

# Digital finance, agricultural industrialisation, and inclusive economic growth in China

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**Abstract:** This study develops a theoretical analytical framework to examine the impact of digital finance on agricultural industrialisation and investigates the effects of both digital finance and agricultural industrialisation on inclusive economic growth, utilising interprovincial panel data from 2011 to 2020. The findings indicate that digital finance is conducive to economic inclusion and can enhance economic inclusion through the promotion of agricultural industrialisation. Furthermore, agricultural industrialisation serves as a vital conduit through which digital finance influences inclusive economic growth. This study highlights that the inclusive growth effect of digital finance escalates in conjunction with inclusive economic growth. By fostering the development of digital finance, this study advances agricultural industrialisation and contributes to the enhancement of inclusive economic growth, thereby offering policy insights to promote such growth.

**Keywords:** financial inclusion; agricultural economy; differential GMM; inclusive development; income distribution

Inclusive growth remains a significant topic of study within economics. This interest is driven by the pivotal role that inclusive growth plays in the efficient allocation of resources and the reduction of poverty globally. Inclusive growth entails the provision of more equitable opportunities, with a high degree of opportunity sharing representing a key aspect of it. This underscores the need for innovative strategies to address economic and social disparities, including those related to income, assets, financial and human capital, education, health, and economic opportunities (Berg and Ostry 2017). Finance is vital in resource allocation, reducing economic inequality, and fostering inclusive growth (Corrado and Corrado 2017; Asongu et al. 2020; van Niekerk 2020; Cui et al. 2022a). As a major agricultural nation, China depends significantly on financial services to develop its

agricultural economy and enhance the earnings of rural populations (Xu 2010; Zhang et al. 2020; Liu 2022; Wang et al. 2022). Finance is instrumental in aiding China's rural low-income populations, as well as small, medium, and micro enterprises, to improve their living standards and productive capacity inclusively (Jiang et al. 2019; Yang et al. 2021; Deng 2022; Zhao et al. 2022). The primary objective of this study is to analyse the role of digital finance in promoting inclusive economic growth and examining how agricultural industrialisation can more effectively boost the income of low-income groups to propel inclusive economic growth.

Agricultural industrialisation is a contemporary management mode and industrial organisation form that is market-oriented, centred on economic benefits, and focused on leading industries and products.

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It aims to optimise the combination of various agricultural production factors. Essentially, it seeks to refine agricultural organisational forms and enhance the efficiency of agricultural development (Jiang et al. 2022; Li and Du 2023). Motivated by the maximisation of profits, enterprises frequently adjust their agricultural production structures to align with market demands and procure agricultural production materials from small farmers, family farms, or agricultural cooperatives according to market needs (Siaw et al. 2023; Ren et al. 2024). Prompted by actual price incentives, rural agricultural producers continually enhance their agricultural structure and scale to secure maximum returns (Carvalho 1991; Sun et al. 2021). Agriculture in China is extensive, and there is considerable potential for rural financing, although the efficiency of such financing is generally low. Additionally, agricultural financing has exhibited a trend of declining before recovering (Liu and Zhan 2019). Rural financing is diverse, with formal and informal borrowing occurring concurrently. A bias towards smallholders in formal lending is closely associated with credit rationing and collateral requirements (Turvey et al. 2010). The scope and magnitude of farmers' financing needs vary significantly, and financial institutions should thus offer credit products with diverse attributes to maximise the potential borrower pool (Kong et al. 2021). The key to achieving inclusive growth lies in elevating the income levels of rural residents and fostering rural economic development. Given the relatively high concentration of low-income groups in rural areas, the judicious utilisation of rural labour and production materials is crucial for rural economic development (Neimark 2016; Jiang et al. 2017; Curry et al. 2021). Therefore, agricultural industrialisation can serve as a vital channel for financially promoting inclusive growth.

Existing studies demonstrate that technological advancements in agriculture and financial funding can enhance both the profitability and the distributability of benefits derived from agricultural development (Beynon 1995; Alston et al. 1998). Various combinations of agricultural production costs and unit commission costs create distinct demands for financing patterns. Moreover, the engagement of financial intermediaries can improve both the welfare of agricultural sectors and the profitability of the agricultural economy (Heidhues et al. 1998; Liang et al. 2010; Yi et al. 2021). Financial development may mitigate the positive impact of financial policies on agricultural investment, necessitating a differentiated and strategic approach to the construction of financial systems to facilitate the

rapid development of diverse agricultural economies (Yan et al. 2020; Li et al. 2022). This study connects financial access with agricultural industrialisation to explore the relationship between the two, positing that agricultural credit can enhance agricultural output and foster agricultural modernisation (Li et al. 2020). Additionally, augmenting rural credit inputs can facilitate agricultural mechanisation and industrialisation while narrowing the urban-rural income disparity (Watson and Achinelli 2008; Zakaria et al. 2019). An observable significant spatial spillover effect emerges from the impact of rural inclusive finance on agricultural industrialisation, accompanied by a law of diminishing marginal effect. Swamy and Dharani (2016) argue that agricultural value chains enhance the sustainability of farmers' access to financial services. Agricultural value chains, which have distinct advantages in financing, can reduce transaction costs, increase the added value of agricultural produce, and consequently promote the transformation of the agricultural industry. The financing model based on agricultural value chains can diminish both the costs and risks associated with financing. Once farmers obtain funding, they can be integrated into high-value markets, thus increasing inclusiveness (Meuwissen et al. 2003; Guyver and McCarthy 2011; Patil et al. 2016).

Constrained by information asymmetry, transaction costs, and distance, rural financing constraints persist, with most farmers unable to secure sufficient funds for their standard production and business activities. The integration of digital technologies such as big data, cloud computing, artificial intelligence, and blockchain with financial services has enhanced the well-being of agricultural production activities. An artificial intelligence-based financial system promotes smallholder economic development (Chen et al. 2022). The employment of blockchain technology in agricultural value chains facilitates the integration of agricultural finance, improves access to information in traditional agricultural value chains, and eases financing constraints for agricultural development (Wang and You 2022). Digital finance can achieve a reduction in agricultural carbon emissions through farmer entrepreneurship and agricultural technology innovation, within which urbanisation plays a moderating role. Digital finance negatively affects households with low agricultural productivity, while it has no effect on households with high agricultural productivity (Liu et al. 2021). The contribution of digital finance to farmers' willingness to adopt agricultural technology increases with the level of financial market development

(Zhou et al. 2022). Digital finance contributes to agricultural total factor productivity by increasing the level of green technology, indirectly helps to enhance agricultural green total factor productivity by stimulating agricultural technology innovation and optimising industrial structures (Gao et al. 2022), and has positive implications for agricultural green development.

Several research implications can be drawn from our review of the relevant literature. Firstly, the key to inclusive growth lies in rural economic development and the improvement of the quality of life of rural residents. Most economic activities in rural areas are closely related to agricultural development, and agricultural industrialisation can serve as a pillar of rural economic development. Secondly, the impact of digital finance on inclusive growth is not pronounced, but inclusive growth can be achieved through agricultural industrialisation, which may serve as an important channel for digital finance to promote such growth. Existing studies also pay less attention to the impact of digital finance on agricultural industrialisation. Finally, the relationship between digital finance, agricultural industrialisation, and inclusive growth may vary across regions in China and among different income groups.

### Theoretical analysis

This study refers to the theoretical analysis framework of Acemoglu et al. (2018) as a basis to analyse the impact of digital finance on inclusive economic growth and the role played by agricultural industrialisation in it.

**Basic assumptions.** Assuming that the representative household is capable of surviving indefinitely and that time  $t$  is continuous within the economy, the symbol  $a$  denotes the agricultural sector and  $m$  the industrial sector. Furthermore, the representative household is characterised by a utility function of CRRA preferences, which is presented as follows:

$$U_0 = \int_0^\infty \frac{C(t)^{1-\theta}}{1-\theta} e^{-\rho t} dt \quad (1)$$

$$C(t) = \left( \int_{N(t)} c_j(t)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

where:  $0 < \rho < 1$  – the time discount rate;  $C(t)$  – the total consumption;  $c_j(t)$  – the consumption of product  $j$  at time  $t$ ;  $\varepsilon > 1$  – the elasticity of substitution between products;  $N(t) \subset [0, 1]$  – the set of active product lines at time  $t$ .

Assuming that the economy is closed and considering that the cost of production incorporates labour

inputs  $c_j(t) = y_j(t)$ , where  $y_j(t)$  – the quantity of product  $j$  produced at time  $t$ . This implies that  $Y(t) = C(t)$ . The economy utilises three types of labour: labour involved in industrial production activities (total labour demand being  $L_m$ ), labour in new agricultural production activities (total labour demand being  $L_a$ ), and labour in traditional agricultural production activities, primarily subsistence (total labour demand being  $L_p$ ). It is assumed that production of each product necessitates at least one labour input. The remaining labour force ( $L_s$ ) is engaged in productive activities in the industrial and new agricultural sectors. This excludes one labour unit retained by the representative household for subsistence production. The labour supply is inelastic, satisfying  $L_p = 1$  and  $L_s = L_m + L_a$  when labour market equilibrium is achieved. The industrial sector employs labour  $L_m$  and capital  $K_m(t)$  to generate output  $Y_m(t)$ , and the new agricultural sector utilises labour  $L_a$  and capital  $K_a(t)$  to produce output  $Y_a(t)$ . The total output  $Y(t)$  is described by a constant elasticity of substitution (CES) production function with a fixed elasticity of substitution, detailed as follows:

$$Y(t) = \left[ \zeta Y_m(t)^{\frac{\sigma-1}{\sigma}} + (1-\zeta) Y_a(t)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \quad (2)$$

The production function for the two sectoral products adopts the Cobb-Douglas form:

$$Y_m(t) = \frac{1}{1-\beta} \left( \int_{N(t)} x_m(j,t)^{1-\beta} dj \right) (L_m K_m(t))^\beta \quad (3)$$

$$Y_a(t) = \frac{1}{1-\beta} \left( \int_{N(t)} x_a(j,t)^{1-\beta} dj \right) (L_a K_a(t))^\beta \quad (4)$$

where:  $\zeta \in (0, 1)$  – the relative importance of the product  $Y_m(t)$  within the CES production function;  $\sigma \in (0, +\infty)$  – the elasticity of substitution between the output from the industrial and the new agricultural sectors;  $\beta$  – the share parameter of the Cobb-Douglas production function;  $x_m(j,t)$  and  $x_a(j,t)$  – intermediate goods. Additionally, the liquidity budget constraint for representative households is depicted in:

$$\dot{K}(t) + C(t) \leq r_m(t) K_m(t) + r_a(t) K_a(t) + L_m w_m(t) + L_a w_a(t) \quad (5)$$

$$\dot{K}(t) = L_a(\phi + \eta) + L_m \phi - \delta K(t) \quad (6)$$

where:  $0 < \eta \leq 1$  – the degree of agricultural industrialisation;  $0 < \phi \leq 1$  – the numerical representation of financial

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development (which can represent the rate of capital production),  $\delta$  – the depreciation rate;  $0 < \delta < 1$ .

The budget constraint adheres to the no-Ponzi game condition  $\int_0^\infty \exp(-r(t)t)K(t)dt \geq 0$ , where  $K(t) = \int_{N(t)} V_j(t) dj$  – the asset position of the representative household;  $r(t)$  – the average interest rate on assets;  $w_m(t)$  and  $w_a(t)$  – the wage levels in the industrial and the new agricultural sectors, respectively.

Equation (6) illustrates the dynamic process of capital accumulation, i.e. the new capital stock in period  $t$ ,  $(\phi + \eta)L_a + \phi L_m$  minus depreciation  $\delta K_m(t)$ . This equation links the capital accumulation process directly to the advancement of digital finance and agricultural industrialisation. Agricultural industrialisation requires substantial capital and labour inputs, which digital finance can provide. Labour demand depends on the level of agricultural industrialisation and the utilisation of financial resources. In the equation, labour  $L$  remains relatively fixed in the short term, while in the long term, it reflects the labour requirements of agricultural industrialisation and changes in the structure of financial resource utilisation. In a static equilibrium, the utility maximisation problem for a representative household satisfies the standard Euler equation.

$$\frac{\dot{C}}{C} = \frac{r - \rho}{\theta} \quad (7)$$

**Equilibrium analysis.** Assuming price levels of  $P_m(t)$  and  $P_a(t)$  for  $Y_m(t)$  and  $Y_a(t)$ , respectively, the monopolist of the final product selects optimal intermediate product inputs  $x_m(j, t)$  and  $x_a(j, t)$  to maximise monopoly profits. Simultaneously, inputs  $x_m(j, t)$  and  $x_a(j, t)$ , as intermediate products, maximise their profits when the prices of factors and products prices  $P_m(t)$ ,  $P_a(t)$ ,  $w_m(t)$ , and  $w_a(t)$  equilibrate with market-clearing conditions. The pricing in a perfectly competitive market

for these two intermediate products equates the product price to its marginal product value. Here, the relative price  $P$  must necessarily satisfy:

$$P \equiv \frac{P_m(t)}{P_a(t)} = \frac{1 - \zeta}{\zeta} \left( \frac{Y_m(t)}{Y_a(t)} \right)^{-\frac{1}{\sigma}} \quad (8)$$

where:  $P_m(j, t)$  and  $P_a(j, t)$  – the prices of the intermediate goods  $x_m(j, t)$  and  $x_a(j, t)$  respectively. These are associated with output maximisation problems in the industrial sector and the new agricultural sector.

Equation (8) indicates that  $Y_m(t)$  is priced relatively lower than  $Y_a(t)$ , and the value of the relative price  $P$  also depends on the magnitude of the elasticity of substitution,  $\sigma$ .

The total capital is the sum of the capital invested in both sectors, i.e.  $K_a(t) + K_m(t) = K(t)$ . The industrial sector and the new agricultural sector exhibit disparities in access to financial services; digital finance has been assumed to lessen this gap, quantified by the parameter  $\phi$ , resulting in  $r_a(t) = (1 + \phi^{-1})r_m(t)$ . The first-order conditions for Equation (9 and 10) on  $L_m$ ,  $K_m(t)$ ,  $x_m(j, t)$ ,  $L_a$ ,  $K_a(t)$  and  $x_a(j, t)$  are defined as:

$$\frac{K_m(t)}{L_m} = \frac{w_m(t)}{r_m(t)}, \frac{K_a(t)}{L_a} = \frac{w_a(t)}{r_a(t)} \quad (11)$$

Assume that the monopolist firms share a common marginal cost  $\xi$ , and the demand for factors of production is isoelastic, enabling a stable price setting based on marginal cost,  $P_i(j, t) = \xi / (1 - \beta)$ . For simplicity, letting  $\xi \equiv 1 - \beta$ , then:  $P_m(j, t) = P_a(j, t) = 1$ . Substituting into Equation (12), we find:  $x_m(j, t) = P_m(t)^{1/\beta} L_m K_m(t)$  and  $x_a(j, t) = P_a(t)^{1/\beta} L_a K_a(t)$ . From Equations (3–4, 8, 11–12) results in Equation (13–14).

$$\max_{L_m, K_m(t), x_m(j, t)} P_m(t)Y_m(t) - w_m(t)L_m - r_m(t)K_m(t) - \int_{N(t)} P_m(j, t)x_m(j, t) dj \quad (9)$$

$$\max_{L_a, K_a(t), x_a(j, t)} P_a(t)Y_a(t) - w_a(t)L_a - r_a(t)K_a(t) - \int_{N(t)} P_a(j, t)x_a(j, t) dj \quad (10)$$

where:  $r_m(t)$  and  $r_a(t)$  – the price of capital at  $K_m(t)$  and  $K_a(t)$ , respectively.

$$x_m(j, t) = \left( \frac{P_m(t)}{P_m(j, t)} \right)^{1/\beta} L_m K_m(t), x_a(j, t) = \left( \frac{P_a(t)}{P_a(j, t)} \right)^{1/\beta} L_a K_a(t) \quad (12)$$

$$Y^*(t) = \frac{(1 - \beta)r_m(t)}{\beta^2} \left[ \zeta \left( \frac{w_m(t)}{P_m(t)^{(1+\beta)/\beta}} \right)^{\frac{\sigma-1}{\sigma}} + (1 - \zeta) \left( \frac{(1 + \phi^{-1})w_a(t)}{P_a(t)^{(1+\beta)/\beta}} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} = C(t) \quad (13)$$

$$\frac{Y_m^*(t)}{Y_a^*(t)} = \left( \frac{1-\zeta}{\zeta} \right)^{\frac{-\sigma(1+\beta)}{\sigma\beta-\beta-1}} \left( \frac{w_m(t)}{w_a(t)} \right)^{\frac{\sigma\beta}{\sigma\beta-\beta-1}} \left( \frac{1}{1+\phi^{-1}} \right)^{\frac{\sigma\beta}{\sigma\beta-\beta-1}} \quad (14)$$

The analysis of the first-order condition on  $\phi$ , when,  $\sigma > (1+\beta)/\beta$   $\partial(Y_m^*(t)/Y_a^*(t))/\partial\phi < 0$ , indicates that digital finance can enhance economically inclusive growth. And when,  $\sigma < (1+\beta)/\beta$   $\partial(Y_m^*(t)/Y_a^*(t))/\partial\phi > 0$ , it indicates a potential inhibition of such growth. By synthesising Equations (5–6 and 13–14), the following becomes evident:

$$C(t) \leq \frac{1-\beta}{\beta} \left\{ \begin{aligned} & \frac{2r_m(t)w_m(t)}{P_m(t)^{1/\beta}} + \frac{\delta w_m(t)}{P_m(t)^{1/\beta}} + \frac{\delta w_a(t)}{P_a(t)^{1/\beta}} \\ & + \frac{2(1+\phi^{-1})r_m(t)w_a(t)}{P_a(t)^{1/\beta}} - \frac{\phi r_m(t)}{P_m(t)^{1/\beta}} \\ & - (\phi + \eta) \frac{(1+\phi^{-1})r_m(t)}{P_a(t)^{1/\beta}} \end{aligned} \right\} = \phi(t) \quad (15)$$

From Equation (15) regarding the first-order condition of  $\phi$ . Assuming a relative price of  $P = P_m(t)/P_a(t)$  further arrangement of the equations is presented in:

$$\frac{\partial\phi(t)}{\partial\phi} \left\{ \begin{aligned} & > 0, 0 < \phi < \sqrt{\frac{P(\eta - 2w_a(t))}{P+1}} \\ & = 0, \phi = \sqrt{\frac{P(\eta - 2w_a(t))}{P+1}} \\ & < 0, \phi > \sqrt{\frac{P(\eta - 2w_a(t))}{P+1}} \end{aligned} \right\} \quad (16)$$

As indicated by Equation (16), digital finance has different effects on inclusive economic growth under different levels of agricultural industrialisation. Since

$$0 < \phi \leq 1, \quad \lim_{\eta \rightarrow 1} \sqrt{\frac{P(\eta - 2w_a(t))}{P+1}} = \sqrt{\frac{P(1 - 2w_a(t))}{P+1}} < 1,$$

it can be judged that  $\partial\phi(t)/\partial\phi > 0$ , thereby indicating the important role of the level of agricultural industrialisation in digital finance for inclusive economic growth. Equation (16) for agricultural industrialisation to find the first order condition is formulated into:

$$\frac{\partial^2\phi(t)}{\partial\phi\partial\eta} = \frac{(1-\beta)r_m(t)}{\beta P_a(t)^{1/\beta}} \phi^{-2} > 0 \quad (17)$$

The derivation of Equation (17) suggests that digital finance can facilitate inclusive economic growth

by promoting agricultural industrialisation. The reason is that the level of agricultural industrialisation remains relatively low due to inadequate financial support. Once the financial resources required for this industrialisation are secured, they can significantly improve the industrialisation level. This enhancement, in turn, increases the operational performance of agricultural industrial enterprises, boosts their enterprise value, raises the income levels of the employed labour force, and improves the sustainability of enterprises.

Digital finance not only mitigates financing constraints but also creates opportunities for the development of agricultural industrialisation (Wu et al. 2025). Upon securing funding, the agricultural industry can adopt advanced technologies, attract specialised talent, and foster technological innovation within the agricultural industry (Cao and Wang 2024). As digital finance continues to evolve and digitisation advances, financial institutions are increasingly investing in the scalability, industrialisation, and specialisation to promote the development of agricultural industrialisation (Jiang et al. 2024). Digital finance enhances the ease with which farmers can access loans, reduces financial exclusion, optimises resource allocation, and promotes the convergence of talent, technology, and capital within the agricultural sector, thereby enhancing the overall productivity of agriculture and driving the development of agricultural industrialisation (Zhang and Ji 2024, Xu and Yang 2025). Predominantly, low-income groups are situated in rural areas and are engaged in agricultural production. Agricultural industrialisation can thus foster rural labour employment, elevate income levels, improve income distribution, and contribute to inclusive growth. Based on the foregoing analysis, this study proposes the following research hypotheses:

$H_1$ : Digital finance significantly supports the promotion of agricultural industrialisation.

$H_2$ : Digital finance enhances inclusive economic growth.

$H_3$ : Agricultural industrialisation acts as a vital conduit through which digital finance can bolster inclusive economic growth.

## MATERIAL AND METHODS

### Model

To examine the impact of digital finance and agricultural industrialisation on the inclusive growth of China's economy, the following model is constructed:

$$\ln ain_{it} = \alpha_0 + \alpha_1 \ln difi_{it} + \sum_{n=1}^n \beta_n X_{n,it} + \varepsilon_{it} \quad (18)$$

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$$\ln inc_{it} = \alpha_0 + \alpha_1 \ln difi_{it} + \alpha_2 \ln ain_{it} + \sum_{n=1}^n \beta_n X_{n,it} + \varepsilon_{it} \quad (19)$$

where:  $\alpha_0$  – the constant term;  $\alpha_1$  and  $\alpha_2$  – the corresponding regression coefficients;  $\ln ain_{it}$  – the level of agricultural industrialisation;  $\ln inc_{it}$  – China's inclusive economic growth;  $\ln difi_{it}$  – digital finance;  $X_{it}$  – a vector of control variables including foreign direct investment ( $\ln fdi$ ), consumer price index ( $\ln cpi$ ), government intervention ( $\ln gov$ ), population density ( $\ln pd$ ), human capital level ( $\ln capital$ ) and unemployment rate ( $\ln rat$ );  $\varepsilon_{it}$  – random disturbance terms.

### Data

Data on digital finance are derived from the Digital Inclusive Finance Index of Peking University's Digital Finance Research Centre (Guo et al. 2020). Data on the agricultural industrialisation index, income level, foreign direct investment, Consumer Price Index, government intervention, population density, human capital level, unemployment rate, and post-and telecommunications business are sourced from the China Statistical Yearbook and the China Social Statistical Yearbook for each year from 2012 to 2021, for example, the 2021 yearbook includes data from 2020. Since digital finance data commences in 2011, and the most recent data on agricultural industrialisation are up to 2020, this study selects the data interval of 2011–2020. The sample comprises balanced panel data from 31 Chinese provinces.

**Variable description.** *i) Inclusive economic growth ( $\ln inc$ ).* Inclusive growth is defined as comprising civil rights and social exclusion, emphasising that low-income groups should not be excluded from economic growth and are also entitled to reap the benefits of socio-economic development (Amponsah et al. 2023; Guo et al. 2024). This approach to growth focuses not only on the efficiency of economic expansion but also on the fairness of income distribution (Bello et al. 2024; Li et al. 2024). Inclusive growth aids in increasing the income of low-income individuals and steadily improves their social welfare levels, while concurrently enhancing their frequency and degree of participation in financial activities (Bhatt et al. 2024; Ofori et al. 2024). Unlike existing literature that has comprehensively measured inclusive growth (Mahmood et al. 2023; Ofori et al. 2023), this study employs *per capita* income as a proxy variable for economic inclusive growth. It further conducts a subsample regression to compare the inclusive effects of high-income and low-income groups and to deeply analyse the impact of digital finance development on China's economic inclusiveness.

*ii) Agricultural industrialisation ( $\ln ain$ ).* Drawing on existing research on Agricultural Industrialisation (Cui et al. 2022b; Yuan et al. 2024; Song et al. 2025), this study constructs an Agricultural Modernisation Index System based on five dimensions: agricultural production conditions, agricultural production efficiency, agricultural production scale, agricultural industrial structure, and agricultural industrial efficiency. The coefficient of variation method is employed to compute the comprehensive index of agricultural industrialisation that reflects the development level of agricultural industrialisation. The total power of agricultural machinery and the area of arable land represent the foundational aspects of agricultural production; the yield of arable land and agricultural output value indicate the efficiency of agricultural production; the sowing area and density are indicative of the scale of agricultural production; and the agricultural product rate captures the efficiency of agricultural production. Specific indices and methodologies for calculating agricultural industrialisation are detailed in Table 1.

*iii) Digital finance ( $\ln difi$ ).* Digital finance implies that traditional financial institutions alongside internet enterprises utilise digital technology to facilitate financial service modes such as financing, payment, and investment (Fan et al. 2024; Zhang et al. 2024). It encompasses all financial activities that foster the development of inclusive finance through digital technologies. The funds supplied cater to the needs of daily production and life while being delivered in a responsible, affordable, and dignified manner, including a variety of financial products such as credit, insurance, wealth management, and payments (Ji et al. 2022; Gao and Wang 2023; Peng et al. 2024). The digital finance measure is based on the research findings of Guo et al. (2020), which define digital finance through three dimensions: breadth of coverage, depth of use, and digitisation. The breadth of coverage differentiates from the number of branches and personnel typical of financial institutions. Following integration with the internet, this breadth reflects metrics such as the number of internet payments and bank accounts, transcending traditional geographic limitations. The term 'depth of use' denotes the actual utilisation of internet financial services, including payment, credit, insurance, and investment. Characterised by high mobility and low loan rates, the degree of digitisation depicts the convenience and cost-effectiveness of financial services. In terms of synthesising the digital finance index, the Analytic Hierarchy Process (AHP) is initially used to determine the relative weights of each intermediary level with respect to its superior level.

Table 1. Agricultural industrialisation index system

| Dimensionality indices               | Specific indices                                                       | Calculation method                                                                                                              | Unit           | Properties |
|--------------------------------------|------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|----------------|------------|
| Livelihoods<br>production conditions | percentage of machine farming area                                     | machine farming area / cultivated land area                                                                                     | %              | +          |
|                                      | percentage of effective irrigated area                                 | effective irrigated area / cultivated area                                                                                      | %              | +          |
|                                      | total agricultural machinery power <i>per capita</i>                   | total power of agricultural machinery / rural population                                                                        | kw/person      | +          |
|                                      | total power of agricultural machinery per unit of cultivated land area | total power of agricultural machinery / arable land area                                                                        | kw/ha          | +          |
| Livelihoods<br>productivity          | agricultural output <i>per capita</i>                                  | agricultural output value / number of rural population                                                                          | million USD    | +          |
|                                      | output per unit of arable land                                         | agricultural output value / arable land area                                                                                    | million USD/ha | +          |
| Livelihoods<br>production scale      | crop sown area <i>per capita</i>                                       | area sown to crops / number of rural population                                                                                 | ha/person      | +          |
|                                      | crop sowing density                                                    | crop sown area / cultivated land area                                                                                           | /              | –          |
| Products<br>industry structure       | forestry, animal husbandry and fishery output value ratio              | forestry, animal husbandry and fishery output value / total output value of agriculture, forestry, animal husbandry and fishery | %              | +          |
| Products<br>industry benefits        | agricultural commodity rate                                            | /                                                                                                                               | %              | +          |

– and + – represent positive and negative indicators, respectively.

Source: Author's own elaboration

Thereafter, the coefficient of variation method is applied to calculate the weight of each specific index relative to its superior level. These weights are then employed to compose the index, resulting in a development index that spans coverage breadth, usage depth, and the extent of digital support services.

**Control variables.** Inclusive growth aims to increase the income of low-income groups while also prioritising social equity and enhancing efficiency. Agricultural industrialisation can boost employment and provide stable income for rural residents, thereby achieving inclusive growth. There are numerous factors that influence inclusive growth, including foreign direct investment (Acheampong 2023), the consumer price index and government intervention (Xu et al. 2024), population density (Mossberger et al. 2022), the level of human capital, and the unemployment rate (Liu and Guo 2023). Therefore, when examining the relationship between digital finance, agricultural industrialisation, and inclusive growth,

it is essential to control the influence of certain factors on inclusive growth as effectively as possible. The control variables in this study include foreign direct investment (*lnfdi*), which is measured by the total foreign direct investment as a share of GDP; the consumer price index (*ln CPI*); government intervention (*ln gov*), measured by general government budget expenditure as a share of GDP; population density (*ln pd*); the level of human capital (*ln capital*), where human capital is measured by average years of education; and the unemployment rate (*ln rat*), measured by the urban registered unemployment rate. The average income level (logarithmic) is 9.959, with maximum and minimum values of 10.93 and 9.219, respectively. The extreme difference is 1.711, indicating a significant disparity in income levels. The mean (logarithmic) of digital finance is 5.212, with a standard deviation of 0.677. The mean (logarithmic) of agricultural industrialisation is –1.371, with a standard deviation of 0.296, and an extreme difference of 1.58. Overall, both the

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standard deviation and the range of the variables are relatively small, displaying a stable trend that does not influence the conclusions of the estimation results. The descriptive statistical analysis of specific variables is presented in Table 2.

### Econometric strategy

Our empirical strategy aims to (i) test whether agricultural industrialisation is one of the channels through which digital finance affects economically inclusive growth; and (ii) examine how different dimensions of digital finance influence economically inclusive growth in regions with varying income levels and stages of economic development. (iii) Addressing potential endogeneity issues, our econometric strategy comprises a four-step procedure.

In the first step, we initially use the OLS regression method on panel data to analyse empirically how digital finance and its sub-dimensions affect agricultural industrialisation, and further investigate how digital finance influences inclusive economic growth. Secondly, we introduce control variables into the model and assess whether there are significant changes in the digital finance coefficient. Finally, we incorporate agricultural industrialisation into the model and explore how the digital finance coefficient is altered.

In the second step, we employ a panel fixed effects model, an instrumental variable method, a dynamic panel difference GMM, and subsample regression to test the robustness of the benchmark results. The instrumental variable method primarily addresses endogeneity issues in empirical research, while the dynamic panel difference GMM method is more effective for robustness analysis. GMM methods are categorised into difference GMM (Arellano and Bond 1991) and system GMM (Blunell and Bond 1998). The system GMM method assumes that the random interference term exhibits no autocorrelation and that a single fixed effect is uncorrelated, making it challenging to conduct effective statistical tests on a single fixed effect (Shen et al. 2024). By contrast, the choice of difference GMM carries particular significance. The panel dynamic differential GMM applies Hansen's test to over-identify instrumental variables and assess their validity. The null hypothesis asserts that the random disturbance term does not display autocorrelation, identifiable through AR testing (Du et al. 2024). Under this hypothesis, there should be first-order serial correlation in the differential transformation of the disturbance term; the absence of second-order serial correlation would lead to a definitive conclusion.

In the third step, we perform quantile regression to examine the potential effects of digital finance and

Table 2. Descriptive statistical analysis ( $n = 310$ )

|                                | Variable         | Definition                     | Mean       | SD        | Min        | Max        |
|--------------------------------|------------------|--------------------------------|------------|-----------|------------|------------|
| Non-logarithmic transformation | <i>lnc</i>       | inclusive economic growth      | 22 324.730 | 7 904.392 | 10 088.400 | 55 674.300 |
|                                | <i>difi</i>      | digital finance                | 216.200    | 97.030    | 16.220     | 431.900    |
|                                | <i>ain</i>       | agricultural industrialisation | 0.265      | 0.072     | 0.091      | 0.440      |
|                                | <i>fdi</i>       | foreign direct investment      | 3 925.175  | 7 599.891 | 0.006      | 36 668.100 |
|                                | <i>cpi</i>       | consumer price index           | 102.500    | 1.171     | 100.600    | 106.300    |
|                                | <i>gov</i>       | government intervention        | 28.580     | 21.070    | 11.880     | 137.900    |
|                                | <i>pd</i>        | population density             | 868.864    | 5 814.313 | 2.516      | 101 526    |
|                                | <i>capital</i>   | human capital level            | 9.094      | 1.068     | 4.640      | 12.80      |
| Logarithmic transformation     | <i>rat</i>       | unemployment rate              | 3.242      | 0.638     | 1.200      | 4.600      |
|                                | <i>lnlnc</i>     | inclusive economic growth      | 9.959      | 0.322     | 9.219      | 10.930     |
|                                | <i>lndifi</i>    | digital finance                | 5.212      | 0.677     | 2.786      | 6.068      |
|                                | <i>lnain</i>     | agricultural industrialisation | −1.371     | 0.296     | −2.401     | −0.821     |
|                                | <i>lnfdi</i>     | foreign direct investment      | −3.605     | 2.309     | −12.160    | −0.058     |
|                                | <i>lncpi</i>     | consumer price index           | 4.630      | 0.011     | 4.611      | 4.666      |
|                                | <i>lngov</i>     | government intervention        | 3.210      | 0.476     | 2.475      | 4.927      |
|                                | <i>lnpd</i>      | population density             | 5.379      | 1.589     | 0.923      | 11.530     |
|                                | <i>lncapital</i> | human capital level            | 2.200      | 0.126     | 1.535      | 2.550      |
|                                | <i>lnrat</i>     | unemployment rate              | 1.153      | 0.230     | 0.182      | 1.526      |

Source: Author's own elaboration

agricultural industrialisation on economically inclusive growth at varied levels, as well as their varied impacts across regions with different levels of economically inclusive growth. We conduct quantile regression on two distinct subsamples, the high-income group and the low-income group, allowing us to determine whether the impacts of digital finance and agricultural industrialisation differ by income level.

One issue that needs addressing in our empirical model is the presence of endogeneity. A significant potential source of endogeneity is the reverse causality between digital finance and agricultural industrialisation, as well as inclusive economic growth. Another source arises from common, yet unobserved, factors that influence both the dependent and main explanatory variables. To tackle this potential endogeneity, we employ instrumental variables for re-estimation to mitigate the issue.

## RESULTS

**Main results.** Prior to estimating empirically, tests for multicollinearity were conducted on the regression models represented in Tables 3 and 4. Results from [Tables S1 and S2 \(Electronic Supplementary Material – ESM\)](#) indicate that there are no issues of multicollinearity within the estimation models (mean  $VIF < 10$ ). Table 3 reports the empirical findings concerning the impact of digital finance on agricultural industrialisation. The study determines that the development of digital finance significantly contributes to advancing the level of agricultural industrialisation; furthermore, the breadth of coverage, depth of use, and digitisation of digital finance all play significant roles in enhancing agricultural industrialisation. The market in rural areas is promising; the process of agricultural industrialisation predominantly occurs in rural settings

Table 3. Impact of digital finance on agricultural industrialisation ( $n = 310$ )

| Variables        | Agricultural industrialisation |                    |                    |                    |
|------------------|--------------------------------|--------------------|--------------------|--------------------|
|                  | (1)                            | (2)                | (3)                | (4)                |
| <i>Indifi</i>    | 0.188***<br>(8.36)             |                    |                    |                    |
| <i>Incovdth</i>  |                                | 0.121***<br>(5.75) |                    |                    |
| <i>Inusapth</i>  |                                |                    | 0.149***<br>(5.90) |                    |
| <i>Indigle</i>   |                                |                    |                    | 0.113***<br>(4.54) |
| <i>lnfdi</i>     | 0.021<br>(0.99)                | 0.009<br>(0.38)    | 0.005<br>(0.24)    | 0.005<br>(0.22)    |
| <i>lnapi</i>     | 1.957**<br>(2.28)              | 0.505<br>(0.67)    | −0.104<br>(−0.13)  | 0.059<br>(0.06)    |
| <i>lngov</i>     | −0.079<br>(−0.82)              | −0.056<br>(−0.53)  | −0.060<br>(−0.59)  | −0.050<br>(−0.43)  |
| <i>lnpd</i>      | −0.000<br>(−0.03)              | 0.003<br>(0.20)    | 0.014<br>(1.06)    | 0.010<br>(0.65)    |
| <i>lncapital</i> | −0.272<br>(−0.65)              | 0.044<br>(0.10)    | −0.067<br>(−0.15)  | 0.350<br>(0.84)    |
| <i>lnrat</i>     | −0.073<br>(−0.75)              | −0.093<br>(−1.05)  | −0.119<br>(−1.29)  | −0.163<br>(−1.55)  |
| <i>_cons</i>     | −10.400***<br>(−2.72)          | −4.114<br>(−1.28)  | −1.240<br>(−0.34)  | −2.720<br>(−0.58)  |
| $R^2$            | 0.509                          | 0.472              | 0.443              | 0.413              |

\*\* and \*\*\*significance levels at 0.05 and 0.01, respectively; regression coefficients are outside of parentheses and z-values are in parentheses

Source: Author's own elaboration

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Table 4. Digital finance, agricultural industrialisation, and inclusive economic growth ( $n = 310$ )

| Variables             | Inclusive economic growth |                        |                        |                       |                       |                       |
|-----------------------|---------------------------|------------------------|------------------------|-----------------------|-----------------------|-----------------------|
|                       | (1)                       | (2)                    | (3)                    | (4)                   | (5)                   | (6)                   |
| <i>Indifi</i>         | 0.308***<br>(36.07)       | 0.360***<br>(23.61)    | 0.346***<br>(18.08)    |                       |                       |                       |
| <i>lnain</i>          |                           |                        | 0.063<br>(0.75)        | 0.192*<br>(1.69)      | 0.183**<br>(2.18)     | 0.331***<br>(4.11)    |
| <i>lncovdth</i>       |                           |                        |                        | 0.204***<br>(7.94)    |                       |                       |
| <i>lnusapth</i>       |                           |                        |                        |                       | 0.295***<br>(9.68)    |                       |
| <i>Indigle</i>        |                           |                        |                        |                       |                       | 0.191***<br>(6.44)    |
| <i>lnfdi</i>          |                           | −0.004<br>(−0.43)      | −0.006<br>(−0.69)      | −0.031**<br>(−2.24)   | −0.032***<br>(−3.04)  | −0.034**<br>(−2.13)   |
| <i>lnpci</i>          |                           | 7.690***<br>(13.70)    | 7.532***<br>(15.18)    | 4.660***<br>(7.39)    | 5.014***<br>(9.56)    | 4.491***<br>(4.74)    |
| <i>lngov</i>          |                           | 0.050<br>(0.75)        | 0.057<br>(0.87)        | 0.111<br>(1.49)       | 0.084*<br>(1.81)      | 0.125<br>(1.54)       |
| <i>lnpd</i>           |                           | 0.013<br>(0.64)        | 0.013<br>(0.63)        | 0.021<br>(0.72)       | 0.033<br>(1.54)       | 0.029<br>(1.07)       |
| <i>lncapital</i>      |                           | 1.202***<br>(5.34)     | 1.243***<br>(5.76)     | 1.820***<br>(6.28)    | 1.467***<br>(5.12)    | 2.171***<br>(6.45)    |
| <i>lnrat</i>          |                           | −0.001<br>(−0.02)      | 0.004<br>(0.07)        | −0.011<br>(−0.13)     | −0.025<br>(−0.35)     | −0.095<br>(−0.92)     |
| <i>_cons</i>          | 8.357***<br>(316.91)      | −30.406***<br>(−12.41) | −29.649***<br>(−13.37) | −16.959***<br>(−6.08) | −18.302***<br>(−8.35) | −16.779***<br>(−3.91) |
| <i>R</i> <sup>2</sup> | 0.811                     | 0.920                  | 0.921                  | 0.871                 | 0.898                 | 0.828                 |

\*, \*\* and \*\*\*significance levels at 0.1, 0.05 and 0.01, respectively; regression coefficients are outside of parentheses and z-values are in parentheses

Source: Author's own elaboration

where financial services are limited. As agricultural industrialisation necessitates considerable financial resources to support production transformation, there exists a high potential demand for financial services. Therefore, given that digital finance can overcome the barrier of physical distance, funds become more readily accessible, providing essential financial support for the development of agricultural industrialisation. This, in turn, attracts part of the rural labour force, elevates the income levels of local residents, and stimulates the growth of other agriculture-related industries. In China, during the transition period, although the total volume of financial resources is substantial and broadly plentiful on a macroscopic level, financial services are not fully accessible to residents in rural areas. This dual reality results in both a macroscopic oversupply

of financial resources and a microscopic insufficiency of financial services, leading to ineffective utilisation of financial resources, particularly in rural regions. Given the costs associated with financial services and the presence of information asymmetry, the generally abundant financial funds often exclude low-income groups. However, with the integration of digital technology in financial services, which enhances the inclusivity of these services, some funds are channelled to rural areas, thereby supporting the development of agricultural industries and promoting agricultural industrialisation.

Table 4 presents the results of the regression analysis of economically inclusive growth. In column 1, only the regression of digital finance on economically inclusive growth is considered, whereas column 2 includes a series of control variables in addition to those

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in column 1. In both cases, digital finance is strongly associated with economically inclusive growth. Moreover, the coefficient for digital finance is significantly positive, indicating that digital finance promotes economically inclusive growth. The estimated coefficients suggest that, on average, a 1% increase in digital finance is associated with a 0.3–0.36% increase in economically inclusive growth. An interesting regression result appears in column 3, where, after adding agricultural industrialisation to the regression, it has a positive effect on economically inclusive growth but loses its significance, concurrently weakening the effect of digital finance on economically inclusive growth. In the regressions considering agricultural industrialisation alongside the breadth of digital finance coverage, usage depth, and digitisation, the results reveal that agricultural industrialisation significantly contributes to economic inclusive growth, with the breadth of digital finance coverage, usage depth, and digitisation all advancing economically inclusive growth. The depth

of use and digitisation strengthen the positive effect of agricultural industrialisation on economically inclusive growth. The empirical results indicate that agricultural industrialisation is a key channel through which digital finance influences inclusive economic growth. As evidenced in Table 4, the magnitude of the coefficient for agricultural industrialisation suggests that for it to be most effective in contributing to economically inclusive growth, increasing the breadth of digital finance coverage needs to be followed by an increase in the use and digitisation of these services.

**Robustness test results.** We test the robustness of our results in four ways. First, we re-estimate the model using panel fixed effects; the estimates in column 1 of Table 5 remain largely consistent with those in column 3 of Table 4, suggesting that digital finance contributes to inclusive economic growth. Second, we employ a differential GMM approach to re-run a quantitative regression of the model and still conclude that digital finance significantly contributes

Table 5. Robustness analysis of the impact of digital finance and agricultural industrialisation on inclusive economic growth

| Variables             | Inclusive economic growth |                    |                     |                     |
|-----------------------|---------------------------|--------------------|---------------------|---------------------|
|                       | fixed                     | differential GMM   | 2011–2015           | 2016–2020           |
|                       | (1)                       | (2)                | (3)                 | (4)                 |
| <i>ln difi</i>        | 0.327***<br>(15.56)       | 0.355***<br>(7.05) | 0.144***<br>(11.45) | 0.617***<br>(21.16) |
| <i>ln ain</i>         | 0.040<br>(0.43)           | 0.019<br>(0.14)    | 0.048<br>(0.87)     | 0.122**<br>(2.72)   |
| <i>ln fdi</i>         | –0.022**<br>(–2.14)       | –0.005<br>(–0.27)  | –0.026**<br>(–2.62) | 0.000<br>(0.01)     |
| <i>ln cpi</i>         | 7.042***<br>(13.04)       | 6.672***<br>(7.12) | –0.312<br>(–0.51)   | 2.024***<br>(5.93)  |
| <i>ln gov</i>         | 0.090*<br>(1.78)          | 0.163<br>(1.54)    | 0.161***<br>(2.95)  | –0.019<br>(–0.69)   |
| <i>ln pd</i>          | –0.007<br>(–1.26)         | –0.032<br>(–0.71)  | 0.001<br>(0.50)     | 0.256<br>(1.49)     |
| <i>ln capital</i>     | 1.599***<br>(8.58)        | 1.949***<br>(3.72) | 0.466***<br>(5.95)  | 0.321**<br>(2.58)   |
| <i>ln rat</i>         | 0.020<br>(0.27)           | –0.136<br>(–0.97)  | 0.051<br>(0.94)     | 0.015<br>(0.66)     |
| <i>_cons</i>          | –28.172***<br>(–11.53)    |                    | 8.919***<br>(3.08)  | –4.606**<br>(–2.06) |
| Observations          | 310                       | 279                | 155                 | 155                 |
| <i>R</i> <sup>2</sup> | 0.924                     |                    | 0.941               | 0.976               |

\*\* and \*\*\*significance levels at 0.05 and 0.01, respectively; regression coefficients are outside of parentheses and z-values are in parentheses

Source: Author's own elaboration

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Table 6. Endogeneity test ( $n = 310$ )

| Variables             | Inclusive economic growth |                      |
|-----------------------|---------------------------|----------------------|
|                       | (1)                       | (2)                  |
| <i>Indifi</i>         | 0.186**<br>(2.69)         | 0.199***<br>(13.16)  |
| <i>lnain</i>          | 0.437***<br>(3.72)        | 0.065<br>(0.92)      |
| <i>_cons</i>          | 10.656***<br>(3.12)       | 34.998***<br>(11.18) |
| <i>Controls</i>       | yes                       | yes                  |
| <i>R</i> <sup>2</sup> | 0.795                     | 0.903                |

\*\* and \*\*\*significance levels at 0.05 and 0.01, respectively; regression coefficients are outside of parentheses and z-values are in parentheses

Source: Author's own elaboration

to inclusive economic growth. Third, sub-sample regressions were conducted by dividing the sample into two periods, 2011–2015 and 2016–2020, and the conclusions reached remained consistent. We can thus conclude that our empirical findings are robust.

**Endogeneity test.** To address potential endogeneity issues, this study utilises information technology and postal services as instrumental variables for digital finance, followed by the application of the two-stage least squares method (IV-2SLS) for estimation (Li et al. 2024). The selection of instrumental variables must meet the prerequisite assumptions of correlation

and exogeneity; that is, they must be highly correlated with the use of digital finance and relatively exogenous to inclusive growth. Firstly, the development of information technology and postal services is highly correlated with digital finance: the faster the development of information technology, the higher the level of digital finance, thus satisfying the hypothesis of correlation. Secondly, information technology and postal services do not directly affect the improvement of income levels and income distribution and are relatively exogenous to inclusive growth, satisfying the assumption of exogeneity (Hao and Zhang 2024). The instrumental variables for digital finance are represented by information technology (*per capita* mobile phone exchange capacity) and postal and telecommunications services (the share of total postal and telecommunications services used in the development of postal and telecommunications services in GDP). The estimation results in Table 6 indicate that the empirical conclusion remains valid after mitigating endogeneity.

**Regional heterogeneity test results.** Table 7 presents the regression results of the effects of digital finance and agricultural industrialisation on economically inclusive growth. The results indicate that digital finance significantly contributes to economic inclusive growth across different regions, with the estimated coefficients showing that the eastern region performs significantly better than other regions. Furthermore, when the regression includes agricultural industrialisation, this effect is more pronounced in the eastern

Table 7. Regional heterogeneity in the impact of digital finance and agricultural industrialisation on inclusive economic growth

| Variables             | Inclusive economic growth |                       |                       |                       |                       |                       |
|-----------------------|---------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
|                       | East                      | Middle                | West                  | East                  | Middle                | West                  |
|                       | (1)                       | (2)                   | (3)                   | (4)                   | (5)                   | (6)                   |
| <i>Indifi</i>         | 0.421***<br>(12.61)       | 0.416***<br>(15.02)   | 0.364***<br>(16.40)   | 0.475***<br>(10.48)   | 0.377***<br>(9.95)    | 0.297***<br>(9.63)    |
| <i>lnain</i>          |                           |                       |                       | −0.251**<br>(−2.07)   | 0.101<br>(1.48)       | 0.252***<br>(2.76)    |
| <i>_cons</i>          | −31.748***<br>(−8.21)     | −35.811***<br>(−9.57) | −28.141***<br>(−6.77) | −31.728***<br>(−8.49) | −32.725***<br>(−7.27) | −22.974***<br>(−5.63) |
| <i>Controls</i>       | yes                       | yes                   | yes                   | yes                   | yes                   | yes                   |
| Observations          | 110                       | 80                    | 120                   | 110                   | 80                    | 120                   |
| <i>R</i> <sup>2</sup> | 0.928                     | 0.939                 | 0.899                 | 0.930                 | 0.944                 | 0.919                 |

\*\* and \*\*\*significance levels at 0.05 and 0.01, respectively; regression coefficients are outside of parentheses and z-values are in parentheses; East region: Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan, Liaoning; Middle region: Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan, Jilin, Heilongjiang; West region: Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang

Source: Author's own elaboration

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region compared to the central and western regions. Interestingly, agricultural industrialisation exhibits certain inclusive characteristics among regions; specifically, the central and western regions perform significantly better than the eastern regions, where industries and services are more developed and infrastructure is more advanced. While in the central and western regions, agriculture occupies a relatively large proportion and holds a more important position within the main economy. Consequently, digital finance is more effective in developed regions in raising income levels and promoting inclusive economic growth, whereas in the central and western regions, agricultural industrialisation helps contribute to farmers' income growth.

**Quantile estimation results.** Table 8 presents the results of the quantile regressions assessing the impact of digital finance and agricultural industrialisation on inclusive economic growth. The first four columns provide the regression results for digital finance development at the 10, 25, 75, and 90% quantiles. The signs of the estimated coefficients across the quartiles of digital finance in columns 1–4 align with the findings in Table 4, indicating that digital finance is associated with increased economic and inclusive growth across all quartiles. Importantly, while digital finance enhances economic inclusion growth across all quantiles, its impact on promoting economic inclusion growth is more significant in regions with higher levels of economic inclusion growth. Columns 5–8 include the estimated results for agricultural industrialisation, which generally align with those in Table 4. In summary, our quantile regression results demonstrate that an increase in digital finance is associated with an enhancement of inclusive

economic growth at all quantile levels. Moreover, the inclusive growth effect of digital finance intensifies with the rise in inclusive economic growth.

**Further analysis.** Table 9 presents the results of the quantitative regressions of digital finance and agricultural industrialisation on economically inclusive growth across different income levels. The results indicate that digital finance is particularly effective in enhancing economically inclusive growth within the high-income group sample when the regressions are categorised into high-income and low-income groups. In contrast, the estimation results for agricultural industrialisation show the opposite effect; it is more beneficial in enhancing economic inclusion in the low-income group sample. The process of agricultural industrialisation capitalises on rural resources, employs rural labour, and uplifts the income levels of rural residents, thereby contributing more significantly to inclusive economic growth.

## DISCUSSION

Existing research has primarily focussed on the impact of financial services on the modernisation of agricultural industrialisation and the total factor productivity of agriculture (Meuweissen et al. 2003; Watson and Achinelli 2008; Zakaria et al. 2019; Li et al. 2020). This study, however, primarily analyses the inclusiveness of digital finance from the perspective of digital financial services for agricultural industrialisation, which characterises this study. The main limitation of this study lies in the incomplete coverage of agricultural industrialisation indices. There are several shortcomings in constructing evaluation indices

Table 8. Impact of digital finance and agricultural industrialisation on inclusive economic growth: quantile estimates ( $n = 310$ )

| Variables             | Inclusive economic growth |                       |                       |                       |                       |                       |                       |                       |
|-----------------------|---------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
|                       | (0.1)                     | (0.25)                | (0.75)                | (0.9)                 | (0.1)                 | (0.25)                | (0.75)                | (0.9)                 |
|                       | (1)                       | (2)                   | (3)                   | (4)                   | (5)                   | (6)                   | (7)                   | (8)                   |
| <i>Indifi</i>         | 0.453***<br>(24.35)       | 0.450***<br>(21.93)   | 0.450***<br>(10.79)   | 0.476***<br>(10.20)   | 0.462***<br>(22.09)   | 0.448***<br>(20.25)   | 0.420***<br>(9.44)    | 0.475***<br>(9.11)    |
| <i>lnain</i>          |                           |                       |                       |                       | 0.031<br>(0.95)       | 0.031<br>(0.92)       | 0.152**<br>(2.22)     | –0.006<br>(–0.08)     |
| <i>_cons</i>          | –32.719***<br>(–6.60)     | –33.005***<br>(–6.02) | –46.011***<br>(–4.14) | –47.998***<br>(–3.86) | –24.888***<br>(–4.83) | –33.306***<br>(–6.12) | –45.546***<br>(–4.16) | –47.594***<br>(–3.70) |
| <i>Controls</i>       | yes                       | yes                   | yes                   | yes                   | yes                   | yes                   | yes                   | yes                   |
| <i>R</i> <sup>2</sup> | 0.620                     | 0.595                 | 0.506                 | 0.539                 | 0.623                 | 0.596                 | 0.514                 | 0.539                 |

\*\* and \*\*\*significance levels at 0.05 and 0.01, respectively; regression coefficients are outside of parentheses and *t*-values are in parentheses

Source: Author's own elaboration

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Table 9. Impact of digital finance and agricultural industrialisation on inclusive economic growth at different income levels

| Variables             | Inclusive economic growth |                        |                    |                        |
|-----------------------|---------------------------|------------------------|--------------------|------------------------|
|                       | low income                | high income            | low income         | high income            |
|                       | (1)                       | (2)                    | (3)                | (4)                    |
| <i>Indifi</i>         | 0.271***<br>(8.74)        | 0.458***<br>(14.97)    | 0.260***<br>(8.96) | 0.466***<br>(16.83)    |
| <i>lnain</i>          |                           |                        | 0.067**<br>(2.25)  | –0.065<br>(–1.01)      |
| <i>_cons</i>          | –7.334<br>(–1.04)         | –21.884***<br>(–10.99) | –7.261<br>(–1.05)  | –22.990***<br>(–10.31) |
| <i>Controls</i>       | yes                       | yes                    | yes                | yes                    |
| <i>n</i>              | 160                       | 150                    | 160                | 150                    |
| <i>R</i> <sup>2</sup> | 0.832                     | 0.934                  | 0.844              | 0.936                  |

\*\* and \*\*\*significance levels at 0.05 and 0.01, respectively; regression coefficients are outside of parentheses and z-values are in parentheses

Source: Author's own elaboration

for agricultural industrialisation, and there is currently no standardised measurement method. As a result, when selecting basic indices for agricultural industrialisation, it is impossible to consider all possible indices. Additionally, *per capita* income has certain limitations as a proxy index for inclusive economic growth. Although supported by relevant literature, it remains insufficient as it fails to incorporate related economic, social, and environmental indices. Future research could develop a more comprehensive composite index. Digital finance, integrating digital technologies such as artificial intelligence with financial services, combines the dual attributes of digital technology and financial services. While providing financial services, it also facilitates income distribution and enhances inclusive economic growth. As a form of financial capital, digital finance has made agricultural development more concrete through the investment of agricultural capital. Agricultural-scale operations also require the support of financial capital, which may be an important research direction in the future.

## CONCLUSION

Based on interprovincial panel data from 2011 to 2020, this study empirically analyses the impact of digital finance and agricultural industrialisation on inclusive economic growth. The findings demonstrate that digital finance is conducive to enhancing economic inclusion and can advance it by supporting agricultural industrialisation. Agricultural industrialisation can be a key channel through which

digital finance influences inclusive economic growth. The breadth of digital finance coverage, depth of use, and degree of digitisation are positively significant in promoting inclusive economic growth. Furthermore, significant variability exists in each dimension, indicating that there is a considerable structural effect of digital finance development on inclusive economic growth. Digital finance makes a significant contribution to inclusive economic growth in different regions, and agricultural industrialisation exhibits certain inclusive characteristics among regions; specifically, the central and western regions perform significantly better than the eastern regions. An increase in digital finance is associated with an increase in inclusive economic growth at all quantitative levels. Moreover, the inclusive growth effect of digital finance grows in tandem with economic growth. Digital finance is more beneficial in increasing economic inclusion in the sample of high-income individuals. Conversely, agricultural industrialisation contributes more significantly to increasing economic inclusion in the low-income group sample.

Based on these research findings, the following policy implications are proposed:

First, in remote and underdeveloped rural areas with low levels of agricultural industrialisation, efforts should be directed towards creating a favourable environment for digital financial investment and financing. Such measures will attract external investment, strengthen interregional industrial support mechanisms, enhance the sharing of achievements across regions, build modern agricultural systems, and further

develop agricultural industrialisation. This strategy is instrumental in helping farmers increase their income and achieve prosperity.

Second, in rural areas within developed regions, the focus should be on enhancing rural information infrastructure, improving transportation accessibility, and reducing commuting costs. This approach enables developed regions to achieve inclusive growth more rapidly, thereby generating positive spillover effects and radiating influence to less developed areas. It also guides the agricultural industrialisation process in these regions.

Third, digital finance provides substantial income-boosting potential for underdeveloped regions, displaying regionally inclusive characteristics. By mitigating information asymmetry and enhancing financial service coverage, digital finance supports rural revitalisation, advances agricultural industrialisation, and significantly elevates rural residents' income levels.

Finally, while digital finance holds considerable potential to enhance residents' income and stimulate rural economic development, it is essential to ensure its standardised and moderate development. Excessive allocation of financial resources not only results in the wasteful use of financial services but may also inadvertently increase service costs and elevate the risk of default. Therefore, it is crucial to fully leverage the informational advantages and accessibility of digital finance to coordinate resource allocation and facilitate rational capital flows across regions and between urban and rural areas. This approach supports agricultural modernisation, strengthens agricultural industrialisation across all regions, builds sufficient capital reserves, and ensures that digital finance can play a pivotal role when financial services are needed.

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