# The impact of digital financial inclusion on innovation in small and medium-sized enterprises

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**Abstract.** Small and medium-sized enterprises (SMEs)account for 95.68% of China's enterprise households and are important contributors to national development. The introduction of more policies aimed at the development of SMEs has demonstrated the importance of SMEs in terms of policy and strategy. Enterprise innovation is an extremely important part of enterprise development, but compared with medium and large enterprises, SMEs are vulnerable to financial constraints due to their single product, insufficient guarantees, and unbalanced allocation of external financial resources, resulting in a lack of funds to invest in enterprise innovation, which makes it difficult for them to realize their own development. Digital financial inclusion (DFI) is an emerging financial model based on new technology, DFI can improve those financial individuals and groups that are constrained in traditional finance. DFI can make it easier for people and businesses to access financial services through digital technology. In this paper, we use the DFI index of Peking University from 2011 to 2020, as well as the enterprise data of CSMAR to data analyze the impact of DFI on SMEs' innovation. The paper first uses a fixed-effects model for this purpose, and then takes financing cost as a mediating variable to analyze the channels of influence. The regression results show that DFI has an important role in promoting SME innovation, and that DFI can promote SMEs innovation by reducing the cost of financing.

**Keywords:** Digital financial Inclusion, Business Innovation, SMEs.

## 1. Introduction

By the end of 2020, SMEs totaled 909,000 households, accounting for 95.68% of the total number of enterprises, compared with 2015, the number of SMEs increased by 12.8% to achieve a steady growth. Therefore, the development of SMEs is an important step for China to realize high-quality development. However, the financing difficulties of SMEs still exist, the development is unfair and unbalanced, and the innovation environment of SMEs is still unfulfilled. Therefore, solving the innovation of SMEs is a very crucial part of the problem and has become an urgent issue.

The People's Bank of China (PBOC) released the Financial Technology Development Plan (2022-2025) [1], (Plan) in January 2022, aiming to put forward the development plan for the next four years in the field of fintech, and put forward the guidance for digital inclusive fintech in the new era, and clarified the general idea and detailed orientation of digital inclusive fintech in the new era. The Plan points out that one of the basic principles of fintech is fairness and universality, with fairness as the criterion and universality as the principle, optimizing the financial supply through the means of fintech, so that fintech can be more deeply used by the people to serve the majority of the people, in order to promote the fairness and universality of the DFI, the Policy points out that the focus of the current round of planning is to solve the unfair and unbalanced problem of the development of the DFI, and to create a digital inclusive financial development. problems, creating an infrastructure for DFI, improving the governance of fintech, and accelerating financial services for the real economy, and these issues focus on how DFI can serve SMEs and promote their innovation, thus enabling social progress.

This paper focuses on the impact of DFI on the innovation of SMEs. The direct effect of DFI on SMEs is investigated by fixing the industry effect and year effect through the fixed effect model. The mediation effect model is used to study how DFI affects financing constraints and debt financing costs to promote SMEs' innovation.

# 2. Theoretical Analysis

## 2.1. The Theory of the Long Tail

The Long Tail Theory is a theory proposed by Anderson, the editor-in-chief of the American magazine Wired [2], who argues that the market share of a best-selling product in a low-volume market is roughly the same as that of a non-best-selling product that is high-volume but low-demand. Niche products with lower demand have a quantitative advantage over bestsellers, and if the cost of acquiring niche goods is lowered, it is easy to realize that they outperform the bestsellers in terms of market share. For enterprises, SMEs account for 96% of the total number of enterprises, and if we can reduce the difficulties faced by SMEs in financing and the limited space for development through DFI, we can stimulate the innovation and vitality of SMEs.

## 2.2. Information Asymmetry Theory

Information asymmetry theory suggests that information, which exists in an uneven distribution among individuals [3], and asymmetric access to information may be due to the unequal relationship between the two parties' ability to obtain information. Adverse selection refers to the asymmetry of information possessed by the buyer and seller resulting in the buyer's willingness to pay only the price that corresponds to the average level of the market product in the market, which leads to a decrease in the quality of the market product in the market. Moral hazard refers to the information asymmetry that arises after a contract is signed, where one party acts to the detriment of others in order to increase the benefits, they receive. The SMEs often face serious financing constraints due to insufficient information.

# 3. Research Hypothesis

## 3.1. The Relationship Between Digital Financial Inclusion and Innovation in SMEs

SMEs are relatively active and energetic groups in the enterprise group, but they are limited by many factors in the traditional financial market. In China's traditional financial market, there are problems such as unequal allocation of resources and uneven development, while SMEs because of product technology, human resources and other resource allocation is not as good as large-scale enterprises, and their own existence of lower risk-resistant ability, lower credit rating factors, these problems lead to SMEs in the traditional financial market access to financial services, access to financing and other difficulties. DFI can reduce the cost of enterprises or stimulate the innovation power of enterprises [4]. Therefore, the hypothesis is proposed:

H1: DFI can foster innovation in SMEs.

## 3.2. Digital Financial Inclusion, Cost of Financing and Innovation in SMEs

The development of SMEs is often affected by the cost of financing, and innovative R&D requires external funding. However, a large number of SMEs face serious financing costs due to their own factors such as low credit rating, weak risk tolerance and weak collateralization, as well as external factors such as imperfections in the financial market, unbalanced allocation of resources, and difficulties in accessing financial services.

DFI can reduce the cost of obtaining information, reduce the difficulty of financial services through new digital financial products, reduce the cost of obtaining information for SMEs, so as to reduce the cost of financing for SMEs [5]. Therefore, the hypothesis is proposed:

H2: DFI can foster innovation in SMEs by reducing the cost of financing.

## 3.3. Heterogeneity in the Impact of Digital Financial Inclusion on Innovation in SMEs

In the eastern and central regions, through the more developed level of DFI [6], it is possible to promote the innovation ability of SMEs by alleviating their financing constraints, reducing their

financing costs, and alleviating the information asymmetry in the market through technologies such as big data. In the western region, where the level of DFI is relatively low, there is a relative lack of resources and a more unbalanced allocation of resources, making it more difficult for enterprises to obtain assistance from DFI to solve the problem of financing constraints, so as to carry out technological innovation. Enterprises are therefore categorized into East, Central and West according to their registered addresses, and hypotheses are made about the consequent:

H3: DFI for SMEs innovation is more pronounced in the central, eastern part of the country relative to the western part.

## 4. Model Construction and Data Selection

### 4.1. Data sources

In this paper, we take the listed enterprises of Venture Edition as the research sample and utilize the enterprise data from 2011 to 2020.The enterprise data from 2011 to 2020 is from CSMAR database, and the DFI data from 2011 to 2020 is from Peking University's DFI Index. In this paper, data exceeding 1% and 99% are indented, and missing data are deleted.

### 4.2. Variable Selection

#### 4.2.1. Explanatory Variable

Innovation of SMEs: In this paper, the innovation investment of SMEs as a percentage of operating revenue [7] is used to measure the innovation capability of SMEs.

#### 4.2.2. Explanatory Variable

The explanatory variable used in this paper is the Peking University DFI Index (2011-2020) [8].

#### 4.2.3. Intermediary Variable

Cost of Debt Financing: The calculation method used in this paper is total finance charges/liabilities as an indicator of the cost of debt financing.

#### 4.2.4. Control Variable

The main control variables are: firm size (Size), total asset turnover (Tat), gearing ratio (Lev), cash ratio (Cash), and industry category (Ind). In this paper, we adopt a fixed effect model with industry and year fixed effects in the model.

Specific variable indicators are shown in Table 1.

**Table 1.** Variable selection

| Variable category | variable name | variable symbol | Variable Definition |
|---|---|---|---|
| explanatory variable | Innovation for small and medium-sized enterprises | Innovation | R&D investment as a percentage of operating revenue |
| explanatory variable | Digital Financial Inclusion Index | Difi | Peking University Digital Financial Inclusion Index (2011-2020) |
| intermediary variable | Cost of debt financing | Debtcost | Finance costs/total liabilities |
| control variable | Enterprise size | Size | Logarithm of total assets |
| | Total asset turnover | Tat | Total turnover/total assets |
| | gearing | Lev | Total liabilities/total assets |
| | industry category | Ind | Based on the SEC's industry classification of companies |
| | cash ratio | Cash | Cash assets/current liabilities |

### 4.3. Model Building

Empirical study examining DFI for innovation in SMEs.

In order to investigate the impact of DFI on SME innovation, a two-way fixed effects model with industry and time is developed.

$$Inn_{it} = \alpha_0 + \alpha_{it} \times Difi_{it} + Controls_{it} + \sum Year + \sum Ind + \varepsilon_{it} \quad (1)$$

In the regression equation, the subscripts I, t indicate that it is the i enterprise and the t year, respectively: the explanatory variable enterprise innovation capacity (Inn), measured by the ratio of R&D investment to total operating revenue; the explanatory variable DFI Index (Difi); and the control variables (Controls) include the above control variables. This paper adopts a model with fixed year effect and industry effect, aiming to reduce the influence of year and industry category, where year effect (YEAR), industry effect (IND).

(2) An empirical study examining the role of financing costs in the role of DFI in innovation for SMEs

In order to study the mediating effect of financing cost in the process of DFI's role in the occurrence of innovation in SMEs, this paper draws on the approach of Wen Zhonglin and Ye Baojuan [9] to develop the following model:

$$Inn_{it} = \alpha_0 + \alpha_1 \times Difi_{it} + Controls_{it} + \sum Year + \sum Ind + \varepsilon_{it} \quad (2)$$

$$debtcost_{it} = \beta_0 + \beta_1 \times Difi_{it} + Controls_{it} + \sum Year + \sum Ind + \delta_{it} \quad (3)$$

$$Inn_{it} = \gamma_0 + \gamma_1 \times Difi_{it} + \gamma_2 \times debatcost_{it} + Controls_{it} + \sum Year + \sum Ind + \varphi_{it} \quad (4)$$

In the regression equation Inn is the firm's innovation capacity and Debtcost is the cost of debt financing. First test the coefficient $\alpha_0$ whether it is significant, i.e., the total effect of DFI on innovation of SMEs, if it is significant, then test the coefficient $\beta_1$ and $\gamma_2$ If it is not significant, the bootstrap method is used to calculate the coefficient of $\beta_1 \times \gamma_2$ If it is significant, then test the coefficient $\gamma_1$, if not significant and $\beta_1 \times \gamma_2$ is the same sign as $\gamma_1$ same sign then it is partial mediation effect.

## 5. Analysis of empirical results

### 5.1. Descriptive Statistics

The descriptive statistics of the data are shown in Table 2, with a total of 5223 valid experimental samples. The minimum value of the explanatory variable Enterprise Innovation Input (Inn) is 0.43, the maximum value is 31.46, which shows that the variability of the innovation input of enterprises in the sample is relatively large. The minimum value of the explanatory variable DFI Index (Difi) is 39.82, the maximum value is 417.88, which can be seen that although the development of DFI in China is very rapid, there is still a very serious regional variability and unfairness and inequality.

**Table 2.** Results of descriptive analysis

| Variable | Mean | SD | Min | P50 | Max. | N |
|---|---|---|---|---|---|---|
| Difi | 281.6 | 91.52 | 39.82 | 296.17 | 417.88 | 5223 |
| Inn | 7.14 | 5.57 | 0.43 | 5.26 | 31.46 | 5223 |
| Cash | 1.97 | 3.48 | 0.03 | 0.70 | 21.60 | 5223 |
| Size | 9.15 | 0.38 | 8.38 | 9.11 | 10.23 | 5223 |
| Lev | 0.29 | 0.17 | 0.03 | 0.27 | 0.73 | 5223 |
| Tat | 0.14 | 0.13 | 0.01 | 0.10 | 0.73 | 5223 |

### 5.2. Regression Analysis

To verify whether H1, which is DFI, promotes innovation among SMEs, this paper runs a fixed effects regression on the innovativeness of SMEs. Table 3 shows the results where (1) is the result of the regression controlling for industry category and year effects, and (2) is the result of the regression controlling for the control variables and controlling for industry category and year effects. The coefficient of the DFI index (Difi) on the innovation index of SMEs is 0.016. This indicates that DFI has a facilitating effect on the innovation of SMEs. Hypothesis 1 was verified.

**Table 3.** Benchmark regression results

| | Inn (1) | Inn (2) |
|---|---|---|
| | | |
| Difi | 0.016*** | 0.016*** |
| | (5.63) | (6.28) |
| Cash | | 0.282*** |
| | | (11.79) |
| Size | | -0.660*** |
| | | (-3.16) |
| Lev | | -4.276*** |
| | | (-8.55) |
| Tat | | -9.179*** |
| | | (-14.32) |
| Constant | 2.348*** | 11.672*** |
| | (3.29) | (5.60) |
| | | |
| Observations | 5,223 | 5,223 |
| R-squared | 0.183 | 0.293 |

### 5.3. Mediation Effect Test

According to the regression results of fixed effects, DFI has a significant role in increasing the innovation of SMEs. To verify H2, that is, DFI promotes the innovation ability of SMEs through the mediating effect, i.e., easing the financing cost of SMEs.

**Table 4.** Intermediation effect regression results

| | Debtcost | Inn |
|---|---|---|
| | | |
| Difi | -0.0001 | 0.0161*** |
| | (-1.45) | (6.28) |
| Debtcost | | -6.7181*** |
| | | (-6.74) |
| Cash | -0.0144*** | 0.1861*** |
| | (-43.79) | (6.69) |
| Size | -0.0033*** | -0.4316*** |
| | (-2.69) | (-4.85) |
| Lev | 0.0616*** | -3.6314*** |
| | (8.91) | (-7.25) |
| Tat | 0.0076 | -9.1188*** |
| | (0.89) | (-14.72) |
| Constant | 0.0622** | 14.5821*** |
| | (2.22) | (7.23) |
| | | |
| Observations | 5,223 | 5,223 |
| R-squared | 0.454 | 0.300 |

The regression results are listed in Table 4 and the bootstrap test results are listed in Table 5. The confidence interval of the indirect effect does not include 0 through 1000 times of bootstrap test, so the test result is significant. And$\gamma_1$ is significant, and$\beta_1 \times \gamma_2$ is the same sign as$\gamma_1$ same sign, indicating that Debtcost plays a partial mediating role. Where, the mediation effect = -0.012 and is significant and it can be concluded that DFI promotes the innovation ability of SMEs by alleviating the financing cost of SMEs.

**Table 5.** Results of bootstrap test

| | ratio | standard error | P-value | 95% confidence interval | |
|---|---|---|---|---|---|
| indirect effect | -.0012 | 0.003 | 0.000 | -.0018 | -.0006 |
| direct effect | .0128 | 0.009 | 0.000 | .0109 | .0146 |

## 5.4. Heterogeneity Analysis

Enterprises are categorized into East, West, and Central according to their registered addresses, and regressions are conducted by setting dummy variables for industry categories and province categories, respectively. The results are shown in Table 6 as follows: in the eastern and central region, the coefficient of the impact of innovation of SMEs is 0.0093 and 0.0105 and the results are significant. Therefore, hypothesis H3: DFI on innovation of SMEs in the central, eastern region is more significant relative to the western region, and it is established.

**Table 6.** Results of Heterogeneity Analysis

| VARIABLES | Inn | Inn (east) | Inn (west) | Inn (middle) |
|---|---|---|---|---|
| | | | | |
| Difi | 0.008*** | 0.009*** | -0.003 | 0.010*** |
| | (10.54) | (10.28) | (-1.01) | (4.59) |
| Cash | 0.2655*** | 0.2930*** | 0.0458 | 0.097 |
| | (7.85) | (7.83) | (0.33) | (1.21) |
| Size | -0.4877*** | -0.5244*** | 0.4765 | -0.6756*** |
| | (-5.66) | (-5.21) | (1.35) | (-3.21) |
| Lev | -3.9599*** | -4.4863*** | -2.0568 | -1.5626 |
| | (-7.73) | (-7.77) | (-1.11) | (-1.04) |
| Tat | -7.6083*** | -7.8677*** | -7.7540*** | -3.7099*** |
| | (-15.62) | (-14.59) | (-3.70) | (-3.07) |
| Constant | 14.2216*** | 14.0644*** | 6.2839 | 16.9783*** |
| | (7.20) | (5.64) | (0.84) | (4.08) |
| Observations | 5,223 | 4,187 | 395 | 624 |
| R-squared | 0.318 | 0.327 | 0.355 | 0.262 |

## 5.5. Robustness Check

Replace the explanatory variable from R&D investment as a percentage of operating revenue [10], to the ratio of R&D personnel to all personnel (Inn2). The regression analysis was re-run while controlling for industry effect and time effect. The results are shown in Table 7 below, it shows that the coefficient of the explanatory variable Difi is 0.056, and there is a significant positive effect, which means that the regression results are robust.

**Table 7.** Robustness test results

| | Inn2 | Inn2 |
|---|---|---|
| | | |
| Difi | 0.0552*** | 0.0570*** |
| | (6.97) | (7.35) |
| Cash | | 0.7678*** |
| | | (7.12) |
| Size | | -0.4067 |
| | | (-1.54) |
| Lev | | -7.1451*** |
| | | (-4.68) |
| Tat | | -11.3041*** |
| | | (-6.56) |
| Constant | 8.0550*** | 21.2071*** |
| | (2.62) | (3.32) |
| Year<br>Industry | Yes<br>Yes | Yes<br>Yes |
| Observations | 4,261 | 4,261 |
| R-squared | 0.287 | 0.323 |

## 6. Conclusion

This paper selects the data of 2011-2020 GEM and the DFI data of Peking University and applies the fixed effect model and the mediation effect model to explore the empirical research of DFI index on the innovation ability of SMEs and conducts a regression analysis of the DFI index and the innovation ability of SMEs. On this basis, this paper takes financing cost as the mediating variable and applies the mediating effect model to explore whether DFI can promote the innovation ability of SMEs by reducing financing cost. In summary, this paper draws the following conclusions 1. DFI can promote the innovation ability of SMEs. And this conclusion is still robust after the robustness test.2. Financing cost plays an intermediary role in the process of DFI to promote the innovation of SMES, that is, DFI through big data, artificial intelligence and other ways to alleviate the asymmetry of information in the process of transaction, reducing the cost of financing for small and SMEs, thus promoting the technological innovation of small and SMEs.

With the further development of DFI, there is a great prospect for its application to SMEs. DFI can help SMEs to obtain financing, reduce costs, improve administrative efficiency, etc. In addition, DFI can provide SMEs with more diversified and personalized financial services, which can help them to better cope with risks and face unknown changes, and based on the above effects, DFI can enable SMEs to have more funds and opportunities to invest in innovative activities. Based on the above, DFI can enable SMEs to have more capital and opportunities to invest in innovative activities.

The policy recommendations for SMEs to invest more in the process of developing DFI technologies include the following. First, they should focus on cultivating digital inclusive financial technology talents in their enterprises, and at the same time introduce technical backbones and graduates of relevant specialties in DFI from outside their enterprises. Secondly, enterprises should respond to the upcoming DFI related technology products with a more open attitude and take a more positive attitude towards DFI related technology. Facing the new DFI technology, they should not take an attitude of rejection, but should actively learn, master and use the new DFI technology, so as to make the enterprise more innovative and dynamic. Finally, enterprises should apply DFI with scientific rigor.

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