Proceedings of the 3rd International Conference on Management Research and Economic Development
DOI: 10.54254/2754-1169/180/2025.22796

The Impact of Digital Finance on Regional Economic Resilience-An Empirical Analysis Based on the Pearl River Delta Region

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Abstract: Focusing on the panel data of nine cities in the Pearl River Delta from 2011-2023, this article constructs a comprehensive indicator to measure regional economic resilience from three dimensions: resistance and recovery ability, adaptation and adjustment ability, and innovation and evolution ability, then explores the impact and mechanism of digital finance on regional economic resilience. The results of the study found that: First, digital finance plays a major role in promoting regional economic resilience; Second, the impact of digital finance on regional economic resilience exists in regional heterogeneity, the first- and second-tier cities are more substantially impacted by the positive impact of digital finance, whereas the impact of the third-tier cities is relatively small, which indicates that the greater the administrative divisions of the region by the influence of digital finance is more pronounced; Third, digital finance may mediately improve regional economic resilience by enhancing regional innovation capacity and optimizing industrial structure.

Keywords: digital finance, regional economic resilience, regional innovation ability, industrial structure

1. Introduction

1.1. Background

In the contemporary era of intertwined globalization and digitalization, digital finance has flourished, exhibiting robust vitality. Digital finance is not only a profound change in the financial field but also an important force in promoting contemporary economic progress. In recent times, the quick advancement of science and technology has brought opportunities and challenges to digital finance. High-tech applications such as artificial intelligence, big data, and cloud computing have greatly improved the accuracy and effectiveness of financial services. Digital finance is characterized by digitization, intelligence, universality, and efficiency. It employs the Internet, mobile devices, and big data technology to offer remote and convenient financial services, breaking geographical limitations and reaching more vulnerable groups. As a result, financial resources are more evenly distributed and regional economies become more resilient.

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1.2. Literature review

Economic resilience is a concept introduced into economics by Reggiani [1]. Nowadays, many scholars agree with Martin [2] who defines regional economic resilience as "the ability of a regional economy to withstand and absorb shocks, or to recover, integrate, and create its own development path in the face of shocks", emphasizing that it consists of four components: vulnerability, resistance, adaptability, and resilience.

The elements that impact economic resilience concentrate upon four aspects: industrial structure, cultural factors, institutional environment, and social capital. In terms of industrial structure, Brown and Greenbaum [3] found that Ohio's industrially diversified regions are more economically resilient, while Xu and Warner [4] found that regions in the United States with a high share of manufacturing are less economically resilient. In terms of cultural factors, Glaeser [5] argued that local conservative culture is detrimental to economic resilience, while Huggins et al [6] found that an open, diverse, and entrepreneurial cultural environment contributes to resilience. From the institutional environment, Boschma [7] stated that institutional factors affect economic resilience by influencing technological and industrial diversity and the ability to nurture new growth paths. From the perspective of social capital, Tanglin Ye et al [8] argued that social capital could improve urban agglomerations' economic resilience.

Moreover, researches on the connection between digital finance and economic resilience on CNKI are scarcer. Using data from 30 Chinese provinces, Gengrui Cui [9] concluded that digital finance significantly boosts economic resilience. Lintong Gao et al [10] found that digital finance has a substantial positive spatial spillover effect on economic resilience.

Synthesizing the existing literature, it can be seen that research in this area is still in the exploratory stage, especially from the level of prefecture-level cities, in-depth analysis is still rare. Therefore, this paper selects nine cities in the Pearl River Delta to explore whether digital finance can effectively enhance regional economic resilience. Using regional innovation capacity and industrial structure as the entry point, the study analyzes transmission mechanism and regional heterogeneity, then finally puts forward practical countermeasures and suggestions.

2. Theoretical mechanisms and research hypotheses

2.1. The direct impact of digital finance on regional economic resilience

Traditional finance often fails to meet the financing requirements of small and medium-sized companies, low-income groups, and remote areas, resulting in financial exclusion. Digital finance, on the other hand, can precisely solve the problems of insufficient coverage and high service costs of traditional finance by lowering service thresholds and costs, improving transaction efficiency, facilitating capital flows between enterprises, and enhancing economic flexibility and resilience. It improves the short-term resilience of the economy by utilizing big data and artificial intelligence to conduct accurate credit analysis and ensure that capital reaches the businesses that need it most. In addition, digital finance has facilitated the development of products such as blockchain finance and smart investment advisors, which improve security and also provide diversified risk management tools. All things considered, digital finance can foster economic resilience. The following hypothesis is put out in this study based on the analysis above.

H1: Digital finance has a positive contribution to regional economic resilience.

2.2. The indirect impact of digital finance on regional economic resilience

Digital finance supplies a new impetus and stage for urban innovation. It analyzes vast volumes of data using big data technologies, empowering enterprises with unprecedented data insights, helping

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them accurately identify demand, optimize products, predict industry trends, layout future markets, and enhance their R&D and innovation capabilities and competitiveness. The advantages of digital finance in information services and resource allocation enable financial institutions to integrate diversified data. Even if their financial situation is poor, they can identify and support enterprises with innovative potential. Meanwhile, digital financial platforms shorten the financing cycle, simplify the process, and reduce costs through technologies such as automatic approval and smart contracts, and their products such as supply chain finance and crowdfunding are directly connected to business operations, promoting efficient matching of funds and driving innovation. The following hypothesis is put forth by our above analysis:

H2: Digital finance can indirectly affect the level of regional economic resilience by improving the innovative and entrepreneurial ability and motivation of enterprises and individuals.

A significant component of high-quality economic development is upgrading industrial structure, which heavily depends on digital finance. Digital finance optimizes the distribution of financial resources, supports technological innovation and introduction of talents, and helps industrial upgrading. It responds quickly to market demand with efficient and convenient services, accurately invests resources in industries with development potential, lowers the expense of business finance, and elevates the efficiency of capital utilization. Concurrently, digital finance fosters the transformation of achievements, accelerates the upgrading process, provides advanced technology support, and propels the evolution of emerging industries and the transformation and modernization of traditional industries. Our above analysis proposes the following hypothesis:

H3: By encouraging the modernization of industrial structures, digital finance has an indirect impact on the degree of urban economic resilience.

3. Model construction and data description

3.1. Empirical modeling

3.1.1. Basic regression model

Based on the panel fixed-effects model can effectively control the unobservable factors in individual and time dimensions, so as to more correctly determine the causality of digital finance on regional economic resilience, this article is dependent on the fixed-effects model:

$$RES_{it} = \alpha + \alpha_1 DF_{it} + \alpha_2 Z_{it} + \varepsilon_{it} \quad (1)$$

Where RES stands for regional economic resilience; DE represents the level of digital finance; Z represents a set of control variables; ε denotes an irregular perturbation term; i signifies the nine cities in the Pearl River Delta, and t = 1,2,3.....13 denotes each year from 2011-2023.

3.1.2. Mediation effect model

To attempt to verify assumptions H2 and H3, this paper takes innovation capacity and industrial structure as the bridging factors to analyze the mediating effect that exists in the impact of digital finance on regional economic resilience. The particular model is constructed as follows:

$$RIA_{it} = \beta_0 + \beta_1 DF_{it} + \beta_c Z_{it} + \varepsilon_{it} \quad (2)$$

$$RES_{it} = \gamma_0 + \gamma_1 DF_{it} + \gamma_2 RIA_{it} + \beta_c Z_{it} + \varepsilon_{it} \quad (3)$$

$$IS_{it} = \omega_0 + \omega_1 DF_{it} + \omega_c Z_{it} + \varepsilon_{it} \quad (4)$$

$$RES_{it} = \mu_0 + \mu_1 DF_{it} + \mu_2 IS_{it} + \mu_c Z_{it} + \varepsilon_{it} \quad (5)$$

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Where RIA represents innovation ability, IS represents industrial structure, and every other variable aligns with the basic regression model's meaning.

3.2. Variables description

3.2.1. Explained variable

The empirical research that has been done on regional economic resilience may be broadly categorized into two areas: one is assessing regional economic resilience, and the other is examining the variables that influence it. This paper refers to Jinhe Zhu's method [11] for constructing an area's economic resilience index, selecting 11 indicators according to data availability and representativeness. These indicators measure resistance and resilience, adaptive and regulatory capacity, as well as innovation and evolutionary capacity, as shown in Table 1.

Table 1: Construction of regional economic resilience indicators

Level I indicators	Level II indicators	Specific indicators	Nature
Regional economic resilience	Resistance and recovery	Per capita disposable income of urban residents (yuan)	+
		GDP per capita (yuan)	+
		External trade dependence	-
	Adaptive and regulatory capacity	Total retail sales of consumer goods (millions of yuan)	+
		Local fiscal expenditures (billions of yuan)	+
		Balance of various RMB deposits in financial institutions (millions of yuan)	+
		Investment in fixed assets (billions of yuan)	+
		Urbanization rate of resident population	+
	Innovation and evolutionary capacity	Fiscal expenditure on education	+
		Expenditure on science and technology	+
		Number of patent applications granted	+

3.2.2. Explanatory variable

Digital Finance (DF), this paper for the measurement of digital financial indicators refers to the research of Gengrui Cui [9], using the digital inclusive finance index published by the Digital Finance Research Center of Peking University to directly indicate the degree of development of the digital economy in various regions. The index is constructed from three dimensions: breadth of coverage, depth of use, and degree of digital support services, reflecting the extent of digital financial development in different regions such as provinces and cities in China.

3.2.3. Intermediary variables

Regional Innovation Ability (RIA) is defined by the quantity of patent applications granted divided by the resident population. Industrial Structure (IS) [12] is measured by the index of advanced industrial structure, which is the ratio of secondary and tertiary industries.

3.2.4. Control variables

With the aim to be able to conduct the connection between digital finance and regional economic resilience more comprehensively and accurately, and to avoid errors in the empirical results caused

DOI: 10.54254/2754-1169/180/2025.22796

by other unnecessary factors, this paper selects the following six control factors: population density (PD) [13], which is the proportion of the resident population to the urban area. Level of the open economy (LOE) is measured by the total volume of imports and exports; Informationization level (IL) is defined as the total amount of telecommunications services; Transportation level (TL) is measured in terms of highway freight per capita; Infrastructure development (IC) is measured by the total volume of postal and telecommunication business; human capital (HC) is measured by the amount of students enrolled in general higher education institutions divided by the resident population.

Table 2: Descriptive statistics of the variables

Variable class	Variable name	Symbol	Obs	Mean	Std. Dev.	Min	Max
Explanatory variable	Digital finance	DF	117	.204	.188	.019	.836
Explained variable	Regional economic resilience	RES	117	230.935	80.775	52.24	359.019
Intermediate variables	Regional innovation ability	RIA	117	46.074	34.8	2.257	157.891
	Industrial structure	IS	117	1.098	.501	.555	2.863
Control variables	Population density	PD	117	2287.017	2219.384	264.56	8953.22
	Level of open economy	LOE	117	7456.668	9187.303	357.92	38710.7
	Informatization level	IL	117	390.774	562.652	30.96	3030.39
	Traffic level	TL	117	23.156	10.865	6.392	49.597
	Infrastructure construction	IC	117	5997885.5	8990398.3	322800	47073800
	Human capital	HC	117	239.678	236.343	45.647	794.955

3.2.5. Data sources

In this paper, the panel data of nine cities in the Pearl River Delta of China from 2011 to 2023 are selected for the study. The economic data of each city is derived from the Guangdong Statistical Yearbook, Guangzhou Statistical Yearbook, and other statistical yearbooks of each city. The digital financial inclusion index is derived from that published by the Digital Finance Research Center of Peking University.

4. Empirical testing

4.1. Basic regression analysis

In order to determine whether the basic regression uses a random effects model or a fixed effects model, this paper uses these two estimation methods separately and selects the optimal model by using the Hausman test to measure the impact of digital finance on the resilience of the regional economy. The Hausman test indicates that a fixed-effects model should be selected for the analysis.

DOI: 10.54254/2754-1169/180/2025.22796

The results of the benchmark regression are displayed in Table 3, in which columns (1) and (2) are the regression results under the fixed-effects model without considering control variables and considering control variables, respectively. As can be observed in Table 3, the coefficients of digital finance in columns (1) and (2) are 0.001 and 0.000, respectively, which implies that the coefficients of the impact of digital finance on regional economic resilience are positive and significant at the 1% level, irrespective of whether or not control variables are incorporated into the model. This suggests that the areas' economic resilience will be improved by the rise of digital finance. Hypothesis H1 is verified.

Table 3: Basic regression results

	(1) RES	(2) RES
DF	0.001	0.000
	(12.081)	(7.621)
PD		0.000
		(10.592)
LOE		0.000
		(5.774)
IL		-0.000
		(-6.346)
TL		-0.001
		(-2.890)
IC		0.000
		(7.233)
HC		0.000
		(2.342)
_cons	-0.017	-0.165
	(-0.881)	(-7.510)
N	117	117
R^2	0.577	0.938
F	145.947	217.725

Standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.10
The same as below.

4.2. Robustness test

4.2.1. Tobit model

To evaluate the stability of the benchmark regression model, this paper follows Bang Liang's research [14], alters the estimation method, and re-estimates using the Tobit model. Column (1) of Table 4 conveys the test outcomes, indicating a positive and significant regression coefficient for digital finance on regional economic resilience at the 1% level. This aligns with previous benchmark regression conclusions, suggesting that our empirical findings are robust.

4.2.2. Replacing the explained variable

Following Congbo Chen and Azhong Ye's research [15], GDP is used to replace regional economic resilience as an indicator for the robustness test, and the outcomes are given in column (2) of Table 4. The regression shows a positive and substantial connection between digital finance and GDP at a

DOI: 10.54254/2754-1169/180/2025.22796

rate of 1%, which reveals that digital finance enhances regional economic resilience, and the benchmark regression results have strong robustness.

4.2.3. Excluding samples

Since Guangzhou is the capital of Guangdong Province, a sub-provincial city, its level of innovation capacity and economic resilience is quite different from other cities. Therefore, we follow Xianxiang Lu's study [16] by excluding Guangzhou from our sample data and re-running the regression to test model robustness, and the outcomes are presented in column (3) of Table 5. It could be noticed that the estimated coefficient of digital finance and regional economic resilience is positive and at the 1% significance level, confirming stronger model robustness.

4.2.4. Instrumental variable method

This paper refers to the study of Zhixin Wang [17] and selects the lagged first order of the digital finance index published by the Research Center of Peking University as an instrumental variable for regression analysis. The regression results are shown in column (4) of Table 4. The regression coefficients remain significant, suggesting that the model's outputs are reliable.

Table 4: Robustness testing results

Variables	(1) Tobit model	(2) Substitution of explained variables	(3) Exclusion of samples	(4) Instrumental variables approach
	RES	GDP	RES	RES
DF	0.000	7.771	0.000	
	(0.000)	(4.413)	(7.161)	
L.DF				0.001
				(0.000)
_cons	-0.053	-3943.379	-0.223***	-0.078
	(0.019)	(-4.586)	(-11.031)	(0.023)
Control Variables	Yes	Yes	Yes	Yes
N	117	117	104	108
R^2		0.916	0.945	0.935
Pseudo R^2	-5.2737			
F		156.985	216.540	
Kleibergen-Paap rk LM statistic				44.349
Kleibergen-Paap rk Wald F statistic				8268.49
Cragg-Donald Wald F statistic				5853.514

4.3. Heterogeneity test

Due to differences in government support, informatization level, infrastructure construction, and other aspects of different regions, economic resilience differs. Thus, we categorize cities into first-tier, second-tier, and third-tier for regression analysis as listed in Table 6. The outputs reveal that digital finance positively impacts regional economic resilience across all tier cities, however, tier 1 and 2 cities have a higher regression coefficient of 0.001 compared to 0.000 for tier 3 cities. This disparity may stem from tier 1 and 2 cities having more technological talents, better infrastructure, and higher informatization levels—factors contributing to broader markets and stronger risk

DOI: 10.54254/2754-1169/180/2025.22796

resistance compared to tier 3 cities facing slower industrial development and resource dispersion. Therefore, when promoting digital finance development, differentiated strategies should be tailored according to the characteristics of the city level to enhance regional economic resilience comprehensively.

Table 5: Heterogeneity test results

	(1) First-tier city RES	(2) Second-tier city RES	(3) Third-tier city RES
DF	0.001	0.001	0.000
	(4.208)	(19.291)	(3.091)
_cons	-0.180	0.102	-0.491
	(-3.129)	(5.298)	(-3.556)
Control Variables	Yes	Yes	Yes
R^2	0.942	0.942	0.996
F	101.527	70.955	645.859

4.4. Analysis of mediation effect

In this research, we draw on the procedure of Yan Hu [18], and analyze the mediation effect by using the stepwise regression method, in order to verify the mediation effect played by regional innovation ability, industrial structure between digital finance, and regional economic resilience.

4.4.1. Regional innovation ability role path

As indicated in column (2) of Table 6, the coefficient reflecting the impact of digital finance on innovation capability is positive and noticeable at the 1% level; thus, advancements in digital finance positively influence innovation capacity. Column (3) confirms that the correlation coefficient for digital finance is lower than that in column (2), suggesting that innovation capacity plays a mediating factor. Hypothesis H2 is verified.

4.4.2. Path of industrial structure role

The coefficient of digital finance's influence on industrial structure, as shown in column (4) of Table 6, is positive and significant at the 1% level. This indicates that advancements in digital finance have a beneficial impact on the upgrading of industrial structure. In column (5), the estimated coefficient for digital finance's influence on regional economic resilience is smaller than that in column (4), suggesting that industrial structure mediates this relationship. Thus, H3 is confirmed.

4.4.3. Dual mediation path test

The innovative capacity and industrial structure are simultaneously included in the model for the regression test, and the outcomes of column (6) in Table 6 are obtained. It is evident that the estimated coefficient of digital finance on regional economic resilience decreases under the addition of the two intermediary variables, which can indicate that the two intermediary variables play an intermediary impact between digital finance and regional economic resilience.

DOI: 10.54254/2754-1169/180/2025.22796

Table 6: Estimated results of the mediated effects model

Variables	(1) RES	Regional innovation ability (2) RIA	(3) RES	Industrial structure (4) IS	(5) RES	(6)
DF	0.000	0.186	0.000	0.001	0.000	0.000
	(7.621)	(10.748)	(3.687)	(5.310)	(5.304)	(2.189)
RIA			0.001			0.001
			(2.216)			(2.521)
IS					0.084	0.085
					(4.231)	(4.405)
Control variables	YES	YES	YES	YES	YES	YES
_cons	-0.165	-32.426	-0.147	1.041	-0.252	-0.235
	(-7.510)	(-3.840)	(-6.359)	(10.144)	(-8.717)	(-8.063)
N	117	117	117	117	117	117
R^2	0.938	0.872	0.941	0.577	0.947	0.950
F	217.725	98.115	198.497	19.695	224.634	211.071

5. Conclusion

5.1. Research conclusion

In this paper, panel data of nine cities in the Pearl River Delta for the period 2011-2023 are selected to study the impact of digital finance on regional economic resilience using a fixed-effects model. The results demonstrate that digital finance greatly enhances economic resilience, and the findings remain robust after changing the estimation method, replacing the explained variable, excluding samples, and introducing instrumental variables. The mediation effect test shows that digital finance can promote economic resilience via innovation capacity and industrial structure. The heterogeneity test finds that the improvement in the level of digital finance in first- and second-tier cities with superior resources has a more obvious effect on the improvement of economic resilience.

5.2. Relevant recommendations

Relying on the above results, this study proposes the following proposals:

First, the innovation capacity must be enhanced. A combination of the advantages of regional economic characteristics, scientific planning and layout, improved incentive policies, increased support and encouragement for young scientific and technological talents, optimized resource allocation, and perfected the operation mechanism of innovation and technology development carriers such as incubators and innovation cities is essential. Enterprises must prioritize the enhancement of innovation capacity, augment R&D investment, collaborate with academic institutions, and expedite the development and implementation of novel technologies.

Second, promote coordinated regional development by strengthening connections between first- and second-tier cities as well as small- to medium-sized cities. Enhance digital finance infrastructure while leveraging each city's factor endowment advantages. Provide targeted policy support to less developed areas to attract technology and talent inflow for synergistic industrial growth. Financial institutions should foster regional cooperation by establishing cross-city financial service networks, innovating financial products, offering convenient digital services for SMEs nationwide, addressing financing challenges, promoting balanced global development, and ensuring that digital finance benefits a wider range of regions and enterprises.

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Third, promote the advanced industrial structure. While actively cultivating new industries, it will transform traditional industries into high-end intelligent fields, optimize the industrial layout, and achieve complementary advantages and synergistic growth. In addition, it is vital to focus on improving the added value of industries and promoting green and sustainable development, so as to enhance the competitiveness of the regional economy. In light of this, it is also necessary to fortify the upstream and downstream enterprises of the industrial chain to cooperate, form an industrial cluster effect, and improve the risk-resistant ability of the industry as a whole.

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