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The appropriate level of financial inclusion: The perspective of financial stability

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ABSTRACT

We construct a global financial inclusion index using data from the World Bank, IMF, and V-Lab and propose an inverted U-shaped relationship between financial inclusion and financial stability. The empirical evidence supports our hypotheses, and the impact of financial inclusion on financial stability is less prominent under strong regulation and supervision. In addition, we use our constructed financial inclusion index, capital adequacy ratio, market power, and macroeconomic variables to simulate and predict the financial crisis. Our research has important policy implications and provides valuable insights to financial regulatory authorities in making decisions related to financial inclusion and financial stability.

1. Introduction

Financial inclusion refers to the provision of appropriate and effective financial services for all social classes and groups in need of financial services at an affordable cost (United Nations, 2016). Over the past few years, financial inclusion has made significant achievement by establishing a well-established financial inclusion service system and extensive service coverage (Zeng et al., 2020). Informal financial institutions, represented by various micro-credit companies, were early entrants in this industry. These financial institutions mainly issued loans to rural residents, small and micro enterprises, and other groups. Because the regulatory system was incomplete at that time, some financial institutions frequently "run off with the money". Afterward, traditional financial institutions have also focused on the financial inclusion area. Apart from city commercial banks, rural commercial banks, and village banks, which mainly serve rural residents and small and micro enterprises, large state-owned commercial banks and joint-stock commercial banks have also established financial inclusion departments around 2017, aiming to allow more financial resources to flow to "agriculture, rural areas, and farmers" and small and micro enterprises and provide effective support to the development of the real economy.

To better serve rural residents, small and micro enterprises, and other groups, it is important to introduce new inclusive financial products and services. Li (2015) is among the early scholars paying attention to the risks brought by financial innovation. He pointed out that financial innovation risks are easily neglected and are likely to show in the form of systemic risks. If financial inclusion is developed safe and sound, it can increase social well-being, improve financial efficiency and social stability, and have a positive effect on the stability of the financial system. However, unreasonable provision of financial supplies to the "disadvantaged groups of financial services" might undermine the financial system, as it is difficult to assess the credit records of these groups.

In 2019, the Fourth Plenary Session of the 19th CPC Central Committee proposed to "improve the modern financial system to one

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that is highly adaptable, competitive and inclusive" and "effectively prevent and resolve financial risks". In August 2020, the spokesperson of the China Banking and Insurance Regulatory Commission stated in an interview that with the reform and opening up, technological empowerment, and intensive management, financial institutions will make precise efforts to provide inclusive financial resources and keep credit risks within a controllable range. To the best of our knowledge, prior studies pay more attention to the positive economic consequences of the development of financial inclusion, leaving the potential negative impact unexplored. We argue that it is important both theoretically and empirically to know whether the development of financial inclusion undermines financial stability to a certain extent. If so, how to reduce or even eliminate the negative impact? This paper aims to answer the above two questions.

Based on the data collected from the Financial Access Survey (FAS) conducted by the International Monetary Fund (IMF) from 2004 to 2019, we first construct the financial inclusion development index of 115 countries and regions using principal component analysis (PCA), and then explore the relationship between financial inclusion and financial stability with the Tobit model and OLS model. The empirical results show that there is an inverted U-shaped relationship between financial inclusion and financial stability. In addition, effective macro-regulation can reduce the systemic risks that come with the development of financial inclusion, and the inverted U-shaped relationship between financial inclusion and financial stability becomes more obvious after the 2008 financial crisis. Finally, we employ the Probit and Logit models to test whether the financial crisis occurs and obtain relatively ideal test results.

This paper contributes to the existing literature in the following aspects: (1) This paper constructs the financial inclusion index of many countries and regions in the world with the statistics of the World Bank, IMF, and other institutions; (2) in contrast to current studies which pay little attention to the relationship between financial inclusion and financial stability, this paper enriches the study by Ahameda and Mallick (2019) on the linear relationship between financial inclusion and bank stability by exploring the nonlinear relationship between financial inclusion and systemic risks; and (3) this paper employs variables such as the financial inclusion index, capital adequacy ratio, and bank market power to forecast the likelihood of a financial crisis occurring in a country or region, which can provide decision-making reference for financial regulators.

The structure of the paper is as follows: the second part elaborates on the theoretical basis for the inverted U-shaped relationship between financial inclusion and financial stability (or the U-shaped relationship between financial inclusion and systemic risks) and research hypotheses; the third part describes various variables, data sources, and models; the fourth part reports the benchmark regression results; the fifth part performs the robustness test; the sixth part reports the heterogeneity test results before and after the 2008 financial crisis and tests results of the likelihood of a financial crisis occurrence; the seventh part presents the conclusions and policy suggestions.

2. Theoretical hypotheses

2.1. The development of financial inclusion promotes financial stability

First, financial inclusion can optimize the allocation of financial resources. The important feature of financial inclusion are "low cost, wide coverage, and sustainability". It emphasizes the access and use of financial services of groups such as small and micro enterprises and rural residents, thus making it possible for the public to allocate financial resources, contributing to the equal access to resources of economic subjects, and achieving economic growth and fairness in income (Levchenko, 2005; Hannig and Jansen, 2010; Li and Han, 2019). In addition, financial inclusion is significantly and negatively related to the non-performing loan ratios and risk premiums of banks. In other words, a higher degree of financial inclusion leads to greater financial stability. Neaime and Gaysset (2018) found that the development of financial inclusion is conducive to reducing income inequality in the Middle East and North Africa, demonstrating that financial inclusion promotes financial stability by optimizing the allocation of financial resources.

Second, financial inclusion helps to diversify risks. On the one hand, it provides basic services such as account opening, depositing and withdrawing money, and payment for daily consumption, and then gradually switches to credit services such as lending. For individuals, financial inclusion generates a wider base of depositors and potential loan recipients (Mehrotra and Yetman, 2015), and the increase in deposits strengthens banks' ability to resist risks (Hannig and Jansen, 2010). For small and micro enterprises, the increase in the number of borrowers can reduce the non-performing loan ratios and default rates of financial institutions and thus increase financial stability (Morgan and Pontines, 2014). On the other hand, financial inclusion users are mainly small-amount depositors, who tend to maintain deposits during the crisis. Therefore, countries with wider coverage of financial inclusion see fewer declines in deposits during the financial crisis and boast more stable financial systems (Han and Melecky, 2013).

Third, financial inclusion can reduce the dependence of the demanders of capital on informal financial institutions. Undeniably, informal finance plays a role in leading money to small and micro enterprises, rural residents, and other groups. However, because of inadequate regulation, informal financial institutions are mostly engaged in leverage operation, maturity/liquidity transformation, and credit risk transfer, which, without proper regulation and supervision, are likely to cause systemic risks and regulatory arbitrage (Financial Stability Board, 2011). Financial inclusion is a kind of formal finance promoted at the macro level and can provide substitution effect to informal finance. (Jain, 1999; Jin and Li, 2009). Developing financial inclusion is conducive to improving financial availability, reducing the likelihood of individuals investing in informal financial institutions, diminishing the supply of informal finance (Yin et al., 2015), and squeezing out the space of the informal financial market (Yin et al., 2020), thereby reducing reliance on informal financial institutions and increasing the stability of the financial system.

2.2. The development of financial inclusion undermines financial stability

First, excessive innovation may exist in the development of financial inclusion. Fintech innovation promotes the development of

financial inclusion through the creation effect, information effect, and inclusive effect (Zhou et al., 2020), such as Internet finance with good motives (Gong and Wang, 2018) and digital financial inclusion powered by artificial intelligence and big data (Tang et al., 2020; Guo et al., 2020). However, without appropriate and timely regulation and supervision, fintech innovation with bad motives may generate adverse effects on financial stability, resulting in maturity mismatch, liquidity mismatch, and excessive volatility of asset prices (Liu et al., 2017). In addition, the lack of regulation and supervision has also created opportunities for some quasi-financial institutions to operate without licenses and gain popularity in the name of "financial innovation" (Huang and Huang, 2018). A case is the P2P financing platform. According to Wangdaizhijia,[1] there were 5970 P2P platforms in 2016. The market competition for these P2P platforms was very fierce at that time (Chu et al., 2018). To attract potential investors, most P2P platforms have made principal and interest guarantee commitments and it makes them to change from a risk-free information intermediary to a risk-bearing credit intermediary (Ye et al., 2016). Moreover, these P2P platforms have no proper risk assessment process (Li and Shen, 2019). Therefore, the risk is accumulating continuously. In 2018, multiple P2P platforms collapsed one after another, severely damaging the stability of the financial system. Accordingly, some scholars call on regulators to pay timely attention to changes in various fintech innovation activities and try to strike a balance between financial innovation and financial stability (Boot et al., 2021; Hua and Huang, 2021).

Second, developing financial inclusion may cause excessive credit. Excessive credit refers to the situation that the funds granted to the borrowers exceed their actual needs. One possible explanation is that financial institutions have granted loans to a specific borrower multiple times to outperform the assessment indicators, or multiple financial institutions have issued loans to a specific borrower. Excessive credit has obvious negative externalities, and it may lead to a vicious circle of continuous decline, resulting in financial system instability (Jia et al., 2021). Under the guidance of macro policies, groups refused by traditional financial services tend to apply for loans from financial institutions. Financial institutions are also subject to the KPIs related to inclusive finance. To meet KPI targets, financial institutions may issue excessive loans to groups with doubtful credit qualifications, which are usually called "inferior customers" (Foos et al., 2010; Lu et al., 2014). From an individual perspective, the wider coverage of financial inclusion has created greater demand for personal credit (Demirgüc-Kunt et al., 2008), but personal credit is at risk of over-expansion (Morgan and Pontines, 2014). Unreasonable credit expansion will lead to overborrowing by individuals with a poor ability to repay loans, which increases the risk to the financial system and poses a challenge to the stability of the financial system. From an institutional perspective, micro financial institutions are the backbone of the development of financial inclusion, but they have limited capital and high default rates and non-performing loan ratios. The accumulation and spillover effect of risks may exert a negative impact on the stability of the financial system. More specifically, if financial institutions all lower their lending threshold, fuelling excessive borrowing, financial risks may spread from individuals to industries, leading to the accumulation of systemic risks and the outbreak of financial crises (Drehmann et al., 2010).

2.3. *There is a nonlinear relationship between financial inclusion and financial stability*

From the macro perspective, financial inclusion encourages "creative destruction" by promoting economic growth, narrowing the gap between the rich and the poor, and contributing to financial stability; from the micro perspective, the excessive development of financial inclusion may also lead to opportunistic behaviours such as abuse of funds and delaying payments deliberately, undermining financial stability. For example, excessive lending by microfinance institutions in India to the poor contributed directly or indirectly to the microfinance crisis in Andhra Pradesh, India, in 2010 (Ghosh, 2013). Soederberg (2013) even believed that the outbreak of the 2008 financial crisis could be ascribed to the excessive borrowing of groups with poor credit records.

In addition, the social and economic impacts of the development of financial inclusion vary in different regions. For example, Fu and Huang (2018) found that the development of digital financial inclusion has reduced the demand for productive formal finance in the central and eastern regions of China but increased such demand in the western region of China. We believe that this is associated with the inverted U-shaped relationship between financial inclusion and the stability of the financial system. In theory, there is a moderate level of development of inclusive finance, or the "threshold value". Financial inclusion benefits financial stability and is "good finance" when it has not reached the threshold value; however, when it surpasses the threshold value, it will turn into "bad finance" featuring disordered and excessive lending, which adversely affects the overall financial stability. Accordingly, this paper proposes the following hypothesis.

Hypothesis 1. there is a nonlinear inverted U-shaped relationship between financial inclusion and the stability of the financial system.

2.4. *The role of financial regulation in tuning the relationship between financial inclusion and financial stability*

We believe that effective macro-regulation can reduce the systemic risks brought about by the development of financial inclusion. First, effective macro-regulation is mostly implemented in a top-down approach (Miao and Wang, 2010), and by issuing policy guidelines. For example, regulatory authorities roll out policies and regulations, set industry entry barriers, and put an end to the operations of some informal financial institutions. Second, effective macro-regulation optimizes resource allocation by providing formal financial institutions with the resources needed to develop financial inclusion through various monetary tools, assisting them in carrying out inclusive financial operations and "crowding out" the risky informal financial institutions. Third, effective macro-regulation tackles financial innovation in the development of financial inclusion. For example, regulatory technology revolving around the technology dimension can quickly monitor the operating conditions of financial institutions, discover the essence of financial products and service innovation, and establish an early warning system for precautionary purposes (Yang, 2018).

[1] The first and the biggest P2P website in China (www.wdzj.com).

To sum up, an effective macro-regulatory system plays a role in two aspects. First, it abates systemic risks. Effective regulation and supervision weaken systemic risks. Second, it moves the turning point of the U-shaped relationship that may exist between financial inclusion and systemic risks further to the right, giving full play to the positive impact of financial inclusion on financial stability. Therefore, the following hypothesis is proposed.

Hypothesis 2. effective macro-regulation reduces the systemic risks brought about by the development of financial inclusion.

3. Research design

3.1. Dependent variable

The dependent variable is financial stability. Financial stability is measured by the systemic risk index (*SRISK*) proposed and improved by Acharya et al. (2012), Brownlees and Engle (2017), and Acharya et al. (2017). *SRISK* refers to the expected capital shortfall of a financial institution in the event of a systemic financial crisis. Changes in the stock market index are usually employed to predict whether a "systemic financial crisis" will occur, and the expected loss of equity is called the long-run marginal expected shortfall (*LRMES*). *SRISK* is calculated as follows:

$$SRISK = k*Debt - (1-k)*(1-LRMES)*MV \tag{1}$$

where k refers to the capital adequacy ratio, *Debt* is the book value of a company's liabilities, *LRMES* is the long-run marginal expected shortfall, and *MV* stands for the total market value of the company's issued shares. $LRMES = 1 - \exp(\log(1-d) \times beta)$, where d is the threshold where the market price of a company will fall within six months, and *beta* represents the dynamic conditional beta of a company's stock. *SRISK* values are those of various countries or regions collected from the V-Lab database of the NYU Stern School of Business.

3.2. Explanatory variable

The explanatory variable is the measure of financial inclusion. International organizations across the globe such as the International Monetary Fund (IMF), the Global Partnership for Financial Inclusion (GPFI), and the Alliance for Financial Inclusion (AFI) have formulated indicators to measure the financial inclusion level (Sun et al., 2016). The IMF financial inclusion index is constructed based on the Financial Access Survey (FAS). The FAS, launched in 1995, is conducted once a year, and the FAS database is also more complete than other database (Sun et al., 2016).[2] Therefore, this paper constructs the financial inclusion index with raw data from the FAS database. Specifically, we first eliminate variables with missing data and then calculate the other variables using PCA.[3]

3.3. Control variables

Following Petersen and Rajan (1995), Beck et al. (2004), Honohan (2008), Carbó-Valverde et al. (2009), Chong et al. (2013), Ryan et al. (2014), Fang et al. (2014), Love and Martínez Pería (2015), this paper introduces the following control variables.

The capital adequacy ratio (*CAR*) reflects the capital cushion of a financial institution in a financial crisis. In this paper, we use the weighted average capital adequacy ratio of financial institutions in a country/region to measure its financial regulation. Market power (*MP*) measures the competition among banks in the market, which is measured by the Lerner index released by the World Bank. A higher Lerner index value suggests weaker competition among banks. The loan ratio (*LR*, the ratio of total loans to total assets) controls a bank's liquidity risk. The loan loss provision (*LLP*) controls a bank's loan portfolio risk. In addition, as banks with stronger management capabilities can take more risks, we also introduce the management quality of a bank (*MQ*) as a control variable; since economic development is usually accompanied by the development of financial inclusion, per capita GDP (*GDP_C*) is also taken as a control variable.[4]

[2] The "more complete" means that comparatively speaking, the FAS database is more complete, but it also has some missing data. The current FAS consists of 64 indicators covering 276 countries/regions. We remove the sub-indicators and choose the remaining 40 indicators. If no data is missing, we should have collected 4416 observations (276 countries/regions × 16 years). However, the 40 indicators are missing to varying degrees. For example, the typical credit indicator "the number of loan accounts opened in commercial banks per 1000 adults" has only 419 observations. Therefore, we only adopt indicators with over 1000 observations. Then, referring to the study by Nguyen (2020), we collectively refer to commercial banks, credit unions, and microfinance institutions as financial institutions and combine indicators of the same kind related to commercial banks, credit unions, and microfinance institutions. Finally, 7 indicators are qualified for PCA.

[3] See Annex Tables 1–3 for the descriptions and calculations of PCA indicators. Due to space limitations, they are not listed here and are available on the official website of *China Economic Quarterly* (https://ceq.ccer.pku.edu.cn/).

[4] Due to space limitations, the list of control variables is presented in Annex Tables 4 and is available on the official website of *China Economic Quarterly* (https://ceq.ccer.pku.edu.cn/).

3.4. Data sources and econometric models

The data used in this paper are obtained through the following channels: data about the financial stability of financial institutions come from the V-Lab database of the NYU Stern School of Business; data of financial inclusion are collected from the FAS, and some variables are selected to construct the overall financial inclusion index of a country/region using PCA; control variables come from the BankScope database and the World Bank database. After data processing, we obtain observations for 115 countries/regions from 2004 to 2019.

The following econometric model is established:

$$SRISK_{i,t} = \alpha_0 + \alpha_1 IFI_{i,t} + \alpha_2 IFI_{i,t}^2 + \sum Controls_{i,t} + \varepsilon_{i,t} \tag{2}$$

where i represents a country/region and t, the year; $SRISK_{i,t}$ refers to the systemic risk of the country/region, $IFI_{i,t}$, is the financial inclusion index of the country/region, $IFI_{i,t}^2$, is the squared term of $IFI_{i,t}$, $Controls_{i,t}$, the control variables, and $\varepsilon_{i,t}$, is the error term.

4. Empirical analysis

4.1. Descriptive statistics

Table 1 shows the results of descriptive statistics, where the dependent variable is the systemic risk index *SRISK*, with a mean value of 0.045 and a standard deviation of 0.127. The results demonstrate that the data are non-normally distributed, and therefore, we perform the censored regression in the empirical analysis. Regression results show that the mean value and standard deviation of *IFI* are 0.272 and 0.219, respectively, indicating that financial inclusion remains at a low level across the globe.

4.2. Benchmark regression results

Due to the data truncation problem (*SRISK* of countries with no systemic risk is set to 0), the simple OLS regression may produce biased results. This paper draws on the research of Zhu et al. (2004) and Li et al. (2020) to use the Tobit model to run a regression and report two categories of regression results: two-way fixed effects OLS regression model (LSDV) and Tobit regression model (LSDV).[5] Regression results are presented in Table 2.[6]

As demonstrated in Table 2, the regression coefficient of IFI^2 is significantly positive, and that of *IFI* is significantly negative, which to a certain extent reveals the U-shaped relationship between financial inclusion and systemic risks. Since the systemic risk index and financial inclusion index in this paper are standardized, it is economically meaningless to merely analyze their regression coefficients. As a result, we turn to analyzing the unstandardized raw data to see its economic significance. Analysis results imply that every 0.01 unit of the systemic risk index represents USD 1114.078 billion. In other words, when the financial inclusion index takes the mean value (0.272) of countries/regions in the world, 0.01 units of change in the financial inclusion index means the change of the systemic risk index by USD 578 billion.[7] For direct comparison, from 2009 to 2012, the systemic risk of European countries/regions increased by USD 503 billion, resulting in plummeting sovereign bond prices of economies in the eurozone (Engle and Ruan, 2018). The systemic risk resulting from the change in the financial inclusion index by 0.01 units is approximately equivalent to a plunge in the sovereign bond prices of economies in the eurozone, which is quite significant.[8]

4.3. The moderating effect of macro-regulation

Capital adequacy ratio (*CAR*) is taken as the moderating variable to study its moderating effect. To this end, the following model is constructed:

[5] Due to truncation, it is impossible to know the exact distribution of the truncated data or determine the sufficient estimator of individual heterogeneity (u_i) by means of the difference or demean methods (Greene, 2004). Referring to current studies, Honoré (1992) used a pairwise trimming to estimate the panel Tobit model with fixed effects. This method makes it possible to obtain consistent estimators even in the case of individual heteroscedasticity. Moreover, this method only works for linear regression equations. However, our regression equation is nonlinear (the right side of the equation includes IFI^2), and there is still no ideal consistent and unbiased estimator for the panel Tobit model with fixed effects of the nonlinear equation. In addition, we also conduct regressions based on the random panel Tobit model. The likelihood ratio test results show that the value of chibar2 is 0.75, and the p value is 0.19, indicating that individual effects are not obvious.

[6] During the regressions, the exact matching yields 848 observations.

[7] Taking the OLS regression results as an example, these results are calculated in the following way: take *IFI* as x, *SRISK* as y, and other variables as constants, calculate the first-order derivative of x with respect to y, and we have $y' = 4.242x - 0.635$. Substitute $x = 0.272$ into the function to get $y' = 0.518824$. This means that when the financial inclusion index takes the mean value of all countries and regions in the world, the 1 unit change in the financial inclusion index will lead to 0.518824 units change in the systemic risk index. Since 0.01 unit of systemic risk index represents USD 1114.078 billion, 0.518824 units of systemic risk index represent USD 578.0104,043 billion, about USD 578 billion.

[8] The marginal influence of financial inclusion on systemic risk is depicted in Annex Fig. 1. Due to space limitations, it is not listed here and is available on the official website of *China Economic Quarterly* (https://ceq.ccer.pku.edu.cn).

Table 1
Summary statistics.

Symbol	Name	N	Mean	Std.	Min	Max	Source
Panel A : Dependent Variable							
SRISK	Systemic risk	1008	0.045	0.127	0.000	1.000	V-Lab
Panel B : Independent Variable							
IFI	Financial inclusion	2489	0.272	0.219	0.000	1.000	FAS
IFI^2	Squared IFI	2489	0.122	0.174	0.000	1.000	FAS
Panel C : Control variable							
CAR	Capital adequacy ratio	2864	0.075	0.049	0.000	1.000	BankScope
MP	Lerner Index	2112	0.277	0.088	0.000	1.000	World Bank
LR	Loan ratio	2944	0.120	0.182	0.000	1.000	BankScope
LLP	Loan Loss Provision	2944	0.043	0.027	0.000	1.000	BankScope
MQ	Management Quality	2944	0.791	0.139	0.000	1.000	BankScope
ID	Income Diversification	2944	0.008	0.061	0.000	1.000	BankScope
GDP_C	Per capita GDP	2976	0.110	0.159	0.000	1.000	World Bank

Table 2
Benchmark regression.

	(1) OLS (LSDV) SRISK	(2) Tobit (LSDV) SRISK
IFI	-0.635***	-0.717***
	(0.214)	(0.127)
IFI^2	2.121***	2.381***
	(0.428)	(0.180)
CAR	0.039	-0.033
	(0.050)	(0.090)
MP	-0.151***	-0.243***
	(0.056)	(0.068)
LR	0.005	-0.001
	(0.009)	(0.016)
LLP	-0.000	0.011
	(0.013)	(0.047)
MQ	-0.061**	-0.075**
	(0.028)	(0.035)
ID	-0.013	-0.073
	(0.214)	(0.189)
GDP_C	-0.178***	-0.224***
	(0.056)	(0.059)
Constant	0.192***	0.242***
	(0.047)	(0.051)
Year fixed effects	Yes	Yes
Country/region fixed effects	Yes	Yes
Observations	848	848
R2	0.837	—

Note: figures in parentheses are standard errors; ***, **, and * represent significance at 1%, 5%, and 10% levels, respectively (the same below).

$$SRISK_{i,t} = \alpha_0 + \alpha_1 IFI_{i,t} + \alpha_2 IFI_{i,t}^2 + \alpha_3 CAR_{i,t} + \sum Controls_{i,t} + \varepsilon_{i,t} \tag{3}$$

$$SRISK_{i,t} = \alpha_0 + \alpha_1 IFI_{i,t} + \alpha_2 IFI_{i,t}^2 + \alpha_3 CAR_{i,t} + \alpha_4 IFI_{i,t} * CAR_{i,t} + \sum Controls_{i,t} + \varepsilon_{i,t} \tag{4}$$

Table 3 reports the regression results, in which the regression coefficient of the interaction term is significantly positive at the 1% level. This indicates that in countries/regions with more developed financial inclusion (higher *IFI*) and stronger regulation and supervision (higher *CAR*), the *SRISK* is relatively small, suggesting that regulation and supervision can adjust the relationship between financial inclusion and systemic risks, and stronger regulation and supervision may mitigate the systemic risks attributable to the development of financial inclusion. Once the interaction term is included in the model, the coefficient of the financial inclusion index becomes smaller, indicating that regulation and supervision have moved the critical point where financial inclusion starts to pose systemic risks further to the right.

Furthermore, we draw the schematic diagram of the benchmark model and the moderating model of financial regulation (Fig. 1). The solid parabola describes the relationship between financial inclusion and systemic risks under strong regulation and supervision, and the solid vertical line points out the corresponding turning point. The dotted parabola illustrates the relationship between the two under weak regulation and supervision, and the dotted vertical line represents the corresponding turning point. As indicated by the figure, effective regulation and supervision play a role in two aspects. First, it moves the turning point of the U-shaped relationship

Table 3
Moderating effect: The role of financial regulation.

	(1) SRISK	(2) SRISK
IFI	-0.717***	-0.796***
	(0.127)	(0.128)
IFI^2	2.381***	2.234***
	(0.180)	(0.184)
CAR	-0.033	-0.849***
	(0.090)	(0.250)
*IFI*CAR*	—	2.947***
		(0.837)
MP	-0.243***	-0.272***
	(0.068)	(0.068)
LR	-0.001	-0.003
	(0.016)	(0.016)
LLP	0.011	0.002
	(0.047)	(0.046)
MQ	-0.075**	-0.070**
	(0.035)	(0.035)
ID	-0.073	-0.145
	(0.189)	(0.189)
GDP_C	-0.224***	-0.227***
	(0.059)	(0.058)
Constant	0.242***	0.291***
	(0.051)	(0.052)
Year fixed effects	Yes	Yes
Country/region fixed effects	Yes	Yes
Observations	848	848

further to the right to delay the negative impact of financial inclusion on systemic risks. Second, it abates systemic risks. With the same financial inclusion level, compared with weak regulation and supervision, stronger regulation and supervision means fewer systemic risks. However, it should be noted that stronger regulation and supervision do not lead to a significant reduction in systemic risks, given the low level of financial inclusion.

5. Robustness test

5.1. Instrumental variables

We introduce instrumental variables to resolve potential endogenous problems. Referring to the study by Yi and Zhou (2018), we select the product of $IFI_{j,t-1}$ and $\Delta IFI_{t,t-1}$ as the instrumental variable for the following reasons. First, the financial inclusion index constructed in this paper is based on the global data from 115 countries/regions. The systemic risk of a country/region is unlikely to influence the global measurement. Consequently, changes in the financial inclusion index are more likely exogenous. Second, although factors at the country/region level other than financial inclusion may also bias the regression coefficients, as long as these factors do not simultaneously affect all 115 countries/regions, the estimates remain valid. In addition, based on the study by Ahameda and Mallick (2019), we also introduce the religious composition index proposed by Houston et al. (2010) as the second instrumental variable for the robustness test.

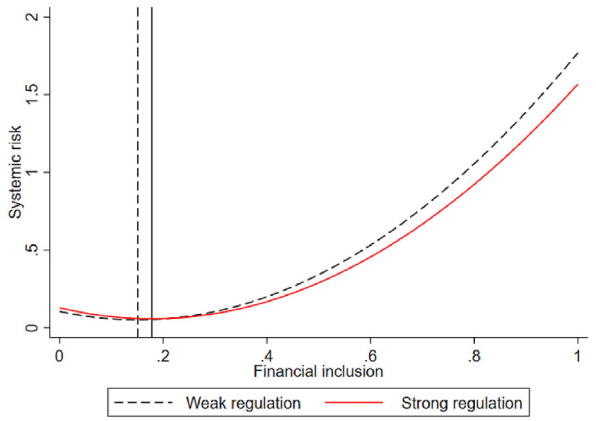

Fig. 1. The moderating effects of financial regulation.

Table 4 reports the regression results. The Wald test results show that the *p* value is 0.0005, rejecting the null hypothesis of exogeneity at the 1% confidence level and demonstrating the existence of instrumental variables. In addition, Sargan test are used to test over-identification, and the *p* value is 0.9580, suggesting no over-identification. The coefficients of the instrumental variable in the first stage are significantly different than 0. We perform a two-stage regression to the equation, and the *F* values in the first-stage regression are 48.13 and 31.25, respectively, indicating there are no weak instrumental variables. The estimation results show that the U-shaped relationship between financial inclusion and systemic risks remains significant after considering endogenous problems.

5.2. Introduction of a new financial inclusion index

Following Sha'ban et al. (2020), we construct the financial inclusion index with a new set of indicators, including the number of deposit accounts, the number of loan accounts, the number of financial institution outlets, the number of ATMs, the total deposits as a percentage of GDP, and the total loans as a percentage of GDP. Then, PCA is used again to construct a new financial inclusion index (*IFInew*).[9]

Then, we substitute *IFInew* into the original model and perform regression again. The regression results are shown in Table 5. As demonstrated in Table 5, the coefficients of $IFInew^2$ are significantly positive in all regressions, demonstrating the robustness of the regression results in this paper.

5.3. Introduction of a new SRISK

We carry out the robustness test with the average *SRISK* weighted by the asset size and market value of financial institutions in all countries/regions (*SRISKnew*) proposed by Engle and Ruan (2019). The regression results are shown in Table 6. The regression coefficients of *IFI* remain significantly negative, and those of IFI^2 remain significantly positive, implying that the results of this paper are robust.

6. Impact and forecast of the financial crisis

6.1. Impact of the 2008 financial crisis

To allow for the potential impact of the 2008 financial crisis, we divide all samples into two groups, and the corresponding regression results are listed in Table 7. Before the 2008 financial crisis, the regression coefficients of *IFI* are not significant, and the regression coefficient of IFI^2 is only significantly positive in Column (1); after the 2008 financial crisis, the regression coefficients of *IFI* are all

Table 4
Robustness: Instrumental variables.

(1) First-stage IFI		(2) First-stage IFI^2		(3) Second-stage SRISK	
z1	-7.742**	$z1^2$	3.171*	*IFI*	-1.706***
	(3.202)		(1.892)		(0.545)
z2	0.233**	$z2^2$	13.286***	IFI^2	4.303*** (1.131)
	(0.094)		(5.135)		
CAR	0.223*	*CAR*	0.001	*CAR*	0.129
	(0.130)		(0.091)		(0.220)
MP	0.200***	*MP*	0.251***	*MP*	-0.899***
	(0.045)		(0.031)		(0.194)
LR	-0.037 **	*LR*	0.049***	*LR*	0.117***
	(0.019)		(0.013)		(0.044)
LLP	-0.092	*LLP*	0.086	*LLP*	0.223*
	(0.083)		(0.059)		(0.131)
MQ	0.062	*MQ*	0.038	*MQ*	-0.052
	(0.043)		(0.030)		(0.064)
ID	1.793***	*ID*	1.092***	*ID*	0.978*
	(0.263)		(0.185)		(0.541)
GDP_C	0.143***	*GDP_C*	0.079***	*GDP_C*	0.019
	(0.025)		(0.017)		(0.046)
Constant	0.515	Constant	0.171	Constant	0.326*** (0.103)
	(0.523)		(0.367)		
Observations	848	Observations	848	Observations	848

[9] The list of indicators of *IFInew* is presented in Annex Table 5. Due to space limitations, it is not listed here and is available on the official website of *China Economic Quarterly* (https://ceg.ccer.pku.edu.cn).

Table 5
Robustness: Alternative financial inclusion measurement.

	(1) OLS (LSDV) SRISK	(2) Tobit (LSDV) SRISK
IFInew	-0.475***	-0.590***
	(0.096)	(0.116)
$IFInew^2$	0.617***	0.834***
	(0.120)	(0.126)
CAR	-0.053	-0.085
	(0.056)	(0.084)
MP	-0.105**	-0.139**
	(0.044)	(0.061)
LR	-0.007	-0.009
	(0.008)	(0.016)
LLP	0.011	0.030
	(0.012)	(0.046)
MQ	-0.007	-0.043
	(0.018)	(0.028)
ID	-0.218	-0.317
	(0.239)	(0.201)
GDP_C	-0.092**	-0.147**
	(0.040)	(0.057)
Constant	0.135***	0.183
	(0.042)	(0.047)
Year fixed effects	Yes	Yes
Country/region fixed effects	Yes	Yes
Observations	937	937
R^2	0.8614	—

Table 6
Robustness: Alternative *SRISK* measurement.

	(1) OLS (LSDV) SRISKnew	(2) Tobit (LSDV) SRISKnew
IFI	-5.298***	-7.401***
	(1.239)	(2.651)
IFI^2	6.240***	8.942**
	(1.285)	(3.757)
CAR	-2.154**	-2.682
	(1.031)	(1.931)
MP	-2.195*	-4.445***
	(1.167)	(1.448)
LR	-0.318**	-0.377
	(0.140)	(0.342)
LLP	-0.279	-0.095
	(0.655)	(0.997)
MQ	-0.366	-0.648
	(0.294)	(0.765)
ID	-6.542***	-7.557*
	(2.037)	(4.055)
GDP_C	-1.558***	-2.918**
	(0.551)	(1.263)
Constant	2.332***	3.611***
	(0.677)	(1.088)
Year fixed effects	Yes	Yes
Country/region fixed effects	Yes	Yes
Observations	848	848
R^2	0.502	—

significantly negative, and those of IFI^2 are all significantly positive. These results imply that the U-shaped relationship between financial inclusion and systemic risks is more obvious after 2008. One possible explanation is that before the financial crisis, financial inclusion was developing at a slow pace. However, after the financial crisis, "bad inclusive finance", in the name of financial technology and financial innovation start to emerge. Given the inadequate regulation, risk started to accumulate, resulting in a more conspicuous inverted U-shaped relationship between financial inclusion and financial stability.

Table 7
Further analysis: The impact of the financial crisis.

	Before 2008		After 2008	
	(1) OLS (LSDV) *SRISK*	(2) Tobit (LSDV) *SRISK*	(3) OLS (LSDV) *SRISK*	(4) Tobit (LSDV) *SRISK*
IFI	-0.060	-0.078	-0.245*	-0.536***
	(0.061)	(0.103)	(0.132)	(0.122)
IFI^2	0.269***	0.235	1.116***	2.037***
	(0.101)	(0.177)	(0.186)	(0.159)
CAR	-0.008	0.013	0.050	0.028
	(0.016)	(0.034)	(0.049)	(0.082)
MP	-0.035	-0.047	-0.044	0.001
	(0.041)	(0.034)	(0.064)	(0.073)
LR	0.003	-0.017	0.006	0.007
	(0.006)	(0.015)	(0.012)	(0.014)
LLP	0.212	-0.231	0.004	0.022
	(0.218)	(0.270)	(0.022)	(0.051)
MQ	-0.042	-0.137***	-0.083**	-0.097***
	(0.026)	(0.025)	(0.036)	(0.033)
ID	-0.794	-0.635*	-0.564**	-0.516***
	(0.660)	(0.359)	(0.232)	(0.151)
GDP_C	0.087*	0.157***	-0.072	-0.080
	(0.049)	(0.051)	(0.061)	(0.055)
Constant	0.023	0.097**	0.140***	0.101*
	(0.043)	(0.043)	(0.048)	(0.053)
Year fixed effects	Yes	Yes	Yes	Yes
Country/region fixed effects	Yes	Yes	Yes	Yes
Observations	212	212	583	583
R^2	0.963	—	0.949	—

6.2. Forecast of a financial crisis

Following Büyükkarabacak and Valev (2010), we perform an additional test with real financial crisis data collected from the World Bank Banking Crisis Dummy Database. The baseline regression results show that the turning point of the inverted U-shaped curve is about 0.15, and the mean value of *SRISK* on the left side of the turning point is 0.0028, which is too small to trigger a financial crisis (Zhang, 2010). In contrast, the mean value of *SRISK* on the right side of the turning point is 0.0562, which is larger. The value of *SRISK* is highly likely to exceed the mean value and stand on the right side of the turning point before the financial crisis. Therefore, referring to the study by Liu et al. (2019), we establish a linear regression model to the right side of the turning point of the original inverted U-shaped curve and use the Probit model and Logit model for robustness tests. The test results are shown in Table 8. The regression coefficients of *IFI* in the Probit model and the Logit model are 2.586 and 5.173, respectively, which are significantly positive, suggesting that the development of financial inclusion is quite effective in predicting a financial crisis.

7. Conclusions and suggestions

Based on the original data collected from the FAS from 2004 to 2019, we first construct the financial inclusion index of 115 countries/regions using PCA. Second, Tobit model and OLS model are employed to explore the relationship between financial inclusion and financial stability. The empirical results show that there is an inverted U-shaped relationship between financial inclusion and financial stability. Third, effective macro-regulation can mitigate the systemic risks that come with the development of financial inclusion, and the inverted U-shaped relationship between financial inclusion and financial stability has become more pronounced after the 2008 financial crisis. Finally, the Probit model and the Logit model are utilized to test whether a financial crisis will occur, and the test results demonstrate the effectiveness of the two models.

According to the research results, we propose the following policy suggestions.

First, we should formulate guiding policies to develop financial inclusion. It is important to roll out policies to encourage formal financial institutions to provide more support for farmers and small and micro enterprises and improve the availability and coverage of financial services. It is necessary to diversify the capital market by adjusting the market access threshold and expanding and strengthening the presence of financial inclusion. Moreover, it is also of vital significance to optimize the market-based pricing mechanism of interest rates and encourage financial institutions to develop a more flexible and independent interest rate system according to their own financial conditions and business objectives. In addition, it is necessary to actively encourage financial institutions to improve their risk management models, cultivate risk management culture, make more efforts to establish and optimize relevant audit and control mechanisms, formulate feasible evaluation of risk control systems, and intensify internal control process supervision and information disclosure.

Second, we should pay more attention to fintech and promote market self-regulation. It is of vital significance to coordinate financial inclusion with fintech and improve the access of residents in rural areas and remote areas and small and micro enterprises among other

Table 8
Further analysis: Financial crisis forecasting.

	(1) Probit CRISIS	(2) Logit CRISIS
IFI	2.586***	5.173***
	(0.510)	(1.364)
CAR	-0.444	-2.453
	(2.905)	(6.046)
MP	-4.639***	-8.034***
	(0.782)	(1.547)
LR	0.586*	0.760
	(0.326)	(0.776)
LLP	6.494	27.534
	(3.968)	(27.601)
MQ	5.537***	11.618***
	(1.831)	(3.473)
ID	-17.186**	-30.720*
	(8.265)	(17.246)
GDP_C	0.692*	1.612
	(0.409)	(1.097)
Constant	-6.187***	-13.465***
	(1.703)	(3.977)
Observations	742	742
Pseudo R^2	0.2464	0.2573

groups to new types of financial services such as Internet payment, Internet credit, and Internet insurance. Modern technology should be used to simplify the loan application process, optimize the loan approval process, and improve post-loan management, so that qualified individuals and enterprises can obtain credit funds more conveniently. Besides, an industry self-regulation mechanism should be established among financial institutions, where industry associations play a critical role in institutional training, financial education, and market regulation and form a complete regulatory system together with external regulators.

Third, we should carry out financial education and optimize the supervision mechanism. Financial literacy education should be included in national educational programs at all levels, and efforts should be made to explore financial education methods with local characteristics according to local conditions. Specifically, family-based financial education, online financial education, and community-based financial education should be carried out to improve national financial literacy. Furthermore, an overall regulatory framework for financial inclusion should be developed based on the status quo and characteristics of financial inclusion. It is necessary to clarify the principal regulator of financial inclusion and establish a joint meeting system for financial regulation coordination at all levels, as well as to eliminate the obstacles to coordination and information sharing, implement supervision, conduct collective financial regulation, and give full play to the role of "good finance" in propelling social development.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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