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A spatial perspective on the impact of digital financial inclusion on the employment structure of the labour force: Evidence from Chinese cities

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Abstract

In the context of big data, the rise of digital inclusive finance is driving the digital transformation of various industries, which in turn, has a profound impact on labour employment. Based on the panel data of 258 prefecture-level cities in China from 2011 to 2021, this article evaluates the impact of digital financial inclusion on the employment structure of the labour force and investigates its spatial spillover effects by constructing a spatial Durbin model and a mediation model. The study finds that: (1) Digital financial inclusion increases the employment demand for high-skilled and low-skilled labour and decreases the employment demand for middle-skilled labour, that is, the employment structure of the labour force shows a polarisation trend. (2) There is a positive spatial spillover effect of the impact of the development of digital financial inclusion on the demand for high- and low-skilled labour. (3) Financial digitisation plays an intermediary role in the process of digital financial inclusion affecting the employment structure of the labour force. Taking advantage of the dividends brought about by the development of digital inclusive finance and formulating policies according to the actual situation of each region indicate an undeniable choice for achieving full employment.

Keywords: digital financial inclusion; mediation effect; spatial Durbin model; structure of labour force employment

Introduction

Digital financial inclusion can be defined as 'the deployment of the cost-saving digital means to reach currently financially excluded and underserved populations with a range of formal financial services suited to their needs that are responsibly delivered at a cost affordable to customers and sustainable for providers' (World Bank 2014). In recent years, the rapid development of digitally inclusive financial technologies has attracted widespread global attention and indeed is changing the landscape of the financial industry, driving a shift in the financial services model towards digitisation, innovation, and intelligence. At the same time, the rise of digital financial inclusion has given rise to new forms of employment, such as the emergence of various forms of employment such as entrepreneurship, innovation, and flexible employment, thus further expanding employment opportunities. In turn, digital inclusive finance can influence labour force participation, for example, by improving the entrepreneurial and employment environment, enhancing employability, and reducing resource mobility constraints. The

development of finance contributes to the rational allocation of resources, reduces the mobility constraints of entrepreneurs, and further improves the financial service system, effectively promoting the enthusiasm of residents for entrepreneurship and employment.

As one of the largest digital financial markets in the world, China has seen a booming development of digital inclusive finance. In turn, this boom has had a particularly prominent impact on the labour force employment structure, which has always been a hotspot and a focus of attention in economic research and which is also directly related to the economic situation of the whole society and people's quality of life. Appreciating the changing trends in labour force employment structure and its influencing factors is of great significance in decision-making for the government, for enterprises, and for individuals.

In recent years, scholars have conducted preliminary studies on the impact of digital financial inclusion on labour force employment. Ran and Tang (2021) empirically found that digital inclusive finance can affect social employment, promoting employment in micro, small- and medium-sized enterprises and tertiary industry but inhibiting employment in the primary industry and part of the secondary industry. Fang and Xu (2020) found that digital inclusive finance has a positive impact on the employment of people with low education, increasing the ability of employees with low education and providing channels to access financial information, thus improving employment prospects. Lin et al (2019) studied the impact of inclusive financial development on employment based on data from Chinese cities and found that inclusive finance can increase employment in the secondary and tertiary industries.

Overall, recent studies have focussed on the employment impact of digital financial inclusion on different industries. However, the impact of digital financial inclusion on the employment structure of the labour force has not yet been fully researched and understood. The strong mobility of technological innovation and new knowledge factors brought by digital inclusive finance and the strong mobility of labour factors, which breaks the geographical limitation of the impact of digital inclusive finance on labour employment, mean that digital inclusive finance can play a role in affecting the employment of labour across regions by resolving information asymmetry, promoting entrepreneurship and employment opportunities, and lowering financial thresholds.

However, the impact of digital financial inclusion on the employment development of differently skilled labour forces has been studied only by a few scholars, and little of the existing literature starts from a spatial perspective. Therefore, building on previous studies on digital financial inclusion and the labour force (Li & Wan, 2022; Feng et al 2024; Ren et al 2023; Zhang, 2023; Elouardigh & Oubejja, 2023), and as there may indeed be spatial spillover effects of digital financial inclusion (Zhang et al 2023; Xing & Zhong, 2023; Jiang et al 2023), this paper focusses on the role of digital financial inclusion on labour force employment from a spatial perspective. It not only complements the relevant literature on the impact of digital inclusive finance development on labour force employment but also provides an in-depth study from a spatial perspective, which can help other scholars or practitioners in related fields to better analyse the connection between the two.

Therefore, the main questions researched in this paper are as follows:

(1) What is the impact of the development of digital inclusion on the employment structure of the labour force?
(2) What is the spatial link between digital financial inclusion and labour force employment structure?
(3) What are the potential mediators between digital financial inclusion and labour force employment structure?

(4) What are the heterogeneous effects of the relationship between digital financial inclusion and labour force employment in the three regions of East, Central, and West China?

Literature review

The rapid development of digital financial inclusion technologies has already had a wide-ranging impact on the labour market. The existing literature has mainly examined the impact of digital financial inclusion on employment promotion, labour mobility, and employment structure.

Looking beyond China, scholars have not only found that digital inclusive finance can stabilise employment and reduce poverty, but also that liberal financial markets have a significant impact on employment promotion (Karlan & Zinman, 2010; Boustanifar, 2014). Moreover, studies analysing data based on European and Central Asian countries have found that a thriving financial sector not only significantly promotes employment but also that the impact is size-neutral (Schäfer & Steiner, 2014). The development of digital inclusive finance is also able to promote overall employment in the service sector (Levy, 2018). From the above literature, we can see that the development of digital finance can promote employment, which in turn affects the employment structure of the labour force. At the same time, we can look at it from the perspective of microenterprises; it is evident that the development of inclusive finance can reduce the layoffs of employees in productive enterprises, thus reducing the unemployment rate (Caggese, 2019). Moreover, it can also bring jobs to more than 5 million labourers and further improve the problem of financing difficulties for small- and medium-sized enterprises (Manyika, 2016). From the perspective of technological advancement and entrepreneurship, digital financial inclusion can promote employment and entrepreneurship by, for example, expanding access to finance, which in turn provides the labour force with new labour opportunities that are not limited to ordinary forms of employment (Ayyagari et al 2021). However, as the cost of automation due to technological advances declines, the demand for non-automated labour increases, which to some extent affects the demand for low-skilled labour (Acemoglu & Restrepo, 2018).

From the perspective of the Chinese region, digital financial inclusion has a significant role in promoting the optimisation of China's employment structure, albeit a role which is heterogeneous (Li, 2022). As the level of digital economy development increases, some scholars argue that labour demand tends to polarise, that is, the increase in the level of digital economy development increases the demand for labour with education levels at primary school and below, and also at tertiary level of education (Yan, 2020). However, other scholars have suggested that although informatisation has driven changes in the labour market, there is no overall labour polarisation in China and that informatisation has facilitated the growth of highly skilled workers while reducing the demand for low-skilled labour (Xu & Zheng, 2020). In addition, digital financial inclusion also has a significant role in promoting rural entrepreneurship, not only enhancing rural entrepreneurial activity but also improving rural household entrepreneurship (Li & Liu, 2021). Meanwhile, from the perspective of labour mobility, digital inclusive finance attracts a net inflow of labour by reducing the degree of distortion of labour factor prices, providing employment opportunities and improving expected income. It is notable that there are also regional differences, with the marginal effect of digital financial inclusion being greater in the eastern coastal region (Zhou, 2022; Ma & Hu, 2022).

In summary, existing studies have tended to focus more on the promotion effect of digital inclusive finance on employment, entrepreneurship, and labour mobility. As a combination of digital technology and finance, few studies have dug deeper into the

impact of the development of digital inclusive finance on the employment structure of the labour force. Moreover, there is almost no literature that starts from a spatial perspective to study the spatial spillover effect of the impact of the development of digital inclusive finance on the employment structure of the labour force.

Therefore, in seeking to add to the existing literature, this article offers five distinct contributions. Firstly, it expands the relevant research on the labour market from the perspective of digital inclusive finance and explores the characteristics of the labour force employment structure driven by the development of digital inclusive finance. Secondly, this paper starts from a spatial perspective to study the relationship between the development of digital inclusive finance and the labour force employment structure and analyse the spatial spillover effect in depth, which supplements the gaps in the relevant research literature. Thirdly, by introducing the intermediary variable of financial digitisation (FD), this paper further studies the mechanism of digital inclusive finance and how it can affect the employment structure of the labour force. Fourthly, through the heterogeneity analysis, we explore the impact of digital inclusive finance on the employment of high-, medium-, and low-skilled labour in different regions and dig deeper into the differences in the demand for labour in the eastern, western, and central regions; this helps to supplement the research on the employment structure of the labour force by digital inclusive finance. Lastly, at the research level, this paper discusses the relationship between the development of digital inclusive finance and the employment structure of the labour force based on the data of prefecture-level cities, which is more general.

Theoretical analysis

The impact of digital financial inclusion on the employment structure of the labour force

First, on the one hand, under the framework of technological substitution theory, technological progress not only replaces part of the labour force but also triggers changes in the structure of the labour market (Acemoglu & Restrepo, 2019). Digital finance often involves a large amount of automation and application of information technology, and the rapid development of digital financial inclusion, has not only reduced the cost of production in the financial sector but also, through a certain crowding-out effect, will reduce the demand for part of the replaceable low- and middle-skilled labour force. That, in turn, may result in the automation or substitution of some middle-skilled labour force jobs (Autor et al 2003). Digital financial services, like automated account management systems, online payment platforms, and smart investment advisors, can perform tasks traditionally done by middle-skilled labour, in a more efficient and accurate manner.

Second, the growth of digital financial inclusion may also increase the demand for both low-skilled and high-skilled labour. Low-skilled labour may play an important role in digital finance, performing tasks such as data entry, customer support, and communicating basic financial literacy (Acemoglu & Autor, 2011). In addition, the development of digital financial inclusion has a significant role in stimulating mass entrepreneurship and promoting employment among the low educated. The willingness and ability of financial institutions to grant loans to individuals directly affect their motivation to start a business. Digital inclusive finance not only eases the credit constraints of farmers but also improves the accessibility of information to farmers, which ultimately stimulates their enthusiasm for entrepreneurship (He and Li, 2019).

An increase in entrepreneurship provides more jobs for the economy and society, broadening the scope of employment for the labour force and increasing the possibility of employment. The development of digital financial inclusion has increased the frequency and ability of people with low education to use financial tools, which improve their

financial literacy, while the development of experience has driven the overall increase in the demand for labour for basic positions (Autor & Dorn, 2013). At the same time, the application of advanced techniques and complex financial instruments in digital finance requires a highly skilled workforce to perform complex tasks such as data analysis, risk management, and strategy planning. Highly skilled labour is more able to take advantage of the innovative and intelligent features of digital financial inclusion technologies, to provide more advanced and complex financial services to meet market demands. Therefore, the development of digital inclusive finance not only promotes the employment of high-skilled labour within data analysis, risk control, and service but also enhances the employability of less-educated groups, ultimately generating the phenomenon of employment polarisation (Goos & Manning, 2007; Acemoglu & Restrepo, 2018).

H1. The development of digital inclusion reduces the demand for middle-skilled labour, while increasing the demand for low- and high-skilled labour, leading to a polarised labour structure.

Spatial spillovers of digital financial inclusion affecting the employment structure of the labour force

First, the development of digital financial inclusion often triggers structural changes in labour demand (Yan et al 2020; Sun & Hou, 2019). Through digitisation and automation technologies, the employment demand for certain traditional financial activities, such as traditional counter services and paper document processing, may decrease. At the same time, the development of digital financial inclusion can generate new employment opportunities in areas such as digital payments and fintech, positively affecting senior labour demand. Second, these changes are mobile, tending to start in one region gradually expanding to others, creating the so-called spatial spillover effect (Zhang et al 2023). Technological innovations and knowledge factors caused by the development of digital inclusive finance gradually accumulate, to a point where they produce spillover effects affecting enterprise and labour in neighbouring regions (Nie & Wu, 2021; Wang, 2023) and producing a positive impetus and overflow of innovation and knowledge (Zhang et al 2023).

Finally, innovation and knowledge spillovers can help improve the competitiveness of industries and the quality of labour in neighbouring regions through industrial linkage, thus changing the employment structure of labour. The upgrading and transformation of the financial industry, driven by the development of digital inclusive finance, promotes the development and change of the industrial chain, through cooperating with other industries, thus forming an industrial linkage effect. The industrial linkage effect then spreads to neighbouring regions promoting the development of other industries, thus affecting the employment structure and the employment prospects of the labour force. Based on the above analysis, this paper proposes the following hypothesis:

H2. There is a spatial spillover effect in the impact of digital inclusive finance on the employment structure of the labour force.

The mediating effect of digital financial inclusion on the employment structure of the labour force

The development of digital inclusive finance will change the organisational form as well as the business model of the financial industry, bringing certain technological innovations as well as application innovations (Hu et al 2024; Duan & Hu, 2023), which in turn will promote the digital transformation of the industry (Li & Zhang, 2023). In the process of the development of digital inclusive finance, the digital transformation of the enterprises and

the application of technology promote the innovation and efficiency improvement of financial services (Song et al 2023), which in turn may change the employment structure of the labour force. Furthermore, the degree of FD can be seen as a reflection of financial innovation in practice. Financial innovation has a broad impact on the economic industrial chain and the labour market, and the development of digital inclusive finance not only changes the organisational form and business model of the financial industry but also promotes innovation in related fields (e.g. e-commerce and internet technology). Such innovation is likely to trigger changes in the employment structure (Li & Wan, 2022) as the needs and skill requirements of financial practitioners change accordingly (Zhang et al 2023). Therefore, based on the above analysis, this paper proposes the following hypothesis:

H3. Digital inclusive finance can affect the employment structure of labour force by enhancing the degree of FD.

Research design: model setting—benchmark regression model setting

Common spatial models include the spatial autocorrelation model (SAR), the spatial error model (SEM), and the spatial Durbin model (SDM). SAR can be used to estimate the spatial spillover of labour force employment; SEM, to estimate the existence of spatial correlation in the error term, its economic significance lying in the fact that the inter-city spillover is the result of the action of stochastic shocks; and SDM, to account for the spatial correlation between the independent and explanatory variables, as it can reflect the spatial spillovers of digital financial inclusion and local labour force employment at the same time. SDM was deemed appropriate through the following steps: first, a significant LM test result (P-value = 0.000) indicated that it was possible to construct the SDM; second, the Hausman test result (P-value = 0.000) explicitly adds fixed effects to this model; furthermore, the LR test (P-value = 0.000) confirms that the data in this paper are not suitable for constructing a spatial lag model and spatial error model (Elhorst, 2012; Lu & Zhu, 2022; Wang, 2023).

A SDM with two-way fixed effects was explored using stata17 software; the specific form is as follows:

$$\text{LABOUR}_{it}^z = \beta_0^z + \beta_1^z W_k^z \text{LABOUR}_{it}^z + \beta_2^z FI_{it} + \beta_3^z W_k^z FI_{it} + \alpha_0^z \eta_{it} + \alpha_1^z W_k^z \eta_{it} + \lambda_{it}^z + \nu_{it}^z$$
$$+ \mu_{it}^z$$

$$(1)$$

In the above equation, LABOUR_{it}^z represents the demand of the city; i for the type of labour; z and t in the year t; z represents the labour force with different skills; FI_{it} is the core explanatory variable of the model, representing the digital financial inclusion index (FI); η_{it} represents a series of control variables; λ_{it}^z represents spatial fixed effects; ν_{it}^z represents time fixed effects; and μ_{it}^z is a random perturbation term.

Mediation effect regression model setting

A step-by-step regression method was used to verify the mediating effect of the degree of FD in the process of digital inclusive finance affecting the employment structure of the workforce (Wen 2014). The specific model setting is shown below:

$$\text{LABOUR}_{it}^z = \rho_0^z + \rho_1^z FI_{it} + \rho_2^z \eta_{it} + \lambda_{it}^z + \nu_{it}^z + \mu_{it}^z \qquad (2)$$

$$\text{FD}_{it} = \sigma_0^z + \sigma_1^z FI_{it} + \sigma_2^z \eta_{it} + \lambda_{it}^z + \nu_{it}^z + \mu_{it}^z \qquad (3)$$

$$\text{LABOUR}_{it}^z = \tau_0^z + \tau_1 FD_{it} + \tau_2^z FI_{it} + \tau_3^z \eta_{it} + \lambda_{it}^z + \nu_{it}^z + \mu_{it}^z \qquad (4)$$
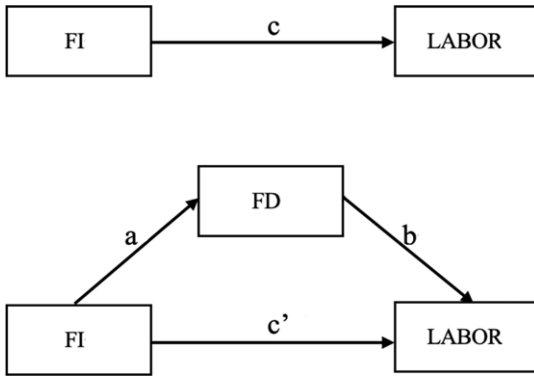
Figure 1. Schematic diagram of the mediation effect model

Table 1. Table of skill levels by educational attainment

Educational attainment	Classification
Primary and below	Low skill level
Middle school	Medium skill level
High school	
Post-secondary	High skill levels
Postgraduate student	

In the above equation, FD_{it} is the mediating variable of the model, representing the degree of FD, while the other variables have the same meanings as in Equation (1). The schematic diagram of the model of the mediating effect is shown in Figure 1.

Indicator setting explained variable: employment of differently skilled labour (LABOUR)

Studies on the measurement of labour force skill mainly include two dimensions: one is to measure skill level by the nature of labour force work, and the other is to measure skill by the education level of workers. Based on data availability, this paper follows Yan (2020) and Sun and Hou (2019) using education level as a proxy for skill, classifying those with a university college degree and above as highly skilled (high), a high school and junior high school education as middle skilled (middle), and primary school education and below as low skilled (low) – as shown in Table 1. In the regression analysis, the proportion of employed persons with high, middle, and low levels of education is used as an explanatory variable in order to discuss the regression results.

Core explanatory variable: digital financial inclusion index (FI)

Following Xie et al (2018), China's Digital Inclusive Finance Index was used as the core explanatory variable to portray the variation in the degree of development of digital inclusive finance in China. The index is published by the Digital Inclusive Finance Research Center of Peking University in conjunction with Ant Financial Services. The index consists of three sub-indicators, namely, the breadth of coverage, the depth of use, and the degree of digital support services.

Table 2. Results of descriptive statistics

Variable	Symbol	Sample size	Mean	Standard deviation	Minimum	Maximum
High skills	HIGH	258	0.1077	0.0900	0.0005	0.4461
Medium skill	MIDDLE	258	0.3447	0.0467	0.1462	0.4748
Low skill	LOW	258	0.3827	0.0561	0.0423	0.5904
Digital financial inclusion index	FI	258	5.0998	0.5162	2.8344	6.0704
Degree of financial digitisation	FD	258	5.2615	0.6010	1.2208	6.3651
Level of regional economic development	REG	258	10.7564	0.6064	7.6163	15.6752
Degree of economic agglomeration	ECO	258	0.7900	0.5798	0.0056	3.1520
Degree of government intervention	GOV	258	0.1834	0.0796	0.0116	0.6500
Labour and technology supply	LAB	258	10.5997	1.3306	5.4161	14.0672

Mediating variable: degree of financial digitisation (FD)
In this paper, we refer to Guo et al (2020) to construct an index measuring the degree of FD by taking the four aspects of mobility, affordability, creditworthiness, and convenience as secondary dimensions.

Main control variables
These are:

- Level of scientific and technological innovation (INNO): this paper uses the number of patents granted in each prefecture-level city to represent the level of scientific and technological innovation in each prefecture-level city.
- Degree of economic agglomeration (ECO): the number of employed people per unit area is used to measure economic agglomeration.
- Regional economic development level (REG): this paper uses local gross domestic product (GDP) per capita to measure the regional economic development level.
- Degree of government intervention (GOV): this paper measures government expenditure as a share of GDP.
- Labour and technology supply (LT): this paper measures the number of students enrolled in general colleges and universities.

The research sample draws on data relating to 258 prefecture-level cities in China from 2011 to 2021 sourced from the China Statistical Yearbook, the China Labor Statistics Yearbook, and the Peking University Digital Inclusive Finance Index. The descriptive statistics of the main variables are shown in Table 2.

Empirical tests and analysis of the regression results of the spatial Durbin model

The SDM constructed in the previous section empirically tested the impact of digital financial inclusion development on the employment structure of China's labour force. Columns (1)–(3) of Table 3 report the regression results of the impact of digital financial

Table 3. Spatial Durbin regression results

Variable	(1) High	(2) Middle	(3) Low
FI	0.0001***	−0.0002***	0.0003***
	(5.38)	(−3.03)	(11.39)
GOV	0.042***	−0.340	0.025***
	(8.01)	(−1.64)	(4.28)
REG	0.002***	0.009***	0.000***
	(2.87)	(2.83)	(6.48)
ECO	−0.004***	−0.008***	−0.002***
	(−5.83)	(−3.20)	(−9.07)
LAB	0.002***	−0.003**	0.000***
	(6.00)	(−2.35)	(4.38)
WFI	0.002***	0.0003	0.001***
	(24.86)	(1.01)	(5.23)
WGOV	4.454***	0.323	−0.491***
	(73.74)	(1.39)	(−11.05)
WREG	0.340***	0.044**	0.000***
	(68.17)	(2.24)	(24.95)
WECO	0.169***	−0.003	−0.094***
	(34.61)	(−0.15)	(−41.20)
WLAB	0.045***	−0.004	0.000***
	(23.18)	(−0.52)	(47.04)
Individual effect	Yes	Yes	Yes
Time effect	Yes	Yes	Yes
N	2838	2838	2838

*, **, ***represent the statistical values of the results that are significant at the 10%, 5% and 1% levels respectively.

inclusion on the employment structure of China's high-, medium-, and low-skilled labour force, respectively. On a national scale, the development of digital inclusive finance leads to a bimodal trend in the employment structure of China's labour force, that is, a decrease in the number of medium-skilled employed persons and an increase in the number of low- and high-skilled employed persons (Yan, 2020), confirming Hypothesis 1. Specifically, the FI coefficient (column 1) is significant and positive, suggesting that digital inclusive finance has a significant promotional effect on the employment of high-skilled labour, satisfying the market demand for more advanced and sophisticated financial services (Acemoglu & Restrepo, 2018).

The WFI coefficient is also significant and positive, indicating that there is a spatial spillover effect and that the development of digital inclusive finance in the local area will have a boosting effect on the employment of high-skilled labour in neighbouring areas, with the intensity of this effect greater than the effect on the local area. The FI coefficient (column 2) is significant and negative, indicating that the development of digital financial

inclusion inhibits the employment of middle-skilled labour. This is consistent with previous analysis finding the presence of a crowding out effect may lead to automation or substitution of some middle-skilled jobs (Autor et al 2003), which in turn reduces the demand for some highly substitutable low- and middle-skilled labour. The WFI coefficient is not significant, suggesting that there is no spatial spillover effect and that the development of digital financial inclusion in the local area will not affect the employment of middle-skilled labour in neighbouring areas.

The FI coefficient (column 3) is significant and positive, indicating that the development of digital financial inclusion has an important promotional effect on the employment of low-skilled labour. This is also consistent with previous analysis demonstrating an increase in demand for basic jobs such as conveying financial knowledge and data entry (which are performed by low-skilled labour), and the development of digital financial inclusion can promote the employment of low-skilled labour by increasing the frequency and ability to use financial instruments and easing the construction of credit constraints (Acemoglu & Autor, 2011; Autor & Dorn, 2013). Meanwhile, the WFI coefficient is also significant and positive, suggesting the existence of spatial spillover effects, where local digital financial inclusion development can promote the employment of low-skilled labour in neighbouring regions, and the strength of the impact is greater than the impact on the local area.

The regression results in Table 3 show that the development of digital financial inclusion can have a significant impact on the employment structure of the labour force, controlling for individual fixed effects, time fixed effects, the level of regional economic development, the degree of government intervention, the degree of economic agglomeration, and the supply of labour skills.

Analysis of spatial spillover effects

In order to better study the impact of digital inclusive finance in each region on the employment structure of the labour force in neighbouring regions, this article decomposes the total effect of digital inclusive finance into direct and indirect effects, with the direct effect being the impact of local digital inclusive finance on the employment structure of the local labour force and the indirect effect being the impact of local digital inclusive finance on the employment structure of the labour force in neighbouring regions. The results pertaining to spillover effects on the employment structure of the labour force are shown in Table 4.

In the short term, for higher-skilled labour, the regression coefficient for the direct effect is significant and positive at the 1% level, indicating that the development of digital inclusive finance can substantially promote employment of higher-skilled labour in the local area. The regression coefficient for the indirect effect is also significant and positive, indicating that the development of the digital inclusive finance in the local area can greatly promote the employment of higher-skilled labour in neighbouring areas. The reason for the spillover may be due to both the importance of technological innovation and the mobility of knowledge factors to production in regions with a high level of digital inclusive finance development (Nie & Wu, 2021; Wang, 2023). Advanced production and technological equipment require highly skilled labour for operation, as this form of production spreads to neighbouring regions so too does the demand for higher-skilled labour (Zhang et al 2023). For middle-skilled labour, the regression coefficient of digital financial inclusion is significant and negative at the 1% level, indicating that the development of digital financial inclusion can substantially inhibit the employment of local middle-skilled labour, but the regression coefficient of the indirect effect is not significant, indicating that there is no spatial spillover effect; similarly for low-skilled labour, the indirect effect is also not significant. This suggests that the spatial spillover effect brought about by the development of digital financial inclusion will only increase

Table 4. Direct effects, indirect effects, total effects

	Variable	(1)			(2)			(3)		
		Direct effect	Indirect effect	Total effect	Direct effect	Indirect effect	Total effect	Direct effect	Indirect effect	Total effect
Short period	FI	0.0001***	0.0012***	0.0014***	−0.0002***	0.0003	0.0002	0.0004	−0.0003	0.0001***
		(5.50)	(5.46)	(5.74)	(−2.86)	(1.24)	(0.60)	(0.18)	(−0.13)	(7.69)
	GOV	0.0024	0.7477***	0.7501***	−0.0307**	−0.0595	−0.0902	0.0894	−0.1430	−0.0537***
		(0.67)	(5.92)	(5.89)	(−2.17)	(−0.63)	(−0.97)	(0.09)	(−0.14)	(−10.80)
	ECO	−0.0004***	0.0027***	0.0023	−0.0019***	−0.0125***	−0.0144**	0.0058	−0.0169	−0.0111***
		(−2.79)	(1.50)	(1.30)	(−3.54)	(−2.62)	(−3.05)	(0.05)	(−0.14)	(−40.20)
Long period	FI	−0.0028	0.0020	−0.0008***	−0.0002	0.0002	0.0001	−0.0003	0.0004	0.0001***
		(−0.09)	(0.06)	(−8.75)	(−0.29)	(0.43)	(0.61)	(−0.13)	(0.15)	(7.72)
	GOV	−0.0659	−0.3940	−0.4599***	−0.0258	−0.0225	−0.0483	−0.0489	0.0176	−0.0313***
		(−0.01)	(−0.09)	(−10.04)	(−0.19)	(−0.16)	(−0.97)	(−0.34)	(0.12)	(−10.84)
	ECO	0.0170	−0.0184	−0.0014	−0.0014	−0.0063	−0.0078***	−0.0011	−0.0053	−0.0065***
		(0.09)	(−0.10)	(−1.40)	(−0.07)	(−0.29)	(−3.20)	(−0.04)	(−0.17)	(−42.49)

*, **, ***represent the statistical values of the results that are significant at the 10%, 5% and 1% levels respectively.

Table 5. Endogeneity test results

	(1)	(2)	(3)
Variable	High	Middle	Low
FI	0.0004*	−0.0004***	−0.000
	(1.70)	(−2.69)	(−0.06)
Other control variables	Control	Control	Control
N	258	258	258
Cragg-Donald Wald F-statistic: 95.7378			

*, **, ***represent the statistical values of the results that are significant at the 10%, 5% and 1% levels respectively.

the demand for higher-skilled labour in neighbouring regions, leading to an advanced labour force employment structure.

However, in the long run, the spillover effect of the impact of digital financial inclusion on the employment structure of the labour force is not significant.

Endogeneity issues

Considering that the problem of reverse causality may arise in the course of empirical research, that is, it is possible that the employment structure of the labour force in a region may drive the development of digital financial inclusion, and not only the level of digital financial inclusion development has an impact on the employment structure of the labour force, which in turn may lead to endogeneity problems. This paper refers to the practice of Yi et al (2018) and other approaches to construct a 'Bartik instrument' (the product of the lagged first-order FI DFI_ (j, t-1) and the first-order difference in time of the FI ΔDFI_ (t, t-1)), followed by two stage least square (2SLS) two-stage instrumental variable estimation. The empirical results in Table 5 show that the Cragg-Donald Wald F-statistic is 95.7378, which is significantly larger than the Stock-Yoo weak instrumental variable threshold of 10, that is, it passes the weak instrumental variable test.

In addition, the basic results of the impact of digital financial inclusion development on the highly and middle-skilled labour force remain significant, and the sign and significance of the coefficients of the digital FI remain consistent with the basic regression results, which supports the validity of the choice of instrumental variables. From the results of the regression of the Bartik instrumental variables in this section, it can be seen that the development of digital financial inclusion still has a significant impact on the employment structure of the labour force, even after taking into account the endogeneity issue; the baseline results are basically robust and basically reliable.

Robustness test

Referring to the study of Li (2022) and others, this paper adopts the method of replacing the core explanatory variables for the robustness test. In the 'Digital Inclusive Finance Index' data released by the Digital Inclusive Finance Research Centre of Peking University, there are also three sub-indicators, which are breadth of coverage (BREADTH), depth of usage (DEPTH), and degree of digital support services (DIGITAL). In this paper, the three segmentation indicators are used as core explanatory variables to substitute into the model, so as to verify whether the research results are robust. The test results are shown in Tables 6–8.

Table 6. BREADTH robustness test results

Variable	(1) High	(2) Middle	(3) Low
BREADTH	0.0026***	−0.0013***	0.0003***
	(43.92)	(−33.01)	(13.76)
Individual effect	Yes	Yes	Yes
Time effect	Yes	Yes	Yes
N	2838	2838	2838
R^2	0.463	0.411	0.989

*, **, ***represent the statistical values of the results that are significant at the 10%, 5% and 1% levels respectively.

Table 7. DEPTH robustness test results

Variable	(1) High	(2) Middle	(3) Low
DEPTH	0.0017***	−0.0010***	−0.0007***
	(22.43)	(−22.35)	(−11.43)
Individual effect	Yes	Yes	Yes
Time effect	Yes	Yes	Yes
N	2838	2838	2838
R^2	0.210	0.226	0.101

*, **, ***represent the statistical values of the results that are significant at the 10%, 5% and 1% levels respectively.

Table 8. Results of the DIGITAL robustness test

Variable	(1) High	(2) Middle	(3) Low
DIGITAL	0.0002***	0.0001***	−0.0002***
	(3.04)	(4.21)	(−2.80)
Individual effect	Yes	Yes	Yes
Time effect	Yes	Yes	Yes
N	2838	2838	2838
R^2	0.020	0.982	0.019

*, **, ***represent the statistical values of the results that are significant at the 10%, 5% and 1% levels respectively.

After replacing the core explanatory variables, the direction of the impact of the depth of digital financial inclusion use, breadth of coverage, and level of digital service support on each type of labour force is generally consistent with the regression results in Table 3, and they are all significant at the 1% statistical level, so the findings remain robust.

Heterogeneity test

In terms of digital financial inclusion itself, its impact on the employment structure of the labour force may be influenced by other social factors, which cannot be revealed by the estimation results of the total sample alone. At the same time, therefore, this paper divides the 258 prefectures into 3 parts according to the eastern, central, and western regions to further explore the differences in the impact of digital financial inclusion on the employment structure of the labour force.

The regression results when high-, medium-, and low-skilled labour force are the explanatory variables are reported in columns (1)–(3) in Table 9, respectively. From the eastern region, the development of digital financial inclusion will have a significant positive impact on the employment of high-skilled labour, but there is a negative spatial spillover effect, that is, the development of local digital financial inclusion will inhibit the employment of high-skilled labour in the neighbouring regions, while there is a significant negative impact on the employment of medium-skilled labour and no spatial spillover effect. At the same time, digital financial inclusion also has a significant positive effect on the employment of low-skilled labour and a negative spatial spillover effect. This indicates that in the eastern region, the development of digital inclusive finance can promote the employment of high-skilled and low-skilled labour and inhibit the employment of medium-skilled labour.

The analysis of the reasons for this may be due to the fact that the eastern region not only has the highest level of economic development but also the development of digital inclusive finance started early. Moreover, the eastern region belongs to the headquartered gathering place of digital inclusive finance enterprises, with a concentration of technology-intensive industries, and the emergence of new types of production tasks generated by technological innovation. Therefore, there is a greater demand for talents with higher education (Li, 2022). At the same time, the role of digital inclusive finance's universality in lowering the threshold of financial services is more obvious in the eastern region, and low-skilled labour groups have easier access to financial support.

From the central region, the development of digital inclusive finance has a significant positive impact on the employment of high-skilled labour, and there is a positive spatial spillover effect, that is, the development of local digital inclusive finance promotes the employment of high-skilled labour in the neighbouring regions, while digital inclusive finance has a significant negative impact on the employment of middle-skilled labour, and there is a negative spatial spillover effect. At the same time, digital inclusive finance also has a significant positive impact on the employment of low-skilled labour and a positive spatial spillover effect. This suggests that in the central region, the development of digital financial inclusion can promote the employment of high-skilled and low-skilled labour and inhibit the employment of middle-skilled labour, similar to the eastern region.

In the western region, the development of digital inclusive finance has a significant positive impact on the employment of high-skilled labour, and there is a positive spatial spillover effect, but the impact on the employment of middle-skilled and low-skilled labour is not significant. That may be due to the fact that the level of the development of digital inclusive finance in the western region is relatively low, and the degree of experience is not yet high, so that the impact on the middle-skilled labour is not yet large or significant. Moreover, there are still certain shortcomings and difficulties in broadening financing channels, which also make it difficult to affect the employment of low-skilled labour.

Further analysis: mediation effect

Referring to the research of Wen (2014), this paper adopts a step-by-step regression method to verify the mediating effect of the degree of FD in the process of digital financial

Table 9. Heterogeneity test regression results

Variable	(1)			(2)			(3)		
	East	Central	West	East	Central	West	East	Central	West
FI	0.0005***	0.0004**	0.0001***	−0.0003***	−0.0003**	−0.0002	0.0002***	0.0017***	−0.0001
	(4.05)	(2.15)	(3.05)	(−3.20)	(−2.38)	(−1.24)	(4.09)	(38.14)	(−1.14)
WFI	−0.0041***	0.0151***	0.0009***	0.0007	−0.0050***	−0.000	−0.0008*	0.0564***	−0.0001
	(−2.86)	(4.73)	(8.93)	(0.80)	(−2.56)	(−0.08)	(−1.86)	(75.90)	(−0.91)
CONTROL	yes	yes	yes	yes	yes	yes	yes	yes	yes
R^2	0.106	0.418	0.986	0.096	0.051	0.067	0.988	0.138	0.988

*, **, ***represent the statistical values of the results that are significant at the 10%, 5% and 1% levels respectively.

Table 10. First step regression results

Variable	Model (2)	Model (3)	Model (4)
FD			0.0001
			(1.61)
FI	0.0001***	1.0381***	0.0001
	(5.08)	(114.19)	(0.68)
GOV	0.0378*	116.299***	0.0269
	(1.87)	(17.85)	(1.26)
LAB	0.000**	−0.000***	0.000**
	(2.04)	(−3.74)	(2.15)

*, **, ***represent the statistical values of the results that are significant at the 10%, 5% and 1% levels respectively.

Table 11. Second step regression results

Variable	Model (2)	Model (3)	Model (4)
FD			−0.0001**
			(−2.00)
FI	−0.0002***	1.0409***	−0.0001***
	(−12.55)	(113.18)	(−3.53)
GOV	−0.0433***	113.016***	−0.0354***
	(−3.46)	(16.66)	(−2.70)
LAB	−0.0017***	−0.000***	0.000
	(−3.29)	(−3.42)	(0.01)

*, **, ***represent the statistical values of the results that are significant at the 10%, 5% and 1% levels respectively.

inclusion affecting the employment structure of the labour force, and the results are shown in Tables 10–12.

In Table 10, models (2)–(4) correspond to Equations (2)–(4), respectively, and the following table is the same. According to the steps, in the first step, testing whether the coefficient c is significant or not, that is, the regression coefficient of FI (0.0001), is significant at 1% level; in the second step, testing the coefficients a and b, that is, the regression coefficients of FI (1.0381) and FD (0.0001), it is found that a is significant and b is not significant at 1% level; in the third step, according to the bootstrap test, it is found that the indirect effect is significant at 10% level; in the fourth step, the coefficient c′, the regression coefficient of FD (0.0001), was tested and the result was not significant, indicating that the direct effect was not significant. Therefore, the above analysis indicates that FD plays a mediating role in the process of digital financial inclusion affecting the employment of highly skilled labour.

In Table 11, according to the steps, in the first step, test whether the coefficient c is significant, that is, the regression coefficient of FI (−0.0002), which is significant at 1% level; in the second step, test the coefficients a and b, that is, the regression coefficients of FI (1.0409) and FD (−0.0001), and it is found that both a and b are significant at 1% level, which indicates that the indirect effect is significant; in the third step, testing the coefficient c′, the regression coefficient of FD (−0.0001), was found to be significant at the 5% level,

Table 12. Third step regression results

Variable	Model (2)	Model (3)	Model (4)
FD			−0.00002
			(−0.59)
FI	0.0001***	1.0409***	0.0001**
	(3.36)	(113.18)	(1.96)
GOV	0.0026	113.016***	0.0056
	(0.16)	(16.66)	(0.33)
LAB	−0.000***	−0.000***	−0.000***
	(−2.66)	(−3.42)	(−2.69)

*, **, ***represent the statistical values of the results that are significant at the 10%, 5% and 1% levels respectively.

indicating a significant direct effect. In the fourth step, since ab and c' have the same sign, it indicates that there is a partial mediation effect, which is 51.26%. Therefore, based on the above analysis, it indicates that FD plays a mediating role in the process of digital financial inclusion affecting the employment of middle-skilled labour.

In Table 12, according to the steps, in the first step, the coefficient c is tested to be significant or not, that is, the regression coefficient of FI (0.0001), which is significant at 1% level; in the second step, the coefficients a and b, that is, the regression coefficients of FI (1.0409) and FD (−0.00002), are tested, and it was found that a is significant at 1% level and b is not significant; and in the third step, according to the bootstrap test, the indirect effect was found to be insignificant; therefore, based on the above analysis, it indicates that FD does not play a mediating role in the process of digital financial inclusion affecting the employment of low-skilled labour.

Conclusion and policy recommendations

Based on the panel data of 258 prefecture-level cities in China from 2011 to 2021, this paper empirically investigates the impact of the development of digital inclusive finance on the employment structure of the labour force and its differences among the 3 major regions of the East, Central, and West from a spatial perspective by constructing a SDM and a spatial threshold model.

The primary results of the study offer three significant insights. First, at the national level, the development of digital financial inclusion leads to a bimodal employment structure with significant spillover effects because digital financial inclusion increases the demand for employment of high-skilled and low-skilled labour and reduces the demand for employment of middle-skilled labour. Moreover, the development of digital financial inclusion in the local area significantly promotes the employment of high-skilled and low-skilled labour in the neighbouring areas and does not have a significant impact on the employment of middle-skilled labour in the neighbouring areas.

Second, on a regional basis, digital financial inclusion development in the eastern and central regions shows a polarisation of labour demand, that is, it raises the demand for high-skilled and low-skilled labour and increases the likelihood that middle-skilled labour will be replaced. In the western region, the impact of digital financial inclusion on the employment of middle-skilled and low-skilled labour is not significant but, conversely, increases the demand for high-skilled labour.

Third, there is a mediating effect in the process of digital financial inclusion influencing the employment structure of the labour force, in which FD plays a mediating role for high-skilled and middle-skilled labour but not for low-skilled labour.

Based on the above conclusions, this paper puts forward the following policy recommendations:

First, the government should strengthen vocational skills training for workers with middle-level education, so that they can acquire the skills needed to transition to higher-skilled positions. At the same time, it should provide more training and consulting services related to digital financial inclusion for workers with low educational attainment, so as to help them improve their management and skill levels and enhance their financial literacy. In addition, the scale and number of tertiary-educated labourers should be further enhanced to cultivate more highly skilled personnel to meet the needs of the labour market and improve the overall labour force human capital level.

Second, the spatial development pattern between digital inclusive finance and labour force employment structure should be optimised, so that extensive exchanges and cooperation between regions should be promoted. From the results of the study, the level of digital inclusive finance development in various regions is not balanced, and there is a positive spatial spillover effect. Local governments, therefore, should strengthen the cooperation between various regions in the development of digital inclusive finance and labour force employment and accelerate the flow of financial factors between regions. For example, the local governments could create a common development centre for digital inclusive finance to complement each other's strengths and weaknesses, to exchange experiences, to optimise the allocation of resources across regions, and to achieve common building and sharing.

The third policy recommendation deals with the need to develop strategies by region. In the central and eastern regions, the development of digital inclusive finance will significantly affect the employment of high-, medium-, and low-skilled labour. The government should not only guide the development of digital inclusive financial services for labour force employment through relevant regulations and policies but also should improve and perfect the relevant legal and regulatory system and strengthen financial supervision to ensure that digital inclusive finance can play an effective role. For the western region, local governments should improve the infrastructure for the development of digital inclusive finance and promote the deep integration of digital technology centred on big data, the internet, and cloud computing with traditional financial institutions. They should also strengthen policy support for talent introduction and promote a balanced distribution of human resources.

Finally, support for FD should be carried out to digitally upgrade the financial industry in many ways in order to change the employment structure of the workforce. The government can support the cultivation of fintech talents, set up research institutions to encourage financial innovation, and at the same time formulate supportive documents and policies to escort the digital development of financial enterprises.

References

Acemoglu D and Autor D (2011) Skills, tasks and technologies: implications for employment and earnings. In *Handbook of Labor Economics*. Amsterdam: Elsevier.

Acemoglu D and Restrepo P (2018) Artificial intelligence, automation, and work. In *The Economics of Artificial Intelligence: An Agenda*. Chicago, IL: University of Chicago Press.

Acemoglu D and Restrepo P (2018) The race between man and machine: implications of technology for growth, factor shares, and employment. *American Economic Review* 108(6), 1488–1542.

Acemoglu D and Restrepo P (2019) Automation and new tasks: how technology displaces and reinstates labor. *Journal of Economic Perspectives* 33(2), 3–30.

Autor DH and Dorn D (2013) The growth of low-skill service jobs and the polarization of the US labor market. *American Economic Review* 103(5), 1553–1597.

Autor DH, Levy F and Murnane RJ (2003) The skill content of recent technological change: an empirical exploration. *The Quarterly Journal of Economics* 118(4), 1279–1333.

Ayyagari M, Juarros P, Martinez Peria MS and Singh S (2021) Access to finance and job growth: firm-level evidence across developing countries. *Review of Finance* 25(5), 1473–1496.

Boustanifar H (2014) Finance and employment: evidence from US banking reforms. *Journal of Banking & Finance* 46, 343–354.

Caggese A, Cunat V and Metzger D (2019) Firing the wrong workers: financing constraints and labor misallocation. *Journal of Financial Economics* 133(3), 589–607.

Duan XP and Hu YL (2023) Research on the impact and mechanism of digital financial development on corporate technological innovation. *System Science and Mathematics* 2023, 2856–2884.

Elhorst JP (2012) Dynamic spatial panel: models, methods, and inference [J]. *Journal of Geographical System* 14(1), 5–28.

Elouardighi I and Oubejja K (2023) Can digital financial inclusion promote women's labor force participation? Microlevel evidence from Africa. *International Journal of Financial Studies* 11(3), 87.

Fang GF and Xu JY (2020) Does digital financial inclusion promote residents' employment - evidence from a Chinese household tracking survey. *Research in Financial Economics* 35(02), 75–86.

Feng R, Shen C and Guo Y (2024) Digital finance and labor demand of manufacturing enterprises: theoretical mechanism and heterogeneity analysis. *International Review of Economics & Finance* 89, 17–32.

Goos M and Manning A (2007) Lousy and lovely jobs: the rising polarization of work in Britain. *The Review of Economics and Statistics* 89(1), 118–133.

Guo F, Wang JY, Wang F, Kong T, Zhang X and Cheng CY (2020) Measuring the development of digital inclusive finance in China: indexing and spatial characterization. *Economics (Quarterly)* 19(04), 1401–1418.

Hu W, Zhang KM, Xu ZY and Yu L (2024) Research on the impact and transmission path of digital inclusive finance on technological innovation of small and medium-sized enterprises. *China Science and Technology Forum* 333(01), 27–37.

Karlan D and Zinman J (2010) Expanding credit access: using randomized supply decisions to estimate the impacts. *The Review of Financial Studies* 23(1), 433–464.

Levy F (2018) Computers and populism: artificial intelligence, jobs, and politics in the near term. *Oxford Review of Economic Policy* 34(3), 393–417.

Li XD and Wan SJ (2022) Employment structure effect of digital finance on labor force: theory and test. *Economic and Management Review* 2022(04), 113–123.

Li XY and Liu YM (2021) How can digital inclusive finance promote rural entrepreneurship? *Economic Management* 2021(12), 24–40.

Lin C, Kang K and Sun YJ (2019) The impact of financial inclusion on urban employment in China - an examination based on heterogeneity of region, industry and city economy size. *Urban Issues* 8, 94–104.

Lu Y and Zhu S (2022) Digital economy, scientific and technological innovation, and high-quality economic development: a mediating effect model based on the spatial perspective. *Plos one* 17(11), e0277245.

Ma SZ and Hu ZX (2022) Does digital finance affect labour mobility? –A micro perspective based on China's mobile population. *Economics (Quarterly)* 22(01), 303–322.

Manyika J, Lund S, Singer M, White O and Berry C (2016) *Digital Finance for All: Powering Inclusive Growth in Emerging Economies*. New York: McKinsey Global Institute.

Nie XH and Wu Q (2021) Study on the spatial spillover effect of digital finance driven regional technological innovation level enhancement. *Contemporary Economic Management* 43(12), 85–96.

Ran G and Tang T (2021) The impact of digital financial inclusion on social employment - an examination of heterogeneity based on firm nature and industry. *Reform* 11, 104–117.

Ren J, Gao T, Shi X, Chen X and Mu K (2023) The impact and heterogeneity analysis of digital financial inclusion on non-farm employment of rural labor. *Chinese Journal of Population, Resources and Environment* 21(2), 103–110.

Schäfer D and Steiner S (2014) *Financial Development and Employment: Evidence from Transition Countries*. Berlin: DIW Berlin, German Institute for Economic Research.

Song JS, Tu HY and Zhao RS (2023) How digital transformation promotes the improvement of corporate innovation efficiency - a Re-examination from the perspective of financial asset allocation. Science and Technology Progress and Countermeasures.

Sun Z and Hu YL (2019) How industrial intelligence reshapes labor force employment structure. *China Industrial Economy* 05, 61–79.

Wang LY (2023) Analysis of spatial spillover effects of digital financial inclusion on innovation activism. *Research on Technology Economy and Management* 04, 71–77.

Wen ZL and Ye BJ (2014) Mediation effects analysis: methodology and model development. *Advances in Psychological Science* 22(05), 731–745.

World Bank (2014) Digital Financial Inclusion. Available at https://www.worldbank.org/en/topic/financialinclusion/publication/digital-financial-inclusion (accessed 30 March, 2024).

Xie XL, Shen Y, Zhang HX and Guo F (2018) Can digital finance promote entrepreneurship? –Evidence from China. *Economics (Quarterly)* 17(04), 1557–1580.

Xing ZT and Zhong RY (2023) Digital financial inclusion, labor mobility and industrial structure optimization: an empirical analysis based on a new economic geography perspective. *Exploration of Economic Issues* 04, 142–156.

Xu SJ and Zheng JH(2020) Has information technology led to labor market polarization in China - a multilevel skill deepening hypothesis and test. *Exploration of Economic Issues* 07, 157–167.

Yan SP, Wu KD and Wei CY (2020) Digital economy development and the evolution of labor force structure in China. *Economic Journal* 10, 96–105.

Yi XJ and Zhou L (2018) Does the development of digital inclusive finance significantly affect residents' consumption - micro evidence from Chinese households. *Financial Studies* 11, 47–67.

Zhang L, Liu XC, Xu S and Xiao Y (2023) Can digital financial inclusion optimize employment structure? A perspective based on spatial econometric modeling. *Exploration of Economic Issues* 12, 175–190.

Zhang X (2023) The impact of digital finance on corporate labor productivity: evidence from Chinese-listed companies. *Journal of Industrial and Business Economics* 50(3), 527–550.

Zhang XP, Jiang L and Wang SF (2023) Research on the entrepreneurial effect of digital financial inclusion. *Economic Jingwei* 03, 139–149.

Zhou TY (2022) Digital financial inclusion, factor prices and labor mobility. *Contemporary Economic Management* 44(4), 77–87.

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