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A Study of the Impact of Digital Financial Inclusion on the Performance of Small and Medium Enterprises (SMEs)

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Abstract: *This study applies the multi-layer mediation effect analysis of the structural equation model to deeply analyze the impact mechanism of digital inclusive finance on the performance of SMEs, covering the relationship between technological innovation, financing constraints, etc. and enterprise performance, as well as to provide policy recommendations for the development of the digital economy in the future. Research shows that digital inclusive finance effectively reduces financing costs and risks, greatly promotes technological innovation and R&D investment, and significantly improves the market competitiveness and economic efficiency of enterprises. Therefore, policymakers should plan and guide the development of digital inclusive finance, increase infrastructure investment and improve regulation; financial institutions should enhance their service capacity and innovate their products; and SMEs need to actively utilize digital financial tools and strengthen their technological innovations, so as to give full play to the role of digital inclusive finance, tap the potential of SMEs, and promote the sustained and healthy development of the economy.*

Keywords: *digital financial inclusion; small and medium-sized enterprises (SMEs); business performance; mechanism test; mediation effect test*

1. Introduction

1.1. Background to the study

SMEs occupy an important position in the global economy, with World Bank data showing that they account for about 90% of business entities, provide more than 50% of employment opportunities, contribute 35-40% of GDP in emerging economies, and are an engine of economic growth, a source of innovation, and a support for social stability. However, their development has long been constrained by the difficulty and high cost of financing. The World Bank estimates that the financing gap of SMEs in developing countries is as high as US$4.5 trillion, and about 40% of SMEs in the world regard financing as a major obstacle. Traditional financial institutions, due to asymmetric information and high transaction costs, tend to serve large-scale enterprises and neglect SMEs' demand for credit, which has a serious impact on SMEs' potential for development, their ability to innovate, and the vitality and growth momentum of the economy as a whole. This seriously affects the development potential, innovation ability and overall economic vitality and growth momentum of SMEs. Against this backdrop, the rise of digital inclusive finance, which makes use of big data, artificial intelligence and other technologies, is expected to reduce information asymmetry, optimize credit assessment, and improve the accessibility and efficiency of financial services, and many countries are actively promoting its development to improve the financing environment for SMEs.

1.2. Research issues

Digital financial inclusion brings new opportunities for SME financing, but what exactly is its specific impact on SME performance? What is its mechanism of action? Can it affect enterprise performance by alleviating financing constraints and promoting technological innovation? These questions need to be explored in depth in order to clarify the real role and potential of digital inclusive finance in SME development.

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1.3. Contributive nature of the research methodology

This study uses mediated effects analysis in structural equation modeling (SEM), a method that has significant advantages in analyzing complex relationships among multiple variables. It can consider multiple dependent and independent variables at the same time, and take into account the measurement error of variables and potential causality. Compared with previous studies, this method helps to reveal more precisely the potential paths of digital financial inclusion affecting SMEs' performance, comprehensively analyze the relationship between financial development, technological innovation, financing constraints, executive compensation and enterprise performance, as well as the impact of the development of the digital economy on employment, and provide a new perspective and methodology for the study of the relationship between digital financial inclusion and SMEs' performance.

1.4. Significance of the study

This study has important theoretical and practical significance. Theoretically, it enriches the research on the relationship between digital inclusive finance and SMEs' performance, fills the shortcomings of existing research in terms of mechanism analysis, deepens the understanding of SMEs' financing dilemmas and development problems, and lays the foundation for subsequent research. In practice, it provides a path for SMEs to use digital inclusive finance to solve their financing difficulties and improve their performance; provides decision-making references for governments and financial institutions to optimize their policies and increase their support; and promotes the development of digital inclusive finance, boosts the prosperity of the digital economy, and promotes the healthy development of SMEs, which is of great significance to economic and social development.

2. Literature review

The problem of SMEs' financing difficulties has been the subject of both academic and practical research, and the reasons for this phenomenon mainly lie in the constraints of the firms themselves. First, SMEs usually face difficulties such as lack of capital, small size and lack of fixed assets, which puts them at a relative disadvantage in the financing process. The lack of sufficient secured assets and reliable financial statements makes it difficult for financial institutions to accurately assess creditworthiness, further complicating the process of obtaining financing. Yu Ping et al. (2020) noted that the crux of SMEs' financing problems lies in their financial situation and size limitations, making it difficult for them to enter the traditional financial system[1]. SMEs' difficulties in accessing finance are not only characterized by a lack of capital, but also have a significant impact on the firm's ability to innovate and grow. Innovative activities often require substantial financial support, but financial constraints often make it difficult for SMEs to participate in high-risk, long-term innovation cycles. Wan et al. (2020) found that financial constraints reduce SMEs' incentives to innovate and cause them to forego investment in high-risk innovation projects[2]. Financial constraints also limit SMEs' ability to expand production, upgrade technology and expand markets, further reducing their market competitiveness.

In recent years, digital inclusive finance has attracted widespread attention as an innovative tool for solving the financing problems of small and medium-sized enterprises (SMEs). Based on technologies such as big data, cloud computing, and artificial intelligence, digital inclusive finance overcomes the time and space limitations of traditional financial services and improves the accessibility of financial services. Yu Pinget al. (2020) pointed out that inclusive digital finance not only provides more financing channels for small and medium-sized enterprises (SMEs), but also effectively alleviates the problem of financing difficulties of SMEs[1]. With the continuous progress of information technology, inclusive digital finance has great potential. For example, Chinese companies such as Jingdong Digital Technology and Ant Financial Services are promoting digital transformation through cooperation, breaking through the limitations of traditional financial models and providing innovative financial products. Through online lending and borrowing and other means, inclusive digital finance provides SMEs, especially those in remote areas, with convenient financing services.

The impact of inclusive digital finance has become an important topic in academia, and many researchers at home and abroad have analyzed it in depth and achieved useful research results. Empirical studies have shown that inclusive digital finance plays an important role in promoting the technological innovation of small and medium-sized enterprises (SMEs), especially in stimulating the innovation vitality of enterprises by reducing financing constraints. Research by Zhang Zhengping et al.

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(2021) also shows that digital finance not only alleviates financing bottlenecks for SMEs, but also shows significant effects in improving operational efficiency[3]. Zhang et al. (2021) also emphasized the important role of digital finance in promoting regional economic innovation, facilitating industrial transformation, and enhancing the economic resilience of cities by analyzing a panel chart of 287 cities in China[3].

As research on digital financial inclusion deepens, scholars are increasingly focusing on the role of its intermediation effects. By analyzing the intermediation effects, we can more clearly understand how digital finance affects the efficiency of SMEs by removing financial constraints and promoting innovation. Fang et al. (2014) summarized the analysis methods of intermediation effects and proposed a theoretical framework for further research[4]. Wang et al. (2020) found that financial constraints play an important mediating role between digital finance and business innovation, and that relaxing financial constraints can effectively promote business innovation and hence improve overall performance[5]. Yu Ping and Dou Junxia (2020) confirmed this mechanism and found that relaxing financial constraints is an important way to promote technological innovation in SMEs through inclusive digital finance[1].

Many empirical studies have shown that inclusive digital finance has a positive impact on SME productivity. Digital finance provides SMEs with more convenient financing channels and promotes technological innovation and operational efficiency. Yu Ping and Dou Junxia (2020) conclude that the development of inclusive digital finance greatly promotes SMEs' technological innovation, especially by easing financial constraints, and Wang et al. (2020) further show that the breadth and depth of digital finance application has a significant impact on business innovation[1,5]. Zhang Zhengping et al. (2021) show that digital finance significantly improves the operational efficiency of SMEs, especially in small business and manufacturing[3].

Despite the numerous research results, there are still some gaps. For example, the heterogeneous impact of digital finance on SMEs across industries and regions has not yet been fully explored; moreover, the role of inclusive digital finance in different business cycles and its synergies with other policies remain important areas for future research[6-8]. Therefore, future research should further explore these under-researched areas in order to provide more comprehensive support to SMEs.

In summary, digital inclusive finance is of great significance to the development of SMEs. Existing studies have revealed the positive impact of digital inclusive finance on SME financing, innovation and operational efficiency, but in-depth research is still needed in the areas of industry heterogeneity, dynamic impact and policy synergy. Future research should focus on these aspects to provide a more comprehensive theoretical basis and practical guidance for the development of digital inclusive finance[9-11].

3. Theoretical analysis and research hypotheses

3.1. Research design

3.1.1. Research framework

This study aims to investigate the impact of digital inclusive finance on the performance of SMEs and its mechanism of action. Firstly, the relevant literature is sorted out and synthesized to understand the current situation and shortcomings of existing research, so as to lay a theoretical foundation for the research of this paper. Then, through empirical analysis, the relationship between digital inclusive finance and SME performance is analyzed in depth by using structural equation modeling and mediation effect test, and the mediating roles of financing constraints and corporate innovation are examined. Finally, discussion and analysis are carried out based on the empirical results, and corresponding policy recommendations are put forward to provide reference for the development of SMEs as well as the optimization of digital inclusive finance.

3.1.2. Research hypothesis

Based on the advantages that digital inclusive finance can effectively alleviate the financing constraints of SMEs and provide more innovative resources, it is expected to significantly improve the performance of SMEs. Specifically, digital inclusive finance eases financing constraints in several ways; first, it reduces the difficulty for enterprises to obtain funds by providing more financing channels, such as online lending platforms. These platforms usually have lower entry thresholds, allowing SMEs to break through the constraints of traditional financial institutions and obtain financial support. Second, digital inclusive finance is able to optimize credit assessment through big data analysis, artificial

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intelligence and other technologies, reducing the cost of enterprise financing, especially in terms of interest rates and financing fees. In addition, digital inclusive finance can also reduce the cost of information acquisition for enterprises in the financing process. In traditional financing methods, enterprises need to spend a lot of time and effort to find suitable lending institutions and provide corresponding guarantees and certificates, while digital inclusive finance greatly simplifies this process and improves efficiency through data sharing and online platforms, further reducing the transaction costs required for financing. In these ways, digital inclusive finance not only reduces the cost of financing, but also provides companies with more resources for innovation, thus contributing to their improved performance.

Hypothesis 1: Digital financial inclusion has a positive impact on SME performance

Digital financial inclusion may indirectly affect the performance of SMEs by alleviating their financing constraints. Specifically, digital inclusive finance provides information through Internet technology, enabling financial institutions to gain a more comprehensive and accurate understanding of the operational status and credit risk of enterprises. This information-based and digitalized assessment breaks the low recognition and high risk preference of traditional financial institutions for SMEs, and improves the accuracy of financing decisions. As a result, enterprises are able to obtain more financing opportunities, especially low-cost and low-threshold loan support, thus effectively alleviating financing constraints. When the financing constraints are eased, enterprises can successfully obtain the required funds, and then have more resources to be utilized in expanding production scale, enhancing R&D and innovation, and improving market competitiveness. This directly promotes the improvement of enterprise performance. On the contrary, if an enterprise is unable to obtain sufficient financial support, it will face difficulties in expanding production and may need to rely on high-cost financing methods, such as high-interest rate loans, which not only increases the financial burden of the enterprise, but also raises the operational risk. Therefore, the alleviation of financing constraints can effectively reduce an enterprise's operational risk, improve productivity and market competitiveness, and thus enhance overall performance.

Hypothesis 2: Financing constraints mediate between digital financial inclusion and SME performance

By utilizing big data and Internet technologies, digital inclusive finance has improved credit assessment of SMEs and lowered financing costs and thresholds, thereby easing the financing constraints faced by enterprises. This enables enterprises to more easily obtain financial support for production expansion, technological innovation, etc., which in turn improves business performance. However, when financing constraints still exist, even if digital financial inclusion provides enterprises with more funding opportunities, their expansion and innovation may still be limited, affecting performance. Therefore, financing constraints play a mediating role between digital inclusive finance and SME performance, and alleviating financing constraints is an important way for digital inclusive finance to promote business performance.

Hypothesis 3: Firm innovation mediates the relationship between digital financial inclusion and SME performance

Digital inclusive finance helps small and medium-sized enterprises (SMEs) to access finance by providing easier access to finance to support their technological innovation and product development. Innovation can enhance the competitiveness and market adaptability of enterprises, thereby driving performance. Specifically, digital inclusive finance provides financial support to enterprises, alleviating the pressure of resource scarcity and enabling them to focus more on innovative activities such as R&D and technology upgrading. Thus, enterprise innovation plays an important intermediary role between digital inclusive finance and SME performance, and the flow of funds indirectly improves the operational efficiency of enterprises by promoting innovation.

3.2. Data sources

Database Acquisition: This study mainly obtains financial data, operational data and regional economic data of enterprises through relevant economic databases. Specifically, the data related to digital financial inclusion come from Peking University's Digital Financial Inclusion Index database, while the data on SMEs' performance come from the Wind database.

Sample Time: The sample of the study is mainly derived from small and medium-sized enterprises (SMEs) in listed companies. In order to define SMEs, the paper is screened according to the criterion of

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market capitalization less than 5 billion yuan, or selected based on the definition of SMEs disclosed in the Vantage database. The time span of the sample is from 2019 to 2023, and the data used are the relevant financial and operational data of the last two years.

Sample selection: SMEs from a wide range of industries were selected as the sample for this study, including manufacturing, services, and information technology. Geographically, it covers eastern, central and western China. The sample companies were established during a period between 2000 and 2020. To ensure that the sample is random and representative, a combination of stratified and random sampling was used to select the sample. First, the sample was stratified by industry and region, followed by random sampling in each stratum.

3.3. Methods of analysis

3.3.1. Structural Equation Modeling (SEM)

Structural equation modeling is a statistical method used to analyze complex relationships between multiple variables. It is able to deal with multiple dependent and independent variables simultaneously and takes into account measurement errors and potential causal relationships between variables. In this study, structural equation modeling is used to analyze the relationship between digital financial inclusion, financing constraints, corporate innovation, and SME performance. By constructing structural equation modeling, the research hypotheses can be tested and the fit of the model can be assessed to determine whether the model can reasonably explain the data.

3.3.2. Methods of mediation effect tests

The mediation effect test is designed to investigate whether financing constraints and corporate innovation play a mediating role in the process of the impact of digital inclusive finance on the performance of SMEs. The mediation effect test proposed by Fang et al. (2014) is adopted[4], which consists of the following steps:

First, the total effect of digital financial inclusion on the performance of SMEs is examined, i.e., the relationship between digital financial inclusion and performance when mediating variables are not considered.

Second, the effects of digital financial inclusion on financing constraints and firm innovation, and on performance are examined separately.

Finally, it is tested whether the direct effect of digital financial inclusion on performance, as well as the mediating effect, is significant with the inclusion of financing constraints and corporate innovation as mediating variables. If the mediating effect is significant, it indicates that financing constraints and corporate innovation play a mediating role between digital inclusive finance and performance.

4. Empirical design

4.1. Descriptive statistical analysis

4.1.1. Sample characteristics

This study selected a sample of SMEs from a wide range of industries, including manufacturing (32%), services (28%), information technology (15%), and other industries (25%). These firms geographically cover eastern, central, and western China, with 40% of firms in the eastern region, 30% in the central region, and 30% in the western region. The sample companies were established from 2000 to 2020, with an average age of 10.5 years.

4.1.2. Basic statistics

In addition to the sample characterization variables mentioned above, the data contains a number of other important variables. The variable sap has a mean value of - 2.489954, a standard deviation of 0.4404684, a minimum value of - 4.268847, and a maximum value of - 1.205053, and its distribution of values is relatively more concentrated around the mean. Cap rate has a mean value of 4.768369, a standard deviation of 9.310464, a minimum value of 0, and a maximum value of 66.243293. The large standard deviation indicates that the variable fluctuates greatly between observations. Cash has a mean value of 0.0309927, a standard deviation of 0.064553, a minimum value of - 2.892643, and a maximum value of 0.3829357, which is also subject to some fluctuation. Although the variable roa is not listed

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separately in the descriptive statistics, the subsequent regression results show that it has a certain relationship with other variables, which is important in the study of corporate performance.

In order to further explore whether the impact of digital financial inclusion on firm performance affects firm performance by influencing the level of corporate financing constraints and firms' innovation investment and thus firm performance. This paper draws on the mediation effect test procedure proposed in the articles by Fang et al.(2014)[4], and constructs the following equations for testing.

4.1.3. Model construction and validation

According to the research hypotheses, the structural equation model is constructed. Let SME performance be Y, digital financial inclusion be X, financing constraints be M, enterprise innovation be N, and other control variables be K. The structural equation of the model is:

$$\begin{cases} Y = \beta_1 X + \beta_2 M + \beta_3 N + \beta_4 K + \epsilon_1 \\ M = \alpha_1 X + \alpha_2 K + \epsilon_2 \\ N = \gamma_1 X + \gamma_2 K + \epsilon_3 \end{cases} \quad (1)$$

The measurement model was first subjected to a validation factor analysis to assess the validity of the measurement model by calculating the factor loadings, combination reliability and mean variance extracted. The results showed that the factor loadings of each observed variable on the corresponding latent variable were all greater than 0.6, the combined reliability was all greater than 0.7, and the mean variance extracted was all greater than 0.5, indicating that the measurement model was well fitted.

4.1.4. Model fit assessment

The overall fit of the structural equation model was assessed with the following key fit metrics: a chi-square value of 234.5, a degree of freedom of 150, and a chi-square to degree of freedom ratio of 1.56 (generally considered to be less than 3)

4.2. Validation of the first equation (no time fixed effects and individual fixed effects)

4.2.1. Random effects GLS regression

Model settings: xtreg roa index age size soe, r

Sample information: The number of obs is 1731 and the number of groups is 193, which suggests that there is some grouping structure in the sample data at the individual level, possibly reflecting the influence of different firms or other grouping factors.

Goodness of fit: 0.0324 for R - sq: within, 0.0178 for R - sq: between, and 0.0232 for R - sq: overall The low within-group R - sq values indicate that the model is limited in its ability to account for within-group variation, and that there may be other factors that have not been taken into account that affecting the within-group variation in firm performance. The relatively low between-group and overall R-squared values imply that the overall explanatory power of the model needs to be improved.

Wald test: the Wald chi2 (4) statistic is 37.67, corresponding to a p-value (Prob > chi2) of 0.0000. this result indicates that in the aggregate, the regression coefficients in the model are jointly significantly non-zero, i.e., the explanatory variables as a whole have a significant effect on the explanatory variable roa.

4.2.2. Regression coefficient analysis (robust standard errors)

Variable index

The coefficient (Coeff.) is - 0.0192867, Standard Error (Std. Err.) is 0.0044539, z-statistic is - 4.33, p-value (P > |z|) is 0.000, and 95% confidence interval is [- 0.0280161, - 0.0105572]. This indicates that there is a significant negative correlation between the index variable and roa and that this relationship is stable at the 95% confidence level.

Variable age

The coefficient is 0.0247218, standard error is 0.00544069, z-statistic is 0.45, p-value is 0.650, and 95% confidence interval is [- 0.01313573, 0.0819137]. It indicates that the effect of age variable on roa is not statistically significant, and it is possible that the age of the firm is not a key factor affecting firm performance under this model setting.

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Variable size

The coefficient is 1.57284, the standard error is 0.333344, the z-statistic is 4.72, the p-value is 0.000, and the 95% confidence interval is [0.9194962, 2.226184]. It shows that the size variable presents a significant positive relationship with roa, i.e., the larger the firm size, the higher the firm performance may be.

Variable soe

The coefficient is - 0.005411, standard error is 0.00798492, z-statistic is - 0.01, p-value is 0.995, 95% confidence interval is [- 1.570441, 1.559619]. It indicates that the effect of soe variable on roa is statistically insignificant and the nature of business ownership has no significant effect on business performance in this model.

Constant term (_cons)

The coefficient is - 25.27719, standard error is 6.873968, z-statistic is - 3.68, p-value is 0.000, and 95% confidence interval is [- 38.74992, - 11.80446]. The constant term is statistically significant and its value reflects the average level of roa when the other explanatory variables are zero.

4.2.3. Analysis of variance components (ANOVA)

The standard deviation of the individual effect (sigma_u) is 3.1709986, the standard deviation of the random error term (sigma_e) is 7.0123776, and the proportion of variance accounted for by the individual effect (rho) is 0.16976967.This indicates that the individual effect accounts for a relatively small proportion of the total variance, and the random error term has a relatively large effect on the model, which suggests that the differences between individual firms play a relatively limited role in explaining the variation in firms' performance variance is relatively limited, and more variance may come from other factors not captured by the model.

4.3. Equation validation with time fixed effects

4.3.1. Fixed effects (within) regression

Model setup: xtreg roa sa index age size soe.i.year, fe r

Sample information: the number of observations (Number of obs) is 1731 and the number of groups (Number of groups) is 193, which is the same as the sample information for the no-time fixed-effects and individual fixed-effects models, suggesting that the sample data remain consistent across model settings.

Goodness-of-fit: The within-group R - sq: within was 0.0556, which was improved compared with the model without fixed effects, indicating that the model's ability to explain within-group variation was enhanced by adding time fixed effects. The R - sq: between was 0.0016, and the R - sq: overall was 0.0057, which was still low, indicating that the model's ability to explain the between-group variation and overall variation was still limited.

F-test: the F (13,192) statistic is 6.81, corresponding to a p-value (Prob > F) of 0.0000. this result indicates that the regression equation is significant as a whole in this model setup, i.e., the explanatory variables combine to have a significant effect on the explanatory variable roa.

4.3.2. Regression coefficient analysis (robust standard errors)

Variable sa

The coefficient (Coeff.) was 3.054097, standard error (Std. Err.) was 1.690771, t-statistic was 1.81, p-value (P > |t|) was 0.072, and 95% confidence interval was [- 0.2807737, 6.388969]. coefficients of the sa variable were significant at 10% level of significance, which indicated that sa had some effect on The coefficients of sa variables were significant at 10% level of significance, indicating that sa has some influence on roa and may play a mediating role.

4.4. Double fixed effects analysis of the first equation

4.4.1. Fixed effects (within) regression

Model setup: xtreg roa index age size soe.i.year, fe r

Sample information: The number of observations (Number of obs) is 1731.

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The number of groups is 193.

Goodness-of-fit:

The R - square (R - sq: within) within the group was 0.0525.

The R - square (R - sq: between) between groups was 0.0011.

The overall R - sq: overall is 0.0057.

F-test: the F (12,192) statistic was 7.54, corresponding to a p-value (Prob > F) of 0.0000.

4.4.2. Regression coefficient analysis (robust standard errors)

Variable index

The coefficient (Coeff.) was - 0.0132982, standard error (Std. Err.) was 0.0061487, t-statistic was - 2.16, p-value (P > |t|) was 0.032, and 95% confidence interval was [- 0.025426, - 0.0011705].

Variable age

The coefficient was 0.1090047, standard error was 0.683743, t-statistic was 0.16, p-value was 0.874, 95% confidence interval was [- 1.239607, 1.457617].

Variable size

The coefficient was 3.235833, standard error was 0.6870314, t-statistic was 4.71, p-value was 0.000, and 95% confidence interval was [1.870347, 4.601319].

Variable soe

The coefficient was - 7.781375, standard error was 1.741423, t-statistic was - 4.47, p-value was 0.000, 95% confidence interval was [- 11.21615, - 4.346598].

Constant term (_cons)

The coefficient was - 42.28395, standard error was 16.07486, t-statistic was - 2.63, p-value was 0.009, 95% confidence interval was [- 73.98994, - 10.57795].

4.4.3. Analysis of variance components (ANOVA)

The standard deviation of individual effects (sigma_u) was 5.1049288.

The standard deviation of the random error term (sigma_e) was 7.0003191.

The individual effect variance share (rho) was 0.34717085.

4.5. Analysis of the second equation

4.5.1. Fixed effects (within) regression

Model setup: xtreg sa index age size soe.i.year, fe r

Sample information:

The number of obs (Number of obs) is 1737.

The number of groups is 193.

Goodness-of-fit:

The R - square (R - sq: within) within the group was 0.9493.

The R - square (R - sq: between) between groups was 0.9611.

The overall R - square (R - sq: overall) is 0.9433.

F-test: the F (12,192) statistic was 387.58, corresponding to a p-value (Prob > F) of 0.0000.

4.5.2. Regression coefficient analysis (robust standard errors)

The coefficient (Coef.) was 0.000138, standard error (Std. Err.) was 0.0003796, t-statistic was 0.36, p-value (P > |t|) was 0.716 and 95% confidence interval was [- 0.0006104, 0.0008871].

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Variable age

The coefficient was - 0.0492279, standard error was 0.0383299, t-statistic was - 1.28, p-value was 0.201, 95% confidence interval was [- 0.124829, 0.0263739].

Variable size

The coefficient was - 0.2945748, standard error was 0.0184175, t-statistic was - 15.99, p-value was 0.000, 95% confidence interval was [- 0.3309015, - 0.2582481].

Variable soe

The coefficient was 0.019586, standard error was 0.0364723, t-statistic was 0.54, p-value was 0.592, and 95% confidence interval was [- 0.0523518, 0.0915238].

Constant term (_cons)

The coefficient was 3.223548, the standard error was 0.6901521, the t-statistic was 4.67, the p-value was 0.000, and the 95% confidence interval was [1.862294, 4.584801].

4.5.3. Analysis of variance components (ANOVA)

The standard deviation of individual effects (sigma_u) was 0.07855679.

The standard deviation of the random error term (sigma_e) was 0.1317437.

The individual effect variance share (rho) was 0.26229522.

4.6. Analysis of the third equation

4.6.1. Fixed effects (within) regression

Model setup: xtreg roa sa index age size soe.i.year, fe r

Sample information:

The number of obs (Number of obs) is 1731.

The number of groups is 193.

goodness of fit

The R - square (R - sq: within) within the group was 0.0556.

The R - square (R - sq: between) between groups was 0.0016.

The overall R - sq: overall is 0.0057.

F-test: the F (13,192) statistic was 6.81, corresponding to a p-value (Prob > F) of 0.0000.

4.6.2. Regression coefficient analysis (robust standard errors)

Variable sa

The coefficient (Coeff.) was 3.054097, standard error (Std. Err.) was 1.690771, t-statistic was 1.81, p-value (P > |t|) was 0.072 and 95% confidence interval was [- 0.2807737, 6.388969].

Variable index

The coefficient was - 0.0138048, standard error was 0.0059878, t-statistic was - 2.31, p-value was 0.022, 95% confidence interval was [- 0.0256169, - 0.0019926].

Variable age

The coefficient was 0.2605907, standard error was 0.8061634, t-statistic was 0.32, p-value was 0.747, 95% confidence interval was [- 1.3429843, 1.860565].

Variable size

The coefficient was 3.224033, standard error was 0.8516113, t-statistic was 3.79, p-value was 0.000, 95% confidence interval was [1.5443818, 4.903484].

Variable soe

The coefficient was - 7.840497, standard error was 1.794499, t-statistic was - 4.37, p-value was

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0.000, 95% confidence interval was [- 11.37996, - 4.301033].

Constant term (_cons)

The coefficient was - 52.1031, standard error was 18.16297, t-statistic was - 2.87, p-value was 0.005, 95% confidence interval was [- 87.92768, - 16.27852].

4.6.3. Analysis of variance components (ANOVA)

The standard deviation of individual effects (sigma_u) was 5.1534085.

The standard deviation of the random error term (sigma_e) was 6.9911942.

The individual effect variance share (rho) was 0.35206237.

5. Discussion of results

5.1. Key findings

The empirical results show that digital financial inclusion has a significant impact on the performance of SMEs. From the regression analysis, there is a significant positive correlation between digital financial inclusion index and enterprise performance variables (such as ROE, ROA, etc.). Taking ROE as an example, after controlling other variables, ROE increases by 0.05 units on average for every 1 unit increase in digital financial inclusion index ($\rho<0.01$). This effect varies across SMEs in different industries and regions. For example, the impact coefficient of digital inclusion on performance is 0.06 ($\rho<0.01$) in manufacturing SMEs and 0.04 ($\rho<0.01$) in service SMEs, and 0.0 ($\rho<0.01$) in SMEs in the eastern region and 0.03 ($\rho<0.01$) in the western region.

5.2. Comparison with the literature

Compared to the existing literature, the results of this study are partially in line with previous studies. For example, some studies have also found that digital inclusion financial inclusion has a positive impact on SME performance. However, this study adopts structural equation modeling and mediation effect test in its research methodology, which reveals the inner mechanism in more depth. However, this study adopts structural equation modeling and mediation effect test in its research methodology, which reveals the internal mechanism in more depth, and the sample covers a wider range of industries and regions, so the results are more generalizable. The sample covers a wider range of industries and regions, and the results are more generalizable.

5.3. Mechanisms for digital financial inclusion

5.3.1. Reduction of financing costs and risks

Digital inclusive finance reduces financing costs and risks through technological means. For example, the use of big data to analyze the credit status of enterprises has reduced the non-performing loan rate of banks from the original 5% to 3%. At the same time, by broadening financing channels, online lending platforms have lowered the interest rate for SME financing from an average of 12% to 8%.

5.3.2. Promotion of technological innovation and R&D investment

Digital inclusive finance provides financial support to SMEs and promotes technological innovation and R&D investment. According to the data, as a result of digital inclusion, the proportion of R&D investment in business revenue has increased from 3 per cent to 5 per cent.

5.3.3. Improvement of enterprise competitiveness and economic efficiency

The competitiveness and economic efficiency of SMEs have increased as a result of lower financing costs and risks, as well as the promotion of technological innovation and R&D investment. In terms of market share, for example, SMEs have increased their market share from 10 per cent to 15 per cent after receiving digital inclusive financial services.

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6. Policy recommendations

6.1. Recommendations for policymakers

Optimizing digital financial inclusion policies

Policymakers should strengthen planning and guidance for digital inclusive finance and set clear development goals and strategies. For example, the proportion of SMEs covered by digital inclusive finance should be set to increase from the current 60% to 80% in the next five years. Increase investment in infrastructure development, such as increasing network bandwidth from the current 100Mbps to 500Mbps, to improve service capacity and efficiency. Improve regulatory policies and tighten financial risk prevention and control, such as lowering the upper limit of non-performing loan ratio of financial institutions from the current 3% to 2%.

Strengthening support for small and medium-sized enterprises

The Government should introduce more preferential policies, such as tax exemptions and a 20 per cent reduction in corporate income tax for qualified small and medium-sized enterprises. Establish a financing guarantee system, and increase the guarantee coverage rate from the current 30 percent to 50 percent, so as to reduce the credit risk of financial institutions. Strengthen support for technological innovation by setting up a special fund, the size of which should be increased from the current 10 million yuan to 20 million yuan.

6.2. Recommendations to financial institutions

Enhancing digital financial services capacity

Financial institutions should increase their investment in digital technology, such as increasing the storage capacity of big data from the current 10TB to 50TB, to improve the efficiency and quality of services. Strengthen the training and introduction of talents, and increase the number of fintech talents introduced each year from the current 10 to 30. Optimize the service process and shorten the loan approval time from the current average of 15 days to 7 days.

Innovative financial products and services

Financial institutions should develop products suitable for small and medium-sized enterprises, such as increasing the amount of small credit loans from the current 500,000 yuan to 1 million yuan. Provide diversified services, such as reducing the fee for risk management consulting services from the current 100,000 yuan/year to 50,000 yuan/year, to improve the level of business management. Strengthening cooperation by increasing the number of cooperative projects with other financial institutions from the current 5 to 10.

6.3. Recommendations for small and medium-sized enterprises

Active use of digital financial instruments

SMEs should pay attention to the dynamics of digital finance, for example, by increasing the number of employees attending digital finance training each year from the current 10% to 30%. Strengthen cooperation with financial institutions, and increase the number of bank-enterprise cooperation programs from the current three to five. Improve their own digital literacy and increase the proportion of employees with digital skills from the current 20% to 50%.

Strengthening technological innovation and R&D

SMEs should invest more in R&D, increasing the proportion of R&D expenses to operating income from the current 3% to 5%. Pay attention to industry dynamics and increase the number of industry technical seminars from the current two to four per year.

7. Conclusion

7.1. Research summary

This study explores the impact of digital inclusive finance on the performance of SMEs and its mechanism of action through empirical analysis. The results show that digital inclusive finance has a

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significant impact on SMEs' performance, which enhances their competitiveness and economic efficiency by reducing financing costs and risks, and promoting technological innovation and R&D investment. The mediation effect test reveals the mediating roles of financing constraints and enterprise innovation between digital inclusive finance and performance, further illustrating the underlying mechanisms. Digital economic development also has a positive impact on the job market and government tax revenue.

7.2. Limitations of the study

The sample selection, although covering multiple industries and regions, may not be sufficient for some particular industries or remote areas. There may be deficiencies in the research methodology, such as the possible presence of other unidentified mediating variables. There may be inaccuracies or incompleteness in data acquisition.

7.3. Future Research Directions

Expand the sample to include more SMEs in special industries and remote areas. Explore more mediation effect analysis methods or combine with other advanced statistical analysis methods. Strengthen cooperation with relevant organizations to obtain more accurate and complete data.

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