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Article

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Changes in rural financial exclusion's supply and demand factors from the perspective of digital inclusive financial policies

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ABSTRACT

This paper employs a Regression Discontinuity Design (RDD) methodology, utilizing data from the Chinese Household Finance Survey (CHFS), China Rural Statistical Yearbook, China Financial Yearbook, and China Statistical Yearbook. The analysis scrutinizes rural financial exclusion from dual vantage points: the demand and supply sides, with households and provinces serving as fundamental analytical units. Employing years as threshold values, we establish 27 supply-side factors and 18 demand-side factors through RDD models. This analytical framework facilitates an assessment of the existence of breakpoint effects across diverse dimensions of financial exclusion in distinct years and fosters a discourse on rural financial exclusion and its structural dynamics within the context of China's Digital Inclusive Finance policies. The findings of this study are as follows: (1) Supply-side determinants of rural financial exclusion in China have exhibited negligible change over the past decade, with Digital Inclusive Finance policies exerting limited influence. (2) Conversely, demand-side factors have exhibited some degree of variability, characterized by substantial reductions in channel exclusion and financial risk exclusion in 2013 and 2015. Digital Inclusive Finance policies have manifested a favorable impact on the demand side of rural financial exclusion. (3) In 2017, both financial knowledge exclusion and channel exclusion on the demand side of rural financial exclusion witnessed rebounded. Shifts in the orientation of Digital Inclusive Finance policies may precipitate a deterioration in the policy-dependent rural financial landscape, jeopardizing the preservation of their initial positive effects.

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1. Introduction

In the early 1990s, research on financial exclusion was introduced to geography by Leyshon and Thrift (1993). It studied the correlation between the actual distance from residents' homes to financial institutions and their ability to access financial services. However, the causes of financial exclusion are not limited to geographic factors. In essence, it involves the influence of common characteristics on a group of people who have a real need for financial services, but often become marginalized due to low income and little wealth, making it difficult or impossible for them to obtain financial services (Solo, 2008). This group is precisely the vulnerable population that requires attention. Due to their lack of credit and high risk, they cannot receive equal treatment in terms of economic opportunities. Rural areas are where these households that have never used financial products are concentrated, including the low-income, socially disadvantaged, uneducated, unemployed, and elderly recipients of pensions (Beck et al., 2007). In China, as of the end of 2008, there were 11,885 townships characterized by a severe deficiency in financial services, where institutions with one or fewer branches were prevalent. These townships constituted 39% of the total township count across the nation. The proportion of rural households that had access to loans amounted to merely 28% of the overall rural household population (Xiuhua, 2009). Furthermore, in line with statistics derived from the China Household Finance Survey, the participation

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rate in the rural household risk financial market was a mere 1.12% in 2013, a figure that rose to 3.07% by 2017. However, this remained significantly lower than one-tenth of urban households. They are most susceptible to financial exclusion, which is caused by various factors such as poor banking infrastructure in rural areas, unequal access to educational institutions, low levels of internet access, and the attitudes of rural communities towards money and financial institutions (Horská et al., 2013). If rural revitalization is to be achieved and effective allocation of resources realized, eliminating financial exclusion in rural areas is an essential step.

One of the most important poverty alleviation policies is to increase access to funding (Bruhn & Love, 2014). However, financial institutions still face significant challenges in expanding services to 'marginalized groups' in rural areas (Braverman & Guasch, 1986). There are various financial institutions in rural China, including rural commercial banks, agricultural banks, village banks, postal savings banks, and credit companies (Wang & He, 2019). But due to fundamental problems such as high transaction costs, information asymmetry, and shortage of collateral (He et al., 2018), farmers are unable to access services from traditional banking sectors, and therefore people have placed great hope on financial digital innovation. The goal of Digital Financial Inclusion (DFI) is to provide affordable digital financial services to all individuals and institutions, regardless of their net costs, institution size, and geographic location, with the aim of addressing rural financial exclusion. The products and services of DFI need to leverage financial technology, such as mobile currency and payment systems (Ozili, 2018). Financial technology broadly encompasses financial innovations supported by digital technology, and in recent years, it has achieved remarkable growth in emerging and developing economies (Gopalan & Rajan, 2021). According to the 2020 Rural Financial Services Operation Report by the People's Bank of China, as of the end of 2020, the impact of digital finance on rural areas had witnessed a significant and sustained rapid expansion. This development has offered substantial support for both rural revitalization and the modernization of agriculture and rural regions. Among the 70 projects encompassed within the regulatory pilot program for financial technology innovation, 45 of them were oriented towards inclusive finance, constituting 64% of the total. Within this category of innovative pilot projects in inclusive finance, 47% incorporated three or more digital technologies, with a primary emphasis on applications such as financing for small and medium-sized enterprises, agricultural loans, and flexible wage disbursements for laborers. Five of these projects were specifically dedicated to rural financial services, harnessing digital technologies to facilitate the integration of agricultural production and enhance the security of rural household data. These initiatives were centered on crucial domains such as agricultural credit, mobile banking, and risk management, with the overarching goal of delivering precise financial services to the rural population. Since the global financial crisis, policy measures aimed at 'financial inclusion' have accelerated. The 2008 World Bank Annual Report, entitled 'Finance for All', emphasized that financial institutions should focus on the early development paradigm of 'inclusive markets' (Mendoza & Thelen, 2008). In China, since the establishment of Alipay in 2004, its level of digital financial development has quickly grown to become a world leader in just over a decade, making it a leading player in the field. In 2015, the State Council issued a notice on the promotion of the development of inclusive finance (2016–2020), and when China served as the leader of the G20, the G20 Financial Inclusion Global Partnership (GPGI) formulated a set of High-Level Principles (HLPs) for Digital Financial Inclusion to encourage governments to use digital technology to promote inclusive finance.

The research on financial exclusion primarily centers on refining its self-defined conceptual framework to evaluate disparities between individuals excluded from the financial system and those who are not (Fernández-Olit et al., 2020). A central debate within this domain pertains to the accessibility of financial products and services (Kear, 2013). Digital technology assumes a pivotal role in shaping financial accessibility in rural areas, harnessing digital innovations to streamline processes, reduce operational costs, and extend financial services to marginalized regions, thereby advancing the overarching goal of inclusivity (Mapanje et al., 2023). The driving impetus behind our research lies in the endeavor to explore and deliberate upon shifts in the supply and demand dynamics of rural financial exclusion, contextualized within the framework of pertinent policy implementation in this research domain. Existing studies that delve into digital financial policies predominantly concentrate on macroeconomic theories, institutional deliberations, and their implications for enhancing productivity, entrepreneurship, and other economic utilities (Nguimkeu & Okou, 2021; Ji et al., 2021). Regrettably, there exists a noticeable dearth of

discourse concerning the mitigation strategies for rural financial exclusion, especially with regards to assessing whether improvements have transpired in this realm under the purview of digital inclusive financial policies. Questions pertaining to which dimensions have exhibited improvements and to what extent have remained largely unanswered. We, therefore, endeavor to supplement this knowledge gap. The potential incremental contributions of this study are threefold: firstly, an in-depth exploration of structural transformations in the supply and demand factors influencing rural financial exclusion in China over the past decade, contextualized within the backdrop of digital inclusive financial policies; secondly, the application of regression discontinuity design to quantify changes in the degree of exclusion across various dimensions and a comprehensive exploration of the underlying causal factors; and finally, the formulation of policy recommendations tailored to address different facets of financial exclusion.

2. Literature review

The issue of financial exclusion has received increasing attention in recent times. Its concept originally emerged from the field of social exclusion. In a broader context, financial exclusion can be defined as the condition wherein equitable and transparent financial services are not accessible to everyone, leading to the exclusion of certain individuals from these services (Solo, 2008). Fuller and Mellor (2008) emphasize that financial exclusion signifies the inability of marginalized groups to access dependable and affordable financial services geared towards promoting their well-being. As a concept continually evolving and maturing, financial exclusion is characterized by a range of impediments and barriers that hinder specific individuals from utilizing financial services (Cnaan et al., 2012). Initially, financial exclusion was analyzed from a financial geography perspective. It is estimated that 31% of the global population lacks access to their own bank account, and a lower percentage can obtain secure credit or savings tools (Demirguc-Kunt et al., 2018). The presence of financial exclusion is determined by observing whether there is a sufficient number of financial institutions within a certain distance and whether relevant groups can use payment transfers, non-cash transactions, and whether they are subject to certain conditions in transactions. This method is still not comprehensive enough and does not provide an explanation for the causes of financial exclusion. Domestic and international scholars have attempted to explain financial exclusion from the supply-side and demand-side factors respectively. Regarding the supply-side factors, Kempson and Whyley (1999) first proposed constructing a comprehensive index from multiple dimensions such as geographic exclusion, assessment criteria exclusion, conditional restriction exclusion, price capability exclusion, and marketing object exclusion to analyze financial exclusion. Samsø Fibæk (2021) believes that the essence of financial exclusion is a spatial planning problem, which is particularly prominent in rural areas where it is difficult to obtain such services. Residents must travel several kilometers to access these services (Náñez Alonso et al., 2022). Moreover, the institutional framework in specific regions can exert a significant influence on financial exclusion. For example, during the process of liberalizing China's banking sector, the transformation from entirely state-owned commercial banks to a mixed ownership structure encompassing both public and private ownership has blurred the demarcation between public and private assets. Consequently, it becomes imperative to consider the influence of non-market economic institutional path dependency (Maity, 2023). In India, the National Bank for Agriculture and Rural Development (NABARD) introduced the Self-Help Group-Bank Linkage Program (SHG-BLP) as a pilot initiative in 1992. Through microfinance services, this program has effectively mitigated social exclusion among marginalized rural communities in the central Assam region and has ensured their financial inclusion. From the demand-side factors, some groups may also experience financial exclusion due to a lack of financial knowledge or access to information (He et al., 2017). Taking Poland, a member state of the European Union, as an example, the knowledge and financial skills of rural residents play a critical role in limiting the phenomenon of financial exclusion (Horská et al., 2013). Research conducted in South Africa has revealed noteworthy correlations between financial exclusion and factors including educational achievement, primary income source, age, household language, and family size (Wentzel et al., 2016). Additionally, Huang and Zhang (2020) found that the speed of financial network expansion may be linked to educational differences between urban and rural areas. The above cases of financial market exclusion are typically caused by differences in the socioeconomic characteristics of individuals or groups most commonly associated with social exclusion variables

(Fernández-Olit et al., 2018; Harper et al., 2018). Therefore, as rural areas are characterized by relatively poor economic conditions and a large population, their financial exclusion issues are worthy of research and attention.

Financial exclusion and inclusive finance represent different perspectives on the same issue. Inclusive finance is a response to the problem of financial exclusion. Marron (2013) delved into the significance of the inclusive finance concept that emerged in 1990s Britain. He contended that this term obscured the underpinnings of neoliberalism, compelling individuals to shoulder responsibility as if they were market participants. In his perspective, inclusive finance represents not a political or moral quandary, but rather a technical challenge demanding resolution. Presently, the favorable influence of digital finance on inclusive finance has captured extensive attention from both policymakers and the academic community. Digital finance has been widely recognized by policymakers and academics for its positive impact on inclusive finance. This promising tool employs software, applications, and digital platforms to provide financial services to consumers and businesses via digital devices such as smartphones (Morgan, 2022). Digital inclusive finance has the potential to foster sustainable economic growth by guaranteeing access to digital financial services for all. In a systematic literature review conducted by Tay et al. (2022), the state of digital financial inclusion in various countries was thoroughly examined. The study revealed that developing nations, particularly those in Asia, are dedicated to improving digital financial inclusion as a means to mitigate poverty. Digital finance and inclusive finance offer several benefits to users of financial services, digital financial service providers, governments, and the economy. These benefits include increasing the opportunity for poor people to access financing, reducing the financial intermediation costs of banks and financial technology providers, and increasing total government expenditure. Brazil has employed branchless banking based on information and communication technology (ICT) to provide financial services to millions of poor Brazilians (Diniz et al., 2012). Zhang et al. (2022) demonstrated that mobile payments can promote the consumption of rural households in China by improving financial inclusion, thereby driving rural economic development. Some scholars have studied the causes of digital inclusive finance. Industrial economy and government intervention are the common determining factors for the development of digital finance inclusiveness. Industrial upgrading and indirect finance play an intermediate role in the determinants of digital finance inclusiveness, and there is a threshold effect between financial development and digital finance inclusion (Liu et al., 2021). These factors have led to continuing differences in the access and use of digital financial services among different genders, the rich and the poor, and urban and rural areas. To address these issues, Kass-Hanna et al. (2022) proposed some revision recommendations, emphasizing the importance of improving digital infrastructure, simplifying complex bank procedures, and highlighting the importance of financial education, as both financial literacy and digital literacy are key factors for establishing inclusiveness and financial resilience. Despite the various benefits of digital inclusive finance, it has not yet fully penetrated the population (G20 Summit, 2013), indicating significant disparities among different populations in terms of accessibility, availability, and usability of digital inclusive finance. Therefore, as the population with the lowest inclusive accessibility, rural areas have attracted much attention.

With the expansion and implementation of digital inclusive finance in rural areas, extensive research has been conducted to investigate the intricate relationship between digital inclusive finance and rural financial exclusion. Digital financial services, serving as a platform, present significant opportunities for accessing funds across various domains. Nevertheless, their adoption remains limited in rural regions. Common obstacles to the adoption of mobile money in these areas encompass, but are not confined to, illiteracy, a restricted understanding of mobile money, and notably low levels of trust, particularly in areas with deficient infrastructure. Another formidable challenge lies in the marked disparity between rural and urban residents, impeding their capacity to reap the benefits of these services (Agwu, 2021). Current research can be roughly divided into two categories. One is the study of the alleviating effect of digital inclusive finance on rural finance exclusion through different channels. Chen and Zhao (2021) found that digital inclusive finance significantly reduced absolute and relative poverty among Chinese rural households by alleviating credit and information constraints, expanding social networks, and promoting entrepreneurial spirit. It also reduces exclusion and promotes economic development by increasing farmers' willingness to adopt agricultural technologies (WTAAT) (Zhou et al., 2022). Unlike failed attempts by traditional physical financial institutions to expand financial coverage in rural areas,

digital inclusive finance is similar to the agricultural supply chain system. They are closer to considering the potential benefits and risks of rural development and livelihoods (Kong & Loubere, 2021). The second type is the shortcomings and weaknesses of digital inclusive finance in alleviating rural finance exclusion. Although digital inclusive finance helps to narrow the income gap between urban and rural areas, path dependence may still lead to spatial clustering of digital inclusive finance development, resulting in limited impact on rural areas (Li et al., 2022). Its impact capacity is also related to human capital, social capital, bank branch penetration rate, and infrastructure such as broadband (Niu et al., 2022). Rural areas have poor infrastructure, and Shala and Grajcevci (2018) research found that in economically difficult areas, rural residents have lower digital literacy, while urban residents with higher socioeconomic status have the highest digital literacy, so the role of digital inclusive finance will be greatly weakened in rural areas. Salemin et al. (2017), following a comprehensive review of 157 scholarly papers on digital development and rural development, likewise discovered that barriers to technology diffusion and the lower levels of education and skills in rural areas had adverse effects on the adoption and utilization of digital finance. Moreover, an enduring disparity in data infrastructure quality between urban and rural areas was observed. In addition, digital financial policies also ignore specific local rural needs. In terms of technology access, the lower average education and skill level in rural areas have a negative impact on the adoption and use of digital inclusive finance, and policies should focus more on the problem of digital technology connectivity in rural areas (Salemin et al., 2017).

In terms of research methodology, while some prior studies have employed policies as instrumental variables in regression analysis (Fang et al., 2012; La, 2014), it has become apparent that over time, the efficacy of policy-related variables may gradually wane, potentially leading to increased effects of other policies (Gao and Smyth, 2015; Kuo and Shiu, 2016). Moreover, when using instrumental variables, few studies have adequately addressed sample selection issues. Notably, the implementation of policies gives rise to Local Average Treatment Effects (LATE), and the direct utilization of policy variables for Instrumental Variable (IV) estimation can significantly introduce bias into regression outcomes (Duflo, 2001). There are also analogous studies that have utilized Structural Equation Modeling (SEM) to investigate how the organizational culture of innovation influences firm performance post-resource planning (Ashraf & Ali, 2022). However, SEM operates on the scale level, reducing multiple variables into a single principal component through factor analysis before conducting path analysis. In contrast, this study necessitates a precise computation of Local Average Treatment Effects at breakpoints. Furthermore, in comparison to alternative causal analysis methods, the academic community widely perceives breakpoint regression designs as being akin to quasi-natural experiments, producing more precise results. Consequently, in recent years, an escalating number of empirical studies have leaned on breakpoint regression designs for evaluating policy impacts. For instance, Bell et al. (2022) employed regression discontinuity design to scrutinize the repercussions of a series of compulsory school-age reforms at the state level in the United States spanning from 1980 to 2010 on crime rates. Similarly, Akhtari et al. (2022) employed this approach to investigate how political turnovers in mayoral elections affect the provision of local government public services. Hence, within the context of assessing structural changes in the supply and demand factors of rural financial exclusion in China against the backdrop of China's digital inclusive financial policy, this study leverages the timing of national policy implementation as a discernible threshold. This threshold aptly exemplifies the utilization of breakpoint regression for several reasons. Firstly, it offers remarkable clarity as only time periods exceeding this threshold fall within the purview of the specific digital inclusive financial policy's occurrence and existence. Secondly, groups meeting the policy criteria receive more substantial resource support. Consequently, this paper is focused on modeling the dynamic effects of breakpoints and employs breakpoint search methods to investigate alterations in the exclusion structure within the framework of this policy context.

In summary, there have been few discussions on the effectiveness of China's digital inclusive finance policies. Current research primarily encompasses two main avenues of inquiry. The first entails an overview of policies and their efficacy through the application of macro-level agenda-setting methodologies. The second avenue involves micro-level analysis, wherein specific (local) projects and approaches aimed at fostering development in underserved regions are evaluated. Since the issuance of digital inclusive finance policies in 2013, China has witnessed a rapid expansion of non-bank digital payments,

internet-based lending, crowdfunding, and virtual currencies, among other non-traditional internet financial services. Nevertheless, this growth has also engendered unprecedented turmoil within the internet financial sector, giving rise to profound societal issues. In response, China introduced a new suite of policies in 2015, signaling a substantial shift in the conceptualization and execution of inclusive finance. Cheng (2020) conducted an analysis and provided recommendations for these novel policies, guided by the perspectives of Douglass North's knowledge availability, people's comprehension and adaptability, and the principle of minimal disruption. Liang and Li (2021) used a double difference model to test the effectiveness of inclusive finance policy in improving the poverty situation in rural areas by increasing rural household income and promoting entrepreneurial behavior. The 'Broadband China' strategy has also successfully narrowed the urban-rural income gap in central and southern large cities by building network infrastructure. However, this has not significantly affected the urban-rural gap in other areas (Chen et al., 2022). Zhang et al. (2022) used the PSM-DID model to study the smart city pilot policy from 2012 to 2014 and found that the policy did not affect the current urban-rural income gap but could reduce the gap in the second and third years by improving the future level of digital inclusive finance. It is clear that research on whether and how digital inclusive finance policies improve rural financial exclusion is still lacking. This paper attempts to contribute to this aspect by searching for breakpoints in a total of seven dimensions of rural financial exclusion supply-side and demand-side factors using time as the driving variable. The findings suggest that (1) there is no significant structural change in supply-side factors of rural financial exclusion in the past decade, indicating that digital inclusive finance policies have not been effective in improving the situation; (2) there has been significant structural changes in demand-side factors of rural financial exclusion in recent years, with a significant decline in channel exclusion and financial risk exclusion after the promulgation of digital inclusive finance policies in 2013 and 2015; and (3) both channel exclusion and financial exclusion rebounded in 2017, indicating that the policy is not sustainable and further regulation and maintenance are needed.

3. Research design

3.1. Data sources and variable selection

The data for this study were obtained from the China Household Finance Survey (CHFS) baseline survey in 2011, as well as the follow-up surveys in 2013, 2015, and 2019, and other sources including the China Rural Statistical Yearbook, China Financial Yearbook, and China Statistical Yearbook. Only the latest data from the 2019 survey were used for data cleaning, and even for the respondents who participated in previous surveys, their answers from the previous survey were only used as a reference for correction and were not included in the sample data.

Based on this, the explanatory variable in this study is the government's release of signals supporting the development of inclusive finance. Specifically, we use the year 2013 when the Third Plenum of the 18th CPC Central Committee proposed the development of inclusive finance, defining it as a financial system that can effectively and comprehensively serve all social classes and groups. We also use the year when 'Internet finance' was first introduced in the government's work report, as well as the year 2015 when the State Council issued a notice on promoting the development of inclusive finance from 2016 to 2020 and subsequently formulated the high-level principles of digital financial inclusion. These two years serve as the core explanatory variables.

The explanatory variable in this article is the supply and demand factors of rural financial exclusion, which encompasses seven dimensions. Following Kempson and Whyley's method of quantifying the supply factors of rural financial exclusion and taking into account Deng Xufeng and Qiu Junjie's research (Deng & Qiu, 2013), the exclusion of prices that have little impact on the study of rural financial exclusion was omitted. Additionally, following the studies of Yao et al. (2020) and Hu et al. (2012), the conditions for measuring similarity were combined with the evaluation of exclusion. As a result, the supply factors of rural financial exclusion were divided into three categories: geographic exclusion, condition evaluation exclusion, and marketing exclusion. On the other hand, the demand factors of rural financial exclusion was categorized into four areas based on the studies of Su and Fang (2016) and Ge et al. (2021).

Table 1. Dimensional system for measuring the degree of financial exclusion.

Supply and Demand Factors	Dimension	Explanation	Nature
Supply-Side Factors	Geographical Exclusion	Rural Financial Institution Coverage Rate: The total number of rural financial institution branches divided by the total rural population (number of branches/ 10,000 people)	–
	Conditional Exclusion Average per capita loan level	The total rural loans divided by the total rural population	–
	Marketing Exclusion	Number of bank financial institution employees per 10,000 people	–
Demand- Side Factors	Self-Exclusion Average education level	Primary school *6 + Junior high school *9 + Senior high school and technical school *12 + College and above *15	–
	Financial Risk Exclusion	Respondents' risk preference ^(a) : Assigned a value from 1 to 5, with higher values indicating a lower willingness to take risks	+
	Financial Knowledge Exclusion	Respondents' degree of attention to the economy and finance ^(b) : Assigned a value from 1 to 5, with higher values indicating a lower degree of attention	+
	Channel Exclusion	Purchase channel for financial management products ^(c) : Not purchasing = 0, purchasing through one channel = 1, and so on	–

'+' indicates a positive indicator, and '–' indicates a negative indicator.

^aThe questionnaire question is: 'If you have a sum of money to invest, which type of investment would you prefer?' The options are: '1. High-risk, high-return projects,' '2. Slightly higher risk, slightly higher return projects,' '3. Projects with average risk and average return,' '4. Slightly lower risk, slightly lower return projects,' and '5. Not willing to take any risks.'

^bThe questionnaire question is: 'How much attention do you usually pay to economic and financial information?' The options are: '1. Very interested,' '2. Interested,' '3. Average,' '4. Rarely interested,' and '5. Never interested.'

^cThe questionnaire question is: 'What channels do you use to purchase financial products?' The options are: 'Physical branches of banks and other institutions,' 'Bank and other institution websites or mobile apps,' and 'Third-party platforms such as Alipay and WeChat.'

These areas include self-exclusion, financial risk exclusion, financial knowledge exclusion, and channel exclusion. Further details can be found in Table 1.

Based on related literature (Ge & Chen, 2022; Su and Fang, 2016; Zou and Deng, 2022), we controlled the following variables for the supply-side factors of rural financial exclusion, including regional characteristic variables in five aspects: economic (logarithmic transformation of per capita disposable income of rural residents in each province), infrastructure (fixed asset investment level: fixed asset investment/GDP of each province), government regulation (government expenditure level: government expenditure/GDP of each province), transportation infrastructure level (logarithmic transformation of road mileage in each province), and population density (logarithmic transformation). For the demand-side factors of rural financial exclusion, we considered demographic and household characteristic variables in five aspects, including economic status (expenditure on cultural and entertainment goods), education expenditure (education and training expenditure of the household in the previous year), creditworthiness (credit limit), technology and lifestyle (current type of mobile phone used: (1) smartphone (for online shopping, social chat, etc.), (2) non-smartphone, (3) no phone), and public services and security (the number of government assistance in 17 areas such as medical care, education, dilapidated housing renovation, resettlement, transportation and roads, etc., with 0 for no assistance and 1 for receiving one type of assistance, cumulatively).

3.2. Model specification

This study employs the design of a sharp regression discontinuity introduced by Imbens and Lemieux (2008) and Lee and Lemieux (2010) to test the hypothesis from the perspective of the policy on digital inclusive finance.

Regression discontinuity aims to study the impact of relevant processing effects on an individual i 's target variable y_i . The probability that an individual receives experimental treatment is a function of the driving variable, which exists as a discontinuity. Whether or not individual i is affected by the treatment factor is entirely dependent on the different values of the continuous variable x_i on either side of the discontinuity. Here, D_i represents a deterministic function of x_i . That is, given the value of x , D is treated as a constant based on Equation (1).

$$D_i = \begin{cases} 1 & x_i > c_i \\ 0 & x_i \leq c_i \end{cases} \quad (1)$$

In the context of a given individual i and a fixed value of x , if the target variable y_i exhibits a marked jump at the discontinuity point of the driving variable, then a significant change in y_i will occur once it passes the threshold c_i . This suggests that the causal relationship between y_i and its treatment effect is established by the significant change in the explanatory variable caused by the change in the year at the discontinuity point. The regression discontinuity method is commonly used to test whether a variable remains smooth or exhibits a sharp mutation before and after a policy intervention. In this study, we define the processing status of the numerical inclusive finance policy announced at the breakpoint in each year as a dummy variable D_i . Therefore, we can express this relationship as:

$$D_i = \begin{cases} 1 & year_i > c_i \\ 0 & year_i \leq c_i \end{cases} \quad (2)$$

Suppose that the financial exclusion index y_i on the supply and demand factors in rural areas is the target variable of interest in this study. If this index is influenced by the policy intervention variable D_i at the breakpoint in a particular year, the observed value of the index is y_{1i} . On the other hand, the value of the index in the absence of intervention is y_{0i} . The local treatment effect *LATE* of the policy intervention variable around $x = c_i$ can be expressed using Equation (3):

$$\begin{aligned} LATE &= E(y_{1i} - y_{0i} | year_i = c_i) \\ &= E(y_{1i} | year_i = c_i) - E(y_{0i} | year_i = c_i) \\ &= \lim_{x \rightarrow c_i^+} (y_{1i} | year_i = c_i) - \lim_{x \rightarrow c_i^-} (y_{0i} | year_i = c_i) \end{aligned} \quad (3)$$

Expanding on the Equations (1)–(3) in the regression discontinuity framework, we can assume the following relationship between the variable y_i and x_i , where $i = 1, 2, 3$, and so on:

$$y_i = \alpha + \beta(year_i - c_i) + \delta D_i + \gamma(year_i - c_i)D_i + \varepsilon_i \quad (4)$$

$$y_i = \alpha + \beta_1(year_i - c_i) + \delta D_i + \gamma_1(year_i - c_i)D_i + \beta_2(year_i - c_i)^2 + \gamma_2(year_i - c_i)^2 D_i + \varepsilon_i \quad (5)$$

If there is a linear relationship between y and $year$, it is expressed by Equation (4). If the relationship between the two is nonlinear, it is expressed by Equation (5). This approach allows us to model the functional relationship between the financial exclusion index in rural areas and the driving variable of year. To simplify the analysis, the breakpoint is standardized to 0 through data processing. This means that the variable $year_i$ is transformed to $year_i - c_i$. The introduction of the interaction term is necessary to account for the differing slopes of the regression line on either side of the breakpoint.

In this study, the target variable of interest is denoted by y_i , which measures rural financial exclusion along seven dimensions. The year in which the policy intervention occurs is the driving variable in the regression model. Whether or not a digital financial inclusion policy was issued is indicated by the binary dummy variable D_i ($year_i < c_i$). A linear fit is used to model the relationship between y_i and $year_i$, where α is a constant and β is the coefficient in the linear regression function. The main coefficient of interest is δ , which is the estimated ‘treatment effect’ *LATE* in the regression model. *LATE* measures the effect of digital financial inclusion policies on rural financial exclusion.

Table 2 shows the descriptive statistical results for all variables.

To provide a more intuitive comparison, we used heat maps and line charts to depict the structural changes in rural financial exclusion at different points in time. Specifically, we created provincial heat maps for geographic exclusion, conditional exclusion, marketing exclusion, and self-exclusion indicators for the years 2010, 2013, 2015, and 2020. Additionally, we calculated the average values for financial risk exclusion, financial knowledge exclusion, and channel exclusion for the years 2011, 2013, 2015, 2017, and 2019 and plotted them in a line chart. The results are presented in Figures 1 and 2.

In Figure 1, it is readily discernible that from 2010 to 2020, both the supply and demand factors of financial exclusion in rural China experienced a discernible reduction. This trend can be attributed to the positive impacts stemming from the rapid evolution of China’s financial industry during the preceding decade.

Table 2. Results of descriptive statistical analysis.

VarName	Obs	Mean	SD	Min	Median	Max
Geographical Exclusion	341	−1.449	0.543	−3.180	−1.360	0.000
Conditional Exclusion Average per capita loan level	341	−10.269	0.724	−12.405	−10.291	−7.696
Marketing Exclusion	341	−3.303	0.315	−4.166	−3.272	−2.621
Self-Exclusion Average education level	341	−2.107	0.171	−2.424	−2.147	−1.228
Financial Risk Exclusion	34,630	4.616	1.156	1.000	5.000	6.000
Financial Knowledge Exclusion	34,510	4.214	1.011	1.000	5.000	5.000
Channel Exclusion	34,643	3.926	0.297	1.000	4.000	4.000
Per capita disposable income of rural residents in each province	341	11,929.171	5594.863	3424.700	11,050.500	34,911.301
Level of fixed asset investment	341	0.968	1.026	0.142	0.821	7.379
Level of government expenditure	341	0.280	0.208	0.106	0.226	1.379
Kilometerage of roads in each province	341	11.656	0.839	9.390	11.932	12.885
Population density	341	456.938	698.419	2.450	277.940	3949.560
Expenditure on cultural and entertainment consumer goods	34,113	353.671	2012.743	0.000	0.000	1.50e + 05
Education expenditure	34,643	4723.323	14,820.297	0.000	0.000	6.00e + 05
Credit limit	33,939	8313.838	48,158.296	0.000	0.000	5.00e + 06
Whether or not individuals use a smartphone	34,643	44.826	1765.752	1.000	1.000	71,740.000
Number of interviewees receiving government assistance	34,643	0.190	0.833	0.000	0.000	17.000

The dataset consists of the China Household Finance Survey (CHFS) baseline survey conducted in 2011, along with subsequent follow-up surveys conducted in 2013, 2015, and 2019. Additional sources of data encompass the China Rural Statistical Yearbook (2010–2020), China Financial Yearbook (2010–2020), and China Statistical Yearbook (2010–2020).

Calculations performed by the author using StataSE 16.

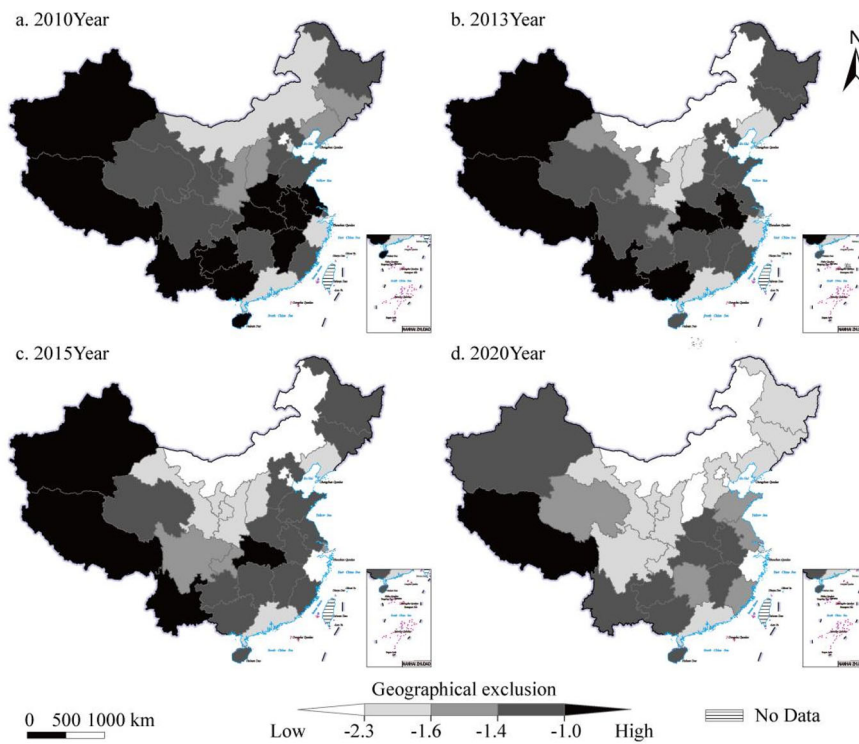
Overall, a higher level of exclusion is observed in the central and southwestern regions, with certain northern and eastern coastal areas exhibiting relatively lower levels of exclusion. Despite the less advanced economic status of the northern regions compared to the eastern coastal areas, rural residents in the north may possess relatively greater personal financial resources, likely due to lower population density.

With regard to geographical exclusion and marketing exclusion, although there has been an overall decline in exclusion levels over the decade, the disparity between the less developed central and southwestern regions and the eastern coastal regions has not significantly ameliorated. The former exhibited marginal changes during the policy implementations of 2013 and 2015, whereas the latter experienced some improvements in the western regions in 2013, possibly due to a stronger reliance on local economic foundations and development rates. In the case of self-exclusion, noteworthy changes were absent in 2013 and 2015. It was not until 2020 that improvements were concentrated in the central and western regions, while the southwestern region remained relatively unchanged, exacerbating the disparity with other areas. Assessment condition exclusion displayed relatively comprehensive enhancements. Both the central and southwestern regions witnessed a certain degree of reduction in exclusion in 2013 and 2015. Up until 2020, apart from the southwestern regions of Tibet and Guangxi in the south, exclusion levels in other regions exhibited relatively minor variations. This trend may be linked to the relatively low cost and accessibility of internet finance.

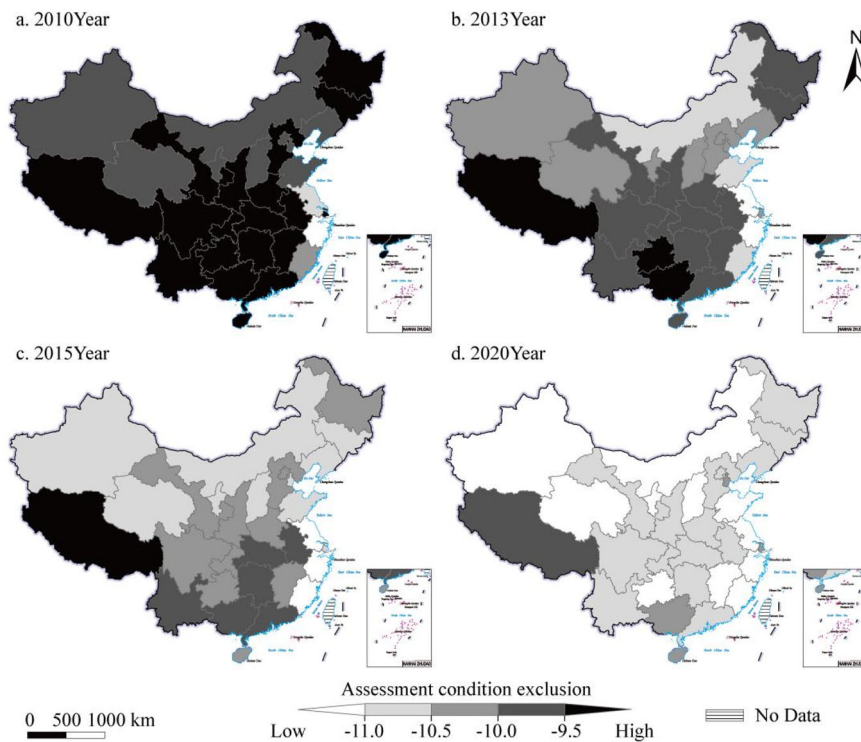
In [Figure 2](#), financial risk exclusion, financial knowledge exclusion, and channel exclusion exhibited a significant decline from 2011 to 2013. This can be attributed to the rapid development of internet finance supported by policy measures, consequently leading to a marked increase in awareness of financial risk, financial knowledge, and financial channels. From 2013 to 2017, these three indicators experienced a gradual decrease, with less pronounced effects. The period from 2017 to 2019 even witnessed a minor rebound. This phenomenon may be attributed to the Chinese government's adjustment of its policy approach in response to previous turmoil in the digital financial market, resulting in a substantial transformation of digital inclusive finance practices in China. Stricter regulations may also have undermined the previously favorable impact on reducing financial exclusion.

4. Empirical results

The authors used regression models with 27 breakpoints for the supply-side factors of geographical exclusion, assessment exclusion, and marketing exclusion, as well as 18 breakpoints for the demand-side factors of self-exclusion, financial risk exclusion, financial knowledge exclusion, and channel exclusion.



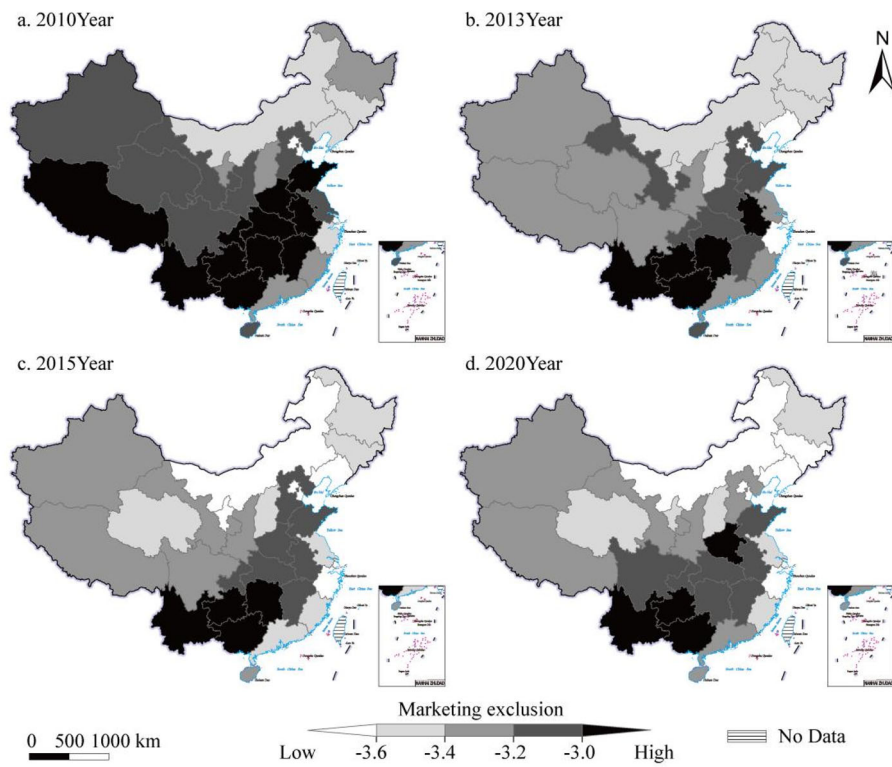
(1)Heatmap of geographical exclusion in 2010, 2013, 2015, and 2020



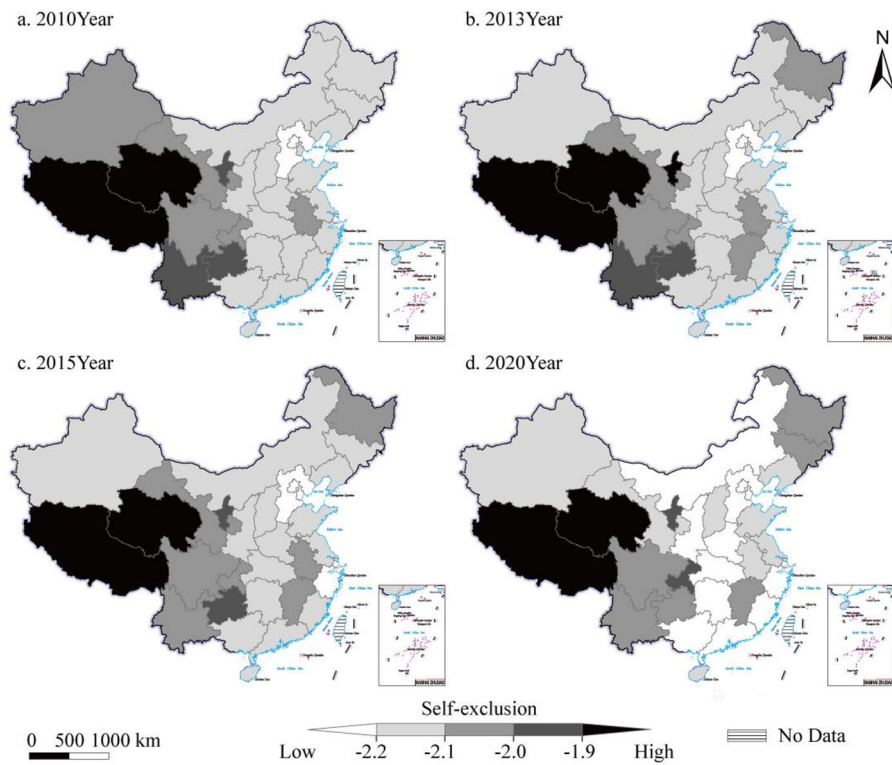
(2)Heatmap of assessment condition exclusion in 2010, 2013, 2015, and 2020

Figure 1. Heatmap illustrating changes in China's rural financial exclusion structure. Review File Number GS (2023) 2767, No alterations have been made to the underlying map.

The authors established these breakpoints using every year between 2010 and 2020, except for 2010 and 2020, as well as 2013, 2015, and 2017 for the demand-side factors. The results indicate that there is almost no breakpoint effect for the supply-side factors of financial exclusion. On the other hand, for the



(3) Heatmap of marketing exclusion in 2010, 2013, 2015, and 2020



(4) Heatmap of self-exclusion in 2010, 2013, 2015, and 2020

Figure 1. Continued.

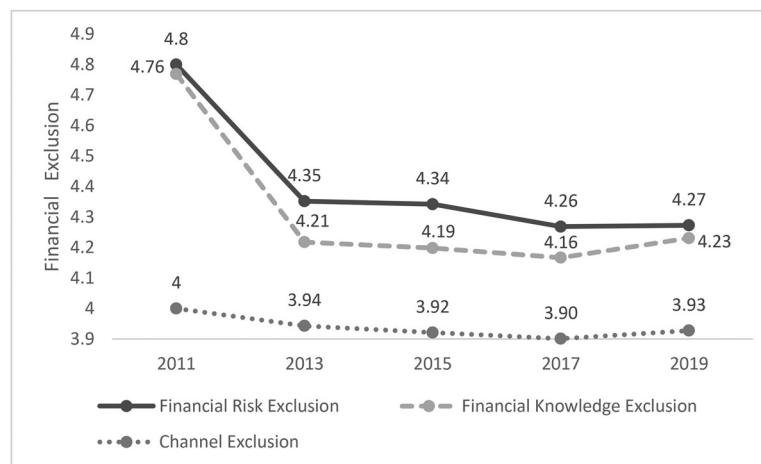
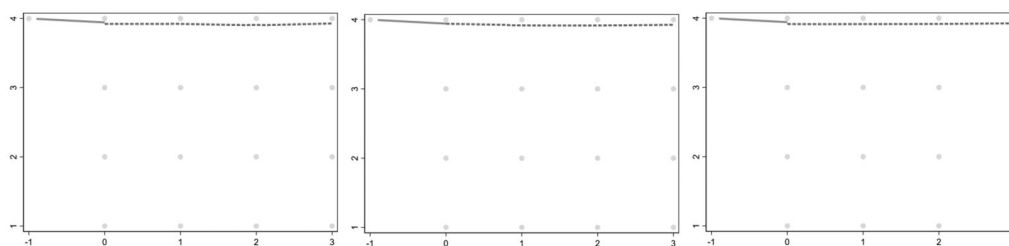


Figure 2. Line graph depicting China's rural financial exclusion.

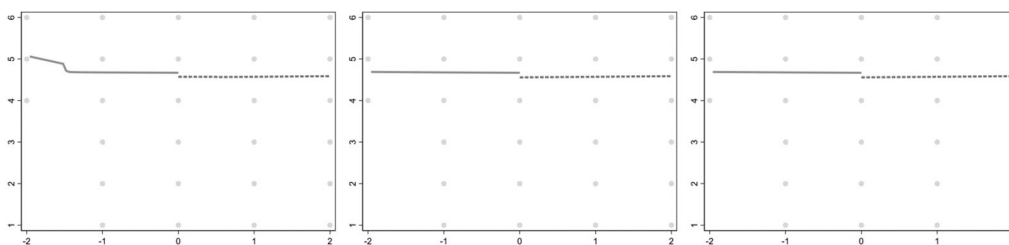
demand-side factors of rural financial exclusion, there are significant breakpoint effects. Specifically, in 2013, channel exclusion had a jump-discontinuity, while in 2015, both financial risk exclusion and channel exclusion had jump-discontinuities. Furthermore, in 2017, both channel exclusion and financial knowledge exclusion showed significant jump-discontinuities, indicating that these three indicators experienced significant changes in different periods. However, besides these five potential breakpoints, the authors did not find other breakpoints in other years that significantly affected the results on both sides of the variable.

As the purpose of this study is to identify the breakpoints and reasons for rural financial exclusion factors of both supply and demand, we focus on the risk exclusion and channel exclusion in 2013 and 2015, and the financial knowledge exclusion and channel exclusion in 2017. We determine the optimal bandwidth at the five breakpoints in 2013, 2015, and 2017, respectively, with the minimum mean square error, which are 1.103, 0.922, 1.308, 1.938, and 1.425. Then, we expand the six bandwidths to double and triple and select ± 1 , ± 2 , and ± 3 as different bandwidth options. The results show that there are clear breakpoints in the risk exclusion, financial knowledge exclusion, and channel exclusion in 2013, 2015, and 2017. Specifically, at the 2013 breakpoint, channel exclusion drops by 2%–3% points. At the 2015 breakpoint, risk exclusion and channel exclusion both drop, with the former by 1%–4% points and the latter by 4%–7% points. At the 2017 breakpoint, both financial knowledge exclusion and channel exclusion jump up, with the former by 5%–6% points and the latter by 2%–3% points. If we consider the official announcement of the ‘development of inclusive finance’ by the Third Plenary Session of the 18th CPC Central Committee in 2013 and the State Council’s issuance of the notice on promoting the development of inclusive finance plan (2016–2020) in 2015 as policy time points, we find that policy announcements have a significant impact on reducing rural financial exclusion factors on the demand side. However, the sustainability of this impact is very limited, and there may even be a rebound. Meanwhile, the impact of policy announcements on the supply side of rural financial exclusion factors is minimal (Figure 3).

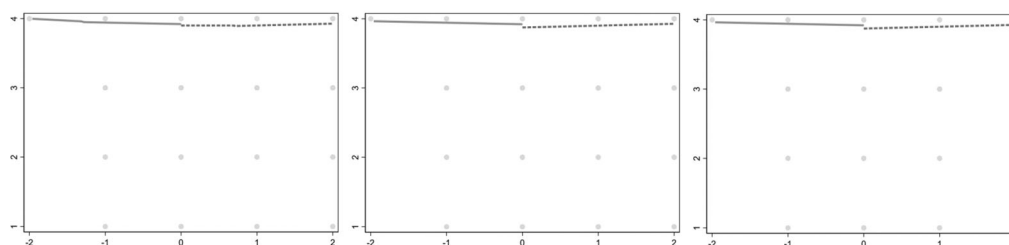
Table 3 presents the various factors that contribute to the structural changes in rural financial exclusion. It is evident that there has been no significant change in the dimensions of supply-side exclusion factors at different breakpoints. For the demand-side factors, there has also been no significant change in self-exclusion. This suggests that the implementation of inclusive finance policies has not effectively reduced geographic exclusion, condition assessment exclusion, marketing exclusion, and self-exclusion in rural finance, as anticipated. This is contrary to the conclusion drawn by Liu (2014) that digital inclusive finance will significantly improve the rural financial situation. However, it is consistent with the findings of Qi and Li (2019) that digital inclusive finance has provided the possibility for low-income people to use financial services to some extent, but has not significantly improved the use of financial services. The observed trend might be attributed to the fact that, as society as a whole undergoes the transition into the digital information era, the infrastructure for accessing and utilizing data in different regions becomes a pivotal factor in determining who can benefit and to what extent. Regrettably, rural areas,



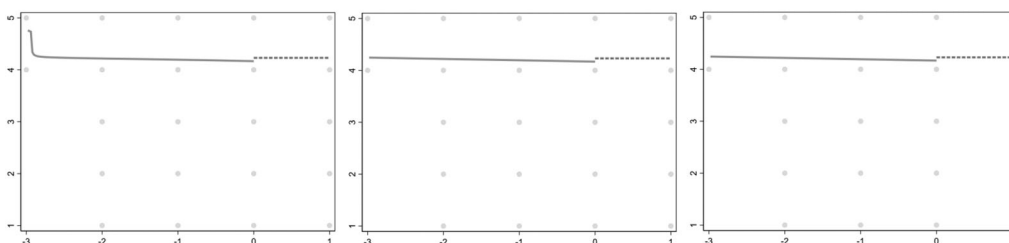
(1) Distribution of exclusion breakpoints for channels with bandwidths of 1x, 2x, and 3x in 2013



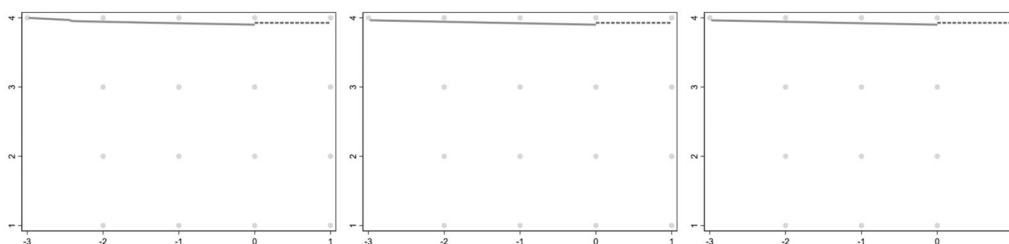
(2) Distribution of exclusion breakpoints for risks with bandwidths of 1x, 2x, and 3x in 2015



(3) Distribution of exclusion breakpoints for channels with bandwidths of 1x, 2x, and 3x in 2015



(4) Distribution of exclusion breakpoints for financial knowledge with bandwidths of 1x, 2x, and 3x in 2017.



(5) Distribution of exclusion breakpoints for channels with bandwidths of 1x, 2x, and 3x in 2017

Figure 3. Distribution of exclusion breakpoints for different dimensions of rural financial exclusion in various years.

due to factors like high deployment costs and limited economic incentives, often find themselves at the tail end of service provision, and in some cases, they may not receive any services at all. Consequently, the impact of relevant policies in alleviating the supply-side factors of financial exclusion is notably

Table 3. Impact assessment of structural changes on rural financial exclusion.

Supply and Demand Factors	Exclusionary structure	Breakpoint	Timeframe						Sample size
			±1		±2		±3		
			(1)	(2)	(1)	(2)	(1)	(2)	
Supply-Side Factors	Geographical Exclusion	2011	0.029 (0.17)	-0.003 (-0.03)	0.027 (0.22)	0.021 (0.26)	0.023 (0.20)	0.009 (0.12)	341
		2012	-0.008 (-0.05)	0.016 (0.14)	-0.011 (-0.09)	0.003 (0.04)	-0.005 (-0.04)	-0.001 (-0.01)	341
		2013	0.019 (0.11)	0.061 (0.55)	-0.005 (-0.04)	-0.008 (-0.11)	0.002 (0.02)	-0.007 (-0.10)	341
		2014	-0.023 (-0.14)	-0.083 (-0.74)	-0.019 (-0.16)	-0.072 (-0.93)	-0.011 (-0.10)	-0.063 (-0.82)	341
		2015	-0.030 (-0.17)	-0.053 (-0.45)	0.004 (0.03)	-0.012 (-0.14)	0.009 (0.08)	-0.006 (-0.07)	341
		2016	0.004 (0.02)	0.025 (0.22)	0.044 (0.32)	0.061 (0.68)	0.046 (0.34)	0.062 (0.70)	341
	Conditional Exclusion	2017	0.080 (0.45)	0.100 (0.86)	0.091 (0.56)	0.116 (1.07)	0.091 (0.56)	0.116 (1.08)	341
		2018	0.066 (0.28)	0.052 (0.33)	0.079 (0.34)	0.079 (0.52)	0.081 (0.35)	0.087 (0.58)	341
		2019	-0.130 (-0.92)	-0.122 (-1.27)	-0.124 (-0.95)	-0.108 (-1.23)	-0.122 (-0.96)	-0.098 (-1.15)	341
		2011	-0.023 (-0.11)	-0.054 (-0.38)	-0.120 (-0.78)	-0.084 (-0.80)	-0.187 (-1.32)	-0.133 (-1.36)	341
		2012	-0.009 (-0.04)	0.025 (0.18)	-0.133 (-0.94)	-0.074 (-0.76)	-0.162 (-1.23)	-0.102 (-1.10)	341
		2013	-0.094 (-0.51)	-0.004 (-0.03)	-0.141 (-1.09)	-0.094 (-1.03)	-0.143 (-1.15)	-0.101 (-1.13)	341
	Average per capita loan level	2014	-0.074 (-0.45)	-0.124 (-1.07)	-0.059 (-0.49)	-0.103 (-1.22)	-0.055 (-0.47)	-0.097 (-1.16)	341
		2015	0.010 (0.06)	-0.018 (-0.15)	0.042 (0.35)	0.011 (0.12)	0.047 (0.40)	0.015 (0.17)	341
		2016	0.021 (0.12)	0.032 (0.24)	0.083 (0.62)	0.074 (0.74)	0.097 (0.74)	0.082 (0.82)	341
		2017	0.033 (0.20)	0.045 (0.34)	0.095 (0.62)	0.093 (0.76)	0.124 (0.82)	0.111 (0.91)	341
		2018	0.038 (0.17)	0.040 (0.24)	0.084 (0.40)	0.087 (0.52)	0.131 (0.62)	0.119 (0.71)	341
		2019	-0.130 (-1.10)	-0.064 (-0.68)	-0.106 (-0.97)	-0.034 (-0.41)	-0.047 (-0.45)	0.015 (0.18)	341
Marketing Exclusion	2011	-0.001 (-0.01)	-0.013 (-0.27)	-0.027 (-0.34)	-0.016 (-0.46)	-0.052 (-0.73)	-0.030 (-0.94)	341	
	2012	-0.025 (-0.23)	-0.027 (-0.51)	-0.040 (-0.53)	-0.019 (-0.52)	-0.055 (-0.81)	-0.031 (-1.00)	341	
	2013	-0.014 (-0.13)	0.031 (0.59)	-0.028 (-0.38)	-0.003 (-0.09)	-0.036 (-0.54)	-0.015 (-0.45)	341	
	2014	0.002 (0.02)	-0.013 (-0.25)	-0.015 (-0.21)	-0.034 (-0.95)	-0.018 (-0.26)	-0.035 (-1.04)	341	
	2015	-0.018 (-0.17)	-0.033 (-0.60)	-0.011 (-0.16)	-0.029 (-0.77)	-0.010 (-0.15)	-0.028 (-0.77)	341	
	2016	-0.009 (-0.09)	-0.008 (-0.15)	0.005 (0.06)	-0.000 (-0.00)	0.008 (0.11)	-0.001 (-0.02)	341	
Demand- Side Factors	Self-Exclusion	2017	0.019 (0.18)	0.029 (0.50)	0.023 (0.25)	0.029 (0.57)	0.030 (0.33)	0.029 (0.58)	341
		2018	-0.021 (-0.15)	-0.010 (-0.14)	-0.009 (-0.06)	0.002 (0.03)	0.006 (0.04)	0.008 (0.12)	341
		2019	0.006 (0.08)	0.039 (0.97)	0.012 (0.17)	0.047 (1.29)	0.028 (0.42)	0.058* (1.67)	341
		2011	-0.010 (-0.15)	-0.019 (-0.78)	-0.002 (-0.05)	-0.003 (-0.19)	0.001 (0.04)	0.002 (0.13)	341
		2012	0.008 (0.11)	0.010 (0.39)	0.007 (0.17)	0.017 (1.12)	0.008 (0.23)	0.015 (1.15)	341
		2013	0.001 (0.01)	0.018 (0.70)	0.002 (0.04)	0.006 (0.39)	0.003 (0.09)	0.004 (0.32)	341
	Average education level	2014	-0.000 (-0.00)	-0.016 (-0.56)	0.000 (0.01)	-0.013 (-0.82)	0.001 (0.03)	-0.011 (-0.75)	341
		2015	0.001 (0.01)	-0.003 (-0.11)	0.000 (0.01)	-0.002 (-0.14)	0.000 (0.00)	-0.002 (-0.15)	341
		2016	0.000 (0.00)	0.006 (0.20)	0.000 (0.01)	0.005 (0.24)	-0.001 (-0.02)	0.003 (0.15)	341
		2017	0.001 (0.02)	0.003 (0.10)	0.001 (0.01)	0.002 (0.09)	-0.001 (-0.02)	0.000 (0.01)	341
		2018	0.000 (0.01)	-0.005 (-0.14)	-0.000 (-0.00)	-0.004 (-0.11)	-0.002 (-0.03)	-0.006 (-0.16)	341
		2019	-0.009 (-0.21)	-0.003 (-0.15)	-0.010 (-0.24)	-0.005 (-0.25)	-0.012 (-0.29)	-0.007 (-0.34)	341
	Financial Risk Exclusion	2013	-0.007 (-0.35)	0.003 (0.17)	0.090** (2.39)	0.090** (2.40)	0.019 (0.72)	0.018 (0.71)	34,630
		2015	-0.097*** (-4.27)	-0.087*** (-3.83)	-0.111*** (-2.93)	-0.108*** (-2.90)	-0.110*** (-2.92)	-0.108*** (-2.89)	34,630
		2017	0.014 (0.73)	0.021 (1.15)	0.003 (0.16)	0.011 (0.64)	0.001 (0.05)	0.009 (0.54)	34,630
		2013	-0.019 (-1.05)	-0.013 (-0.69)	-0.010 (-0.35)	-0.011 (-0.36)	-0.050** (-2.14)	-0.050** (-2.10)	34,510
		2015	-0.031 (-1.54)	-0.023 (-1.14)	-0.031 (-1.54)	-0.023 (-1.14)	-0.031 (-1.54)	-0.023 (-1.14)	34,510
		2017	0.064*** (3.88)	0.067*** (4.08)	0.063*** (4.08)	0.066*** (4.34)	0.063*** (4.10)	0.066*** (4.36)	34,510
Channel Exclusion	2013	-0.022*** (-4.14)	-0.016*** (-3.11)	-0.002 (-0.15)	0.004 (0.40)	-0.027*** (-3.73)	-0.022*** (-3.10)	34,643	
	2015	-0.020*** (-3.04)	-0.019*** (-2.90)	-0.047*** (-4.18)	-0.047*** (-4.26)	-0.047*** (-4.18)	-0.047*** (-4.26)	34,643	
	2017	0.027*** (4.83)	0.028*** (5.08)	0.027*** (5.25)	0.027*** (5.43)	0.027*** (5.33)	0.027*** (5.49)	34,643	

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard deviations are shown in parentheses, the table presents marginal effects. Calculations performed by the author using StataSE 16.

limited. Although the internet can bridge some gaps in certain areas, the usage rate of financial activities in rural areas is still much lower than in economically developed areas. This exacerbates financial exclusion for those who lack access to new tools or have usage barriers (ie people in remote rural areas who cannot purchase or do not know how to use electronic devices such as smartphones and computers, and have inadequate basic network infrastructure), resulting in a new internet exclusion phenomenon. Moreover, it does not solve the core problem of credit in rural financial exclusion. The internet is often just a means, and its essence is the same as that of the traditional financial services industry. Rural areas still have a higher risk due to low income levels, lack of collateral, and other reasons, and they are not the target audience of most financial institutions. Therefore, their condition assessment exclusion and marketing exclusion cannot be effectively improved. At the same time, the reason for self-exclusion, in which people believe that they are unlikely to obtain financial services, is due to the low financial literacy in rural areas. Thus, it is challenging for digital financial policies to reduce self-exclusion by improving financial literacy.

The policy of digital inclusive finance has had a certain effect in reducing financial exclusion on the demand-side factors. For the breakpoint of the policy of 'developing inclusive finance' at the Third Plenary Session of the 18th CPC Central Committee in 2013, the main factor driving the decline in rural financial exclusion was channel exclusion, with the degree of channel exclusion decreasing by about 2% caused by the breakpoint, which effectively promoted people's wider access to channels for financial activities. This was achieved by providing more credit and network technology support to rural areas, optimizing platform construction, and providing payment and settlement services, thus greatly promoting the cultivation of new payment habits. However, this policy did not have a significant impact on other aspects, as it failed to effectively address the challenges prevalent in rural areas, including remote distances, low credit security, high risks, and limited financial literacy. The primary reason for this may lie in the fact that comprehensive improvement in rural financial exclusion demand-side factors sustained support from local government organizations over the long term. Non-profitable areas struggle to establish self-sustaining network economies, which are essential for economic support. Consequently, the initial effects of the policy were limited to direct channel expansion. Due to constraints stemming from an underdeveloped economy, inadequate infrastructure, and educational foundations, rapid reductions in financial exclusion factors on both the supply and demand sides were not achievable.

In terms of the policy on promoting inclusive finance, it has had some effect in reducing financial exclusion factors from the demand side. Taking the inflection point of the policy on 'developing inclusive finance' at the Third Plenum of the 18th CPC Central Committee in 2013, the main factor driving the reduction of rural financial exclusion was channel exclusion, and the degree of channel exclusion decreased by around 2% as a result of the inflection point, which effectively encouraged people to access channels for financial activities more widely. The policy provided more credit and network technology support for rural areas, optimized platform construction, and provided payment settlement services, thereby greatly promoting the cultivation of new payment habits. However, the policy did not have a significant impact in other areas, and it did not have a substantial effect on the disadvantages of remote rural areas, low credit guarantee, high risk, and low financial literacy. As for the inflection point of the State Council's release of the notice on promoting the development of inclusive finance plan (2016–2020) in 2015, the main factors driving the reduction of rural financial exclusion were financial risk exclusion and channel exclusion. The degree of financial risk exclusion and channel exclusion caused by the inflection point decreased by about 9% and 2%, respectively. The policy's release strengthened communication between rural areas and the outside world and played a certain role in reducing the information gap between urban and rural areas, thereby reducing the degree of 'ambiguous risk aversion' of some rural areas to financial assets and lowering the degree of risk aversion of villagers to risk assets. At the same time, through new financial models such as mobile banking, the policy effectively lowered the entry barrier to financial services and broadened the coverage of various channels, making its services more easily accessible to a wide range of service targets. Compared to the 2013 policy, the ideological framework and implementation measures of this digital inclusive finance policy are clearer and more mature. Through an extended period of policy promotion and channel expansion, it resulted in a noticeable reduction in financial risk exclusion in 2015, a marked improvement from the unchanged situation in 2013. However, the supply-side factors of rural financial exclusion have not yielded effective

results. The underlying reason may be that these underserved regions initially had limited exposure to digital technology. To encourage these areas to embrace and explore connections with the broader digital world, policy recommendations need to incorporate targeted measures adapted to the local way of life. Nevertheless, this policy regulation continues to primarily focus on urban areas and does not align well with the needs of rural communities. Consequently, it lacks effective support and does not yield substantial returns. Addressing supply-side exclusion factors present greater challenges, as it is difficult to achieve widespread impact and can even be perceived as a top-down, poorly executed mandate.

In 2017, both financial literacy exclusion and channel exclusion increased by an average of 6% and 2%, respectively. The increase in exclusion may be related to problems in emerging financial models, such as online lending, cash loans, and ICOs, as well as the strict regulatory policies introduced by the government. In July of that year, the National Financial Work Conference was held in Beijing, which established the Financial Stability and Development Committee of the State Council and a new financial regulatory framework and philosophy. In September, seven government departments, including the central bank, jointly issued a notice that characterized the first issuance of tokens as illegal fundraising without approval, and shut down all virtual currency trading platforms. In November, the office of the Leading Group on Internet Financial Risks Remediation issued a notice to immediately suspend the establishment of online small loan companies, which stopped the establishment of new online small loan companies and triggered an ‘earthquake’ in the cash loan industry. Consequently, the regulation of digital financial markets is challenging, and various problems are prone to occur, which can lead to pessimistic market sentiment and may deepen the degree of financial exclusion in rural areas. Furthermore, rural areas inherently face elevated operating costs and lack the advantages of economies of scale. Their limited innovation capacity to provide comprehensible and cost-effective financial products to the target demographic further exacerbates these challenges. Consequently, the financial activities of the majority of rural residents heavily depend on government policy support. In the absence of subsidies, this model becomes financially unsustainable. Therefore, when the government shifts its focus to regulating the turmoil in the internet finance sector and reduces its support for the development of digital inclusive finance policies, the previous accomplishments and positive impacts cannot be sustained. Consequently, the extent of financial exclusion in rural areas is likely to intensify as a result.

5. Robustness test

Firstly, in Table 3, Model (1) is estimated without covariates and Model (2) includes covariates. However, the estimated coefficients are largely consistent regardless of the inclusion of covariates, indicating that the model is robust. Moreover, the estimated coefficients remain largely consistent with the baseline bandwidth when different bandwidths are used. When the bandwidth is set to ± 2 or ± 3 , the results show a significant negative correlation between the ‘Development of Inclusive Finance’ policy announced at the Third Plenum of the 18th CPC Central Committee in 2013 and channel exclusion, and a significant negative correlation between the ‘Inclusive Financial Development Plan (2016–2020)’ released in 2015 and both financial risk exclusion and channel exclusion. These results are consistent with the baseline bandwidth and further confirm the robustness of the model.

Moreover, the validity of RD estimation requires that the running variable is not subject to manipulation. However, in this study, the running variable is time, and individuals are unable to anticipate the announcement of the ‘Development of Inclusive Finance’ policy and the Digital Finance Inclusive High-Level Principles before their publication, let alone manipulate the running variable. Therefore, there is no issue of self-selection (Liu & Xin, 2018).

Thirdly, the RD estimation requires that the covariates are continuous at the cutoff point and do not have significant jumps. In this study, rural per capita disposable income, fixed asset investment, government expenditure, kilometers of highways per province, population density, cultural and entertainment consumption, education expenditure, credit limit, whether using smartphones, and the number of interviewees who received government assistance were used as proxy variables in the regression analysis to test the continuity of the covariates at the cutoff point. Table 4 shows that none of the ten covariates experienced a significant jump at the cutoff point under the three different bandwidths. Therefore, the continuity and smoothness of the covariates were good, ruling out the possibility that the significant

Table 4. Continuous covariate testing.

Covariates	Breakpoint	Timeframe			Sample size
		±1	±2	±3	
Economic status: Per capita disposable income of rural residents in each province	2011	0.002 (0.02)	0.032 (0.36)	0.061 (0.77)	341
	2012	−0.009 (−0.07)	0.037 (0.45)	0.053 (0.71)	341
	2013	0.057 (0.55)	0.053 (0.71)	0.053 (0.77)	341
	2014	0.008 (0.08)	0.001 (0.02)	0.001 (0.01)	341
	2015	−0.011 (−0.11)	−0.022 (−0.31)	−0.024 (−0.35)	341
	2016	−0.007 (−0.07)	−0.021 (−0.28)	−0.029 (−0.39)	341
	2017	0.002 (0.02)	−0.010 (−0.12)	−0.026 (−0.29)	341
	2018	0.024 (0.19)	0.016 (0.13)	−0.005 (−0.04)	341
	2019	0.070 (1.01)	0.070 (1.10)	0.051 (0.84)	341
Infrastructure: Level of fixed asset investment	2011	0.057 (0.22)	0.111 (0.58)	0.166 (0.92)	341
	2012	0.011 (0.04)	0.092 (0.44)	0.137 (0.71)	341
	2013	0.034 (0.12)	0.120 (0.56)	0.129 (0.62)	341
	2014	0.101 (0.33)	0.113 (0.48)	0.113 (0.49)	341
	2015	0.045 (0.14)	0.030 (0.12)	0.029 (0.11)	341
	2016	−0.024 (−0.08)	−0.047 (−0.16)	−0.049 (−0.17)	341
	2017	−0.089 (−0.24)	−0.124 (−0.35)	−0.129 (−0.37)	341
	2018	−0.036 (−0.07)	−0.098 (−0.20)	−0.112 (−0.23)	341
	2019	0.012 (0.04)	−0.048 (−0.19)	−0.074 (−0.30)	341
Government regulation: Level of government expenditure	2011	0.013 (0.14)	0.002 (0.03)	0.003 (0.07)	341
	2012	−0.004 (−0.04)	−0.011 (−0.20)	−0.004 (−0.09)	341
	2013	−0.022 (−0.24)	−0.001 (−0.03)	0.003 (0.07)	341
	2014	0.023 (0.28)	0.019 (0.37)	0.017 (0.37)	341
	2015	0.005 (0.06)	0.003 (0.06)	0.003 (0.05)	341
	2016	−0.008 (−0.09)	−0.007 (−0.12)	−0.006 (−0.12)	341
	2017	−0.004 (−0.04)	−0.003 (−0.05)	−0.004 (−0.07)	341
	2018	0.009 (0.09)	0.006 (0.06)	0.003 (0.04)	341
	2019	−0.002 (−0.05)	−0.002 (−0.04)	−0.004 (−0.09)	341
Transportation infrastructure: Kilometerage of roads in each province	2011	0.004 (0.02)	0.011 (0.05)	0.012 (0.07)	341
	2012	0.004 (0.01)	0.009 (0.05)	0.009 (0.05)	341
	2013	0.003 (0.01)	0.006 (0.03)	0.005 (0.03)	341
	2014	0.006 (0.03)	0.002 (0.01)	0.001 (0.01)	341
	2015	0.003 (0.01)	−0.004 (−0.02)	−0.005 (−0.03)	341
	2016	−0.010 (−0.04)	−0.014 (−0.07)	−0.015 (−0.07)	341
	2017	−0.015 (−0.06)	−0.019 (−0.07)	−0.019 (−0.08)	341
	2018	0.002 (0.00)	−0.004 (−0.01)	−0.006 (−0.02)	341
	2019	0.032 (0.16)	0.030 (0.17)	0.028 (0.16)	341
Population density	2011	0.002 (0.00)	0.004 (0.01)	0.006 (0.02)	341
	2012	−0.000 (−0.00)	0.003 (0.01)	0.003 (0.01)	341
	2013	0.001 (0.00)	0.003 (0.01)	0.003 (0.01)	341
	2014	−0.000 (−0.00)	0.002 (0.00)	0.002 (0.01)	341
	2015	0.002 (0.01)	0.002 (0.01)	0.002 (0.01)	341
	2016	0.002 (0.01)	0.001 (0.00)	0.001 (0.00)	341
	2017	0.000 (0.00)	−0.001 (−0.00)	−0.001 (−0.00)	341
	2018	0.001 (0.00)	−0.000 (−0.00)	−0.001 (−0.00)	341
	2019	0.001 (0.00)	−0.001 (−0.00)	−0.002 (−0.01)	341
Economic status: Expenditure on cultural and entertainment consumer goods	2013	75.000** (2.62)	45.129 (1.14)	49.251 (1.26)	34,113
	2015	56.844 (1.50)	46.032 (0.71)	45.946 (0.71)	34,113
	2017	8.077 (0.26)	7.489 (0.24)	7.310 (0.24)	34,113
Education: Education expenditure	2013	−0.049 (−0.35)	−0.077 (−0.79)	−0.079 (−0.81)	34,643
	2015	−0.043 (−0.31)	−0.043 (−0.31)	−0.043 (−0.31)	34,643
	2017	0.129 (1.97)	0.131* (2.03)	0.132* (2.05)	34,643
Credit status: Credit limit	2013	93.881 (0.10)	−743.675 (−0.67)	−555.572 (−0.50)	33,939
	2015	2,165.69* (2.80)	2,245.50* (1.75)	2,241.384 (1.75)	33,939
	2017	42.202 (0.07)	205.085 (0.34)	235.751 (0.39)	33,939
Technology usage: Whether or not individuals use a smartphone	2013	−3.965 (−0.39)	−4.644 (−0.31)	11.831 (0.92)	34,625
	2015	18.777 (1.53)	52.732** (2.52)	52.706** (2.52)	34,625
	2017	−0.020 (−1.33)	−0.005 (−0.33)	0.000 (0.02)	34,625
Public services and security: Number of interviewees receiving government assistance	2013	−0.038 (−1.39)	−0.038 (−1.39)	−0.065*** (−3.39)	34,643
	2015	−0.005 (−1.05)	−0.007 (−0.98)	−0.007 (−0.98)	34,643
	2017	0.002 (0.68)	0.004 (1.08)	0.004 (1.22)	34,643

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard deviations are shown in parentheses, the table presents marginal effects.

Calculations performed by the author using StataSE 16.

jump in the outcome variable was not entirely explained by the treatment variable. This further validates the effectiveness of the model.

Finally, we conducted stability tests by using alternative estimation methods to verify the utility at the cutoff. Table 5 presents the results of OLS regression models, with Model 1 not including any control variables and Model 2 including individual and household characteristics as control variables. The results show that the 2013 and 2015 policies on digital inclusive finance have a significant positive impact on financial risk and channel exclusion. The 2013 policy resulted in a decrease of about 2% in channel exclusion, while the 2015 policy led to a decrease of about 7% and 1% in financial risk and channel exclusion, respectively. In contrast, the 2017 problems in the internet finance market and the introduction of regulatory policies resulted in an increase of about 4% and 6% in financial knowledge exclusion and channel exclusion, respectively. These findings are consistent with the results of the RD analysis, indicating the robustness of our results.

6. Conclusion and recommendations

This study first decomposes rural financial exclusion into a total of 7 dimensions on the supply-side and demand-side factors, then uses time as the driving variable to conduct a regression discontinuity analysis of the impact of digital inclusive finance policies on changes in the structure of rural financial exclusion. The research indicates that:

1. Over the last decade, there has been no significant improvement in the supply-side factors of financial exclusion in rural China. While scholars like Liang Bang, Li Xiaolin, and Zhang Wanli have proposed that digital inclusive finance policies could narrow the urban-rural gap and effectively mitigate financial exclusion in rural China by stimulating entrepreneurial activities among rural households and advancing internet infrastructure development, their practical effectiveness remains limited. This constraint is underscored by research conducted by scholars such as Agwu, Shala, and Salemin, who have observed that rural residents exhibit lower digital literacy levels, and rural areas suffer from inadequate infrastructure. Consequently, digital financial policies often overlook the specific needs of rural areas, thereby significantly diminishing their potential for fostering inclusive finance. As seen from the analysis in this paper, the policy did not significantly reduce all dimensions of rural financial exclusion factors, especially those related to the supply side, such as geographical, conditional, evaluation, and marketing exclusion. Digital inclusive finance policies have had a relatively modest influence on the broader rural financial environment, predominantly functioning as a novel tool with restricted effectiveness in disadvantaged areas, rather than fundamentally reshaping the fundamental attributes of traditional finance. The policy still has limited impact on addressing the problems of financial institutions withdrawing from remote areas, pursuing high profits, and neglecting vulnerable groups.
2. The demand-side structure of rural financial exclusion factors in China has shown some degree of improvement at two breakpoints, 2013 and 2015. However, the dimensions that supported and drove structural changes were not the same at each breakpoint. For the breakpoint in 2013, when the policy of 'developing inclusive finance' was promulgated at the Third Plenary Session of the 18th Central Committee, the dimension that showed significant improvement was mainly channel exclusion. The reason for this improvement may be that the promulgation of the policy has stimulated the rapid development of digital financial tools. In 2013, which is also known as the year of the development of Internet finance, the launch of 'Yu'eobao' represented the start of China's Internet finance high-speed development mode. With the promotion of network technology, channel exclusion was effectively suppressed. As for the breakpoint in 2015, when the Notice on the Development Plan for Inclusive Finance was promulgated, the dimensions that showed significant improvement were mainly financial risk exclusion and channel exclusion. The reason for this may be that the promulgation of the principle of digital financial inclusion has further accelerated the development of Internet finance. With the emergence of more channels and information, people's attitudes towards financial risks have also begun to change. More people can understand and accept financial risks, resulting in a decrease in the degree of financial risk exclusion and channel exclusion.

Table 5. Ordinary least squares (OLS) regression results as a benchmark.

	2013 Channel Exclusion		2015 Financial Risk Exclusion		2015 Channel Exclusion		2017 Financial Knowledge Exclusion		2017 Channel Exclusion	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Issuance of Digital Inclusive Financial Policies	-0.021*** (-6.17)	-0.015*** (-4.12)	-0.091*** (-7.14)	-0.069*** (-5.34)	-0.013*** (-3.87)	-0.008*** (-2.35)				
Issuance of Regulatory Policies							0.033*** (2.99)	0.044*** (4.03)	0.002 (0.73)	0.006** (1.97)
Per capita disposable income of rural residents in each province		-0.000*** (-4.05)		-0.000*** (-5.13)		-0.000*** (-4.05)		-0.000*** (-3.93)		-0.000*** (-4.06)
Level of fixed asset investment		-0.002*** (-4.59)		-0.000*** (-7.37)		-0.002*** (-4.59)		-0.023*** (-14.36)		-0.002*** (-4.64)
Level of government expenditure		-0.000*** (-2.88)		-0.000*** (-2.88)		-0.000*** (-2.88)		-0.000*** (-2.78)		-0.000*** (-2.87)
Kilometrage of roads in each province		0.000*** (11.60)		0.000 (1.35)		0.000*** (13.78)		0.000** (2.20)		0.000*** (15.33)
Population density		0.016*** (18.51)		0.063*** (7.77)		0.016*** (18.55)		0.019** (2.54)		0.016*** (18.56)
Constant		3.954*** (1,211.69)	4.674*** (465.37)	4.725*** (411.26)	3.934*** (1,580.78)	3.948*** (1,409.02)	4.198*** (542.02)	4.294*** (455.35)	3.925*** (1,720.62)	3.940*** (1,459.45)
Observations	34,643	33,430	34,630	33,421	34,643	33,430	34,510	33,310	34,643	33,430
R2	0.001	0.035	0.001	0.044	0.000	0.035	0.000	0.034	0.000	0.035

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard deviations are shown in parentheses. Calculations performed by the author using StataSE 16.

This discovery further substantiates the perspective put forth by Chen, Zhou, and Kong, which proposes that digital inclusive finance can mitigate credit and information constraints by expanding access channels. Consequently, it widens the social networks within rural finance and takes into account the potential advantages and risks of financial development within a more rural-centric context. This viewpoint diverges from the traditional stance upheld by physical financial institutions, which posits elevated barriers in terms of channels and information knowledge for disadvantaged regions.

3. In 2017, the demand-side factors of financial exclusion in rural China worsened, with a deterioration in financial knowledge exclusion and a rebound in channel exclusion. This alignment closely mirrors Cheng's observations, wherein, since the issuance of China's digital inclusive finance policies in 2013, various non-traditional internet financial institutions and tools have experienced rapid expansion. However, the presence of outdated regulatory frameworks has concurrently resulted in an unprecedented state of chaos within the internet financial sector, contributing to a multitude of severe societal issues. Consequently, China initiated the formulation of a new set of policies and underwent a significant transformation in the conceptualization and implementation of inclusive finance beginning in 2015. This transformation provides substantial evidence for this phenomenon. The underlying reason behind this shift could be attributed to the fact that as China's rapid development in internet finance unfolded, it gave rise to a plethora of new products and models, while the corresponding market regulations lagged behind this growth. The reason for this could be the rapid development of various new products and models in the Chinese internet finance industry, while related market regulations lagged behind its development. Therefore, many problems arose in internet finance, such as digital currency and blockchain projects, P2P lending, and cash loans. The frequent problems in digital finance also influenced people's awareness, causing them to avoid unsafe internet finance behavior, which may have led to an increase in financial knowledge exclusion. In the same year, the People's Bank of China determined that risk prevention should come before financial innovation, and the China Banking and Insurance Regulatory Commission issued the 'Guidelines for the Online Lending Fund Custody Business', and cash loans were also included in internet finance regulation. The collaborative issuance of regulatory documents by the central bank and the banking regulatory commission, aimed at rectifying practices like 'cash loans' and other measures to enhance supervision, has cumulatively impeded the swift expansion and growth of financial channels. Concurrently, the shift in policy priorities has resulted in the forfeiture of earlier accomplishments in the development of rural financial services, which heavily relied on policy support and lacked commercial sustainability. Consequently, rural financial exclusion has experienced a resurgence.

Based on the above research conclusions, this paper proposes the following policy recommendations:

First and foremost, the current development policies for digital inclusive finance exhibit limited overall effectiveness in mitigating rural financial exclusion. This limitation arises from the fact that rural regions, in contrast to urban areas, present fewer profit opportunities and incur higher costs for providing coverage over extensive distances. Consequently, telecommunication companies are unlikely to furnish rural households or businesses with high-speed internet connectivity on par with urban areas. Consequently, the infrastructure supply base upon which these policies rely in these underserved regions is exceedingly frail. Policymakers should prioritize the rectification of the supply-side issues of rural financial exclusion factors by allocating additional funds to offset infrastructure development costs. It is only when the government is willing to shoulder the heightened deployment expenses that network expansion in rural areas can become feasible, thereby allowing policy effectiveness to manifest on the supply-side of rural financial exclusion factors. Moreover, tailored solutions and policy measures must be devised to address specific aspects of exclusion, including geographic, conditional, assessment, and marketing exclusions. Policies should be tailored to local conditions and aimed at creating a favorable rural financial environment, increasing the quantity and quality of rural financial services. Attention should also be given to the credit security of vulnerable groups, providing better credit endorsements for farmers, thus increasing the likelihood of villagers using financial products.

Secondly, digital inclusive finance policies primarily target the demand-side factors of rural financial exclusion. It has become an axiom that information and communication technology enable rural residents to become more actively engaged in community life, education, and knowledge-based economic activities. Consequently, the efficacy of channel expansion is more pronounced in this context. As the government leverages internet finance as an effective tool for disseminating financial education, it should concurrently take into account the unique community cultures present in various rural areas and incorporate them into knowledge dissemination initiatives. Recognizing the significance of specific community cultures in ensuring sound policy implementation is imperative. It is only by aligning with local cultures that the needs of farmers can be more effectively addressed. In the process of integrating digital inclusive finance policies into community life, local knowledge and cultural dynamics should also be harnessed to maximize their impact.

Thirdly, the rapid development of digital finance is a double-edged sword, necessitating appropriate and judicious policy measures by the government to regulate its unchecked growth. While digital inclusive finance promotes channel expansion and knowledge dissemination, caution is imperative to avert the adverse consequences that may result in more acute social issues. Regulatory policies and measures should be implemented with the objective of preserving existing achievements, rather than indiscriminately diminishing their impact. This approach is pivotal in averting disruptions of past progress and the resurgence of rural financial exclusion, as evidenced by China's 2017 regulatory policies, which triggered simultaneous rebounds in both knowledge and channel exclusion. In response, local governments should establish efficient and targeted classification management systems and coordination mechanisms. These systems should incorporate corresponding incentives and penalties to facilitate the sustained development of positive impacts while concurrently mitigating negative effects. Government initiatives should prioritize the establishment of effective rules that, in tandem, safeguard the noteworthy innovations in digital inclusive finance while mitigating financial risks. Furthermore, elevating the sustainability of digital inclusive finance as a means to reduce rural financial exclusion assumes paramount importance. Tailored solutions, customized to local conditions, and innovative models for sustainable rural digital inclusive finance should be explored, reducing dependence on policy and subsidy support for long-term commercial viability.

In conclusion, it is essential to acknowledge that this paper's utilization of the regression discontinuity design method to examine the structural shifts in the supply and demand factors of rural financial exclusion entails certain limitations attributed to inherent shortcomings of the regression discontinuity design methodology. Specifically, the regression discontinuity design approach can solely furnish estimates within the framework of Local Average Treatment Effects (LATE), potentially diverging from estimates derived from the comprehensive sample encompassing the entirety of supply and demand factors pertaining to rural financial exclusion. Furthermore, this study predominantly centers its analysis on policies and rural financial conditions within the Chinese context, without extending consideration to circumstances in other nations. Nonetheless, against the backdrop of the current global landscape marked by rapid advancements in digital inclusive finance and the persistent challenge of rural financial exclusion, this investigation bears noteworthy implications. It prompts contemplation regarding how the implementation of digital inclusive financial policies can facilitate effective and sustainable enhancements across various dimensions of rural financial exclusion. Consequently, the research addressing alterations in the supply and demand factors of rural financial exclusion from the vantage point of digital inclusive financial policies retains substantial practical significance.

Future research endeavors may find merit in refining the granularity of exclusion dimensions under examination and in probing the nexus between digital inclusive financial policies and rural financial exclusion across a broader spectrum of countries and regions. Such endeavors could yield pertinent theories and recommendations that garner widespread acceptance and facilitate effective implementation.

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