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Heterogeneous Study of the Impact of Digital Financial Inclusion on the Income Level of the Population from a Double Cycle Perspective

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Abstract

With the introduction of the double-cycle pattern, the level of economic development of all countries has been significantly enhanced. At present, the Internet has been developing rapidly in many industry sectors, under which digital inclusive finance has gradually become a source of vitality for economic development. This paper uses panel data of 31 provinces in China from 2011 to 2022 to study the impact of digital inclusive finance on the income level of residents under the double-loop perspective, and analyzes the study from three aspects, namely, regional differences, urban-rural differences, and the effect of income level. First, the effect of digital inclusive finance on residents' income level is studied from the perspective of regional differences. Secondly, based on the foundation of the measurement model of regional differences, the model of urban-rural differences in the effect of digital inclusive finance on the income level of residents is established. Then, based on the relevant data calculated above, the Z-score standardization analysis of the quantitative data of the income level of residents in each city is carried out, and finally, we put forward the following three policy recommendations for the conclusions of this paper: firstly, to actively promote the development of digital inclusive finance, and to rely on digital finance to drive the increase in the level of residents' income. The second is to increase the scale of publicizing and building digital finance in backward areas. The third is to develop new digital financial products and services.

Keywords

Two-loop Pattern; Digital Financial Inclusion; Population Income Level; K-means Modeling.

1. Description of the Problem

1.1. Background of the Study

Since the new crown epidemic swept the world in 2020, China's real economy has been hit more seriously since then. Against this background, the leaders of the Party Central Committee proposed to vigorously develop the domestic demand market and realize the new pattern of internal circulation as the main body and internal and external double circulation co-development [1]. Firstly, in the domestic macro-cycle market, the supply side improves the industrial base re-engineering and industry chain engineering, and the demand side builds a complete system of domestic demand; secondly, in the domestic and international cycle market, the inherent potential is given full play to, the level of openness is improved, and the trade between domestic and international is strengthened, so as to realize the sustainable development of the domestic and foreign economies. In this process, the study of expanding the domestic demand market has become a topic of concern for many scholars, in which the income level is a major important factor affecting the demand situation.

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As we all know, the development of the real economy can not be separated from the strong support of finance, expanding domestic demand is the basis for the development of the real economy, therefore, how to effectively realize the finance to improve the level of income, for the domestic and international double cycle to inject new blood has an important significance in reality [2]. However, the increase in income level brought by traditional finance has certain limitations and cannot realize its inherent role from a comprehensive perspective, but with the development of the Internet in the past two years, digital finance has also gradually stepped into people's lives, and its advantages have become more and more obvious [3]. Therefore, this paper takes 31 provinces in China as the research object, takes 2011-2022 as the research interval, takes digital inclusive finance affecting the income level of residents as the research theme, and carries out an in-depth study from the regional as well as urban and rural levels.

1.2. Purpose of the Study

By studying the heterogeneity of the income level of residents affected by digital inclusive finance, we understand that the income level of residents in different provinces of China is affected by digital inclusive finance to different degrees, and the income level between urban and rural areas is also affected by the influence of a large difference [4]. Based on the geographic location of different provinces, we divide them into three regions, namely, the eastern region, the central region and the western region, put forward reasonable suggestions for the development of digital inclusive finance based on the actual situation of each region and combined with the regional division of the situation, and take some feasible measures for the planning of each urban and rural area, so as to make the digital inclusive finance achieve efficient and steady development under the background of the double-cycle, and to make the income level of each province and each urban and rural area more and more stable, so that each province and each urban and rural area will be able to realize the development of digital inclusive finance. The income level of each province and each urban and rural area can be further improved, and the stable and sustainable development of the domestic economy can be guaranteed in the end [5].

1.3. Significance of the Study

With the development of the Internet economy, a large number of domestic and international bubble economy has gradually appeared, the real economy has been greatly affected, and people's income level has also been affected to different degrees as a result, so the root cause of guaranteeing the national income and the good life of the residents lies in the development of the national real economy, and the digital inclusive finance, as a future direction of the development of inclusive finance, will inevitably be the impact of the future real economy key factor [6]. Therefore, it is of great practical significance to take digital inclusive finance as the main research object. In the research of previous scholars, most of the impact of digital inclusive finance on the overall income, while in this paper, the research will be divided into different regions and urban and rural levels from the perspective of heterogeneity to carry out the research, which has a certain degree of relevance, that is, to effectively give certain policy recommendations for the development of digital inclusive finance in different regions [7].To explore the heterogeneity of digital inclusive finance affecting the income level of residents, based on the geographic location of the provinces on the regional division, and according to the urban and rural areas of different research objects, the corresponding region to put forward feasible recommendations, which is conducive to stabilizing and maintaining the balance of the development of digital inclusive finance in various regions, which in turn effectively improve the income level of residents, and ultimately promote the sustainable development of the socioeconomic and the domestic and international double-circle pattern. [8].

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2. Data Processing

2.1. Data Sources

This paper takes China's 31 provinces, municipalities and autonomous regions as the research unit, divides them into three regions: eastern, central and western, and studies the three regions as well as their urban and rural data separately, with the exception of the Digital Financial Inclusion Index, which is based on the data from the China Statistical Appraisal for the twelve-year period from 2011 to 2022. The core explanatory variable of this paper, digital financial inclusion index, comes from the "Peking University Digital Financial Inclusion Index 2011-2022" published by the Digital Finance Research Center of Peking University.

Figure 1. Zoning map

2.2. Data Preparation

Since the collected data may have similar problems of missing, abnormal or even the existence of influencing factors with different scales, we will interpolate and standardize the data.In order to deal with the problem of missing data and anomalies, we use the average value method, the average value of the previous and subsequent data as a definite value to interpolate the missing parts of the data, and the interpolation formula is as follows.

$$Y = \frac{Y_i + Y_{i+1}}{2} \tag{1}$$

To address the issue of magnitude, if the original data are analyzed directly, the role of influencing factors with lower values will be covered, and in order to ensure that the differences in the level of consumption are studied under the same conditions, the data of each province and region are standardized by the Z-score, which is calculated by the following formula.

$$X = \frac{X_i - \overline{X}}{s} \tag{2}$$

2.3. Construction of a System for Evaluating Income Levels

In recent years, digital inclusive finance has flourished in China and has had an important impact on many aspects of the economy and society. This paper empirically analyzes the impact of digital inclusive finance on the income level of residents using panel data from 31 provinces

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in China from 2011 to 2022, and further analyzes it from the perspectives of regional distribution differences, urban-rural distribution differences, and correlation tests.

The study finds that (1) in general, digital inclusive finance has a significant contribution to the income level of residents. The higher the level of digital inclusive finance, the higher the level of residents' income. (2) The impact of digital inclusive finance on residents' income reflects heterogeneous characteristics. From the regional point of view, digital inclusive finance has a significant role in promoting the income of residents in the eastern and central regions, while the eastern region has a greater impact, but there is a certain inhibition of the western region; from the urban and rural perspectives, digital finance has a significant positive impact on the income level of urban and rural residents, while promoting the income level of rural residents is greater than the impact of urban residents, which suggests that the impact of digital inclusive finance on narrowing the urban-rural income gap is very favorable. (3) In terms of correlation with residents' income, the digital inclusive financial system has a positive correlation with residents' income in about 60% of the provinces and a negative correlation with 30% of the provinces.

3. Empirical Analysis based on Regional Differences

3.1. Model Selection

In order to test the impact of digital inclusive finance on the income level of residents, this paper draws on the research of previous scholars to construct the following econometric model:

$$income_{it} = \alpha + \beta IFI_{it} + X_{it} + U_i + \varepsilon_{it} \quad (3)$$

$income_{it}$ is the explanatory variable, denoting the level of residents' income in the ith province in year t; IFI_{it} is the core explanatory variable, denoting the digital financial inclusion index in the ith province in year t; X_{it} is a series of control variables, such as GDP per capita, disposable income per capita, and other influences; U_i is unobservable individual heterogeneity, i.e., individual fixed effects; and ε_{it} is a random perturbation term.

3.2. Setting of Variables

1) Income level of the population. This variable is the explanatory variable of this study, measured by the natural logarithm of the level of residents' income. In the existing relevant academic research, the measurement of this variable is directly using the original data, the natural logarithm of the original data, the natural index of the original data of the three measures, in the comprehensive consideration of the accuracy and convenience of the research data on the premise that this paper uses the natural logarithm of the variable for further numerical research.

2) Digital financial inclusion index. This variable is the core explanatory variable of this paper's research, which is derived from the "Peking University Digital Inclusive Finance Index 2011-2022" released by the Digital Finance Research Center of Peking University, and consists of three dimensions, such as the breadth of digital financial coverage, the depth of digital financial use and the degree of digitization of inclusive finance, in order to construct the digital inclusive finance index system. This paper takes the above three dimensions of the breadth of coverage, depth of use and degree of digitization of digital inclusive finance to study in-depth the heterogeneity of its impact on the income level.

3) Per capita disposable income level. This variable is one of the control variables studied in this paper and is expressed as the natural logarithm of per capita disposable income. As we all know, the level of residents' income directly affects the situation of residents' disposable income, in the case of other influencing factors remain unchanged, the situation of per capita

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disposable income reflects the situation of residents' income level, that is, the higher the level of per capita income, the higher the level of residents' income.

4) Local economic development level. This variable is one of the control variables studied in this paper, measured by the logarithm of per capita GDP. According to Keynes's macroeconomics theory, the level of GDP is closely related to the income level of residents, and in most cases, there is a positive correlation between the two, i.e., the higher the level of local economic development, the higher the corresponding level of residents' income; the worse the level of local economic development, the lower the corresponding level of residents' income.

5) Industrial structure. This variable is one of the control variables in this study, and is expressed by the ratio of tertiary industry to GDP. The industrial structure of a region affects the income level of local residents to a certain extent, and using the ratio of the GDP of the tertiary industry to the total GDP to measure the industrial structure is both consistent with the practical significance and has certain research value.

6) Urbanization level. This variable is one of the control variables in this research, and is measured by the urbanization rate. The urbanization rate is an important indicator of the level of regional economic development, which has an important impact on the income level of residents. The use of the urbanization rate as a control variable avoids the interference of the core explanatory variable of digital financial inclusion and ensures the reliability of the results of this paper.

7) Relative size of government expenditure. This variable is one of the control variables in the study of this paper, which is expressed by total fiscal expenditure and total regional GDP. Government expenditure has a certain role in promoting the income level of residents, when the government spends more, according to the cyclic theory, residents will absorb the cost of the government expenditure part of the cost, so that their income level is improved. The symbols of each variable and the metrics are shown in Table 1 below.

Table 1. Variable Settings

Variant	Variable symbol	Metric
Population Income Level	Inincome	Natural logarithm of population income level
Digital Financial Inclusion Index	IFI	Digital Financial Inclusion Index
Per capita disposable income level	InPCDI	Natural logarithm of disposable income per capita
Local Economic Development Level	LogpGDP	Natural logarithm of GDP per capita
Industrial Structure	Industry	Ratio of tertiary industry to GDP
Urbanization Level	City	Urbanization rate

3.3. Empirical Analysis

The empirical analysis data used in this paper is the panel data of 31 provinces in China from 2011 to 2022, in which some of the indicators only started to be released in 2012, resulting in the missing data in 2011, so the interpolation method is used to fill in the data. The following is a regression analysis of the impact of digital financial inclusion on the income level of residents from the baseline regression and regional heterogeneity regression.

1) Benchmark regression

Firstly, the F test and Hausman test are conducted, and after the test, the most suitable regression method - fixed effect model regression (FE) is found. Then it is found that in the fixed effect model, the coefficient of the index of digital financial inclusion is 0.000651 and is

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significant at the 1% level, which indicates that the index of digital financial inclusion presents a positive correlation on the income level of the residents, and that every time the digital financial inclusion increases by one unit, the corresponding level of the income of the residents will increase by 0.065%. Among the control variables, the coefficients of the relative scale of government expenditure, urbanization level, industrial structure, natural logarithm of per capita GDP and per capita disposable income are 0.854, 0.954, 0.644, 0.642, 0.521, respectively, which indicates that the above five control variables have a positive relationship on the level of income of the residents, and the coefficients of each of them are larger. Meanwhile, when the relative size of government expenditure increases by one unit, the level of residents' income increases by 0.854 units; the increase in the level of residents' income caused by each unit increase in the level of urbanization is about 0.954 units; the increase in the level of residents' income caused by each unit increase in the industrial structure is about 0.644 units; the increase in the level of residents' income caused by each unit increase in the natural logarithm of per capita GDP is about 0.644 units; the increase in the level of residents' income caused by each unit increase in the natural logarithm of per capita GDP is about 0.521 units. The increase in residents' income level caused by each unit increase in the natural logarithm of GDP per capita is about 0.642 units; the increase in residents' income level caused by each unit increase in disposable income per capita is about 0.521 units. In summary, the variables studied in this paper have positive impacts on the explanatory variables, and there are some differences in the degree of impacts between different variables.

2). Regression of regional heterogeneity

The 31 provinces in the Chinese region are divided into eastern, central and western regions based on geographic location, and the 2011-2022 digital financial inclusion index of each province in the region is divided to calculate the mean value, and the calculated results are sorted in descending order.

From an overall perspective, most of the provinces with top rankings in the digital financial inclusion index are concentrated in the eastern region, such as Shanghai, Beijing, Zhejiang, etc., in which the digital financial inclusion index of Shanghai has exceeded 300, at 303.60, and the regional average value has reached 259.46; while most of the provinces with lower rankings are located in the western region, and the regional average value of the digital financial inclusion index is only 213.35. The provinces in the central region are located in the western region, and the regional average value of the digital financial inclusion index is only 213.35. The average value of the digital financial inclusion index of the provinces in the central region is 220.74, and the ranking of each province is also in the middle of the level. Therefore, in summary, the overall digital financial inclusion index shows a decreasing trend of the development level of the eastern region → central region → western region.

It can be seen that the development level of financial inclusion has significant regional heterogeneity on the income level of residents.

3) Digital inclusion in the eastern region at the 1% significance level has a significant contribution to the income level of residents, when the digital financial inclusion index increases by one unit, the level of residents' income increases by approximately 0.0646%, and the promotion effect is most pronounced in the east-central region of the three regions. In the central region, digital financial inclusion has the same effect on the income level of residents, but the effect is not as strong as in the eastern region, and the impact of the digital financial inclusion index in the central region is that when the digital financial inclusion index is raised by one unit, the income level of the residents is raised by about 0.0495% of a unit. In the western region, digital financial inclusion has a depressing effect on the income level of the population at the 1% significance level, with the income level of the population decreasing by about 0.0714% of a unit when digital financial inclusion is increased by one unit.

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4. Analysis of the Impact of Digital Financial Inclusion on the Income of the Population

The above has used the econometric model and regression analysis to analyze the regional differences in residents' income on the basis of digital financial inclusion, so now, based on the relevant data, we conduct the Z-scroe standardized analysis on the quantitative data of the digital financial inclusion index and residents' income, and use the K-means analysis to classify China's 31 provinces, municipalities directly under the central government, and autonomous regions into positively correlated and negatively correlated categories, according to the role of digital financial inclusion on residents' income.

4.1. Standardization of Data

Denote the digital financial inclusion index after standardization, the digital financial inclusion index of the first province, municipality (autonomous region), the total number of provinces, municipalities and autonomous regions under study, the average of the digital financial inclusion indexes of 31 provinces, municipalities and autonomous regions, and the standard deviation of the digital financial inclusion indexes of 31 provinces, municipalities and autonomous regions, with the following formula:

$$X = \frac{X_i - \overline{X}}{s} \tag{4}$$

$$X' = \frac{1}{n}\sum_{i=1}^{n} X_i \tag{5}$$

$$S = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(X - X')^2} \tag{6}$$

4.2. Modeling and Solving the K-means Algorithm

4.2.1. Symbolic Description of the Model

Table 2. K-means Algorithm notation description

Symbol	Description
k	Given the number of clusters
$C^{(i)}$	Sample with the closest category among the categories
U_j	Guess value of the center sample
X_i	Given training samples

4.2.2. Model Building

For each urban area sample i calculate the regional category to which it belongs with the following formula:

$$C^{(i)} := arg\min_j ||X^{(i)} - U_j||^2 \tag{7}$$

For each class, recalculate the center of mass of the class with the following equation:

$$U_j = \frac{\sum_{i=1}^{m} 1\{c^{(i)} = j\} X^{(i)}}{\sum_{i=1}^{m} 1\{c^{(i)} = j\}} \tag{8}$$

Repeat the calculation operation until the center of mass is unchanged, and end the algorithm when the value of the J function is minimized, Eq:

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$$J = \sum_{i=1}^{n} \sum_{j=1}^{k} r_{ij} \left\| X^{(i)} - U_j \right\|^2 \quad (9)$$

4.2.3. Solving the Model

Using python software to input the K-means algorithm program to classify the quadrant classification of each city area, and visualize the results (as shown below), it can be seen that each city in China is clearly divided into two regions, with fewer discrete points, and the results are more accurate.

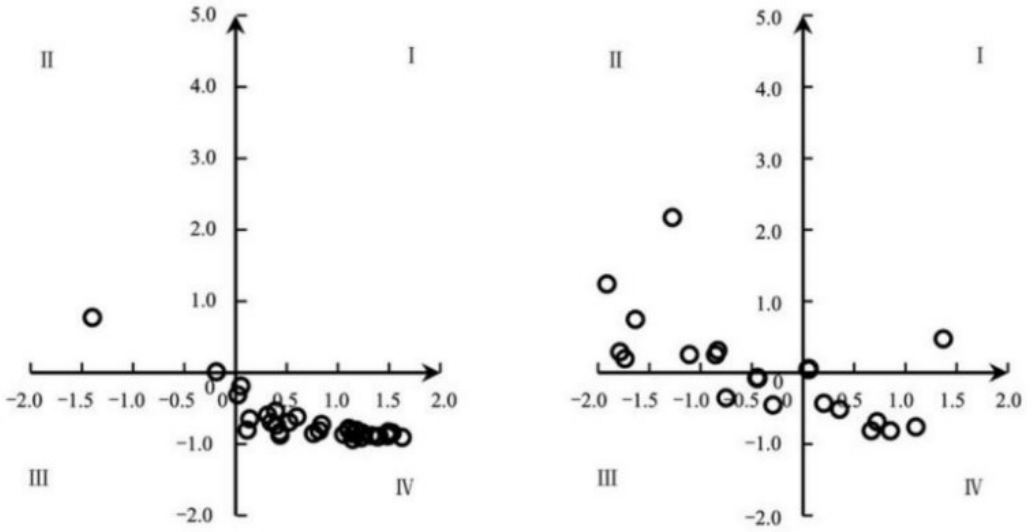

Figure 2. Map of algorithm results divided into regions

The data from each province were clustered and the categories were determined to be two categories based on the images, and the following results were obtained.

1) Positive Related Groups:Shanghai, Beijing, Zhejiang Province, Guangdong Province, Fujian Province, Jiangsu Province, Tianjin, Hainan Province, Shandong Province, Liaoning, Hebei Province, Chongqing, Sichuan Province, Hubei Province, Anhui Province, Jiangxi Province, Hunan Province, Henan Province, Jilin Province, Inner Mongolia Autonomous Region, Yunnan Province.

2) Negative Related Groups:Shaanxi Province,Guangxi Zhuang ,Autonomous Region,Ningxia Hui Autonomous Region,Qinghai Province,Gansu Province,Guizhou Province,Xinjiang Uygur Autonomous Region,Tibet Autonomous Region,Shanxi Province,Heilongjiang Province.

4.3. Conclusion

The positive correlation group represented by Beijing, Shanghai, and Guangzhou is highly overlapping with the previous division of provinces in the eastern and central regions, but provides a more precise respective division. The disadvantage of dividing by region is that only broad conclusions can be drawn, i.e., financial inclusion in a certain region has a facilitating effect, and there is a more nuanced analytical perspective after obtaining the clustering results of each province.

For example, Chongqing and Sichuan, which are classified as western regions, are classified into a positive association group in the clustering and are no longer bound to be analyzed together with other regions when there is a suppression of financial inclusion in the western regions. After getting the detailed data, the results can be relied on to target the actual role of financial inclusion.

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Meanwhile, the results of this clustering confirm the conclusion of regional heterogeneity, that is, financial inclusion has a facilitating effect on provinces with higher income levels; conversely, it has an inhibiting effect.

On the whole, digital inclusive finance plays a positive role in promoting the income level of residents, i.e. the higher the degree of development of digital inclusive finance, the higher the income level of residents. Finance is an important source of vitality in the process of economic development, in the current domestic and international double-cycle pattern, digital financial inclusion has been the rapid development, but there are still certain deficiencies in the entire development process, so to make the economy can be sound and sustainable development, we need to study and analyze the level of development of digital financial inclusion from the theoretical and empirical point of view, as well as the impact of the development on China's economic development. This paper takes the residents' income level as the main object of research and analysis, that is, from the perspective of reality to explain the impact of the development of digital inclusive finance on the residents' income level.

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