

Has the development of digital finance driven population agglomeration?

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Abstract. Digital finance is considered an important driving force for improving the level of population agglomeration. This article matches the data of Peking University's digital inclusive finance with information on regional population agglomeration to study the relationship between the development of digital finance and population agglomeration. The regression results of the instrumental variable method show that the development of digital finance can promote population agglomeration at a significant level of 1%, and a series of robustness tests further support this finding. In addition, this article finds that the breadth of coverage in the digital finance index has a greater impact on population agglomeration, and the heterogeneity analysis of regions shows that the promotion of digital finance development on population agglomeration is more evident in western regions. This has reference significance for promoting the even distribution of the national population.

Keywords: Digital Finance, Population Agglomeration, Nighttime Lights, Heterogeneity.

1. Introduction

China is the most populous country in the world. Affected by natural, social, economic and political factors, China's current population agglomeration is manifested in the dense population of the eastern coastal area, followed by the central region, and the sparsely populated western plateau area. In other words, China's population agglomeration presents a pattern of regional imbalance. Population agglomeration can further promote population expansion, economic growth and urban resilience [1], At the same time, it will promote urban economic growth, and under the role of dual economic and population growth, it will further promote the growth of urban scale. Therefore, promoting the uniform distribution of population and alleviating the agglomeration imbalance can further promote China's economic development, and its important role can be regarded as one of the important issues to be solved in China's development process. China has emphasized the population issue many times, because China is the most populous country in the world, so the population issue has always been an overall and strategic issue. To this end, the Chinese government has successively issued the Notice of the State Council on Printing and Distributing the National Population Development Plan (2016-2030) (Guo Fa [2016] No. 87), the National New-type Urbanization Plan 2014~2020 and other relevant documents, which not only provide an important basis for population and family planning policies, but also lay a foundation for promoting urban optimization and reform and expanding the scale of cities.

With the rapid development of China's Internet technology and the innovation and popularization of 5G technology, countless industries have undergone changes in this scientific and technological revolution. In this revolution, the combination of Internet technology and traditional financial services has produced a new generation of financial services - digital finance. In recent years, blockchain has first begun to be applied in the financial field, and the development of digital finance has ushered in a boom. Digital finance further promotes the basic functions and subsequent development functions of digital finance by combining with the logic and technology of blockchain.

Can digital finance provide an opportunity to alleviate demographic imbalances? At present, more research focuses on the relationship between traditional financial services and population agglomeration, but there is still insufficient research on the role of non-traditional services such as digital finance in promoting population agglomeration. At present, the country attaches great

importance to the combination of digitalization and economy, in this regard, the State Council issued the "14th Five-Year Plan" digital economy development plan, from the top-level design to clarify the overall thinking, development goals, key tasks and major measures of China's digital economy development, which is also China's "14th Five-Year Plan" period to promote the high-quality development of the digital economy action program. In order to clarify the data and measurement indicators of digital finance, the Digital Finance Research Center of Peking University has cooperated with Ant Financial to produce digital inclusive financial indicators that are in line with the development of China's digital finance. In view of the existing research on population agglomeration, it is discussed that urban commercial banks have a positive effect on population agglomeration [2], and should also be research on promoting integrated development through central urban services [3]. Unfortunately, most of these studies are based on traditional financial models and business economic models, so it is difficult to reflect the impact of recent non-traditional finance, digital finance, on population agglomeration. This paper studies the role of digital financial inclusion development on population agglomeration from 2011 to 2019 by matching the digital financial inclusion index with China's municipal-level population density data.

The main contribution of this paper is to carry out research on digital finance and population agglomeration from the perspective of digital finance. In view of the importance of population agglomeration, there are now abundant studies on the influencing factors of agglomeration. At present, scholars have studied the impact that digital finance can have on local government debt risk [4], market development and trade circulation [5], and villagers' consumption [6]. However, few of them affect the regional economy from the perspective of digital finance, enhance population agglomeration by driving regional economic development, and introduce the role of economy in driving population agglomeration from the perspective of digital finance. This finding helps to consider the enlightening role of how the development of digital finance can promote regional population agglomeration.

The remainder of this paper is arranged as: the second part reviews the development of digital finance in China; the third part introduces the data and empirical models used; The fourth part will first study the overall effect of digital finance on population agglomeration, and then analyze the impact of three indices of digital finance on population agglomeration, including the breadth of coverage, depth of use and degree of digitalization, and discuss the impact of digital finance on population agglomeration in different regions. The fifth part puts forward some suggestions on the impact of digital finance on population agglomeration.

2. Theoretical analysis and hypothesis

2.1. The mechanism of digital finance to promote regional population agglomeration

Population agglomeration can affect regional development because it can improve urban resilience and make it more resilient and resilient when the urban economy is shocked [1]; Population agglomeration also has a good role in promoting the upgrading of industrial structure.

In China's research, it can be found that the influencing factors of population agglomeration are related to the basic situation of the region, such as local economic activities [7], wage gap with other regions [8], regional innovation channels [9], business investment intensity and economic servitization [10], and even natural disasters in some regions will also affect population agglomeration [11]. These conclusions are consistent with the conclusions of relevant research, and it is found that population agglomeration is affected by many basic conditions such as economy, services, and education in urban areas, but if you want to further attract population agglomeration by optimizing these basic conditions, it is inseparable from the support of key forces such as finance, technology and market.

The development of digital finance can lead to the improvement of regional education and water, the increase of scientific and technological talents, and the reduction of economic level differences. Through cooperation with the government, we will give full play to financial products to alleviate

poverty problems such as education, medical care and services in the region, improve the level of public services, and increase the living satisfaction index of local residents. Further reduce population outflow, improve the basic conditions for regional development, and lay a solid foundation for subsequent population agglomeration [12]. In view of the impact of population agglomeration caused by economic imbalance, the difference in economic level and economic resource allocation between regions can be narrowed through a combination of policies and technological construction such as high-speed rail, so as to improve public services and business activities. Through technological upgrading, more financial resource flows can be further carried out with developed regions to undertake knowledge spillover and resource radiation in developed regions [13]. But the main question is how to strengthen regional technological strength? At the same time, the government formulates digital financial development policies and balances local fiscal revenue and expenditure, which can also reduce the gap between regional fiscal revenue and promote local economic development [14]. At this time, the implementation of science and technology finance policies promotes financial development, can attract scientific and technological talents, promote the agglomeration of talents, and can also improve regional human capital [15]. With the help of the innovation ability of scientific and technological talents, talents will further cultivate advantages, improve regional innovation and development, lay a solid foundation for subsequent talent attraction and population agglomeration, and gradually form a virtuous circle of regional innovation population agglomeration [16].

Based on the above analysis, the following hypotheses are proposed:

Hypothesis 1: Digital finance can promote regional population agglomeration.

2.2. Digital finance promotes the heterogeneity of population agglomeration

With the rapid development of high-tech such as 5G technology, digital finance can cover areas and people that are difficult to reach in the development of traditional finance, and promote the development of more regions. Because of the extensive and inclusive use of digital finance, it may lead to differences in the role of digital finance in promoting population agglomeration in different regions. At present, China is mainly divided into the eastern region, the central region and the western region. The eastern region has a large population agglomeration and a good basic economic situation, while for the central and western regions, the opposite is true, and the population agglomeration effect in the central and western regions is poor, and there is a large imbalance. According to existing studies, when digital finance promotes local fiscal revenue, the promotion effect on the western region will be more significant [14], which may be closely related to the basic situation of the western region. From this point of view, the role of digital finance in promoting regional population agglomeration will be more significant in the western region.

Based on the above analysis, the following hypotheses are proposed:

Hypothesis 2: The role of digital finance in promoting regional population agglomeration is more obvious in the western region.

3. Study design

3.1. Data sources

In order to demonstrate the hypothesis, this paper uses the following data: (1) Peking University Digital Financial Inclusion Index, released by the Center for Digital Finance Research of Peking University. (2) From 2011 to 2019, the relevant information on city-level control variables such as population density, per capita GDP, financial development level, and industrial upgrading level of Chinese cities comes from the China Statistical Yearbook, the regional Statistical Yearbook and the data released by the National Bureau of Statistics. (3) Nighttime lighting data for China, from the year-by-year artificial nighttime lighting dataset compiled by the National Tibetan Plateau Scientific Data Centre.

3.2.1. Explained variables

We used various data on social development of prefecture-level cities between 1999 and 2019, mainly from the "China City Statistical Yearbook" and the "China Regional Economic Statistical Yearbook". The statistical units were divided into the whole city and the urban districts. After matching with digital financial data and deleting data outside the time interval of the digital financial index, we finally selected data from 2011 to 2019 to further analyze the impact of the digital financial index and different dimensions on population agglomeration.

3.2.2. Explanatory variables

Peking University's Digital Finance Research Centre uses Ant Group's massive data on digital financial inclusion to compile a set of digital financial inclusion indices. The index is constructed from three dimensions, including the breadth of digital financial coverage, the depth of digital financial use and the degree of digitalization of inclusive finance, to calculate the digital financial inclusion index. The digital financial index used in this paper contains 33 specific indicators, which cover 31 provinces and 337 cities above prefectural level.

3.2.3. Instrumental variable

Although the city and time dual fixed effects mitigate the endogeneity problem to some extent due to omitted variables, they do not fundamentally address the endogeneity problem. Specifically, in identifying the impact of digital finance on population agglomeration, there are two main reasons for endogeneity: firstly, omitted variables, for the empirical part has controlled for some of the relevant variables that would have an impact on population agglomeration, but there may still be errors in the omitted variables due to some unobservable variables; secondly, two-way causality, this paper studies the impact of digital finance on population agglomeration. Second, two-way causality, this paper examines the effect of digital finance on population agglomeration, but because of the possibility of two-way causality, population agglomeration may have an impact on digital finance. In view of this, we use instrumental variables to fundamentally address the endogeneity issue. In this paper, we construct the instrumental variable $\ln iv$, which is the logarithm of the product of the variable distance and net. Where distance is the distance variable, as the birthplace of digital finance in China is Hangzhou, the closer to Hangzhou may be the earliest to be affected by the diffusion effect of digital finance, so distance is the distance of other cities from Hangzhou, however as distance does not change over time, fixed effects are difficult to estimate, so another variable net is constructed. net is the product of the product of the product of distance and net. Internet penetration from 2011 to 2019, and the new variable iv is obtained by multiplying distance with net as a way to satisfy the need for constructing instrumental variables in this paper. In order to ensure the validity of the instrumental variables, a weak instrumental variable test was conducted in this paper. The test results show that the Cragg-Donald Wald F statistic is much larger than the critical level of 10%, so the instrumental variables selected in this paper are reasonable.

3.2.4. Control variables

There are six main control variables (1) $\ln fdi$, the logarithm of the ratio of the amount of foreign capital actually used in the city to GDP during the year; (2) GDP per capita $\ln pergdp$, expressed through the logarithm of the ratio of GDP to the number of people registered at the end of the year; (3) the level of financial development $\ln finance$, expressed through the logarithm of the ratio of loans to deposits; (4) the local general public budget revenue per unit of GDP corresponding to (4) local general public budget revenue per unit of GDP $\ln czsr$, expressed through the logarithm of the ratio of local general public budget revenue to GDP; (5) fixed asset investment $\ln gdzc$, expressed through the logarithm of the ratio of fixed assets to GDP; (6) industrial upgrading level $\ln high$, expressed through the logarithm of the ratio of the share of the tertiary industry in regional GDP divided by the logarithm of the share of the secondary industry in regional GDP.

3.2. Model setting

This paper focuses on the relationship between digital finance and population agglomeration, setting up the following model.

$$\text{popden}_{it} = \beta_0 + \beta_1 \ln\text{DFD}_{it} + \alpha X_{it} + a_i + a_t + \varepsilon_{it} \quad (1)$$

The explanatory variable we focus on is popdenit, which represents the level of population concentration, using the population density of the area obtained by dividing the year-end resident population by the city's land area; the core explanatory variable is DFDit, which represents the Digital Inclusion Index. ai represents city fixed effects, controlling for inherent city characteristics that do not change over time; at is a time fixed effect, controlling for a series of exogenous shocks that change over time but do not change with urban variation. Xit is a set of control variables.

4. Empirical analysis

4.1. Baseline regression

The results of the main regression are reported in Table 2. to avoid endogeneity problems caused by omitted variables, this paper uses a new variable iv consisting of the product of distance from each city to Hangzhou, the birthplace of digital finance, and the annual internet penetration rate net as the instrumental variable.

Table 1 shows the descriptive statistics of the explanatory variable regional population density y and the explanatory variable digital financial inclusion index lnDFD. It can be concluded that the maximum value of regional population density lnpopden is 8.960 and the minimum value is 1.628, while the maximum value of digital financial inclusion index lndig is 5.772 and the minimum value is 3.057. the variance of the two variables is 0.899 and 0.513.

Table 1. Descriptive statistics of variables

	(1)	(2)	(3)	(4)	(5)
	Obs	Mean	Std. Dev.	Min	Max
lnpopden	2,383	5.813	0.899	1.628	8.960
lnDFD	2,383	4.994	0.513	3.057	5.772
lnfdi	2,383	1.637	3.139	-11.267	5.700
lnpergdp	2,383	2.528	2.988	-0.283	13.085
lnfinance	2,383	-0.424	0.279	-2.470	1.725
lnczsr	2,383	5.562	2.918	-3.364	7.729
lngdzc	2,383	7.893	2.947	-1.773	10.140
lnhigh	2,383	-0.038	0.121	-0.607	0.466

Column (1) of Table 2 reports the impact of digital finance on population agglomeration, using instrumental variables along with temporal and spatial fixations. The results show that the coefficient on the digital finance index is significantly positive at the 1% level. To further reduce the problem of omitted variables, control variables such as GDP per capita and level of financial development are added. According to column (2) of Table 2, there is some increase in the coefficient of the digital finance index, which may be caused by the omitted variables, but the coefficient remains positive at the 1% level of significance. The regression analysis allows us to conclude that there is a significant contribution of the development of digital finance to population agglomeration.

Table 2. Impact of digital finance on population clustering

	(1)	(2)
	lnpopden	lnpopden
lnDFD	0.0118***	0.0475***
	(0.0032)	(0.0090)
lniv	3.0464***	2.7974***
	(0.0128)	(0.0320)
lnfdi		0.009
		(0.0017)
lnpergdp		-0.0329**
		(0.0143)
lnfinance		0.0030
		(0.0106)
lnczsr		0.0039
		(0.0097)
lngdzc		0.0135**
		(0.0058)
lnhigh		-0.2478***
		(0.0378)
_cons	5.7632***	5.4913***
	(0.0156)	(0.0746)
City FE	Yes	Yes
Year FE	Yes	Yes
N	2382	2382
R ²	0.0092	0.0012

Note: ***, **, * represent 1%, 5%, 10% significant levels respectively, with standard errors in brackets.

4.2. Robustness tests

4.2.1. Municipal level clustering

In view of the possible outlier problem, this paper adjusts the robust standard errors of the previous paper for clustering standard errors at the municipal level. The results of the robustness tests are shown in Table 3. Column (1) of Table 3 shows the results of the analysis of the municipal-level clustering. From the results, it can be seen that the standard errors of the digital finance index have become significantly larger and remain significant at the 5% level of significance, meaning that digital finance development can still significantly contribute to population clustering.

4.2.2. Replacement of population density variables

The population density of an area obtained by dividing the number of people registered at the end of the year by the land area of the city may differ to some extent from where people actually live, and there may be a time lag between the number of people registered and the statistics. For stability reasons, the population density is reflected in the night light data, so the year-by-year artificial night light dataset from the National Tibetan Plateau Scientific Data Centre is used. Here, the nighttime light data lnlight is chosen to replace the population density lnpopden, which further reflects the degree of population concentration through light intensity. In order to ensure the same time span as data such as the digital financial index and population density, so the nighttime light data from 2011 - 2019 was finally selected for robustness testing.

Table 3, column (2) shows the results of the regression analysis after replacing the explanatory variables. In this regression, the explanatory variable remains the digital finance index and the control variables are the same as the original regression function, except that the explanatory variable population density lnpopden is replaced with night light data lnlight. the test results show that digital

finance development still increases the level of population agglomeration at the 1% level of significance after replacing the explanatory variable with night light data. The findings still hold true for both municipal level agglomeration and replacing the explanatory variables, as digital finance has a significant contribution to the agglomeration with population. The above demonstrates the reliability of the conclusions of this paper.

Table 3. Stability tests of digital finance on population clustering

	(1)	(2)
	lnpopden	lnpopden
lnDFD	0.0475**	0.1843***
	(0.0218)	(0.0413)
lniv	2.7974***	2.7974***
	(0.0465)	(0.0320)
_cons	5.4913***	-6.7093***
	(0.0870)	(0.3405)
Control	Yes	Yes
City FE	Yes	Yes
Year FE	Yes	Yes
N	2382	2382
R ²	0.0012	0.5135

Note: Standard errors for clustering at the municipal level are in parentheses in column (1); standard errors after replacing variables are in parentheses in column (2) ***, **, * represent 1%, 5%, 10% significance levels respectively.

4.3. Heterogeneity analysis of the digital finance sub-index

The Digital Finance Index is constructed from three dimensions: breadth of coverage, depth of use and degree of digitisation. Breadth of coverage is an index constructed from the number of Alipay e-accounts etc. in each region, reflecting the extent of the scope of the digital financial environment; depth of use refers to the service capacity of each region for Internet digital finance and the use of digital finance, reflecting the service capacity of regional digital financial services; the degree of digitisation reflects the transaction costs, ease of use and efficiency of digital finance in each region. In order to further clarify more the factors influencing the digital finance index on population concentration, this paper will conduct a sub-index heterogeneity analysis of the three dimensions of digital finance and elaborate on the impact of the three dimensions of digital finance separately, Table 4 shows the results of the heterogeneity analysis.

By comparing columns (1), (2) and (3) of Table 4 for breadth of coverage, depth of use and degree of digitisation in the digital finance index respectively, it can be seen that all three dimensions of digital finance have a significant contribution to population agglomeration. The differences between these three dimensions are small, but the breadth of coverage has the greatest contribution to population agglomeration. If one wants to promote regional population agglomeration through digital finance, breadth of coverage can be a priority, followed by the degree of digitization and the weakest contribution is the depth of use.

Table 4. Heterogeneity analysis of the digital finance sub-index

	(1)	(2)	(3)
	breadth of coverage	depth of use	degree of digitisation
	lnpopden	lnpopden	lnpopden
lnDFD	0.0504*** (0.0096)	0.0260*** (0.0069)	0.0356*** (0.0068)
lniv	2.6392*** (0.0685)	2.8461*** (0.0449)	3.7320*** (0.0878)
_cons	5.5357*** (0.0743)	5.5436*** (0.0733)	5.4888*** (0.0752)
Control	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	2382	2382	2382
R ²	0.0032	0.0001	0.0092

Note: ***, **, * represent 1%, 5%, 10% significant levels respectively; standard errors are in brackets.

4.4. Regional heterogeneity analysis

After regression analysis, robustness testing and heterogeneity analysis of the various dimensions of digital finance development, this paper can conclude that digital finance has a significant positive effect on population agglomeration. However, in China there is currently an uneven distribution of population, for example, in the eastern part of the country, population agglomeration is more effective, with rapid development and good economic construction. In the western part of the country, however, the population is less well concentrated. Today, digital finance can break more time and space constraints by digitising traditional finance. Compared to the eastern regions, where population concentration is more effective, digital finance may play a greater role in population concentration in the western regions. In this paper, the provinces of China are divided into three groups, namely the eastern, central and western regions, according to the regional distribution of each province, and an empirical test is conducted to examine whether the contribution of digital finance to population agglomeration is influenced by region.

The results are reported in Table 5, where a comparison of the coefficients in columns (1), (2) and (3) shows that digital finance has a small and insignificant effect on the population concentration in the central region. Comparing columns (1) and (3) with column (2), it can be seen that both for the eastern and western regions, there is a more significant contribution to regional population agglomeration. A further comparison of columns (1) and (3) shows that the western region has a more pronounced role in promoting digital finance. It can be seen that digital finance development has a better contribution to both eastern and western regions, but to a lesser extent to the central region, but for the western region, which has a poorer base of population agglomeration, digital finance has the greatest contribution to population agglomeration.

Table 5. Analysis of regional heterogeneity in digital finance

	(1)	(2)	(3)
	lnDFD_east	lnDFD_mid	lnDFD_west
lnDFD	0.0772*** (0.0239)	-0.0070 (0.0078)	0.0800*** (0.0148)
lniv	2.7793*** (0.0445)	3.0283*** (0.0465)	2.8148*** (0.1112)
_cons	5.6366*** (0.1868)	5.3220*** (0.0678)	5.4956*** (0.1087)
Control	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	868	1075	439
R ²	0.1740	0.0052	0.0400

Note: ***, **, * represent 1%, 5%, 10% significant levels respectively; standard errors are in brackets.

5. Conclusions and recommendations

This paper is based on data such as the China City Statistical Yearbook and the China Digital Inclusive Finance Index published by the Digital Finance Research Centre of Peking University, using an instrumental variables approach and conducting regression analysis. Robustness tests were also conducted to ensure the reliability of the findings. Finally, two types of heterogeneity analysis were conducted. The impact of digital financial development on population agglomeration was tested. The final findings show that digital financial development has a significant positive effect on population agglomeration. The test of heterogeneity revealed that all three dimensions - breadth of coverage, depth of use and degree of digitalization - play a significant positive role in population agglomeration, but at the same time it can be found that breadth of coverage plays the largest role. In the regional heterogeneity test, the digital finance effect on population agglomeration was examined by dividing the Chinese provinces into three regions: the eastern region, the central region and the western region. The results show that digital finance does not have a significant effect on the central region, but both the western and eastern regions are significantly boosted by digital finance, with the western region being more affected.

Based on the results of the current analysis, we can make the following recommendations. Based on the significant effects of digital finance on population agglomeration in this paper, new insights are provided to promote even population agglomeration: greater emphasis on digital finance as an important force in promoting population agglomeration; the government can formulate the development of digital finance, which in turn drives regional population agglomeration; and attention is paid to the regulation of digital finance in the development process to avoid adverse effects. With regard to the significant effects of the three dimensions of digital finance, it can be suggested that in the process of driving population agglomeration through digital finance, primary attention should be paid to the breadth of coverage of digital finance, but as the difference between the three promoting effects is relatively small, attention should also be paid to the development of the remaining two dimensions. Based on the different effects of digital finance on the promotion of population agglomeration in the three regions of China, it is suggested that the development of digital finance should be increased in the western region, where the population agglomeration is less effective, the economic infrastructure is weaker and the development rate is slower, so as to strengthen the population agglomeration and future development of the western region through a new model of digital finance-led development.

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