Empirical Study on the Impact of Digital Inclusive Finance on Urban-Rural Consumption Quality Gap based on Dynamic Panel and Spatial Econometric Models

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Abstract

The concept of digital inclusive finance has gained significant attention in recent years, especially in China, where it plays a crucial role in addressing financial exclusion and promoting economic equality. As China strives for common prosperity and balanced development, digital inclusive finance offers a promising solution to bridge the gap between urban and rural residents, enhancing consumption capacity and reducing regional disparities. This study investigates how the development of digital inclusive finance affects the consumption quality gap between urban and rural areas. Using the Digital Inclusive Finance Development Index from Peking University, the study measures the progress of digital finance across provinces. Consumption quality is evaluated through 11 key indicators, with BP neural networks employed to improve evaluation accuracy. The research further explores the dynamic evolution of digital finance using kernel density estimation and KNN methods. To examine the impact on the consumption quality gap, dynamic panel models are applied, focusing on both direct and indirect effects. The study also explores non-linear relationships by using threshold panel models and investigates spatial spillover effects through spatial econometric models, including spatial autocorrelation and Moran's indices. The results reveal that digital inclusive finance significantly narrows the consumption quality gap between urban and rural residents, with the most pronounced effects observed in the western and southwestern regions. Additionally, the study finds that the development of digital inclusive finance in one province has spillover effects on neighboring areas, indicating the importance of regional coordination. Based on these findings, the study recommends increasing the visibility and accessibility of digital finance, tailoring policies to regional needs, and leveraging spatial spillover effects to maximize its benefits.

Keywords

Digital Financial Inclusion, Urban and Rural Consumption, Thiel Index, Spatial Econometric Modeling.

1. Introduction

The development of urban and rural areas has always been a key issue in national development and the well-being of the people in China. The relationship between cities and rural areas has continually evolved with policy adjustments[1]. The transformation of urban-rural relations is closely connected to the socialist system with Chinese characteristics, which has played a crucial role in promoting urban-rural integration and reducing development disparities. Since the release of the "Opinions on Establishing and Improving the Urban-Rural Integration Development System and Policy Mechanism" by the Central Committee of the Communist Party of China and the State Council in 2019, China has focused on reshaping urban-rural relations, with the goal of promoting rural revitalization and the modernization of agriculture and rural

areas. Although the income gap between urban and rural residents has narrowed over the past decade, with the urban-rural per capita disposable income ratio falling to 2.50 in 2021, there still remains a significant economic disparity between urban and rural areas[1][2].

The socialist system with Chinese characteristics, which includes public land ownership, smooth urban-rural mobility, and a dynamic social mechanism, has provided a solid foundation for China to avoid the phenomenon of urban slums, which is common in many developing countries. Unlike the widespread slum problems found in many developing countries, China has effectively provided stable living conditions and job opportunities for migrant workers and other groups through urban development and rural economic growth, which has boosted people's confidence in the future[3].

In 2005, the United Nations introduced the concept of inclusive finance, which focuses on effectively providing financial services to all layers and groups of society. In 2023, the State Council emphasized that inclusive financial products and services should support the sustainable development of small and micro enterprises, contribute to the effective implementation of the national rural revitalization strategy, improve the quality of financial services in people's livelihoods, and support green and low-carbon development[4]. The advancement of inclusive finance, particularly digital inclusive finance, provides a new avenue to narrow the urban-rural development gap. Digital inclusive finance helps alleviate the objective and subjective relative poverty of urban and rural residents by utilizing both formal and informal credit channels, as well as enhancing social and human capital.

The core concept of digital inclusive finance aligns closely with the goal of reducing the urban-rural development gap. This paper is based on the Peking University Digital Inclusive Finance Index and uses BP neural network models, dynamic panel models, spatial econometric models, and threshold panel models, combined with indicators such as per capita GDP, to study the current urban-rural relationship and the feasibility of reducing the urban-rural development gap[5]. The purpose of this research is to explore the development status of digital inclusive finance and its impact on the consumption quality gap between urban and rural residents. This not only helps reveal the potential role of digital inclusive finance in reducing the consumption quality gap but also provides valuable insights for policymakers to promote social equity and sustainable economic development. By evaluating the application effects of digital inclusive finance in different regions, this study can also help identify effective policy measures that promote inclusive financial growth and improve the well-being of the people.

This study contributes to the literature in several ways:

1) It provides an empirical analysis of the impact of digital inclusive finance on the consumption quality gap between urban and rural residents, highlighting its dynamic evolution and regional variations.

2) By integrating dynamic panel and spatial econometric models, the study overcomes the limitations of traditional cross-sectional analyses and captures the temporal and spatial dimensions of digital finance’s impact.

3) The research identifies the spatial spillover effects of digital inclusive finance, revealing how the development of digital finance in one region can influence neighboring regions, offering insights for regional policy coordination.

4) It offers a deeper understanding of how digital technologies, by reducing information asymmetry and transaction costs, directly affect consumption behavior and consumption quality, providing a theoretical foundation for future policy design and implementation.

2. Methodology

2.1. Dynamic Panel Modeling

There is a strong ratchet effect in residents' consumption, the current consumption is limited by the previous consumption, so this paper introduces a dynamic panel model, that is, adding the lag of the explanatory variables for empirical analysis. The model is as follows:

$$gapc_{it} = \alpha_0 + \alpha_1 gapc_{it-1} + \alpha_2 \ln difi_{it} + \alpha_3 X_{it} + \varepsilon_{it} \quad (1)$$

Where $gapc_{it}$ and $gapc_{it-1}$ denote the gap between urban and rural residents' consumption quality in year t and year t-1 of the i-th province, respectively, $\ln difi_{it}$ denotes the logarithmic value of the digital financial inclusion index in year t of the ith province, X_{it} is the set of control variables, and ε_{it} is the random disturbance term.

The model is endogenous due to the introduction of lagged one period of the explanatory variables, and in order to obtain accurate parameter estimates, this paper uses a systematic GMM approach to ensure that consistent parameter estimates are obtained, and a differential GMM approach is also used for comparison. Differential GMM estimation produces errors in the estimation process under the influence of weak instrumental variables, while system GMM estimation has the advantage of solving the problem of unidentified individual differences, the effect of unaccounted for variables, and the correlation of the variables with the random term in the estimation.

2.2. Threshold Panel Model

In order to explore the non-linear impact of digital inclusive finance on the existence of urban and rural residents' consumption quality gap, this paper takes the level of financial development as a threshold variable to construct a threshold panel model, and takes the ratio of financial institutions' year-end deposit and loan balances to GDP as a variable to measure the level of regional financial development.

The threshold effect test was first performed and the results are as follows:

Table 1. Threshold effect test results.

Threshold number	F	P	1%	boundary value 5%	10%
Single threshold	37.43	0.0000	26.4832	20.6025	15.5311
Double threshold	6.48	0.6800	51.4925	35.4376	27.2266
Triple threshold	7.03	0.7100	39.4461	27.4242	23.8155

From the test results, it can be seen that the P-value of single threshold is less than 0.01, indicating that there is a single threshold effect at 1% significance level, while the P-value of double threshold and triple threshold are both and that, therefore, the single threshold panel model is selected for regression analysis in this study.

Based on the results of the threshold effect test, the following threshold panel model is constructed:

$$gapc_{it} = \delta_i + \delta_{11} \ln difi_{it}(fin_{it} \le \tau_1 + \delta_{12} \ln difi_{it}(fin_{it} > \tau_1) + \delta_2 X_{it} + \varepsilon_{it}) \quad (2)$$

$$gapc_{it} = \varphi_i + \varphi_1 gapc_{it-1} + \varphi_{21} \ln difi_{it}(fin_{it} \le \tau_2 + \varphi_{22} \ln difi_{it}(fin_{it} > \tau_2) + \delta_3 X_{it} + \varepsilon_{it}) \quad (3)$$

The two equations represent the model with and without the lagged terms of the explanatory variables, respectively, and τ_1 and τ_2 are unknown thresholds.

2.3. Spatial Measurement Models

From the consumption quality scores of different provinces and different years obtained above, it can be seen that there is obvious spatial aggregation in the consumption quality level of residents, and it is speculated that digital financial inclusion can break through the spatial and temporal limitations to have an impact on the local region, and also have an additional impact on the neighboring regions. Therefore, a spatial econometric model is introduced to explore the impact of digital financial inclusion on the consumption quality gap between urban and rural residents at the spatial level.

The three models, SAR, SEM, and SDM, consider the lag term of the explanatory variables, the spatial dependence of the error term, the lag term, and the error term, respectively. Set the model form as follows:

$$\begin{aligned} gap_{it} = \theta_0 + \theta_1 gap_{it-1} + \theta_2 W_{gap_{it-1}} + \theta_3 \, \mathrm{W}_{gap_{it}} + \theta_4 lndifi_{it} \\ +\theta_5 D_{it} + \theta_6 D_{it} lndifi_{it} + \theta_7 X_{it} + \omega_t + \mu_i + \varepsilon_{it} \end{aligned} \tag{4}$$

$$gap_{it} = \varphi_0 + \varphi_1 lndifi_{it} + \varphi_2 D_{it} + \varphi_3 D_{it} lndifi_{it} + \varphi_4 X_{it} + \omega_t + \mu_i + \vartheta_{it} \tag{5}$$

$$\vartheta_{it} = \rho W \vartheta_{it} + \varepsilon_{it} \tag{6}$$

$$\begin{aligned} gap_{it} = \rho_0 + \rho_1 gap_{it-1} + \rho_2 W gap_{it-1} + \rho_3 W gap_{it} \\ +\rho_5 D_{it} + \rho_6 D_{it} lndifii_{it} + \rho_7 W lndifii_{it} \\ +\rho_8 W D_{it} + \rho_9 W D_{it} lndifii_{it} + \rho_{10} X_{it} \\ +\rho_{11} W X_{it} + \omega_t + \mu_i + \varepsilon_{it} \end{aligned} \tag{7}$$

Where W is a spatial weight matrix reflecting the degree of interdependence of different regions on certain attributes.

3. Results

3.1. Analysis of the Evolution of Digital Financial Inclusion Dynamics

In this paper, we pre-study the impact of digital financial inclusion on the consumption quality gap between urban and rural residents, firstly, we need to explore the evolutionary trend and change process of the digital financial inclusion index in recent years. In this study, 31 provinces in China are divided into central, eastern, western, and northeastern regions, and the sum density estimation method and KNN (K Nearest Neighbor Algorithm) are utilized to obtain the dynamic evolution density curve of the digital financial inclusion index.

The regional distribution is shown in Table 2:

Table 2. Regional distribution.

Region	Provinces
central section	Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan, Jilin, Heilongjiang
eastern section	Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan, Liaoning, Hebei
western section	Neimenggu, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang

The dynamic analysis of the development of digital financial inclusion at the holistic level is displayed in Figure 1:

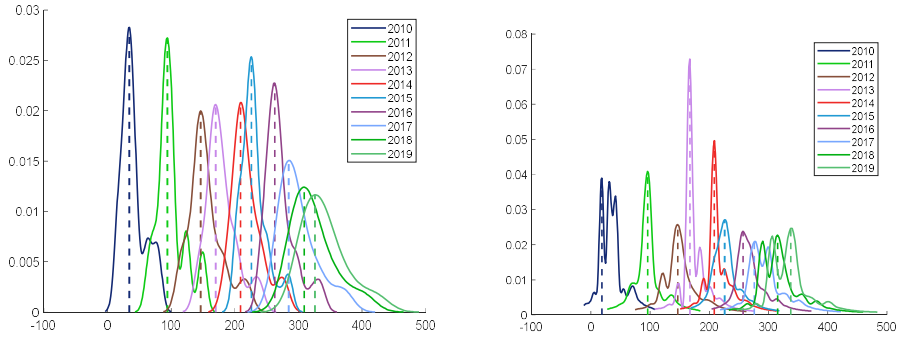

Figure 1. Overall level digital financial inclusion kernel density map (left) KNN map (right).

As can be seen from the results, both density estimation methods show that digital financial inclusion is slowly developing over time. Starting from 2010, the average level of digital financial inclusion has shifted to the right every year, indicating that there is a new development of digital financial inclusion every year. On this basis, the height of the digital financial inclusion density curve has declined in recent years, indicating that digital financial inclusion has developed more slowly in recent years, sometimes showing a trailing condition, suggesting that the level of digital financial inclusion development in some provinces has reached a very high level, and that there is a large difference in the level of development between different provinces.

The dynamic analysis of the development of digital inclusive finance in the eastern and central regions is displayed in Figure 2:

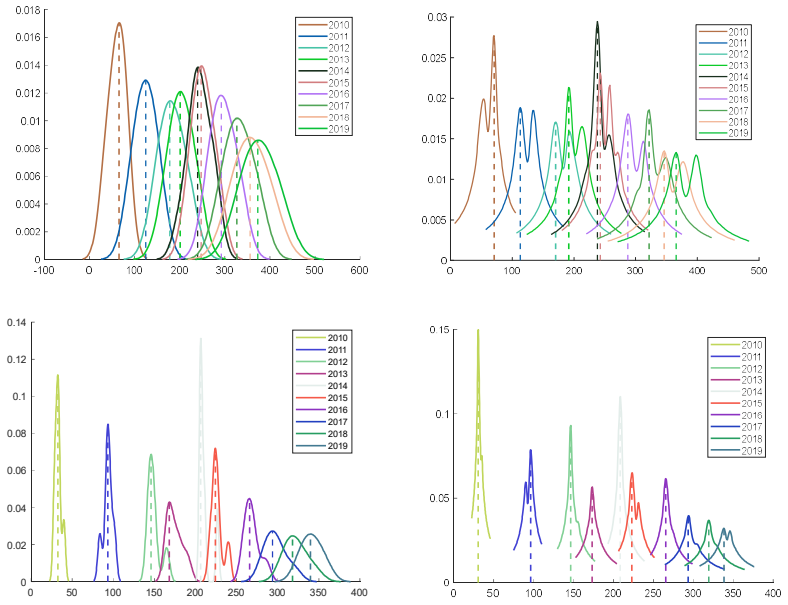

Figure 2. Eastern (top) and Central (bottom) digital financial inclusion kernel density map (left) KNN map (right).

As can be seen from the results, the level of development of digital inclusive finance in the eastern and central regions has been gradually developing over time, and in recent years, the

same density function has been characterized by a highly decreasing height and longer tails, and in recent years, there are a large number of overlapping parts of the density function in different years, which indicates that although the digital inclusive finance in the eastern and central regions in recent years has still been developing, the speed of development is relatively slow, and the differences between different provinces are large.

The dynamic analysis of the development of digital financial inclusion in the western region is displayed in Figure 3:

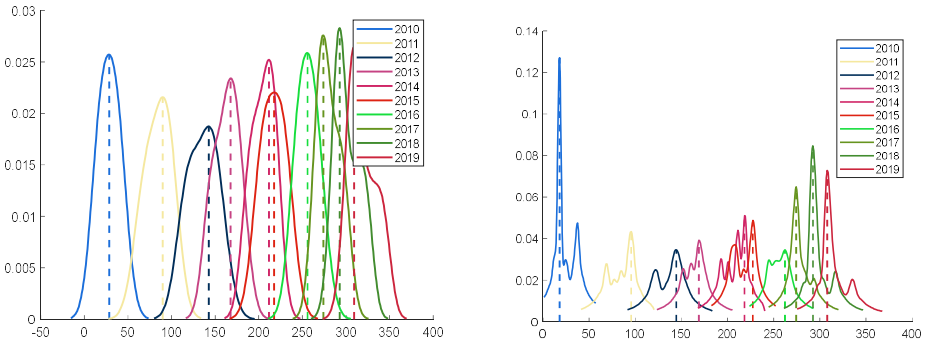

Figure 3. Western Digital Financial Inclusion Kernel Density Map (left) KNN Map (right).

The Tyrell's decomposition chart is displayed in Figure 4:

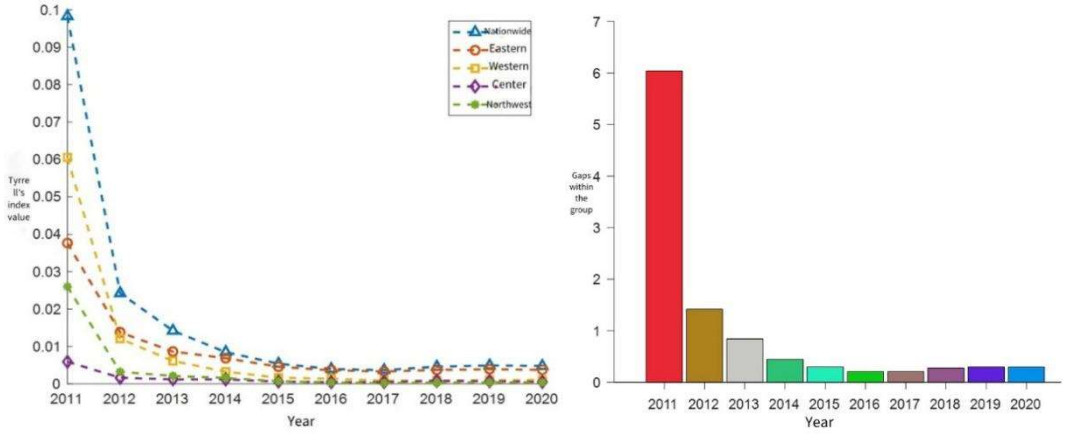

Figure 4. Tyrell's decomposition chart.

On the basis of the above analytical methods, this paper adopts the Terrell Index structural analysis method to explore the differences in the digital financial inclusion index among different regions. As a whole, the regional gap in the development level of China's digital inclusive finance has been narrowing year by year, indicating that China's implementation of the policy of “adapting to local conditions”, and the targeting of different geographically situated provinces to put forward different development ideas have achieved significant results, and promoted the balanced development of each region. In terms of intra-group disparities, the trend has been towards a narrowing of the gap within each region, but there has been some rebound in recent years, and the State should also formulate relevant policies to prevent the potential risk of widening disparities between different regions.

In this paper, we determine whether it is possible to use differential GMM and systematic GMM for estimation through the test of serial correlation of the perturbation term, and after the test

of serial correlation of the perturbation term is passed, we use the correlation test to carry out the validity test of instrumental variables. The regression results are shown in the Table 3:

Table 3. Estimation results for differential GMM and system GMM.

	Differential GMM	System GMM
Variant	Gap in quality of consumption between urban and rural residents	Gap in quality of consumption between urban and rural residents
L. Gap in quality of consumption between urban and rural residents	0.250***	0.436***
	(10.33)	(20.43)
Digital Inclusive Finance Index	-0.079***	-0.027**
	(-5.97)	(-2.43)
GDP per capita	-1.961	-4.877
	(-0.49)	(-0.63)
Industrial structure	-0.264	-0.400**
	(-0.85)	(-2.13)
Urbanization level	1.898***	0.297
	(6.21)	(1.61)
Per capita level of financial support to agriculture	2.381*	11.912***
	(1.86)	(6.48)
Child dependency ratio	0.204*	0.861***
	(1.84)	(8.07)
Old-age dependency ratio	-0.319*	-0.692***
	(-1.82)	(-3.82)
Constant	14.355	2.166
	(0.50)	(0.09)
AR(1)	0.0271	0.0238
AR(2)	0.1478	0.5653
Sargan(p)	0.1231	0.6515

From the results, the p-values of AR (1) for differential GMM and system GMM are 0.0271 and 0.0238, and the p-values of AR (2) are 0.1478 and 0.5653, indicating that the hypothesis of the existence of first-order autocorrelation is not rejected, while the hypothesis of second-order autocorrelation is rejected, and furthermore, the p-values of the statistics of differential GMM and system GMM are 0.1231 and 0.6515, indicating that the selected work variables are valid.

In the difference GMM and system GMM, the effect of the urban-rural residents' consumption quality gap lagging one period on the current period is significantly positive at the 1% significance level, both of which indicate that the consumption quality gap in the previous period will have a certain effect on the current period, and that there exists inertia in residents' consumption.

4. Conclusion and Future Work

4.1. Conclusion

(1) Digital financial inclusion helps to narrow the gap in the quality of consumption between urban and rural residents

China's modernization process emphasizes common prosperity and equality for all people, and the development and promotion of digital inclusive finance plays a crucial role in this regard. This report reveals the important role of digital financial inclusion in promoting the modernization process by analyzing the current status and development trend of the digital financial inclusion index and its impact on the gap in the quality of consumption between urban and rural residents[6]. In terms of the current development status of digital inclusive finance, the development of enterprises is one of the most popular topics at present. With the advancement of technology and policy support, the development level of digital inclusive finance has increased year by year, and the development gap between different provinces has been gradually narrowed, with the development speed leveling off. The impact of digital inclusive finance on the consumption quality gap between urban and rural residents is significant at the 1% level, when the threshold value is 6.255. Specifically, when the level of financial development is lower than 6.255, for every unit increase in the digital inclusive finance index, the urban-rural residents' consumption quality gap narrows by 10.3%, and when the level of financial development is higher than the threshold value of 6.255, for every unit increase in digital inclusive finance, the urban-rural residents' consumption quality gap narrows by 10.3%. unit, the gap between urban and rural residents' consumption quality narrows by 6.9%. When the level of financial development is lower than 5.1836, the gap in the quality of urban-rural residents' consumption narrows by 18.9% for each unit increase in the digital inclusive finance index, while the gap in the quality of urban-rural residents' consumption narrows by 10.1% for each unit increase in digital inclusive finance when the level of financial development is higher than the threshold value of 5.1836. Overall, digital inclusive finance helps to narrow the gap in the quality of consumption between urban and rural residents. This impact includes both direct effects and indirect effects through the reduction of the income gap between urban and rural residents[7].

(2) Spatial spillovers from digital financial inclusion are evident

In addition, the consumption behavior of residents shows the “ratchet effect”, that is, the consumption habits of the previous period will have a significant impact on the current consumption decisions. From a geographical perspective, the gap between urban and rural residents' consumption quality is wider in the western and southwestern provinces, with neighboring provinces also showing similar trends. In contrast, the gap between urban and rural residents' consumption quality is smaller in provinces in the coastal region and the middle and lower reaches of the Yangtze River[8]. Meanwhile, the level of digital financial inclusion development is higher in the eastern coastal region and first-tier cities and their neighboring areas, while digital financial inclusion services are relatively weak in the western, northeastern and southwestern regions. The coefficient of the spatial lag model is 0.241, which is significant at the 1% significance level, the coefficient of the spatial error model is 0.275, which is significant at the 1% significance level, and the coefficient of the spatial Durbin model is 0.273, which is significant at the 1% significance level, all of which indicate that there is an obvious spatial spillover effect of the consumption quality gap between urban and rural residents in China. It is worth noting that the impact of digital financial inclusion is not only limited to the local area, but also has a positive spillover effect on the neighboring areas. In summary, digital inclusive finance not only promotes balanced economic development, but also plays a key role in narrowing the gap between urban and rural residents' consumption quality, which strongly supports the process of Chinese-style modernization.

(3) Digital Inclusive Financial Services Coverage and Utilization Rates are Increasing Year by Year

The development of digital inclusive finance in different regions within China shows obvious regional differences. Eastern coastal regions have seen relatively rapid development of digital inclusive finance due to their higher level of economic development and improved financial

infrastructure; while central, western and remote regions, despite their late start, have seen the coverage and utilization of digital inclusive financial services rise year after year with policy support. The data show that the volume of loans to small and micro-enterprises has increased, the surface has expanded, and the price has dropped, indicating that more and more small enterprises are able to obtain the financial services they need, lowering the cost of financing and enhancing the vitality of enterprises. Production and business loans grew rapidly and in smaller individual amounts, indicating that financial services are closer to the actual needs of small and micro-enterprises and individual entrepreneurs, improving the flexibility and efficiency of capital utilization[9]. The promotion of first-lien loans and credit loans has increased, helping to build a more complete credit system, so that more individuals and small and micro enterprises lacking credit records have access to credit services. The digital inclusive financial infrastructure has continued to improve, especially the development of mobile payments in villages, providing more convenient financial service options in rural areas[10].

4.2. Future Work

The future work mainly focus on some directions. Policy orientation and financial institution services are the two pillars of inclusive financial development, with policy on the one hand and financial institution services on the other, both of which are indispensable. The People's Bank of China needs to coordinate the incremental expansion and commercial sustainability, and accelerate the construction of an incentive-compatible long-term mechanism for the development of inclusive finance. The analysis in this paper focuses on certain specific regions or cities with better economic conditions, and lacks a comprehensive examination of inclusive financial practices in different regions across the country. This means that existing findings may not be applicable to all regions, especially for regions with lower levels of economic development or poorer infrastructure, where existing research fails to adequately reflect their unique challenges and opportunities. In addition, this study focuses on short-term effects analysis, neglecting long-term impacts and specific barriers that may be encountered during policy implementation. It fails to explore, from the perspective of consumers, how their level of financial literacy, consumption habits, and other factors affect the acceptance and use of inclusive financial products.

To make up for these shortcomings, future research should be devoted to the following directions: strengthening comparative research on the development of inclusive finance in different regions, and exploring differentiated development models applicable to various regions. Increase research efforts on strategies to improve consumer financial literacy, while exploring how to design more attractive financial products and services based on user behavioral characteristics. Through these efforts, the theoretical system in the field of inclusive finance can be further enriched and improved, providing a more scientific and reliable basis for governmental decision-making, and at the same time pointing out the direction for financial institutions to innovate their service models.

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