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Research on the Impact of Digital Inclusive Finance on the Urban-Rural Income Gap ——Panel Analysis Based on Province-Level Data in China

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Abstract: With the rise of digital technology, digital inclusive finance has emerged as a game-changing innovation in modern finance. It's been instrumental in making financial services more accessible and convenient, reshaping income distribution patterns and fueling economic growth. This paper delves into the urban-rural income disparity stemming from financial exclusion, examining the impact of digital inclusive finance on this gap. Using panel data from 31 provinces and the latest Peking University digital financial inclusion index, we conducted empirical analyses to explore the overall and threshold effects. Our findings clearly indicate that the expansion of digital inclusive finance in China is significantly bridging the urban-rural income gap. Furthermore, our research reveals that the convergence effect of digital inclusive finance on the urban-rural income gap is contingent on thresholds related to economic development and urbanization. Finally, we propose actionable policy recommendations to foster the robust development of digital inclusive finance and promote urban-rural integration.

keywords: Digital Inclusive Finance; Urban-Rural Income Gap; Threshold Effect

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1.Introduction

For years, the urban-rural income divide in developing nations has been a topic of significant discussion. Overcoming internal hurdles and sourcing funds has proven to be a tough row to hoe, resulting in substantial financial strain for folks living in rural areas. The stark differences in terms of wealth, income levels, and access to financial services have led to a noticeable trend of financial exclusion and a dearth of available financial products. China, as the globe's most populous developing nation, and its enduring urban-rural economic divide, continue to cast a spotlight on this issue [1]. The United Nations introduced the concept of inclusive finance in 2005, framing it as a revolutionary finance model aimed at boosting service coverage, broadening financial reach, and achieving inclusive financial access. Following the G20 summit in 2016, the digital finance inclusivity agenda was brought to the fore, marking a fresh trajectory for inclusive finance. This is where the fusion of traditional banking and digital tech comes into play. Now, how does this digital finance inclusivity really tackle the urban-rural income chasm? What's the ins and outs of its impact? Understanding these queries is vital for driving development in impoverished regions and bridging the urban-rural income divide.In the earlier years, most researchers have focused on the relationship between inclusive finance and the urban–rural income gap, but have seldom mentioned digital inclusive

finance. For example, some of them pointed out that the advancement of regional inclusive finance is likely to boost resident income and soothe the problem of income distribution inequality [2]. Besides, inclusive finance helps alleviate mass poverty by increasing people's income in rural areas and relieve the imbalance of urban-rural development [3,4].What's more, the improvement in the availability of financial services exerts an obvious impact on resident income[5] .Inclusive finance made it possible for all residents to contribute to economy growth and benefit from it by lowering the threshold of financial services, which narrow down the urban-rural income gap[6-10]. However, in recent years, researchers noticed that the application of digital technology in finance has brought about a variety of interesting and desiring results including mitigating financial risk[11] and facilitating the inclusive growth of economy [12].Digital technology gave birth to the innovations of online payment channels for non-financial institutions which enabled low income residents to benefit from financial services and products that were out of touch before[13].Thus, the inclusiveness of traditional finance is greatly enhanced[14]. In the meantime, we can see other opportunities inclusive finance provided as regards a larger variety of job options and the possibility of investment return for rural residents [15,16]. To sum up, digital inclusive finance reduces the risk of severe poverty for rural families and thus precluded the urban-rural income gap from going further [17]. On that basis, there has been a consensus that by extending the traditional function of inclusive finance, digital inclusive finance will be able to reduce trade costs and lower the threshold of financial service to a whole new level [18-20]. It contributed to the economic development of vast rural areas and plays a vital role in shortening the urban-rural income gap [21,22].

While there's been a wealth of insights into how inclusive digital finance is impacting the urban-rural income divide, the bulk of existing research has zoomed in on the straightforward, linear influence of digital finance on income disparities between cities and countryside. However, the more intricate, nonlinear dynamics have largely been overlooked and definitely warrant a deeper dive. To this end, we've leveraged a dataset of 31 provincial-level panels and the digital inclusive finance index compiled by Peking University. Employing statistical models like the panel fixed effect model and threshold model, we've delved into the convergence impact of digital finance on both urban and rural incomes. Moreover, we've touched on the likelihood of a non-linear relationship between digital finance and the income gap between cities and the countryside.

Our article has the following marginal contributions: for one thing, the previous literature mainly focuses on the relationship between economic changes, financial development and urban-rural income differences, but ignores the impact of digital inclusive finance, which is increasingly emerging with the progress of mobile Internet. From the perspective of digital inclusive financial services, this paper analyzes its impact on the urban-rural income gap. For another thing, the current researches mainly focused on the linear effect that digital inclusive finance imposed on urban-rural income gap. However, the nonlinear effects seem to be more complicated and call for more attention. Thus, we further discussed the possibility of a nonlinear relation between digital inclusive finance and the urban-rural income gap.

The rest of the paper is organized as follows: Section 2 conducts theoretical analyses and clarifies our testable hypotheses; Section 3 is data sources and variable description; Section 4 conducts empirical analyses including panel fixed effect, and threshold effect; Section 5 is conclusions and recommendations.

2.Theoretical analysis and research hypotheses

Digital inclusive finance overcomes geographical and temporal constraints, reducing financial exclusion [23]. China's urban-rural economic gap has persisted for decades, exacerbated by early industrial policies that concentrated resources like labor, capital, and infrastructure in cities [24,25]. Limited education and information further restricted rural access to financial services, prompting institutions to withdraw from remote areas and deepen financial exclusion [26]. By leveraging internet technologies, digital inclusive finance expands rural financial access via mobile networks, lowering operational costs and broadening service coverage [27]. Big data enables precise credit assessments, reduces information asymmetry, and helps match rural residents with suitable financial products, cutting risk management costs while meeting diverse needs [28]. Thus, digital inclusive finance plays a vital role in equitable financial resource allocation [29] and narrowing the urban-rural income gap, supporting our first hypothesis (H1).

H1: The development of digital inclusive finance helps shrink the urban-rural income gap.

Moreover, the advancement of digital inclusive finance plays a pivotal role in strengthening financial infrastructure

and fostering a robust financial ecosystem. Residents in remote rural areas, where infrastructure has traditionally been lacking, now enjoy expanded access to diverse financial services [30]. That said, given the disparities in regional economic development, uneven policy implementation, and lingering skepticism toward modern internet-based solutions, the impact of digital inclusive finance is likely to vary significantly across different regions. Additionally, since digital finance relies heavily on technology, its effectiveness hinges on users' familiarity with digital tools. In China, rural populations generally have lower educational attainment compared to their urban counterparts [31]. Consequently, the adoption and success of digital inclusive finance in underdeveloped regions may fall short of outcomes seen in more prosperous areas. This observation leads us to the second hypothesis of this study—H2.

H2: There might be a nonlinear threshold effect in the impact that digital inclusive finance has on urban-rural income gap

3.Data sources and Variable description

We chose the panel data from China's 31 provinces as the main source in this article (the data of Hong Kong, Macao and Taiwan is not included temporarily). All indicator data were selected from "China Statistical Yearbook" each year and "The report of digital inclusive finance index from Peking University"(the third issue).The dependent variable, core independent variable and control variable are chosen as follows:

3.1. Dependent variable: Urban-rural income gap (theil)

Three key approaches measure urban-rural income inequality: the Gini index, urban-rural income ratio, and Theil index. While the Gini index assesses overall inequality, the income ratio ignores demographic factors crucial to China's urban-rural divide. The Theil index, however, accounts for population shifts and income fluctuations across wealth groups, making it our preferred method for this analysis [35].

3.1 The formula of Theil Index is as follows:

$$theil_{i,t}=\sum_{j=1}^{2}\left(\frac{Y_{ij,t}}{Y_{i,t}}\right)\ln\left(\frac{Y_{ij,t}}{Y_{i,t}}\Big/\frac{X_{ij,t}}{X_{i,t}}\right)$$

$theil_{i,t}$ stands for the Thiel index of province i during t time, j=1 represents urban areas and j=2 represents rural areas. $Y_{ij,t}$ stands for the urban/rural per capita disposable income of province i during t time.$Y_{i,t}$ stands for the overall per capita disposable income of province i during t time. $X_{ij,t}$ stands for the urban/rural population of province i during t time. $X_{i,t}$ stands for the overall population of province i during t time.

3.2 Core independent variable: Digital Financial Inclusion Index of China(lndifit)

This study employs the Peking University Digital Financial Inclusion Index of China (PKU-DFIIC), spanning 2010–2020, as its key independent variable. Developed collaboratively by Peking University's Institute of Digital Finance and Ant Group, the index measures coverage breadth, usage depth (including payment, credit, insurance, investment, and money funds), and digitization level. Using provincial-level aggregate data sourced primarily from Ant Group, the analysis applies logarithmic transformation to the financial inclusion index [36].

3.3 Control variables

(1) Level of economic development(lnrgdp). Economic development significantly influences urban and rural income distribution. Higher development levels enhance rural productivity through better resource allocation and factor mobility, boosting resident incomes. Per capita GDP, log-transformed for analysis, serves as the development measure [37].

(2) Urbanization rate(urban). Urbanization drives the shift of rural populations to cities. A higher urbanization rate reflects not only the absorption of surplus rural labor but also improved productivity, often raising rural wages. This study measures urbanization as the urban population's share of the total population. [38]

(3) Regional education level(lnedu). Higher regional education levels enhance rural human capital investment, narrowing the urban-rural income gap. College enrollment per 100,000 people measures education levels, with logarithmic transformation applied to this data [39].

(4) Government expenditure(gov). Government spending helps balance regional economic growth and urban-rural income distribution. This study measures it using local budget expenditure as a percentage of regional GDP [40].

(5) Regional financial development level(fina). Regional financial development is crucial to assess. The financial sector's

value-added proportion to GDP effectively indicates its development level [39].

(6) The level of industrial structure(is). The primary, secondary, and tertiary sectors differ in productivity and GDP contributions. Consequently, shifts in a nation's industrial structure alter labor force dynamics, affecting urban-rural income disparities [42]. We measure industrial structure by the combined secondary and tertiary sectors' share of GDP.

(7) The registered urban unemployment rate(unem). We obtained this date directly from China Statistical Yearbook [42].

(8) Opening up level(imex). China's economic growth, particularly the opening degree, significantly impacts the urban-rural income gap, alongside the enduring dual economic structure and other inherent factors. The ratio of imports and exports to GDP serves as a measure of this openness [43].

(9) Regional innovation level(lnpa). Patent approvals gauge regional innovation, with logarithmic transformation applied to the data [45,46].

3.4 the descriptive statistics of variables

Table 1 shows the descriptive statistics of the main variables.

Table1 Descriptive statistics of main variables

Variable	Obs	Mean	Std.Dev.	Min	Median	Max
theil	310	1.561	0.637	0.719	1.427	4.877
lndifit	310	5.212	0.677	2.786	5.410	6.068
lnrgdp	310	10.779	0.440	9.682	10.734	12.009
urban	310	0.580	0.131	0.227	0.570	0.896
lnedu	310	7.823	0.292	6.987	7.793	8.633
gov	310	0.297	0.210	0.120	0.238	1.354
fina	310	0.071	0.030	0.026	0.067	0.196
is	310	0.902	0.052	0.742	0.902	0.997
unem	310	3.242	0.638	1.200	3.300	4.600
imex	310	0.292	0.491	0.007	0.145	7.010
lnpa	310	9.964	1.620	4.796	10.120	13.473

The Theil Index averages 1.561, ranging from 0.719 to 4.877, reflecting significant urban-rural income disparities. Similarly, China's Digital Financial Inclusion Index averages 5.212, with values between 2.786 and 6.068, highlighting further inequality. Regional economic imbalances also lead to notable variations in control variables.

4.Empirical analysis

4.1 The panel overall effect test of the influence that digital inclusive finance exerts on urban-rural income gap

4.1.1 Model settings

We set the panel data linear regression model as:

$$\text{theil}_{it} = \beta_1 \text{lndift}_{it} + \beta_i X_{it} + \delta Z_i + \mu_i + \lambda_t + \epsilon_{it} \quad (1)$$

Among them, i stands for provinces. t stands for a certain year. stands for the index of province in year . lndifit_{it} is the logarithm of the digital inclusive finance index of province i in year t. X_{it} is supposed to mean other control variables that affect urban-rural areas. Z_i here stands for the unobservable individual effects that don't change over time and μ_i stands for the intercept of individual heterogeneity. λ_t is the individual-invariant but time-varying variable, which is the time effects of different individuals, ε_{it} is the idiosyncratic error that changes over time and individuals.

4.1.2 The methods and results of panel regression on that basis

This study employs Theil index (dependent variable) and digital inclusive finance index (independent variable) to assess digital finance's impact on the urban-rural income gap. Stata 17 was used to perform pooled regression, random effects, and one-way/two-way fixed effects analyses, with results presented in Table 2. The following test procedures were implemented:

First of all, we conducted a pooled regression as our reference frame. The disturbances of the same individual in different years inclined to present autocorrelation. Taking consideration of the within autocorrelation of the disturbances, we adopt cluster robust standard errors in our pool regression estimate.

Secondly, the disparity of different provinces may bring about some missing variables that do not change over time, which ends up with inconsistency in pooled regression. We therefore decided to adopt fixed effect model. Successively adopting within estimator method and Least Square Dummy Variable (or LSDV, for short) method to estimate individual fixed effect model, we found that the coefficients of dummy variables in different provinces are quite significant, which denies the null hypothesis that individual effect does not exist. This means we have to give up pooled regression.

Moreover, we added time effect into the fixed effect model to cover factors that change over time while staying fixed among different provinces, which is Two-way fixed effects model. Here we put in Annual dummy variables to estimate two-way fixed effects model and the result shows that the coefficients of dummy variables in some years are significant. Next, we tested the joint significance of the dummy variables throughout all the years and a P value approaching zero came into sight. Thus, the null hypothesis that there is no time fixed effect must be rejected and it's wise to adopt two-way fixed effects model.

Finally, we decided to make good use of Hausman Test to make a choice between fixed effects and random effects model. As is known to all that the traditional Hausman Test does not work properly in heteroscedasticity situation, we adopt the unofficial "xtoverid" order in Stata17 to conduct robust Hausman Test. The P value derived from this result approach to zero, which gave us a strong urge to reject the null hypothesis that the random effects model fits here. To sum up, the two-way fixed effects model should be our final choice.

Table2 Regression results for model (1)

	(1)	(2)	(3)	(4)
	Pooled regression	**Radom effect**	**Individual fixed effect**	**Two-way fixed effect**
lndifit	-0.105***	-0.0532***	-0.0347**	-0.264**
	(0.0311)	(0.0146)	(0.0149)	(0.127)
lnrgdp	0.127	0.108	0.129	-0.849**
	(0.110)	(0.123)	(0.164)	(0.325)
urban	-5.460***	-4.170***	-3.509***	-4.237***
	(0.556)	(0.527)	(0.774)	(0.637)
lnedu	0.230	0.0526	-0.114	-0.0199
	(0.185)	(0.234)	(0.322)	(0.318)
gov	1.165***	0.989***	0.793*	-0.410
	(0.181)	(0.212)	(0.467)	(0.445)
fina	5.888***	1.459	0.261	-2.569*
	(1.572)	(1.114)	(1.467)	(1.364)
is	0.916**	1.512*	0.828	1.173*
	(0.446)	(0.820)	(1.341)	(0.629)
unem	0.0438	-0.0100	-0.00424	-0.0361
	(0.0337)	(0.0256)	(0.0286)	(0.0250)
imex	0.0817**	0.0127	0.00551	0.00217
	(0.0388)	(0.0102)	(0.0112)	(0.00737)
lnpa	0.0514*	-0.0154	-0.0397	-0.0876
	(0.0264)	(0.0423)	(0.0650)	(0.0559)
_cons	-0.158	1.107	2.686	14.06***
	(1.702)	(1.836)	(2.281)	(2.799)
N	310	310	310	310
R^2	0.923		0.724	0.857

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.1.3 The Analysis of empirical results

The two-way fixed effects model reveals a significant coefficient β_1 of -0.264 ($p < 0.05$), indicating that a 1% rise in digital inclusive finance reduces the Theil index by 0.264%. This is likely due to digital inclusive finance's inclusive, poverty reduction, and growth effects, optimizing the rural environment and raising marginal output elasticity [48]. Additionally, China's targeted poverty alleviation policies boost rural economic potential, increasing rural incomes.

Control variables reveal that per capita GDP, urbanization, and regional financing development significantly reduced the urban-rural income gap, with coefficients of -0.849 (5%), -4.237 (1%), and -2.569 (10%). In contrast, regional education, government expenditure, urban unemployment, and innovation had weakly negative but insignificant effects. Industrial structure and trade openness showed significantly positive coefficients, likely because secondary/tertiary industries and trade activities disproportionately benefit urban areas, widening the income gap.

The above can verify H1.

4.2 The threshold effect test of how digital inclusive finance impacting urban-rural income gap

4.2.1 Model settings

Digital inclusive finance's impact on the urban-rural income gap is contingent on a country's economic development and urbanization. Therefore, threshold models are constructed using per capita GDP and urbanization rate to analyze this nonlinear relationship.

$$\begin{aligned}\text{Theil}_{it} = \theta_0 + \theta_{11}\text{lndift}_{it} \cdot I(\text{urban}_{it} \le \gamma_1) + \theta_{12}\ln(\text{dift}_{it}) \cdot I(\gamma_1 < \text{urban}_{it} \\ \le \gamma_2) + \cdots + \theta_{1n}\ln(\text{dift}_{it}) \cdot I(\text{urban}_{it} > \gamma_n) + \theta_i X_{it} + \epsilon_{it}\end{aligned} \tag{2}$$

$$\begin{aligned}\text{Theil}_{it} = \theta_0 + \theta_{11}\text{lndift}_{it} \cdot I(\text{lnrgdp}_{it} \le \gamma_1) + \theta_{12}\text{lndift}_{it} \cdot I(\gamma_1 < \text{lnrgdp}_{it} \\ \le \gamma_2) + \cdots + \theta_{1n}\text{lndift}_{it} \cdot I(\text{lnrgdp}_{it} > \gamma_n) + \theta_i X_{it} + \epsilon_{it}\end{aligned} \tag{3}$$

i represents individuals and t stands for time. Theil represent urban-rural income gap and is also the dependent variable here. lndifit is digital inclusive finance which plays the role of core independent variable. Urban and lnrgdp is adopted as the threshold variables. I(·) is the indicator function whose value is 1 if the conditions in the bracket are meet, otherwise the value of this function is 0. X_{it} is the set of control variables and $\gamma_1, \gamma_2 \ldots \gamma_n$ are the threshold value of n different levels.

4.2.2 Threshold effect test and Threshold parameter estimation

We have conducted single threshold, double threshold and triple threshold tests using urbanization rate and per capita GDP. Here is the result from Stata17.

Table 3 Self sampling threshold effect test

Threshold variables	Number of thresholds	F value	P value	Bs times	critical value		
					10%	5%	1%
urbanization rate (*urban*)	single	108.39**	0.0167	300	49.6690	68.2395	128.4596
	double	17.07	0.3733	300	102.7485	142.4191	188.2903
	triple	23.59	0.2233	300	77.3326	107.6272	142.2001
per capita GDP (*lnrgdp*)	single	60.42***	0.0000	300	29.6924	35.6094	51.0906
	double	32.69*	0.0800	300	29.4107	37.1350	56.6689
	triple	14.87	0.7667	300	47.8696	55.9120	70.9589

F value and P value are the results of 300 simulations by Bootstrap method. *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively.

We can see from Table 3 that the estimate of urbanization rate passed the significance test in single threshold while it failed in double and triple threshold, thus urbanization rate fit single threshold model. The estimate of per capita GDP passed the significance test in both single and double threshold but failed in triple threshold, hence per capita GDP fit double threshold model. The results are displayed below:

Table 4 Threshold estimation results

Threshold variables	models	The threshold estimate	95% CI
urbanization rate (*urban*)	Single threshold	0.3147	[0.2747, 0.3324]
per capita GDP (*lnrgdp*)	Double threshold	10.0933	[10.0782, 10.0955]
		10.4145	[10.3672, 10.4147]

As is shown in Table 4, the estimate of urbanization rate in single threshold is 0.3147 and the estimate of per capita GDP in double threshold is 10.033 and 10.4145.

4.2.3 The regression of the threshold and analysis

We conducted panel threshold regression with model (2) and (3) and the results are displayed as bellow:

Table 5 Estimated results of the threshold regression

Variables	theil	
lndifit-1 (*urban*≤0.3147)	-0.163*** (0.0429)	
lndifit-2 (*urban*>0.3147)	-0.263*** (0.0416)	
lndifit-1 (*lnrgdp*≤10.0933)		-0.142*** (0.0442)
lndifit-2 (10.0933<*lnrgdp*≤10.4145)		-0.201*** (0.0427)
lndifit-3 (*lnrgdp*>10.4145)		-0.219*** (0.0425)
Control variable	Yes	Yes
Cons	12.78***(1.047)	10.72***(1.113)
N	310	310
R^2	0.894	0.892

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 5 shows that digital inclusive finance significantly reduces the urban-rural income gap, with effects varying by economic development level. At per capita GDP below 10.0933, a 1% increase in digital finance narrows the gap by 0.142%. Between 10.0933 and 10.4145, the effect rises to 0.201%, and above 10.4145, it reaches 0.219%. This demonstrates that greater economic development enhances digital finance's impact, likely due to improved infrastructure, education, and financial access in rural areas. Lower development levels hinder these benefits due to limited resources, whereas advanced economies enable digital finance to more effectively reduce income disparities. The relationship is nonlinear, with infrastructure and education acting as key enablers.

Table 5 also shows that below the urbanization threshold of 0.3147, digital inclusive finance significantly reduces the urban-rural income gap by 0.163% per 1% increase (significant at 1%). Above this threshold, the effect strengthens to -0.263%. The greater coefficient suggests that higher urbanization enhances digital finance's impact on narrowing income disparities, likely due to increased rural employment and skill development opportunities [47]. Consequently, income convergence accelerates with rising urbanization rates, confirming H2.

4.4 Robustness check

In order to test the reliability of these conclusions, we will apply upper and lower 1% winsorization to all variables and on that basis estimate all the models above once more with Stata17.According to the results of the regression we can see that no matter the positive and negative direction or the significance of the coefficient of digital inclusive finance remains unchanged,

and besides that ,the threshold value did not alter significantly, which confirmed the robustness of the empirical results we have.

5.Research Conclusions and Policy Recommendations

From the perspective of the urban-rural disparity, we conducted empirical analyses on the overall impact, threshold impact, and mediating effect of digital inclusive finance on the urban-rural income disparity using panel data from 31 provinces and the Digital Inclusion Index provided by Peking University. Here's what we found: (1) The development of digital inclusive finance can significantly help reduce the urban-rural income gap. (2) There has been a threshold of economic development and urbanization level in the convergence effect that digital inclusive finance exerts on urban-rural income gap and it tends to be more and more significant as economy continues to grow and urbanization rate proceeds to soar.

Based on the above research findings, the following policy recommendations are proposed:

(1) To advance digital inclusive finance, we must broaden its reach, deepen its application, and enhance digitization. This involves upgrading digital financial infrastructure, integrating finance with technology, and reducing service costs. A diversified digital product system with lower barriers is crucial. The government should improve information transparency and regulation, especially in rural areas. Simultaneously, improving financial and internet literacy in rural populations will foster a better financial environment.

(2) Boost economic growth and urbanization by developing key industries, attracting investment, and fostering innovation, thus enabling wider access to digital inclusive finance. Integrate rural revitalization with urbanization by easing urban settlement restrictions for rural migrants, fostering urban-rural synergy. Prioritize modern agriculture and allocate resources to rural areas, accelerating integrated urban-rural development.

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Conflict of Interests

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