regional innovation capacity [11], stimulate urban entrepreneurship [12], and promote intergenerational income mobility [13]. Furthermore, studies have verified its role in rural poverty reduction [14] and regional economic growth [15].

With the implementation of China’s regional coordinated development strategy, regional economic development has become an increasingly important research area. Scholars have explored the factors influencing regional development in depth. Guo Yang and Liao Dongchang [16] argue that the free trade zone has significantly reduced regional disparities and promoted coordinated regional growth. Government intervention, technological innovation, population density, and system quality all have heterogeneous effects on regional economic development [17]. Intelligent transportation optimizes the transportation network and facilitates scheduling and monitoring, providing strong support for regional development [18]. Bidirectional FDI fosters regional economic resilience by improving resource allocation efficiency and technological innovation [19]. Additionally, concentrated internet infrastructure [20] and high-tech industries [21] enhance urban economic development.

Resources and the environment are key endogenous drivers of economic growth, and scholars have offered various perspectives on the factors influencing environmental quality and potential improvement paths. Yao Shujun and Chen Keyu [22] argue that the digital economy can enhance ecological quality, while Zhou Yi et al. [23] suggest that strategic environmental regulation by local governments can improve environmental structure. This highlights the role of government responsibility in promoting environmental quality [24]. Optimizing the business environment can reduce pollution by improving the quality of foreign direct investment (FDI) [25]. Advances in internet technology also contribute to better regional environmental quality [26], whereas fiscal decentralization in local governments can hinder the effectiveness of environmental pollution governance [27]. Many scholars have also explored the link between trade and the environment. While Antweiler et al. [28] provide empirical evidence of a positive relationship between trade openness and environmental quality, treating trade intensity as exogenous may limit causal conclusions. Frankel et al. [29], using exogenous geographic factors as instruments, found that trade tends to reduce air pollution and improve environmental quality.

3. Data

3.1. Data Source

In order to ensure the accuracy and authority of the empirical analysis, this paper uses the data released by the National Bureau of Statistics as the data source, selects 31 provinces in China as samples, and uses the panel data from 2012 to 2022 for research.

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3.2. Variable Definition and Sample Description

1) Interpreted variables: regional economic development level and environmental quality.

This study uses regional per capita GDP data from the National Bureau of Statistics to measure regional economic development, with higher values indicating greater economic development. Additionally, following Deng Rongrong and Zhang Aoxiang [30], and Liu Feiyu and Zhao Aiqing [31], the study constructs an environmental pollution index based on the entropy method. This index, reflecting environmental quality, is derived from wastewater discharge, sulfur dioxide emissions, and industrial solid waste production. Data for this index is sourced from the China Statistical Yearbook and provincial statistical yearbooks.

2) Core explanatory variable: digital financial inclusion Development index .

In this study, the "Digital Financial Inclusion Index" released by the Digital Financial Research Center of Peking University is used to measure the development level of digital financial inclusion. The index is constructed from three dimensions: breadth of coverage, depth of use and degree of digitalization, reflecting the development status of digital inclusive finance in different dimensions.

3) Control variables: ① Education level of residents: select the per capita years of education in each province; ② Financial development level: select the proportion of the balance of financial institutions in the regional GDP; ③ urbanization rate: select the proportion of the urban population at the end of the year; ④ the number of unemployed: ⑤ the registered unemployment number of foreign investment level: select the number of foreign invested enterprises in each province; ⑥ inflation rate: select the provincial GDP reduction index, CPI consumer price index and PPI industrial factory price index, and sum up the three.
4) Intermediary variable: industrial structure upgrading and scientific and technological innovation index

In order to verify that technological innovation is the mechanism for promoting regional economic development through digital inclusive finance, this article introduces the Science and Technology Innovation Index, referring to the research of Liu Anle et al. [32], and reflects the level of technological innovation through the number of science and technology fiscal expenditures in general fiscal expenditures. The data is sourced from the Guotai An database.

To verify that industrial structure upgrading is the mechanism by which digital inclusive finance affects regional environmental quality, this article empirically tests this mechanism from two perspectives: rationalization of industrial structure and upgrading of industrial structure. Refer to Gan Chunhui et al [33], the study uses the Thiel index (TL) as the measure of industrial structure, and the ratio of the output value of the tertiary industry to the secondary industry (TS) as the measure of advanced industrial structure.

The formula of the Tyre index is calculated as follows:

$$TL = \sum_{i=1}^{n} \left(\frac{Y_i}{Y}\right) ln\left(\frac{Y_i}{L_i} / \frac{Y}{L}\right) \quad (1)$$

The index considers the relative importance of industry, avoids the calculation of absolute value, while retaining the theoretical basis and economic meaning of structural deviation, so it is a good measure for the rationalization of industrial structure. If the economy is in equilibrium, then TL = 0. If TL is not 0, it indicates that the industrial structure deviates from the equilibrium state and that the industrial structure is unreasonable.

Descriptive statistics were performed for the samples used in the text regression analysis. Descriptive statistics of the main variables are presented in Table 1.

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Table 1: Descriptive statistics of samples

type of variable	Variable	number	average value	standard error	MIN	Max
explained variable	lnGDP	341	10.862	0.447	9.706	12.123
	EPI	341	-0.212	0.138	-0.668	-0.003
explanatory variable	DL	341	259.918	90.878	61.470	475.790
controlled variable	EDU	341	9.206	1.129	4.222	12.782
	FIN	341	3.547	1.136	1.784	7.609
	URR	341	59.800	12.682	22.870	89.600
	UR	341	26.495	15.32335	1.600	82.500
	FDI	341	17789.130	29851.91	208	189439
	INF	341	310.112	6.157	291.270	340.550
Intermediary variable	TL	341	2.408	0.119	2.132	2.836
	TS	341	1.392	0.740	0.611	5.283
	TII	341	13.579	1.140	10.637	16.283

4. Model

4.1. The Benchmark Regression Model

In order to better explore the relationship between digital inclusive finance on regional economic growth and environmental quality, this paper uses the two-way fixed effect model to explore the relationship between the development level of digital inclusive finance and regional economy and environmental quality in different provinces.

1) To estimate the impact of digital financial inclusion on the level of regional economic development, the model is set as formula (2).

$$ln\ G\ DP_{it} = \alpha_1 + \beta_1 DL_{it} + \theta X_{it} + u_i + \lambda_t + \varepsilon_{it} \quad (2)$$

2) To estimate the impact of digital financial inclusion on regional environmental quality, the model is set as Equation (3).

$$EPI_{it} = \alpha_2 + \beta_2 DL_{it} + \theta X_{it} + u_i + \lambda_t + \varepsilon_{it} \quad (3)$$

4.2. Mediator Model

In order to verify the role mechanism of digital inclusive finance in influencing regional economic development through the level of scientific and technological innovation, an intermediary model is established, as shown in Equation (4).

$$TII_{it} = \alpha_3 + \beta_3 DF_{it} + \theta X_{it} + u_i + \lambda_t + \varepsilon_{it} \quad (4)$$

In this formula, TII is the science and technology innovation index, which is expressed by the logarithm of science and technology financial expenditure in the general financial expenditure.

In order to verify the role mechanism of digital inclusive finance in affecting environmental quality through industrial structure, an intermediary model is established, as shown in Equation (5).

$$ISU_{it} = \alpha_4 + \beta_4 DF_{it} + \theta X_{it} + u_i + \lambda_t + \varepsilon_{it} \quad (5)$$

In the formula, ISU is the industrial structure upgrading index, including the industrial structure advanced (TS) and the industrial structure rationalization (TL).

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5. Empirical Study

5.1. Impact of Digital Inclusive Finance on Regional Economic Development Level and Environmental Quality

Based on regression equations (2) and (3), this paper estimates the impact of digital inclusive finance on regional economic development and environmental quality. Both regression results incorporate control variables and two-way fixed effects, showing that under fixed city and year effects, digital inclusive finance has a significant positive impact on regional economic development and a significant negative impact on environmental pollution. Regression result (1) shows a coefficient of 0.0070 for the effect of digital inclusive finance on the logarithm of per capita GDP, which is significant at the 1% level, indicating its positive influence on regional economic development. Regression result (2) reveals a coefficient of -0.0014 for the effect of digital inclusive finance on the environmental pollution index, also significant at the 1% level, demonstrating its significant negative impact on environmental pollution.

Table 2: Baseline regression results

explained variable	lnGDP(1)	EPI(2)
	FE	FE
DL	0.0070***	-0.0014***
	(0.0006)	(0.0003)
FIN	-0.0986***	-0.0288***
	(0.0162)	(0.0061)
EDU	0.0713***	0.0324***
	(0.0237)	(0.0101)
URR	0.0305***	-0.0022**
	(0.0029)	(0.0011)
FDI	-2.32e-07	1.30e-06***
	(6.69e-07)	(2.48e-07)
INF	-0.0040***	0.0011
	(0.0012)	(0.0014)
UR	0.0014**	0.0041***
	(0.0007)	(0.0004)
constant term	8.1375***	0.0422
	(0.5271)	(0.4691)
observed value	341	341
R-squared	0.9784	0.5660
City fixed effect	yes	yes
Year fixed effect	yes	yes

Note: * * * P <0.01, * * P <0.05, * P <0.1 indicates significance level, robust standard error in parentheses, the same below.

5.2. Robustness Test

Empirical analysis shows that digital inclusive finance has a significant effect on promoting regional economy and inhibiting environmental pollution. The reliability of the conclusions is further tested below by replacing the core explanatory variables.

This paper uses breadth (coverage) and usage depth as substitutes for the digital finance index. Using data from Eastern regions, the explained variables are regressed, and the results are shown in Table 3. From regression result (1), the coefficient for the coverage of digital inclusive finance on

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regional economic development (lnGDP) is 0.0072, which is statistically significant at the 1% level. Similarly, the coefficient for regional economic development is 0.0030, also significant at the 1% level, indicating a stable positive impact of digital inclusive finance on regional economic growth. From regression result (3), the coefficient for the environmental pollution index (EPI) is -0.0024, statistically significant at the 5% level, and -0.0008, also significant at the 5% level. This suggests a robust negative impact of digital inclusive finance on environmental pollution.

Table 3: Replaces the interpreted variable.

Replace explanatory variables	lnGDP(1)	lnGDP(2)	EPI(3)	EPI(4)
	FE	FE	FE	FE
Coverage	0.0072***		-0.0024**	
	(0.0019)		(0.0010)	
Depth		0.0030***		-0.0008**
		(0.0006)		(0.0003)
FIN	-0.0560	-0.0822**	0.0868***	0.0927***
	(0.0340)	(0.03380)	(0.0173)	(0.0180)
EDU	0.0320	0.0716	-0.0021	-0.0152
	(0.0591)	(0.0561)	(0.0302)	(0.0298)
URR	-0.0039	0.0162***	0.0209***	0.0150***
	(0.0053)	(0.0053)	(0.0027)	(0.0028)
FDI	-2.83e-08	-5.51e-07	1.03e-06***	1.16e-06***
	(7.43e-07)	(7.31e-07)	(3.79e-07)	(3.88e-07)
UR	0.0036***	0.0015	-0.0005	0.0001
	(0.0011)	(0.0011)	(0.0005)	(0.0006)
INF	-0.0981**	-0.0036	0.0021	0.0009
	(0.0031)	(0.0031)	(0.0016)	(0.0016)
constant term	11.86488***	9.945139***	-2.061161***	-1.599412**
	(1.1807)	(1.2626)	(0.6023)	(0.6697)
observed value	110	110	110	110
R-squared	0.9757	0.9773	0.9662	0.9659
City fixed effect	control	control	control	control
Year fixed effect	control	control	control	control

5.3. Analysis of the Heterogeneity

Considering the differences in the level of economic development in different regions, according to the economic zone division method of the National Bureau of statistics, China is divided into four regions, namely, the eastern region, the central region, the western region and the northeast region, to test whether there is regional heterogeneity in the impact of digital Inclusive Finance on regional economy and environmental quality. The regression results are shown in Table 4.

5.4. Mechanism Test

The above benchmark regression verifies that digital financial inclusion promotes regional economic development and environmental quality improvement. In order to test whether the two transmission mechanisms of digital inclusive finance affecting regional economy through scientific and technological innovation and environmental quality through industrial structure upgrading exist, this

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paper tests them, and the results are shown in Table 5. Results (1) shows that scientific and technological innovation has some intermediary effect on digital inclusive finance and regional economy, and the transmission mechanism of scientific and technological innovation exists in the process of digital inclusive finance affecting regional economy. From the regression results (2), digital financial inclusion can promote the advancement of industrial structure. According to the regression results (3), digital inclusive finance can promote the rationalization of industrial structure. This indicates that there is a partial mediating effect of industrial structure upgrading on digital inclusive finance and environmental quality.

Table 4: Regression results of regional heterogeneity

variable name	east		middle		west		Northeast	
	lnGDP(1)	EPI(2)	lnGDP(3)	EPI(4)	lnGDP(5)	EPI(6)	lnGDP(7)	EPI(8)
DF	0.0079***	-0.0013*	0.0043**	0.0011	0.0069***	-0.0011**	0.0069	-0.0108***
	(0.0014)	(0.0008)	(0.0016)	(0.0008)	(0.0012)	(0.0005)	(0.0077)	(0.0026)
FIN	-0.0962***	0.0910***	-0.1894***	-0.0811**	-0.0573***	0.0043	0.1703	-0.0662
	(0.0321)	(0.0183)	(0.0614)	(0.0310)	(0.0214)	(0.0084)	(0.1415)	(0.0469)
EDU	0.0715	-0.0152	-0.0758	0.0578**	0.0406	-0.0427***	-0.2970	0.0344
	(0.0529)	(0.0302)	(0.0527)	(0.0267)	(0.0272)	(0.0106)	(0.2217)	(0.0735)
URR	-0.0135***	0.0167***	-0.0084	0.0215***	0.0570***	0.0005	0.1487**	-0.0384
	(0.0047)	(0.0027)	(0.0143)	(0.0072)	(0.0074)	(0.0029)	(0.0674)	(0.0224)
FDI	-5.81e-07	1.09e-06***	-8.33e-07	-6.77e-06*	0.0000	4.92e-06	0.0000	-0.0000*
	(6.85e-07)	(3.91e-07)	(7.18e-06)	(3.63e-06)	(9.60e-06)	(3.75e-06)	(0.0000)	(0.0000)
UR	0.0024806**	-0.0002	-0.0017	0.0010*	0.0046**	0.0015**	0.0092	0.0013
	(0.0010)	(0.0006)	(0.0012)	(0.0006)	(0.0019	(0.0007)	(0.0054)	(0.0018)
INF	-0.0036	0.0012	-0.0074***	-0.0014	-0.0033**	-0.0004	0.0063	-0.0025
	(0.0029)	(0.0016)	(0.0022	(0.0011)	(0.0015)	(0.0006)	(0.0048)	(0.0016)
constant term	8.7512***	-1.6587**	13.6122***	-1.5916**	6.7788***	0.4995*	-0.7618	5.7804***
	(1.2451)	(0.7104)	(1.3298)	(0.6726)	(0.7338)	(0.2865)	(4.3419)	(1.4397)
observed value	110	110	66	66	132	132	33	33
R-squared	0.9799	0.9650	0.9831	0.9682	0.9791	0.9632	0.9567	0.9884

Table 5: Baseline regression results.

variable name	economy	environment	environment
	(1)	(2)	(3)
	TII	TS	TL
DL	0.0165***	0.0020**	0.0006***
	(0.0017)	(0.0003)	(0.0002)
FIN	-0.1057**	0.0988***	0.0173***
	(0.0472)	(0.0298)	(0.0048)
EDU	-0.1278*	-0.1238***	-0.0342***
	(0.0687)	(0.0433)	(0.0069)
URR	0.0815***	-0.0431***	0.0005
	(0.0085)	(0.0053)	(0.0009)
FDI	6.72e-06***	-1.43e-06	-6.41e-08
	(1.94e-06)	(1.22e-06)	(1.96e-07)

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Table 5: (continued).

UR	-0.0030	-0.0004	0.0000
	(0.0020)	(0.0013)	(0.0002)
INF	0.0014	-0.0043**	-0.0008**
	(0.0034)	(0.0021)	(0.0003)
constant term	5.5102***	5.6274***	2.7202***
	(1.5291)	(0.9640)	(0.1544)
observed value	341	341	341
R-squared	0.9721	0.9736	0.9741

6. Conclusion and Suggestion

6.1. Conclusion

This paper uses panel data from Chinese prefecture-level cities between 2012 and 2022 to empirically analyze the impact of digital inclusive finance on regional economic development and environmental quality. The analysis employs both a two-way fixed effects model and an intermediary effect model, and reaches the following conclusions:

1) Impact on Environmental Pollution: Digital inclusive finance significantly reduces environmental pollution, with robust results.
2) Mechanisms for Economic and Environmental Impact: Digital inclusive finance promotes regional economic growth through scientific and technological innovation, and curbs environmental pollution by driving industrial upgrading.
3) Regional Heterogeneity: The effects of digital inclusive finance vary across regions in China. In economically developed areas, the foundation of strong industrial structures and innovation momentum enhances both economic growth and environmental quality. In underdeveloped regions, digital inclusive finance drives industrial transformation and upgrading, leveraging green effects to improve the ecological environment.

6.2. Suggestions

Local governments should tailor policies to regional economic and environmental conditions to promote digital inclusive finance. In the east, focus on supporting high-tech and green industries. In the central and western regions, prioritize transforming traditional industries, implementing green financial policies, and reducing pollution. Infrastructure development is key in underdeveloped areas to expand digital finance and stimulate growth. Green finance tools like green credit and bonds are vital for funding environmental projects and balancing economic and environmental goals.

Financial institutions should innovate products, especially in less developed regions, to support green enterprises and enhance risk management using big data and AI. Enterprises should leverage financial and government support to transition to green manufacturing and improve environmental technology.

Regions should collaborate: the east can provide technical support to the central and west, while green finance in the west can direct capital to environmental projects, fostering sustainable development.

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