Research on the Influence of Digital Financial Inclusion on Multi-dimensional Poverty of Farmers

Wang Shan

Central University of Finance and Economics, Beijing, 102200

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Abstract: The threshold effect of low availability and low efficiency leads to the limited development of traditional inclusive finance. Digital financial inclusion provides a new solution to improve the multidimensional life quality of micro families. In order to explore whether the development of digital financial inclusion can alleviate multi-dimensional poverty, this paper uses the entropy weight method to construct multi-dimensional poverty as the explained variable and uses the digital financial inclusion index to build a cross-sectional model based on the micro-sample data of Chinese households, and uses the Probit model to estimate the model. The empirical analysis results show that digital financial inclusion can reduce the incidence of multi-dimensional poverty and improve the overall quality of life of residents. In addition, the digitization of financial inclusion has the strongest effect on poverty reduction, and the impact of digital financial inclusion is better in groups with low years of education and low math test scores. Promoting differentiated digital poverty alleviation strategies can promote the development of digital financial inclusion to a certain extent.

1. Introduction

In the Outline of the Fourteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China, it is proposed to "accelerate digital development", promote the deep integration of digital economy and real economy, improve the digital skills of the whole people, implement the digital rural construction and development project, and develop rural digital financial inclusion. At the same time, "realize the effective link between consolidating and expanding the achievements of poverty alleviation and rural revitalization". When China's poverty alleviation is coming to an end, digital financial inclusion can enhance the achievements of poverty alleviation and endogenous development capacity.

Yang Jun et al. (2008) found that traditional financial development can alleviate poverty through the "trickle-down effect" of economic growth, improving income distribution and reducing credit constraints. However, due to regional, income, family, personal cognition and other reasons, low-income and poor groups are usually excluded from the formal financial system, making it difficult for poor groups to obtain the financial services they need. The implementation of inclusive finance can effectively reduce this threshold effect. In recent years, the large-scale popularization of the Internet in China and the application and promotion of digital technology have effectively promoted the development of digital financial inclusion. Then, through what mechanism does inclusive finance act on the poor? Will it be effective in reducing poverty? Will it have different effects on families from different backgrounds? Park and Mercado (2016) took 37 Asian countries and regions as research objects and found that the development of inclusive finance could significantly reduce poverty through empirical tests. Bittencourt (2010) took Brazil as the research object, and its research results show that if the financial service level and service radius are improved in areas with lower income levels, the living standard of 20% low-income groups will be improved. Gulli (1998) found in his study that inclusive finance can reduce poverty in four ways. Huang Zongping and Hu Zongyi et al. found that there was a non-linear relationship between the mitigation effect of inclusive finance on poverty and the effect of inclusive finance on poverty gradually

weakened from significant inhibition with the development of inclusive finance. Zhang Jianbo used the threshold model to study the impact of inclusive finance on the urban-rural income gap. The research results showed that, with economic improvement, inclusive finance had a non-linear relationship with the urban-rural income gap expanding at first and then shrinking.

The impact of inclusive finance on poverty has two mechanisms: direct effect and indirect effect. The direct effect is reflected in that the financial threshold can be lowered for the poor group, and the financial support can be increased so that they can obtain low-cost funds, thus contributing to the "long tail effect" of formal credit access of families. Yunus (1998) pointed out that loans should be regarded as a human right, and the development of inclusive finance can precisely enable low-income and vulnerable groups to access and utilize economic resources. Yang Bo and Wang Xiangnan et al. found that digital financial inclusion significantly promoted the access to formal credit of families mainly through digital payment channels, and the "long tail effect" of digital financial inclusion was obvious, which mainly improved the possibility of rural areas, central and western regions, low-income people and women groups to obtain formal credit. The indirect effect is reflected in the economic growth and income distribution effect of inclusive finance, increasing financial facilities and improving financial efficiency, promoting the accumulation of funds, and stimulating entrepreneurship and innovation. Yang Weiming et al. (2020) found that economic growth and entrepreneurial behavior had a partial mediating effect between digital financial inclusion and residents' income. Patriek Honohan (2004) believed that the continuous deepening of finance could improve the income of the poor, reduce the proportion of the poor, and reduce the inequality in income distribution. Xia Ling (2020) found from the provincial level that digital financial inclusion had a significant promoting effect on the income growth and poverty alleviation of the poor group, and the per capita disposable income had an intermediary effect in the process of promoting the poverty reduction effect of digital financial inclusion.

All the above studies are carried out from a macro perspective, while a few scholars have studied the poverty reduction effect of inclusive finance from a micro perspective. Zhou Li et al. (2020), based on the family micro perspective, found that the development of digital financial inclusion can bring "digital dividend" and significantly narrow the urban-rural income gap. At present, domestic researches mostly focus on the macro data analysis of provincial panel data, while the micro perspective analysis is a little insufficient. In addition, from the perspective of the level of economic development and income distribution in recent years, relative poverty has increasingly become a prominent problem in China's poverty. In addition to the income gap, the gap of public services such as education, health care and social security is significantly higher than the income gap. In the existing studies, the definition of poverty is mainly limited to indicators such as income level, income gap and Gini coefficient, and lacks consideration of the impact of digital financial inclusion on multidimensional poverty.

The contribution of this paper mainly lies in: First, compared with past literature using provincial panel data analysis, this paper using the city level digital and microscopic investigation data, the combination of financial and family and consider the heterogeneity of different households, from the perspective of microscopic digital finance and mechanism of the urban and rural poverty in China, overcome the limitations of the macro data sample size. Second, this paper uses the entropy method to measure the multidimensional poverty of rural households and uses the Probit regression model to investigate whether the development of digital financial inclusion can alleviate the poverty of residents. It is no longer confined to the single Gini coefficient or the urban-rural income gap so as to enrich the related research on digital financial inclusion and poverty alleviation

2. Materials and Methods

2.1 Data sources

The data at the household level came from the China Family Panel Studies (CFPS) of Peking University. CFPS is a comprehensive national social tracking survey project in China. Its survey

samples cover 25 provinces and cities in China. Through a dynamic tracking survey every two years, CFPS has established a tracking database at three levels: individual, family and community. At the end of this paper, this paper uses the latest cross-section data of the 2018 tracking survey.

For classification variables: 1 with chronic disease, 0 without chronic disease. 1 for male and 0 for female. Married status includes married and unmarried, with married status is set to 1, including remarried (with spouse) and widowed, and unmarried status is set to 0, including divorce, cohabitation and single. The household type is divided into agricultural household and non-agricultural household. The agricultural household is set to 0, and the non-agricultural household is set to 1. Continuous variables are assigned their original values. A total of 9,511 valid samples were collected.

2.2 Variable selection

2.2.1 Dependent Variable

Shang Weiping and Yao Zhimou (2005) regard poverty as a multidimensional concept. Alkire (2007) also believed that the multi-dimensional poverty measurement related to the ability method could provide more accurate information and facilitate the identification of people's ability deprivation. Chen Lizhong (2008) adopted the Watts Multi-dimensional Poverty Index to measure the multi-dimensional poverty in China's transition period from three dimensions: income, knowledge and health. The results show that from 1990 to 2003, the multi-dimensional poverty in China has decreased dramatically with income poverty falling the most and health poverty the least. Gao Yanyun (2012) measured, decomposed and analyzed the multidimensional poverty in China's urban and rural areas in the past decade, and believed that the poverty level in both urban and rural areas had been reduced on the whole.

Table.1. Comprehensive measure index system of family poverty

Level Indicators	The Secondary Indicators	Indicator Description	Weight	Mean of household poverty
Education	Education Years	Taking the family as the unit, secondary indicators are used to construct educational indicators to quantify the educational level of family members.	0.2134	0.319
	Math Test Score		0.1283	
	Word recognition score		0.1247	
Health	Have chronic disease or Not	Analyze the level of health in terms of the presence or absence of disease.	0.1434	
Living Standard	Diet Fee	Household consumption of the family members on food, use, housing and transportation is measured to measure the family living standard.	0.0065	
	Meals out		0.0060	
	Water &Electricity		0.0056	
	Housing costs		0.0054	
	Fuel Cost		0.0058	
Economic level	income	Household income.	0.3610	

In this paper, concerning the planning put forward by Millennium Development Goals (MDGs) and MPI constructed in the UN human development report, with balancing the availability and quality of data and China's reality, identifies four dimensions of 10 indicators, on CFPS data to construct a set of microscopic poor family-integrated measurement system. The poverty of micro families is measured from four perspectives: education, health, living standard and economic level. The educational dimension includes the number of years of schooling of the representative members of the family, the math test score and the word-memorization score. The health dimension examines

whether family members have chronic diseases. In the previous literature, there are a variety of methods to determine the health dimension, such as calculating BMI, comparing weight and age, etc., but these measures have little direct impact on poverty. This paper believes that chronic diseases can better represent the health level of a family. In the dimension of living standard, five daily expenses including family meals, meals out, water and electricity, housing and fuel are considered. Economic level takes into account household income.

The entropy weight method is used to give weight to the secondary indexes of four dimensions: education, health, living standards, and economic level. The income with the highest weight is obtained, followed by years of education, and then chronic disease. The average value of the multi-dimensional poverty index was 0.319.

2.2.2 Independent Variable

In order to characterize the inclusive nature of China's digital finance, this paper adopted the China Digital financial inclusion Index jointly compiled by the Digital Finance Research Center of Peking University and Ant Financial Services Group (Guo Feng et al., 2020). The index, which uses trading account data from Ant Financial, largely describes the development and inclusiveness of digital finance in China. In this paper, the digital financial inclusion development index DFI_{ji} is used as the core explanatory variable to measure the development degree of digital financial inclusion in various provinces and cities. The index is built on three dimensions: covering breadth, usage depth and digitization level, which is highly authorized and widely used in the research on digital financial inclusion in China. In the robustness test, three sub-dimensions of coverage breadth, usage depth and digitalization degree were used to replace the index.

2.2.3 Control Variable

$Control_i$ is other control variables affecting the poverty of residents, including gender, age, marital status, household type, and risk preference of household head.

Table.2. Variable description and descriptive

Variable Categories	Variable Name	Variable Description	Mean	Std.
Explained Variable	household poverty	Comprehensive score	0.3189	0.1189
Core Explanatory Variable	digital financial inclusion index	2018 provincial digital financial inclusion index	300.2811	28.7516
Control Variables	gender	The gender of household head	0.5745	0.4945
	age	The age of household head	54.5113	13.5391
	marriage status	The marital status of the head of the household, which is divided into married and unmarried	0.9404	0.2368
	household type	Household type of family	0.2756	0.4468
	risk preference	The type of household registration	0.1871	0.3900

2.3 Research methods

2.3.1 Entropy weight method

This paper uses the entropy value method to measure the multidimensional poverty of peasant households. The entropy value method is an objective weighting method, which only depends on the discreteness of data and reduces the interference of many human factors. Before the index data processing, a series of basic data processing is needed to make the value obtained by the entropy value method more reasonable and usable.

(1) Standardized processing of data:

Since the measurement units of various indicators in the evaluation system are not uniform, in order to eliminate the influence of various factors on the results, the indicators are standardized before the comprehensive calculation, that is, the absolute value of the indicators is converted to the

relative value so as to solve the problem of homogenization of various index values and make the indicators more comparable. As indicators can be divided into positive and negative ones, and their values represent different meanings, different algorithms need to be adopted for data standardization processing of positive and negative indicators:

Positive indicator:

$$X_{ij} = \frac{x_{ij} - minx_{ij}}{maxx_{ij} - minx_{ij}} \tag{1}$$

Negative indicator:

$$X_{ij} = \frac{maxx_{ij} - x_{ij}}{maxx_{ij} - minx_{ij}} \tag{2}$$

X_{ij} is the index value after standardization. $maxx_{ij}, minx_{ij}$ represents the maximum and minimum values of the original index values, respectively.

(2) Calculate the proportion of the i_{th} sample in the j_{th} index:

$$p_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \tag{3}$$

(3) Calculate the entropy e_j of the j_{th} term according to the formula:

$$e_j = -k \sum_{i=1}^{n} p_{ij} \ln p_{ij} \tag{4}$$

e_j is entropy, $k = {}^{1}/_{\ln(n)} > 0$, $e_j \geq 0$.

(4) Calculate the difference coefficient of information entropy d_j:

The difference of indicators will directly affect the size of the weight. The smaller the entropy is, the larger the differential coefficient is, and the more important the indicators are.

$$d_j = 1 - e_j \tag{5}$$

(5) Calculate the weights of each indicator:

$$w_j = \frac{d_j}{\sum_{i=1}^{n} d_j} \tag{6}$$

The importance of each index in the welfare level evaluation system can be seen from the weight.

(6) Calculate the comprehensive score of each sample:

$$S_i = \sum_{i=1}^{n} w_j X_{ij} \tag{7}$$

S_i is the comprehensive score of each sample after calculation. The results can be evaluated and compared according to the calculation results.

2.3.2 Probit Model

Probit model is a generalized linear model, which assumes that the random terms obey the normal joint distribution. The simplest Probit model is that the explained variable *Y* is a 0,1 variable, and the probability of the occurrence of the event is dependent on the explanatory variable, that is, *P(Y=1)=f(X)*. In other words, the probability of $Y = 1$ is a function of *X*, where *f(X)* obeys the standard normal distribution. The partial regression coefficient of Probit regression means the change value of the probability density function of a certain result when the independent variable increases by one unit when other independent variables remain unchanged.

$$F(X) = \Phi(X) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{X} e^{-t^2/2}\, dt \tag{8}$$

In order to investigate whether the development of digital financial inclusion can alleviate the poverty of residents, this paper constructs the following regression equation:

$$Poverty_{ji} = \beta_0 + \gamma_1 DFI_{ji} + \beta_1 Control_i + \varepsilon_t \tag{9}$$

In Equation (9), $Poverty_{ji}$ is the multidimensional poverty indicator of the i_{th} family in city *j*, which is an important explained variable in this paper and represents the poverty level of residents' families. According to the average poverty level obtained by the statistics described below, if the poverty index is lower than the mean of 3.19, $Poverty_{ji}$ is set as 0, which means it is not poor. Otherwise $Poverty_{ji}$ is set as 1.

3. Empirical analysis

3.1 Benchmark Regression

In order to explore whether the independent variable digital financial inclusion index has a mitigating effect on the dependent variable multi-dimensional poverty, this paper adopts the Probit model. The results are shown in Table 3, in which the coefficients (1), (2), (3) and (4) are respectively the Probit regression results of the digital financial inclusion index and its coverage breadth, use depth and digitalization degree. Table 3 shows that the coefficient of digital financial inclusion index is positive, indicating that digital financial inclusion has a significant slowing effect on the multidimensional poverty index of families. The gender coefficient is significantly negative, indicating that the poverty degree of male-headed households is lower than that of female-headed households. The household type coefficient is quite negative, indicating that the poverty status of non-agricultural households is considerably lower than that of agricultural households.

Table.3. Digital Financial Inclusion and Resident Poverty: Probit Regression Results

Variables	Coefficient	Fractional dimension test			Robustness test
		Coefficient	Coefficient	Coefficient	
digital financial inclusion index	-0.0006 *** (0.0000)				-0.0007 *** (0.0002)
coverage breadth		-0.0006 *** (0.0002)			
use depth			-0.0005 *** (0.0001)		
digitization degree				-0.0008 *** (0.0002)	
gender	-0.1416 ** (0.0092)	-0.1414 *** (0.0092)	-0.1419 *** (0.0092)	-0.1415 *** (0.0092)	-0.1421 *** (0.0092)
age	0.0130 *** (0.0003)	0.0130 *** (0.0003)	0.0130 *** (0.0003)	0.0130 *** (0.0003)	0.0130 *** (0.0003)
marital status	-0.0336 ** (0.0206)	-0.0335 ** (0.0206)	-0.0340 ** (0.0206)	-0.0340 ** (0.0206)	-0.0329 ** (0.0208)
household type	-0.2633 ** (0.0102)	-0.2654 ** (0.0102)	-0.2621 ** (0.0102)	-0.2640 ** (0.0102)	-0.2622 ** (0.0102)
risk preference	-0.0049 ** (0.0121)	-0.0046 ** (0.0121)	-0.0051 ** (0.0121)	-0.0050 ** (0.0121)	-0.0055 ** (0.0122)
LR chi2	1914.99	1910.62	1918.77	1912.68	1910.39
Prob>LR chi2	0.0000	0.0000	0.0000	0.0000	0.0000
N	9,511	9,511	9,511	9,511	9,511
R^2	0.1459	0.1456	0.1462	0.1457	0.1456

Note: ***, ** and * indicate significant at the level of 1%, 5% and 10%, respectively.

The impact of coverage breadth on the degree of family poverty: Different from the main mode of traditional financial institutions that take offline outlets as their business, digital financial inclusion is no longer limited by region with the popularity of the Internet and can cover people far away from

the outlets on the basis of traditional finance. Table 3 shows that the impact coefficient of the coverage of digital financial inclusion on multi-dimensional poverty is significant, indicating that the coverage of digital financial inclusion greatly reduces the level of multi-dimensional poverty.

The impact of depth of use on household poverty: the depth of use of digital financial inclusion is measured by financial services that actually mainly use the Internet, such as payment services, money fund services and credit services, and can also be measured by activity indicators such as the number of transactions per person and the amount of money. Table 3 shows that the use depth of digital financial inclusion has a significant impact on multi-dimensional poverty, indicating that the use depth of digital financial inclusion has significantly reduced the level of multi-dimensional poverty.

The impact of digitalization on household poverty: The digitalization of digital financial inclusion mainly measures the convenience and cost of residents' access to digital services, which can be measured by data such as mobile payment amount. Table 3 shows that the degree of digitalization of digital financial inclusion has a significant impact on multi-dimensional poverty, indicating that the degree of digitalization of digital financial inclusion has significantly reduced the level of multi-dimensional poverty. It can be seen from the regression results that the digitization degree index has the most obvious effect on poverty alleviation, indicating that the improvement of the convenience of digital financial inclusion and the reduction of financing cost provide an efficient way to reduce poverty for all social classes, especially the disadvantaged groups in underdeveloped areas.

By using the Logit model, the regression results show that digital financial inclusion has a significant effect on poverty alleviation. The robustness of the model was tested.

3.2 Heterogeneity Analysis

Table.4. Heterogeneity analysis result

Variables	Low years of schooling	High years of schooling	Low math test scores	High math test scores	Poor health	Good health
digital financial inclusion index	-0.0010 ***	-0.0001 ***	-0.0010 ***	0.0002 ***	-0.0001 ***	-0.0010 ***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
gender	-0.1675 ***	-0.0220 **	-0.1592 **	-0.0329 **	-0.0392 **	-0.1315 ***
	(0.0110)	(0.0138)	(0.0118)	(0.0121)	(0.0119)	(0.0099)
age	0.0138 ***	0.0052 ***	0.0093 ***	0.0064 ***	0.0040 ***	0.0108 ***
	(0.0004)	(0.0005)	(0.0005)	(0.0004)	(0.0005)	(0.0003)
marital status	-0.0659 **	0.0372 **	-0.0314 **	0.0402 **	0.0235	-0.0535 **
	(0.0264)	(0.0303)	(0.0264)	(0.0283)	(0.234)	(0.0217)
household type	-0.1559 **	-0.0697 **	-0.1983 **	-0.0941 **	-0.1714 **	-0.3151 **
	(0.0146)	(0.0135)	(0.0149)	(0.0127)	(0.0125)	(0.0119)
risk preference	-0.0066 **	-0.1680 ***	0.0200 ***	-0.0429 **	0.0052 **	0.0027 **
	(0.0148)	(0.0173)	(0.0159)	(0.0155)	(0.0155)	(0.0128)
LR chi2	1059.25	141.95	592.59	257.92	295.02	1483.44
Prob>LR chi2	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
N	6,857	2,025	5,732	3,779	2,070	7,441
R^2	0.1117	0.1042	0.0803	0.0768	0.2291	0.1562

Note: ***, ** and * indicate significant at the level of 1%, 5% and 10%, respectively.

The Probit model was used to confirm the mitigation effect of digital financial inclusion development on multidimensional poverty of families. However, it did not reveal the poverty reduction effect of digital financial inclusion on different groups. In order to explore whether each group can benefit equally from the development of digital financial inclusion, this paper differentiated the household sample according to education, math test scores, and health.

From the perspective of education level, this paper divide the educational level of the population into two groups: low education level and high education level according to the nine-year compulsory education. The results show that the digital financial inclusion index has a significant poverty alleviation effect on both low education level and high education level groups. However, in the low education group, the multi-dimensional poverty level of the married households is lower than that of the unmarried households at the significance level of 5%. In the highly educated group, the multi-dimensional poverty level of the households with married head status is higher than that of the households with unmarried head status at 5% significance level.

From the perspective of math test scores, the regression results show that the digital financial inclusion index has a significant poverty alleviation effect on the group with low math test scores, while it has a significant poverty increase effect on the group with high math test scores. In the group with low math test scores, the multi-dimensional poverty level of the married households was lower than that of the unmarried households at the significance level of 5%. In the group with high math test scores, the multi-dimensional poverty level of the households with married head status was higher at the significance level of 5% than that of households with unmarried head status. Among the groups with low math test scores, the poverty level of families with low-risk preference was significantly lower than that of families with high-risk preference. Conversely, families with low-risk preferences had higher poverty levels than those with high-risk preferences at a significant level of 5%.

From the perspective of health status, digital financial inclusion has significantly reduced the poverty level of both the poor and the good health groups, and the poverty reduction effect is more obvious for the good health groups.

From poor heterogeneity analysis, it can be concluded that promoting financial development is conducive to poverty residents. More importantly, the financial poverty reduction effect can benefit the poor and more vulnerable groups, such as low education level or low math test score group. Digital financial inclusion development for disadvantaged groups brings higher marginal contributions, which is in line with the experience of Kenya, Zambia and South Africa. In these countries, the development of mobile financial services will help narrow the gap in Africa’s financial infrastructure and increase the poor’s access to financial services. Technological innovations have indeed increased financial inclusion.

4. Conclusions

This paper empirically discusses the impact of digital financial development on reducing multidimensional poverty of residents from a micro perspective, which enriches the existing research and confirms the accuracy of the results by using a robustness test. Further, this paper explores the impact of digital financial inclusion on different families by analyzing the heterogeneity among families. In summary, the main conclusions and implications of this paper are as follows:

Firstly, the development of digital financial inclusion can reduce the occurrence of poverty and improve the overall quality of life of residents. Among the sub-dimensions, the coverage breadth index, the use depth index and the digitalization degree index all have significant effects on poverty reduction, among which the digitalization degree has the most apparent effect on poverty reduction. This shows that the improvement of the convenience of digital financial inclusion and the reduction of financing cost have effectively lowered the service threshold for all social strata, especially the vulnerable groups in underdeveloped areas, and provided "digital dividend".

Secondly, digital financial inclusion has a more significant effect on the poverty reduction of vulnerable groups. For groups with low years of schooling and low math test scores, the

popularization of digital financial inclusion has a significant inhibiting effect on the poverty of these families, and can bring higher marginal benefits. For poorer health groups, digital financial inclusion has a certain effect on poverty reduction. However, it has a higher marginal benefit for better health groups, possibly due to higher outputs for a better health group.

In view of the above conclusions, the following policy suggestions can be drawn:

Firstly, improve the construction of digital infrastructure and enhance the application of digital technology in inclusive finance. Research shows that the development of digital financial inclusion can significantly reduce household poverty, and the degree of digitalization plays a greater role in poverty alleviation. The government should strengthen the construction of network facilities in poor rural areas, improve the Internet coverage, and build the relevant digital financial poverty alleviation platform.

Secondly, this paper needs to implement differentiated digital poverty alleviation strategies. Since digital financial inclusion has a higher marginal effect on the disadvantaged groups, it is secondary to the advantaged groups. It is not appropriate to unduly pursue the "quantity" of digital financial inclusion. Instead, personalized digital products should be promoted according to the households of different classes.

Thirdly, enhance the level of publicity and supervision of digital finance. On the one hand, the government should strengthen the publicity of digital finance, explain and introduce good digital finance products, and go deep into the grassroots people. On the other hand, while expanding the scope of services, digital financial inclusion also brings the corresponding security and regulatory issues. Due to the low threshold of participation in digital finance, the level of participants is not uniform, which leads to the increasing difficulty of supervision. The government should make use of Internet technology to improve the supervision capacity and improve the digital financial inclusion supervision system.

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