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Mechanism Analysis and Response of Digital Financial Inclusion to Labor Economy based on ANN and Contribution Analysis

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Abstract: Given the inclusiveness of digital inclusive finance and its complex impact mechanism on the labor economy. This paper uses the characteristics of adaptive and self-learning ability of artificial neural network (ANN) to complete the hierarchical analysis of index weight. At the same time, the neural network structure is used to approach the real situation of the real response index data to the greatest extent, and the link weight between neurons is adjusted adaptively. Garson algorithm is used for sensitivity analysis. The study found that: (1) the indexes of digital inclusive finance have different importance to the indexes of labor economy, among which the most important are the number and amount of insurance per capita and the proportion of the number and amount paid by digital technology; (2) For different subdivided indicators, the indexes of digital inclusive finance determine different significance. This paper uses the concept of digital inclusive finance related tools and policies to solve the labor economy, so as to promote the overall economic construction. Based on data mining technology, this study studies the response and transmission mechanism of the concept of digital inclusive finance to the labor economy, and explores the labor economy problems such as improving labor productivity and labor mismatch in the economy under its 'inclusive' principle. Compared with the traditional weight analysis, it is closer to the real situation and has a stronger ability to fit the reality.

Keywords: Digital Inclusive Finance; labour economy; ANN; contribution analysis; influence mechanism

1. Introduction

The term "inclusive finance" was first formally proposed by the United Nations in 2005. It is defined as a financial system that can effectively and comprehensively serve all sectors and groups of society and aims to promote the provision of banking services on affordable terms to the broadest segments of society (Corrado & Corrado, 2017). The purpose of achieving inclusive finance is to enable economic entities of different social strata to obtain necessary and reasonable financial services and financial support (Qiu, 2022). In recent years, technical means represented by artificial intelligence, big data, cloud computing, blockchain, and the Internet of Things have contributed to a digital and intelligent development path represented by intelligent investment advisors, big data risk control, and blockchain collaboration, driving the rapid development of inclusive finance (supplementary literature) (Hasan, MM et al., 2020). As inclusive finance has become an important concept of global development, while traditional financial institutions have increased their practice of inclusive finance, Internet finance, which relies on innovative technologies, has further expanded the service scope and accessibility of inclusive finance and reduced financial constraints (Feng et al., 2020). The framework of traditional finance based on 'credit' has gradually been changed to digital realization based on 'data', which broadens the boundary of traditional economic theory, among which the transmission mechanism of digital inclusive finance is the most critical part.

At present, there are abundant macro-level studies on digital inclusive finance, mainly discussing its relationship with economic development and regional inequality. Empirical analysis shows that the

development of digital inclusive finance can significantly narrow the income gap between urban and rural residents (Song, 2017). The development of digital finance can significantly improve the level of inclusive financial development, and the improvement of inclusive financial development can significantly narrow the income gap between urban and rural areas (Zhang 2016). Digital inclusive finance can significantly improve China ‘s agricultural green total factor productivity, and the optimization of agricultural industrial structure can bring significant ‘structural growth effect ‘(Mingyong et al., 2022). In addition, digital inclusive finance has narrowed the regional differences in China ‘s urban-rural income gap. At the same time, digital inclusive finance has also narrowed the urban-rural gap between primary distribution and redistribution (Hongbo et al., 2022). Further research shows that digital inclusive finance contributes to sustainable economic growth by increasing loans from financial institutions, the number of household savings, the number of household consumption, etc. (Yang & Xinwei, 2022). Poor households can use digital finance to smooth survival consumption and accumulate development factors, but the effect is not significant. While non-poor households can effectively use digital financial functions to prevent risks, smooth consumption and accumulate factors, they can also have leisure and entertainment. The Matthew effect of digital financial development is obvious (Wang & Zhao 2020). For rural development, research shows that digital inclusive finance plays a significant and positive role in promoting high-quality rural development mainly through economic efficiency, urban-rural structure, green ecological development, people ‘s livelihood harmony, innovation and development potential and other channels (Le & Congmou, 2022). The above research has explored the various effects of digital inclusive finance on labor production. It is not clear what aspects of digital inclusive finance and how to transmit the changes in labor economy. This paper uses the labor economy as a starting point, and uses artificial neural network (ANN) -contribution analysis to study the transmission mechanism of various aspects of digital inclusive finance to the labor economy.

The structure of this paper is as follows. In section 2, we review the relevant research on digital inclusive finance and labor economy and construct a framework for the impact mechanism of digital inclusive finance. In Section 3, we introduce the algorithms and evaluation metrics used in this paper. In Section 4, we make a specific analysis of Northeast China. Sections 5 and 6 show the importance of digital inclusive finance indices and review our work.

In summary, the structure of this article is shown in Figure 1:

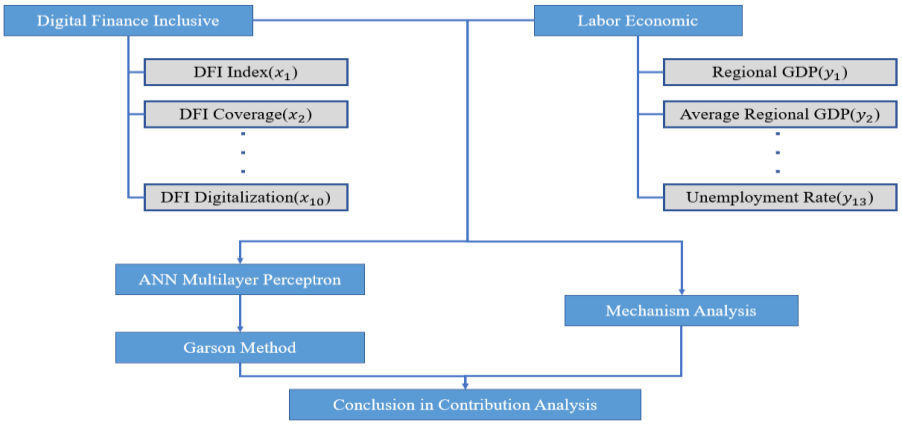


Figure 1. Mechanism Analysis and Corresponding Research Architecture

This study has the following four contributions:

In view of the inclusiveness of digital inclusive finance, the research perspective is locked in its research object, that is, the labor relationship between workers and capital owners, and the micro-study of the transmission and response mechanism of digital inclusive finance to the labor economy (Aisaiti et al., 2019).

Using artificial neural network algorithm to deal with the nonlinear, non-convex and non-limitation problems that may arise in the correlation of multiple secondary indicators in the field of digital inclusive finance and labor economy (Maia & Menezes, 2014; wu et al., 2009).

Using the characteristics of adaptive and self-learning ability of artificial neural network, the analytic hierarchy process of index weight problem is completed. At the same time, in order to approach the neural network structure of the real response index data as much as possible and adaptively adjust the link weight between neurons, the Garson algorithm is used for sensitivity analysis (Casadei & Astolfi, 2018; fischer, 2015; wu et al., 2009).

As a microscopic study of the transmission and response mechanism of digital inclusive finance to the labor economy, testing the empirical marginal effects of research results from the perspective of contribution analysis has practical guiding significance in policy formulation, economic prospect development and sinking market extension (Wang and Chen; zhou et al., 2022).

2. Literature Review

2.1 Digital Inclusive Finance

Digital inclusive finance (DFI), that is, through big data, blockchain, and other technologies to break the boundaries of space and time, provides convenient, efficient, and reliable financial services to people in non-developed areas and rural areas. It specifically encompasses two concepts, one is "inclusion" and the other is "digital". (Ozili, 2018) To further clarify the connotation and meaning of digital inclusive finance, this paper understands it from the following two dimensions:

First, "Inclusion" is the core purpose of the financial system. It can be divided into two characters in Chinese which respectively mean "universal" and "benefit". That is to say, the financial system not only emphasizes the universality and wide coverage of the audience but also emphasizes its essence of benefiting the people (Zhang et al., 2022). The concept of inclusive finance was first introduced by the United Nations in 2005 and is defined as "a financial system that effectively and comprehensively serves all segments and groups of society, especially poor, low-income people".(Yang & Zhang, 2020) In the early days, inclusive finance was mainly in the form of microfinance, providing affordable capital lending to the general public, especially the disadvantaged, and also providing channels for start-ups to raise funds. And with its gradual development, both internationally and in China, inclusive finance has gradually moved from a focus on microfinance to cover a wide range of business areas such as payments, deposits, loans, insurance, credit services, and securities. However, while China has made significant progress in financial inclusion, digital financial services are still crucial to fill the gaps in financial inclusion (Ji et al., 2021).

Therefore, digital is an effective way to promote the vision of "inclusive". Unlike traditional inclusive finance, digital inclusive finance combines "digital" with "inclusive", using digital technologies such as big data and cloud computing to increase the scope and coverage of financial services, lower the threshold for financial services, and provide lower cost, faster and wider coverage financial services to a wider range of people (Gabor & Brooks, 2017). It also further reduces the financing constraints on entrepreneurial activities due to information asymmetry in financial transactions and thus improves the efficiency of financing (Fan & Zhang, 2017). In addition, digital

inclusive finance can contribute to urban innovation through improved access to credit, consumption and industrial upgrading (Li & Li, 2022). Studies have shown that financial inclusion in practice is now strongly correlated with innovative digital finance, and it is evident that new digital economic models have become important drivers and sources of growth for sustainable financial inclusion(Chen et al.).

In summary, digital inclusive finance is a financial system that combines digital technology and finance to achieve inclusive purposes, and the addition of digital technology has opened up a new and viable path for the sustainable development of inclusive finance. To understand the current status of digital inclusive finance development in each region and further achieve the goal of promoting inter-regional inclusive finance development, a set of indicators to measure the level of digital inclusive finance development in different regions is essential (Chen et al. 2020). In 2011, a team of researchers from Peking University's Digital Finance Research Centre and Ant Group Research Institute used Ant Group's massive data on digital inclusive finance to compile a "Peking University Digital Inclusion Index", which provides a set of instrumental data reflecting the current status and evolution of digital inclusive finance development in China. Based on clarifying the connotation and meaning of digital inclusive finance, this paper introduces and explains the first two dimensions of the index system, and explores the construction of a digital inclusive finance-related index system in China, thus providing a reference for the construction of an international digital financial inclusion index system.

The Peking University Digital Inclusive Finance Index (PKU-DFIIC) meets all the principles in the construction process, conforms to the connotation of digital inclusive finance ,and provides a reliable and authoritative indicator system for measuring the development status of this financial system(Arner et al., 2020), which can provide a reference for the construction of an international digital financial inclusion index system. In this study, the Peking University Digital Inclusive Finance Index is compiled as follows (Table 1).

Table 1. Digital financial inclusion indicators and meanings

Tier 1 indicators	Tier 2 indicators	Indicator Description	Indicator number
Digital Inclusive Finance Index	Index	Combined values calculated for each indicator	X_1
Breadth of Digital Financial Coverage	Breadth	Alipay account coverage and number of bank cards per capita	X_2
	Depth	A calculated composite of all indicators on depth of use	X_3
	Payments	Number and value of payments per capita	X_4
	Insurance	Number and value of insurance policies per capita	X_5
Depth of digital financial usage	Money Funds	Number and value of money fund purchases per capita	X_6
	Investments	Number and number of investments per capita	X_7
	Credit	Number of credits calls per capita for natural persons	X_8
	Credit	Number and value of loans per capita	X_9
Digitization of financial inclusion	Degree of digitization	Number and value of payments made using digital technology	X_{10}

2.2 Labor Economics

The theory of labor economics mainly focuses on labor relations and summarizes the laws of development of labor economy. It analyzes how to create the highest economic efficiency with the lowest labor cost (Wang, 2016). With the development of labor economics, it was labeled as "personal economics" in 1980. However, this label ignored the impact of intrinsic management on labor economics. There are two important assets in labor economics, namely fixed assets and human assets, among which there is a distinction between individual human assets and team human assets. Also, human capital is an indirect market influenced by salary designation mechanism and labor market wages. Thus, it can be concluded that labor economics is an emerging doctrine with a special character because it takes "labor force" as its object of study. The core of this doctrine is to study the factors affecting labor supply and labor demand in the labor market and the interaction between them. Since labor has special properties that make it different from ordinary commodities, classical theories that do not distinguish it cannot fully take into account the problem of unsystematic risks and residuals (Xia 2001; Yuan & Lin 2011). In summary, labor economics is used here as a primary indicator, while secondary indicators are established by considering the factors that affect labor supply and labor demand from a microeconomics perspective and the factors that cause interactions from a macroeconomics perspective. The labor economic indicators and related meanings are shown in Table 2.

Table 2. Labor economic indicators and their meanings

Level 1 Indicators	Level 2 Indicators	Indicator Description	Indicator number
3Labor Economics	Gross Regional Product	The sum of the value added of each industry in the region	Y_1
	Gross regional product per capita	Gross regional product calculated on average for the entire resident population in a year	Y_2
	Total Retail Price Index	A relative number reflecting the trend and extent of changes in retail prices of goods over a certain period of time	Y_3
	Consumer Price Index	Relative measure of price changes over time for consumer goods and services	Y_4
	Birth rate	Ratio of births per 1,000 population in a year	Y_5
	Mortality rate	Ratio of average number of deaths per 1,000 population in a year	Y_6
	Natural growth rate	Ratio of natural population growth per unit of time in a year to the average annual total number of people	Y_7
	Total Wages	The total amount of labor compensation paid directly to all employees of each unit in a certain period of time	Y_8
	Average Wages	The average amount of monetary wages received per person in a certain period	Y_9
	Average wage index	Ratio of the average wage of employees in the reporting period to the average wage of employees in the base period	Y_{10}
	Number of employed persons	Number of people who are engaged in certain social labor and receive labor compensation or business income in a certain period	Y_{11}

Unemployed persons	Persons of working age who have the ability to work, are currently unemployed, and are seeking work in some way	Y_{12}
Unemployment rate	Number of employed people who meet all employment conditions in a given period who are still not working in the labor force	Y_{13}

2.2.1 Analysis of the impact mechanism of digital inclusive finance

Digital inclusive finance facilitates the action of financial inclusion through digital technology, which contains mobile payment and microfinance to serve the majority of micro and small enterprises as well as residents (Huang & Huang, 2018). The labor economy contains various factors such as labor supply and demand allocation, macro and micro management of labor, labor efficiency, and labor reproduction, and the specific influence mechanism is shown in Figure 2.

From the connotation of both, digital inclusive finance has a coupling effect with the benign development of the labor economy. First of all, a sound financial system also has very good support for financial products and services for the lack of credit history, non-high-income groups and micro and small enterprises. A complete credit system for micro and small enterprises brought by digital inclusive finance can, to a certain extent, alleviate the financing constraints of micro and small enterprises (Jiang and Jing 2021) and facilitate the expansion of business scale (Kerr and Nanda, 2010) while stimulating the labor demand side of enterprises and, to a certain extent, improving the unemployment problem and raising the hourly wage rate of workers (Phillips, 1958). In addition, the development of digital inclusive finance can stimulate the demand side of business and improve the unemployment problem to some extent and raise the hourly wage rate of workers (Phillips, 1958).

In addition, the development of digital inclusive finance can further enhance the productive capacity and technology level of firms by alleviating the level of financing constraints in the financial market, which leads to an increase in the marginal output per unit of labor in firms, which in turn increases the demand for labor or the ability of firms to pay wages, and this transmission mechanism promotes labor productivity and employment levels. As a result, this paper proposes hypothesis H1.

H1: Digital inclusive finance can alleviate the financing constraint of business operation and entrepreneurship process and thus promote the labor economy.

Digital inclusive finance contributes to the mobility and convenience of services, and on this basis, it has both breadth and depth of service coverage, and digital inclusive means represented by mobile payment contribute to the development of the platform economy (Wang et al. 2017). The development of platform economy contributes to the refinement of the demand side of labor, the increase of labor flexibility, the diversification of employment forms, and the significant increase of the number of payments and insurance holdings per capita of labor. As a result, this paper proposes hypothesis H2.

H2: Digital inclusive finance can promote the development of labor economy by promoting the mobility, convenience, and coverage of various services and thus the development of labor economy.

Second, due to the existence of market segmentation, factors of production cannot flow freely, or it is difficult to promote the flow of factors to more efficient areas due to information asymmetry, which will lead to factor mismatch (Zhang & Wang, 2020). Digital inclusive finance can improve information asymmetry and alleviate the problem of weakened free mobility of factors for the purpose of protecting local industries, thus improving labor mismatch and macro and micro management of labor, but there is some heterogeneity in this mechanism, so digital inclusive finance has a moderating

effect on the benign development of labor economy. As a result, this paper proposes hypothesis H3.

H3: Digital inclusive finance can improve labor allocation and macro and micro management and thus promote the development of labor economy.

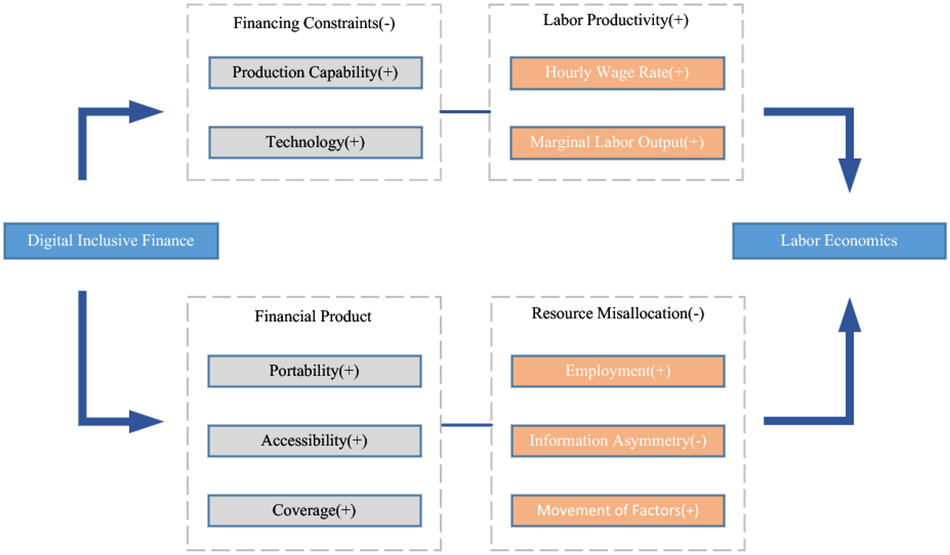


Figure 2. The Transmission Mechanism of Digital Inclusive Finance on Labor Economy

3. Methodology

3.1 ANN method

An artificial neural network (ANN) is a numerical and mathematical model that simulates the neural structure of the human brain and is a framework for different machine learning algorithms that are used to process complex data inputs and work in tandem. Such a system simulates the process of transmitting stimuli by means of linear weighted summaries and function mappings to nerve cells in the human brain, with the adjustment of weights in the network structure achieved through optimised learning algorithms, featuring massively parallel processing, distributed information storage, self-organisation and self-learning. As a means of statistical modelling artificial neural networks have the following characteristics: (1) They have the ability to perform better for complex non-linear relationships. (2) No pre-specified fitting functions are required, with learning and highly adaptive recognition patterns(Chen, S. W. et al.) , i.e. they do not require a pre-determined mathematical relationship for mapping between input and output, and can reproduce complex non-linear input-output relationships and be applied in the sequence training process.

The network consists of at least three layers of nodes forming a synaptic hierarchical framework: the basic components of an artificial neural network are an input layer, a hidden layer and an output layer, combined by weights, biases and activation functions(ZY, AW, & CH, 2022) The general topology of the ANN is shown in Figure 3. The dots represent the nodes of the neural network and are often referred to as neurons. The lines connecting the neurons are called synapses, which can be understood as connections between neurons, and serve to allow signals from the previous layer to be received by the next layer of neurons. Figure 4 illustrates the working mechanism of neurons in a typical ANN structure.

During ANN training, each neuron in the input layer receives data, multiplies the values by the

weights and passes the results to the hidden layer. The neuron in the hidden layer generates the output signal by means of an activation function on the activation signal transmitted by the previous layer. The activation signal is a weighted sum of all signals entering the neuron, as shown in equation (1).

$$x_j = \sum_i^n x_i \omega_{ij} \qquad (1)$$

x_i are the neurons in the input layer and ω_{ij} is the first neuron of the input layer neuron i of the hidden layer and the x_j is the weight vector between the first neuron in the input layer and the first neuron in the hidden layer, and x_j is a neuron j is the activation signal received by the neuron in the hidden layer. The hidden layer neuron generates the output signal through the activation function. There are various forms of activation functions for the hidden layer, usually Sigmoid and RELU functions, which produce a non-linear dependency between the input signal and the output result, and therefore a non-linear fitting algorithm must be used to determine the model parameters(J., J., A., N., & M., 2021) . The general form of one of these Sigmoid functions is as follows.

$$f(x_j) = \frac{1}{1 + e^{-x_j}} \qquad (2)$$

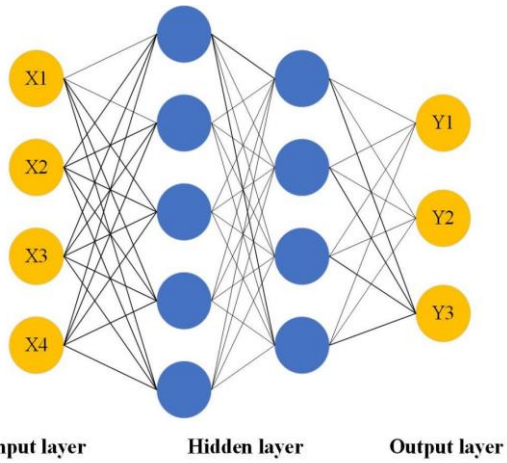


Figure 3. Artificial neural network training architecture

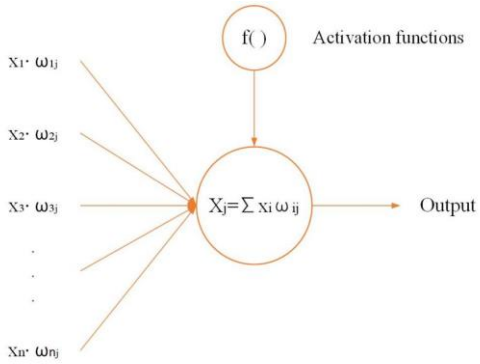


Figure 4. Hidden layer cell activation function

3.2 Garson's algorithm

Garson's algorithm is a method for weight analysis based on the connection weights between layers of a neural network (Wong et al. 2011). It is a typical algorithm for sensitivity analysis based on connection weights. The basic principle is to calculate the contribution of the input variables to the output variables by the product of the connection weights, and the Garson method takes into account the effect of the interaction of multiple variables on the output compared to other methods (Zheng et al. 2018). The Garson algorithm uses the connection weights between each input signal in the network as a 'bridge' and calculates the relative contribution of each input parameter to the output parameter using a matrix of weights (Cao et al. 2022). The Garson algorithm uses the connection weights between each input signal in the network as a 'bridge'. Specifically, the algorithm determines the contribution of each input value to the input value by assigning the hidden layer-output layer connection weights of each hidden layer neuron to the connection weights of each input signal to which it is connected (Bai et al. 2020). The formula for the degree of influence of the algorithm's input variables on the output variables is

$$Q_{it} = \frac{\sum_{j=1}^{l}\left(\left|w_{ij}v_{jt}\right| / \sum_{r=1}^{n}\left|w_{rj}\right|\right)}{\sum_{i=1}^{n}\sum_{j=1}^{l}\left(\left|w_{ij}v_{jt}\right| / \sum_{r=1}^{n}\left|w_{rj}\right|\right)} \tag{3}$$

Of which n, the l and q are the number of neurons in the input layer, the hidden layer and the output layer, respectively, and w is the connection weight of the input layer to the hidden layer, and v is the connection weight of the hidden layer to the output layer.

3.3 Algorithm test index setting

The number of nodes in the hidden layer is determined by training the network, and in order to construct the optimal performance network, when testing the trained ANN model with test samples, some test metrics need to be selected to better guide the evaluation of the results of the trained model. In this paper, two common tests are selected, the mean absolute percentage error (MAPE) and the coefficient of determination (R^2)The MAPE error evaluation metric is calculated in Equation (4), where $y_i - \hat{y_i}$ is the true value on the test set MAPE is commonly used as a measure of accuracy, reflecting the degree to which the model is good or bad, and is a holistic approach to evaluating the model from an "average" perspective (Li & Peng 2018). It is an overall assessment of the model from an 'average' perspective. The closer the MAPE is to zero, the better the model is. (Zhi et al., 2022) MAPE is a measure of relative error. Mean absolute percentage error is a relative error measure that

uses absolute values to avoid positive and negative errors cancelling each other out.

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - y_i}{y_i} \times 100\%\right| \quad (4)$$

R^2 The range of values of $[0, 1]$, the formula for the calculation process is given in Equation (5), where the numerator part represents the sum of squared differences between the true and predicted values; the denominator part represents the sum of squared differences between the true and mean values. R^2 larger and closer to 1, the higher the correlation, the closer the forecast value is to the actual observed value and the model provides a good fit. If R^2 is close to 0, the model is a poor fit. R^2 is an important indicator for determining the goodness of fit of a model (Zhang, 2015).

$$R^2 = 1 - \frac{\sum_i (\hat{y_i} - y_i)^2}{\sum_i (\overline{y_i} - y_i)^2} \quad (5)$$

4. Result

4.1 Selection of the study population

The Northeast China region, which comprises the three provincial administrative divisions of Heilongjiang, Jilin, and Liaoning provinces (from 118°53′E in the west to 135°05′E in the east, from 38°43′N in the south to 53°33′N in the north), was an extremely important center of heavy industry in the early years of China's history, based on its geographical location, natural resources, and history. The data from the Northeast region of China is chosen because its major economic sectors are more closely aligned with the labor economy, and the data from the Northeast region is more representative of the impact of financial inclusion on the labor economy than the more advanced regions, which is of greater importance to the empirical evidence in this paper.

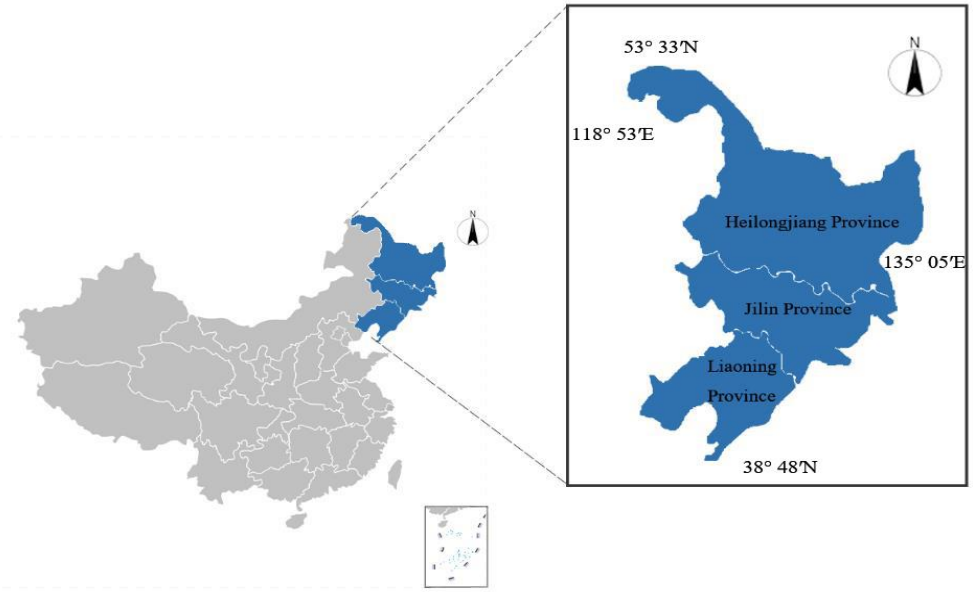


Figure 5. Geographical location of the North East Region

As the origin of the rapid industrial development of new China, the Northeast rapidly developed an industrial and agricultural economic production model in the 1950s, characterized by planned production and Soviet model management. By the end of the 1950s, the GDP of the Northeast had exceeded 15% of China's total GDP, reaching 19% at one point, and has remained at around 13% since then.

However, as China's modernization process has increased the need for productive forces and relations of production, the main contradictory features of the old industrial bases in the Northeast, such as a single industrial structure, a rigid management system, and a lack of innovation, have gradually come to light, leading to a slowdown in economic growth and, with it, a gradual loss of labor. According to the data disclosed in the China Labor Statistics Yearbook by year, the number of laid-off workers in the Northeast Region has been increasing rapidly year on year, from a total of 60,500 in 1992, accounting for 3.7% of the region's working population, to 225,400 in 2000, accounting for 10.95% of the region's working population, which was among the highest in China during the economic transformation and reform of the 1990s. The data also shows that between 1998 and 2000, the number of registered urban unemployed nationwide reached 5.71 million, 5.75 million, and 5.95 million respectively, while the number of unemployed workers in the Northeast Region reached 833,000, 854,000, and 895,000, which together accounted for 14.83% of the total number of unemployed people in the national economy and the population continued to maintain a negative natural growth rate during the reform and opening up process. In particular, in the context of the current new industrialization path of high quality and light pollution, the focus on innovation-driven, transformational development and digitization has led to the integration of information technology into the industrial model, which has led the Northeast, which relies heavily on heavy industry, to finally face the serious challenges posed by the resource-based industrial layout for sustainable urban development after decades of resource consumption and environmental pollution. With a total GDP of RMB 5.57 trillion by 2021, the economic growth rate of the Northeast has been lower than China's average growth rate of 8.1%.

The Northeast, with its natural resources and other advantages, was once the lifeblood of China's economic development as the first heavy industrial base built after the founding of New China. However, the problem of slow economic growth and overall economic decline caused by a series of factors such as difficulties in industrial transformation, severe environmental pollution problems, and a large loss of young people is a dilemma that the Northeast has always faced.

4.2 Data collection and pre-processing

In summary, the Northeast region of China is used as the objective of this study. Combined with the character of informatization and universality of digital inclusive finance, the purpose of this paper is to quantify the response mechanism and correlation degree of digital financial inclusion to the labor economy by taking into account the problems of an aging population, imbalance of labor supply and demand, and weak blood generation mechanism in the Northeast region, and to explore the solution of labor economy problems through the construction of digital financial inclusion, thus further promoting the modernization process. Table 3 and Table 4 show the data of digital inclusive finance and labor economy after descriptive statistical processing.

Table 3. Data on digital financial inclusion indicators

Tier 1 indicators	Tier 2 indicators	Max	Min	StdError	Mean
Digital Inclusive Finance Index	*X1*	345.93	33.79	97.13	216.71
Breadth of digital financial coverage	*X2*	331.03	29.94	95.74	196.19
	X3	344.44	34.99	95.23	209.31
Depth of use of digital finance	*X4*	248.66	35.62	79.79	169.51
	X5	651.16	37.40	205.46	465.72
	X8	237.91	33.91	63.34	138.27
Digitization of financial inclusion	*X10*	414.42	44.34	119.87	297.93

Table 4. Labour economic indicators data

Tier 1 indicators	Tier **2** indicators / Unit	Max	Min	StdError	Mean
Labor economy	*Y1/billion*	18566.27	9538.35	2512.49	14353.57
	Y2/yuan	55914.00	25650.76	8635.15	40846.63
	Y3	104.80	100.13	1.33	101.76
	Y4	105.40	100.77	1.22	102.37
	Y5/ %	8.13	4.96	0.93	7.00
	Y6/ %	9.83	6.19	1.01	7.16
	Y7/ %	1.46	-2.92	1.48	-0.16
	Y8/ billion	2733.12	1245.03	495.85	2216.18
	Y9/ yuan	77340.33	31353.00	15180.70	52574.59
	Y10	110.67	105.47	1.63	108.08
	Y11/ million people	1856.07	1691.81	51.07	1798.73
	Y12/ million people	37.53	32.20	1.75	34.97
	Y13/ %	3.90	3.60	0.08	3.80

Among the above data and indicators, three of the digital financial inclusion indicators, X6 (monetary funds), X7 (investment), and X9 (credit) are identified as invalid variables and removed from this study because of the large amount of missing data. The labor economic indicators of Y5 (birth rate), Y6 (mortality rate), Y7 (natural growth rate), Y10 (average wage index), and Y11 (employed persons) have missing data for individual provinces in individual years. Therefore, this study performs multiple interpolations of missing data for the scalar variables Y5, Y6, Y7, Y10, and Y11 by the fully conditional designation (MCMC) method.

4.3 ANN training and results

The article uses IBM SPSS Statistics as the ANN training software. The ANN is trained using a neural network multiple perceptions, with a hyperbolic tangent function for the hidden layer activation function and a range of 10-30 hidden layer units on a single hidden layer, to measure the R^2, and

MAPE between the predicted and true values for different hidden layer units, as a criterion to evaluate the optimal model. It was found that the prediction deviation was the smallest for a single hidden layer of unit 14, and the model accuracy converged to the best state with the highest confidence level. In this paper, a single hidden layer of unit 14 is chosen as the optimal parameter.

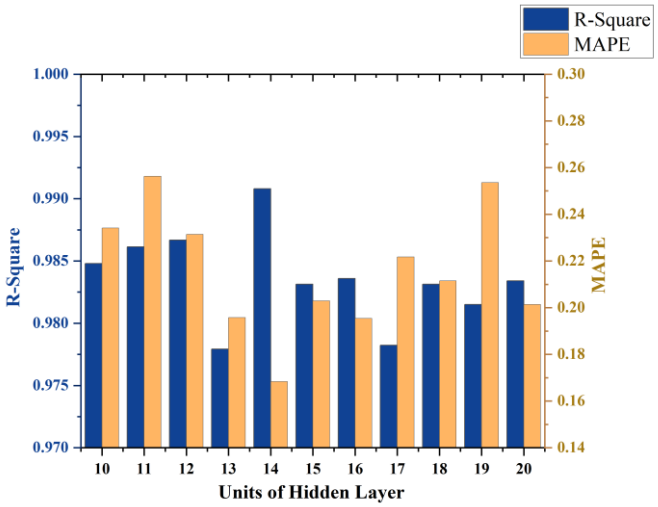


Figure 5. The degree of prediction deviation under different hidden layer units(Layer 10-20)

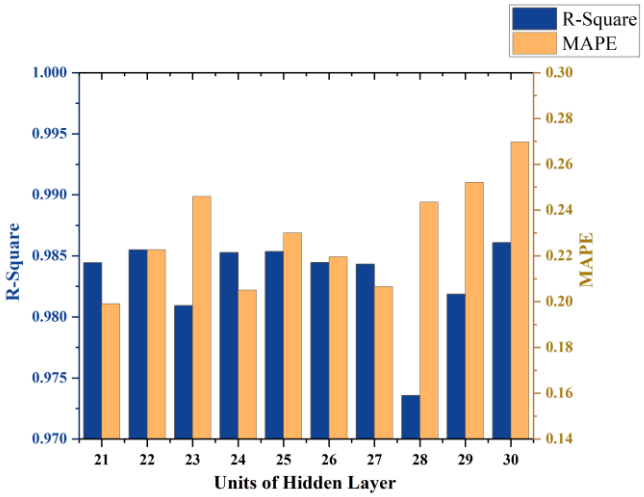


Figure 6. The degree of prediction deviation under different hidden layer units(Layer 21-30)

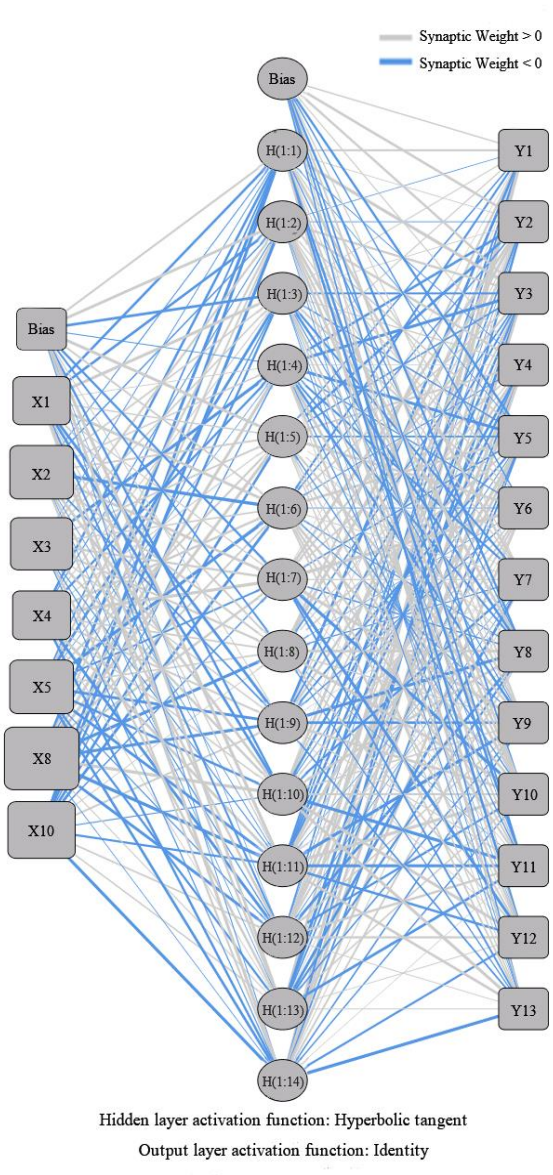


Figure 7. Artificial neural network training architecture and synaptic weights

5.Discussion

Based on the training results in Section 4.3, i.e., the importance of digital inclusion finance for the labor economy and the overall independent variable importance analysis, the following discussion is derived in conjunction with the mechanism analysis:

For the overall digital inclusive finance-labor economy variable weights, the normalized importance of the number and value of insurance policies per capita, and the number and value of payments made using digital technology for labor economy indicators in the Northeast China Region between 2011 and 2020 were 100% and 99.3%, with very significant determination and transmission effects. The transmission effect of digital technology payments on enhancing monetary liquidity and thus boosting national economic dynamics is significant. With a well-developed electronic payment infrastructure and a well-developed and convenient personal platform, almost all workers will use digital payments as their primary means of payment, regardless of their macro-orientation or personal economic life. On the other hand, with the new demand for individual labor endowment distribution

and labor protection brought about by the development of the economic base, the issue of laborer rights and interests in the labor economy is also reflected here through the importance of insurance independent variables. Meanwhile, the importance of the digital financial inclusion index, digital financial coverage breadth, and digital financial usage depth indicators also reflect the role of digital finance in influencing the whole labor economy, as shown respectively in Figure 6 and Figure 7.

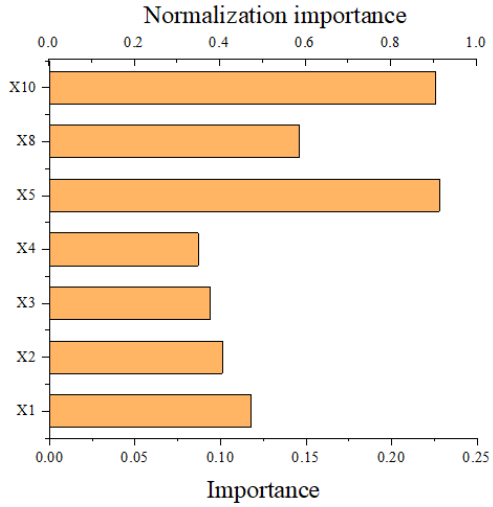


Figure 8. Overall independent variable importance graph

For gross regional product (*Y1*), the significance of the two independent variables, depth of digital financial use and breadth of digital financial coverage, is highly significant, fully reflecting the transmission of the impact of digital financial system building on capital inputs in the production relations to the final regional output. Similar to the overall digital financial inclusion-labor economy, the insurance variable also has a high degree of impact on regional gross product (*Y1*). As for the per capita gross regional product (*Y2*), the depth of digital financial use (*X3*) and the insurance variable (*X5*) are the two most significant independent variables, while the credit variable (*X8*) also shows relatively significant importance because of its focus on the number of credits calls per capita for natural persons.

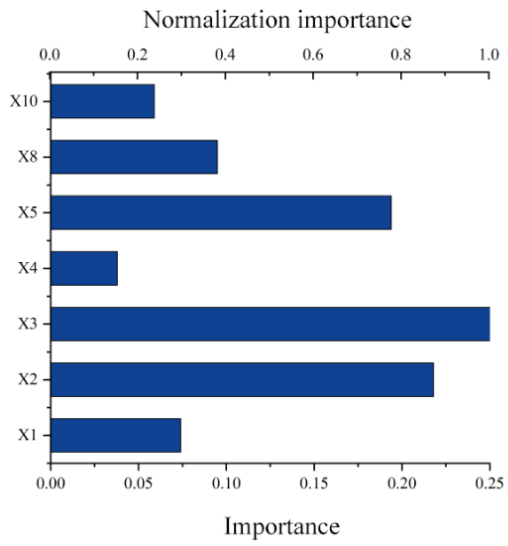
For the total retail price index of goods (*Y3*) and the total consumer price index (*Y4*), the breadth of digital financial coverage (*X2*), the number of payments per capita (*X4*), and the digitalization index (*X10*) are of significant importance because they are directly related to residents' personal consumption issues, and the credit variable (*X8*) is also of more significant importance because it is directly related to residents' credit consumption.

Concerning the demographic composition of the labor economy (*Y5* and *Y6*), the breadth of digital financial coverage, credit, insurance, and digitalization (*X2*, *X5*, *X8*, and *X10*) are also significant, while the depth of digital financial use and digital inclusion indices are relatively significant in relation to the natural growth rate of the population. This characterization is inextricably linked to the difficulties encountered in the transformation and upgrading of the Northeast Region. Due to the interference of the target production process in the late planned economy with the operation of the old industrial bases in Northeast China, the unemployment of workers in the reform of state-owned enterprises in the 1990s, and the relative backwardness of the reform of the economic model in the process of reform and opening up, the revitalization process of the old industrial bases in Northeast

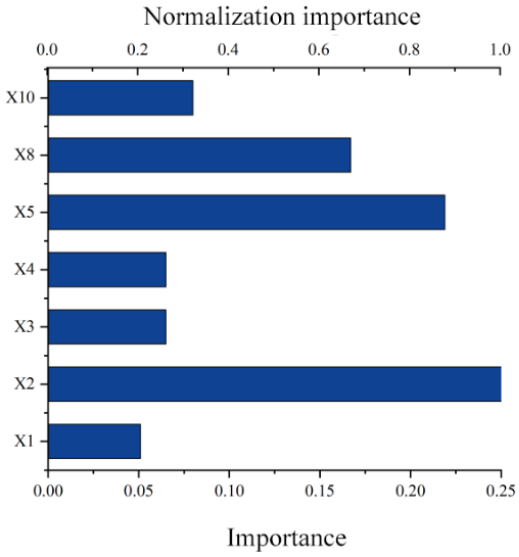
China has been slow. Although the educational resources are excellent, the loss of the labor force with middle and high-education backgrounds is so serious that there is a continuous negative natural growth rate. This shows that the depth of digital financial usage and the digital financial inclusion index have a significant effect on the response of the economic and financial system to demographic and talent issues.

For total wages (*Y8*), the digital financial inclusion index (*X1*) shows particularly significant importance, while for average wages (*Y9*), the breadth of digital financial coverage (*X2*) shows particularly significant importance, and for the average wage index (*Y10*), the number and amount of insurance per capita (*X5*) shows relatively significant importance. Meanwhile, the number of credits calls per capita for natural persons (*X8*) and the depth of digital financial usage (*X3*) also occupy a significant proportion of this normalized importance.

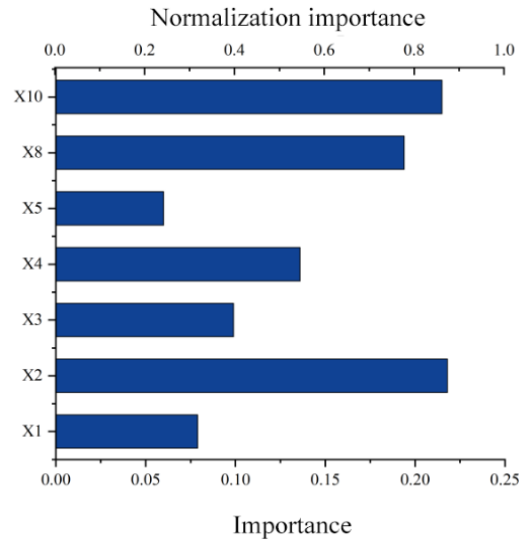
For the number of employed persons (*Y11*), all independent variables have similar normalized importance except for the degree of digitalization and the number and number of payments per capita (*X2* and *X8*). For the unemployed and the unemployment rate (*Y12* and *Y13*), there is a strong significance for the degree of digitization, the digital inclusion index, and the breadth of digital financial coverage (*X1*, *X2*, and *X10*), which is consistent with the additional focus on the more vulnerable labor groups in the "inclusiveness" principle of digital inclusion finance.



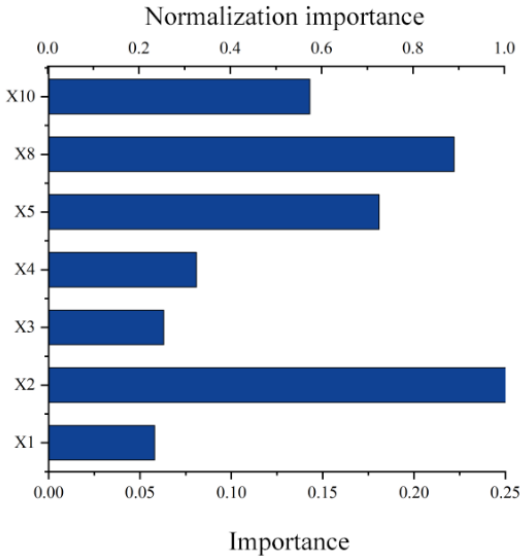
(a) Gross regional product/Y_1



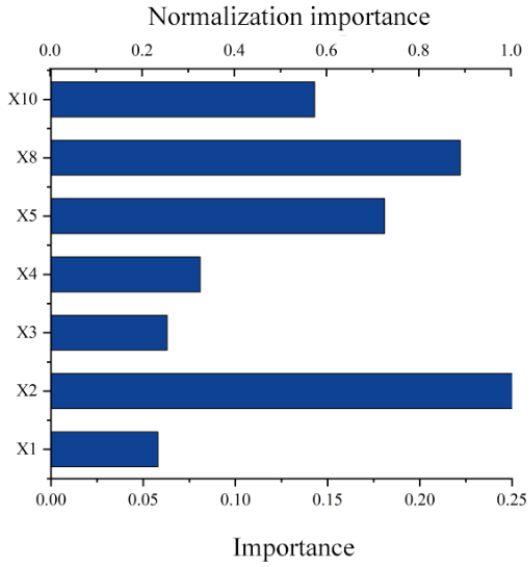
(b) Gross regional product per capita/Y_2



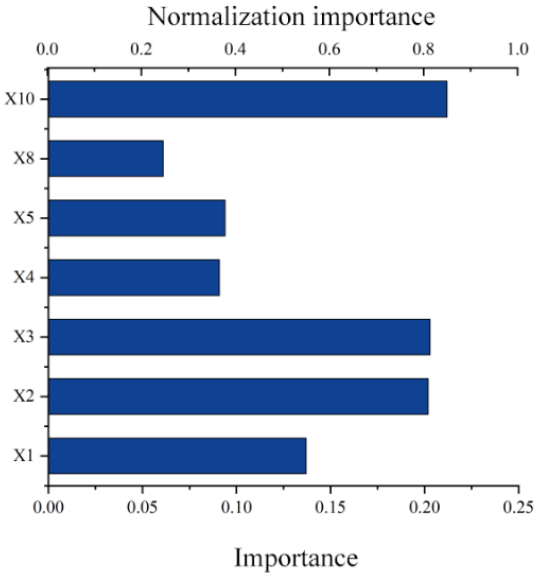
(c) Total retail commodity price index/Y_3



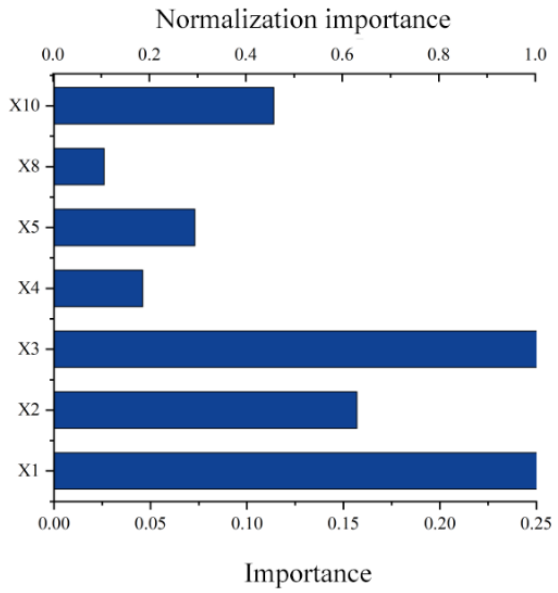
(d) Total Consumer Price Index/Y_4



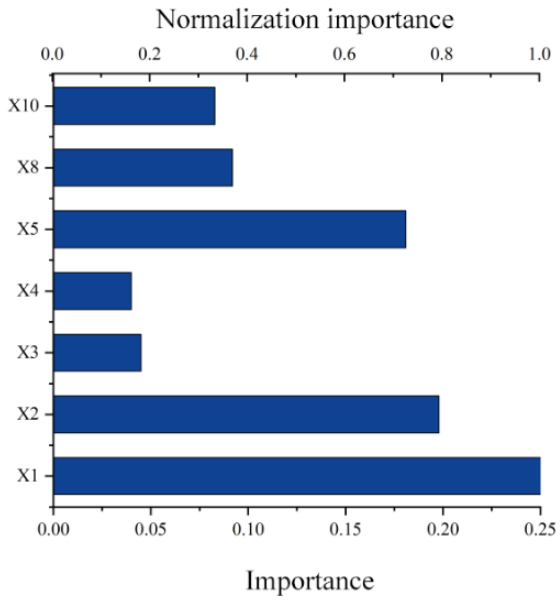
(e) Birth rate/Y_5



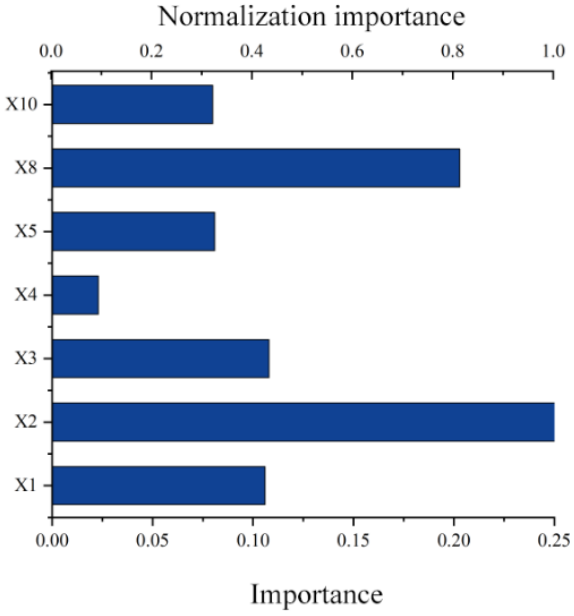
(f) Mortality rate /Y_6



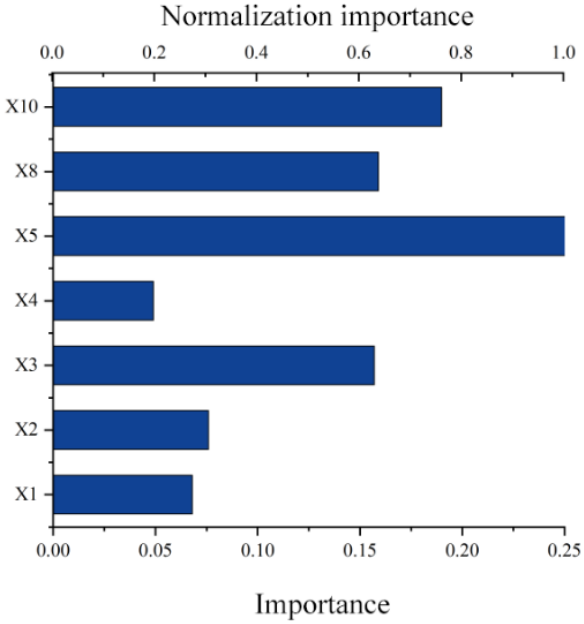
(g) Natural growth rate/Y_7



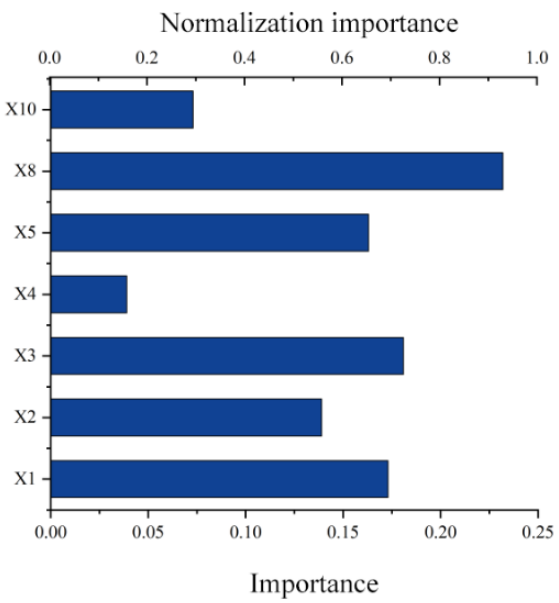
(h) Total Wages/Y_8



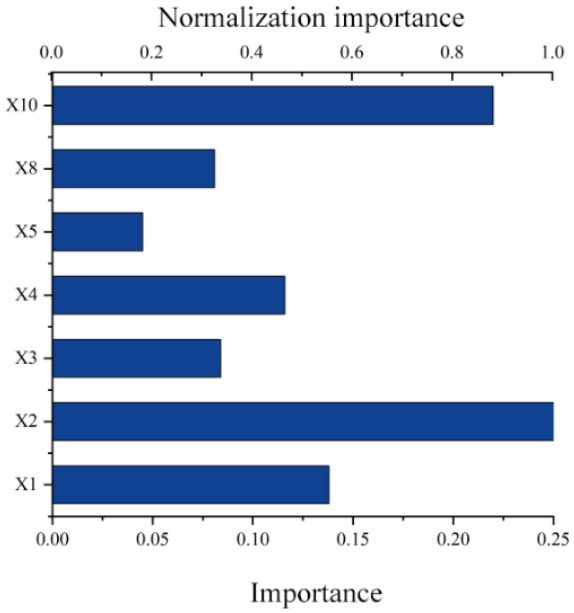
(i) Average wage/Y_9



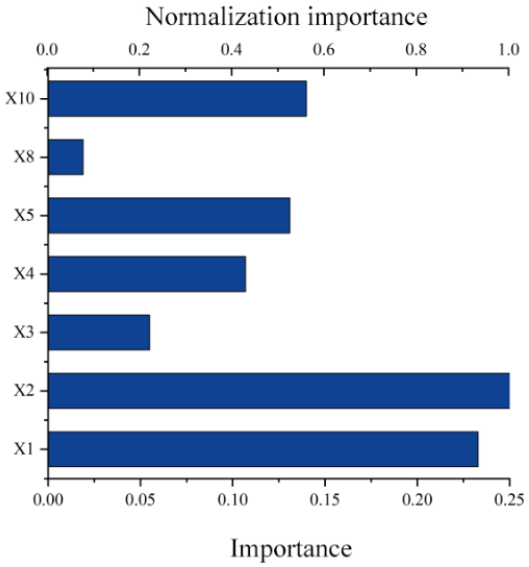
(j) Average wage index/Y_{10}



(k) Employment/Y_{11}



(l) Unemployment/Y_{12}



(m) Unemployment rate/Y_{13}

Figure 9. Labor Economic Impact of Digital Inclusive Finance

Based on the research results of this paper, the following policy recommendations are proposed:

(1) Improve the construction of digital infrastructure in backward regions, promote the popularity of economical smartphones among rural residents, narrow the differences in residents' external digital resource endowments, encourage financial institutions to provide digital products and services to lower net worth, and improve the coverage of digital inclusive finance. The digital dividend is used to improve residents' living standards and achieve universal benefits for the people, thus contributing to the realization of the goal of common prosperity.

(2) Strengthen the public welfare counseling and training of residents' basic financial knowledge, and enhance their willingness and ability to use digital inclusive finance, so as to fully enhance the accessibility of digital financial services and products, thus providing the possibility for low-income people to increase their property income.

(3) Further guide digital inclusive finance to focus on serving less developed regions, complementing traditional financial tools to better provide affordable financial support for production and living in less developed regions, narrowing the income gap between different regions, so that digital inclusive finance can better promote the common prosperity of all people.

6.Conclusion

In this paper, we innovatively use the analysis materials of the Peking University Digital Inclusive Finance Index released by the Peking University Digital Finance Research Center to study the response and transmission mechanism of the concept of digital inclusive finance on the labor economy and to discover the impact of its "inclusive" principle on the labor economy in such aspects as labor productivity enhancement and labor mismatch. At the same time, compared with most of the internationally constructed traditional inclusive finance indices, the concept of digital inclusive finance is also innovative in terms of combining digital technology and finance, which can improve information asymmetry, and alleviate the problem of reduced free mobility of factors caused by the purpose of protecting local industries.

In terms of research methodology, this paper makes use of the characteristics of ANN's adaptive and self-learning capabilities to complete the hierarchical analysis of the indicator weighting problem. The Garson algorithm is also used for sensitivity analysis to maximize the neural network structure that truly responds to the real situation of the indicator data and adaptively adjusts the link weights between neurons. Compared with the more common linear regression methods, the artificial neural network can more accurately fit the complex relationships between multiple independent variables and multiple dependent variables and deal with the possible nonlinearity, nonconvexity, and non-limitations that may appear in the correlation problem, Moreover, the positive-terminated importance derived from the artificial neural network training test is closer to the real situation compared with the traditional weight analysis, that is, it has a stronger ability to fit the reality. By discussing the results, different components of the digital inclusive finance index have different significant correlations to various secondary indicators of the labor economy. The Garson algorithm is also used for sensitivity analysis to maximize the neural network structure that truly responds to the real situation of the indicator data and adaptively adjusts the link weights between neurons. Digital inclusive finance complements various factors in the labor economy such as labor supply and demand allocation, macro and micro management of labor, labor efficiency, and labor reproduction, which alleviates the level of financing constraints in the financial market and can improve labor productivity and thus promote the development of the labor economy.

As a microscopic study of the transmission and response mechanism of digital inclusive finance to the labor economy, the empirical marginal effects of the research results are examined under the perspective of a contribution analysis, which has practical guidance in policy formulation, economic prospect development, and sinking market extension. At the same time, as the application of artificial neural network research methods in empirical economics, it has a certain degree of inspirational exploration significance for economic and financial empirical tests. Further, as a mechanism analysis and corresponding research of the digital inclusive finance concept and traditional labor economy, it promotes the advantages of the digital inclusive finance concept relative to the international traditional inclusive finance concept in terms of digital technology.

The study aims to explore what and how aspects of digital inclusive finance are transmitted to cause changes in the labor economy and to provide a quantitative study of the changes. After measuring

the importance of the variables of digital inclusive finance on the labor economy under the sub-indicators, linear regression analysis can be considered to measure the impact coefficients on this basis for further truth testing and expansion. The target geographic scope of this study is the Northeast China region, which shows strong sensitivity to labor economy indicators. The scope of the study can be further extended in the future.

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The order of the author's name is in alphabetical order, and the workload of each author is equivalent.

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