An Investigation of the Relationship between Digital Finance Development and SMEs' Investment Efficiency

Yue Xuan

***Abstract*—The digitalization of finance has shown many benefits for firms in different areas worldwide, but whether it is more of assistance or a hindrance to companies with existing disadvantages in gathering finance is still to be questioned. This paper explores the effect of digital finance development on the investment efficiency of SMEs, treating digital finance development as the independent variable and investment efficiency as the dependent variable, with several other controlled variables clearly defined. The paper uses OLS benchmark regressions with a heterogeneity test, concluding that the development of digital finance lowers the investment efficiency of SMEs and is not affected by company size as a controlled variable. Several potential reasons could lead to this conclusion, which would be discussed in detail in the passage.**

***Index Terms*—Digital finance, investment efficiency, firm size, SME, benchmark regression, heterogeneity test, OLS regression.**

I. Introduction

A. Background Introduction

If we are told to describe a global trend with the greatest influence amongst all industries worldwide in the past 20 years, digitalization would undoubtedly be crowned as one of the champions. Digitalization has increased efficiency in various industries and administrations, and more importantly, created various technological revolutions within the financial sector, amongst which digital finance prospered. According to previous research [1], digital finance is the new methodology to provide financial services and create new business opportunities via the internet to individuals and groups. It has been promoted in many countries for its convenient and cost-saving properties and is also noticed by the UN as an ideal method to promote financial inclusion which, as described by CGAP 2015.1 [2], means "the digital access to, and the use of, formal financial services by the excluded and underserved population".

In the past one and a half-decade, China has been the leading country in creating a leading digital economy worldwide. According to the 2017 Digital Evolution Index (DEI) [3] provided by the Fletcher School of Business, Tufts University, the measurement of digital economy development in China is reported to be 'rapid' and majorly attributed to the great support of the policymakers. China is also active in responding to the UN proposal of digital financial provision, where the construction of a national digital finance system has been swiftly established and has achieved great improvements in reducing the poverty gap as well as providing actual assistance to underserved populations and Small and Medium Enterprises (SMEs). Another research also proposed in 2019 [4] that investment efficiency for SMEs is likely to increase due to the construction of digital finance, which promotes firm innovation and reduces production costs, leading to more finance or purposes available for new investments. At the same time, the authority of the traditional state-owned banks is greatly challenged due to the complicated administration process and high benchmark for obtaining new sources of finance. [5] Digital finance increases transparency as well as the cost of administration, putting pressure on traditional state-owned banks to lower their barriers for company loans and forcing them to digitalize to adapt to the surrounding environment of fast-prospering digital finance. Policymakers also favor digital finance development and have set up a series of policies to assist firms, especially SMEs, to get access to this service. Therefore, it is generally proposed in previous academic papers that digital finance development promotes investment efficiency in SMEs. This paper mainly discusses whether the previously proposed positive effect of digital finance development on SMEs' investment efficiency could be proved, and if so, to what extent could it affect SME investment efficiency.

B. The PUDFI Index and Its Function

One typical benchmark for measurement of the popularity rate of digital financial coverage throughout China is the Peking University Digital Financial Inclusion Index of China (PUDFI INDEX), which measures popularity in coverage breadth, usage depth, and digitization level where usage depth involves sub-indexes such as payment, credit, insurance, investment, and money funds. The panel data from 2011 to 2018 demonstrates a clear and continuous upward growing trend, indicating an increase in coverage breadth, usage depth, and digitization level for digital finance coverage.

The trend of the Index's average standard deviation is demonstrated in Fig. 1, and it is obvious to see that the standard deviation of the Index is stabilized around 18% and has become relatively stable. This indicates that the distribution of existing digital finance coverage is not concentrated and is relatively dispersed throughout the entire country, and as only 3 nullities are existing in the entire panel, this proves that people from most of the regions in China can get access to digital finance if necessary.

The Year-On-Year growth rate for PUDFI INDEX is demonstrated in Diagram 2. The annual average of the index remains to be positive despite moving in a downward trend. As China is a country with nearly 15 billion people and

Manuscript received October 31, 2021; revised January 13, 2022.

Yue Xuan is with Bayes Business School, City University of London, United Kingdom (e-mail: yue.xuan@cass.city.ac.uk).

doi:10.18178/joebm.2022.10.1.671

different types of natural conditions where towns cities are located remotely, the annual coverage growth is expected to be gradually decreasing as it is more difficult for digital finance propaganda and facilitation to reach those destinations. Therefore, it could be observed from the previous data that digital finance has been popularly distributed throughout China, enabling most of the firms nationwide could get access to digital finance easily.

C. Literature Review

Two pieces of literature are directly related to this study: Wang 2006 [6] and a study performed by Beijing Technology and Business University in 2021 [7]. Wang 2006 discussed the relationship between the development of digital finance over the operating efficiency of SMEs from 2011 to 2019, which used an OLS model and a mediating effect model with fixed effects during the analysis. It has a strong logic and clear evidence for its calculations and would be most cited in this paper for its theory part on the relationship between digital finance development and firm development. The study was done by Beijing Technology and Business University in 2021 discussed the effect of digital finance development on investment efficiency for all Chinese companies that had gone public from 2011 to 2018. It showed clear constructions on its calculation models and is the major source of reference during the construction of variable calculations. Quite a few other pieces of literature are indirectly related to this study. Lu, Wu, and Liu investigated in 2020 [8] the relation between Chinese bank concentration and SME financing availability, and the role of digital finance was majorly discussed between the relationship. It provides methodological guidance and reliable result to refer for this paper, as well as a logical reference for this paper in exploring the relationship between traditional banks, SMEs, and SMFI when digital financial is promoted and executed. Lu, Wu, Li, and Nyugen [5] provided a closer exploration of the relationship between traditional banks' application of digital finance and SME financing, stating clearly the logical relation between the three parts and providing reliable results and important literature for reference. Other literature references in this paper include Ketterer's in 2017 [9], which described the general situation of the digital finance industry; Bo 2019 [10]'s research on the Influence of Digital Inclusive Finance on Financing Constraints of SMEs, despite highly overlapping my current topic the methodology description for this paper is not clear enough to demonstrate its logic, and would only be one of the results references; Siddik and Kabiraj [11] who discussed the general relation between Digital Finance for Financial Inclusion and Inclusive Growth, provided detailed methodology and logic and is useful for discussing whether Chinese digital finance provision is typical enough to represent world trend, etc.

II. Methodology

A. Data Source

The source of data for the calculation of SME investment efficiency comes from CSMAR, China Stock Market & Accounting Research Database, which is a comprehensive research-oriented database focusing on China's Finance and Economy. CSMAR was developed by Shenzhen CSMAR Data Technology Co., Ltd based on academic research needs, meeting with the international professional standards while adapting to China's features. Listed Stock Data from 2011 to 2018 within the Chinese SME board in stock exchanges nationwide were extracted and carefully selected. Companies labeled ST and PT are eliminated as well as those with missing data. All companies in the finance sector are also eliminated. A bilateral tailing treatment was applied to the sample at the level of 1% and 99%, and 5096 qualified data were observed.

The source of data for the measurement of digital finance development was the PUDFI INDEX mentioned in Part 1, with the data of each region from 2011 to 2018.

B. Model Design and Definition of Variables

To identify the relationship between digital finance development and investment efficiency, the measurement of investment efficiency must be defined, therefore the measurement of New Investment must be constructed. According to Richardson's study in 2006, the New Investments of a firm are divided into Expected Investment in New Projects and Over-investment in New Projects. The study calculated New Investment via subtracting net cash receipt from the disposal of fixed, intangible, and other long-term assets from cash paid to construct such categories of assets,

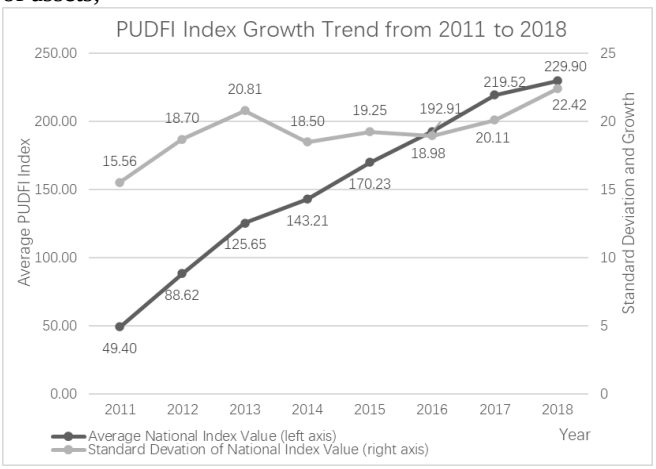

Fig. 1. PUDFI index growth from 2011 to 2018.

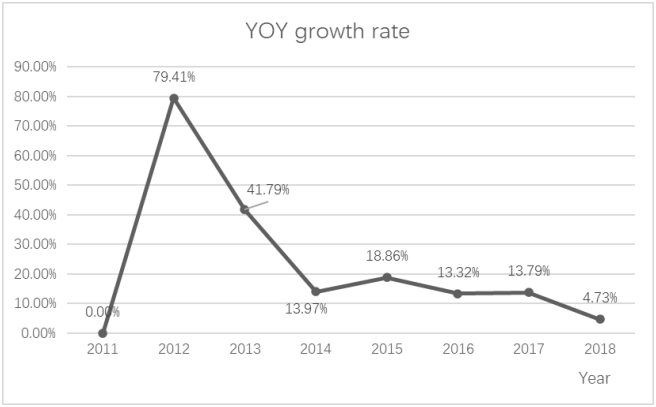

Fig. 2. Year-on-year growth rate for an annual average of PUDFI index.

Shown as in Equation (1) below:

$$I_{new} = OUTFLOW_{Fixed,Intangible\ and\ other\ Long-Term\ Asset} - INFLOW_{Fixed,Intangible\ and\ other\ Long-Term\ Asset} \quad (1)$$

After obtaining new investment of each firm, the calculation of investment efficiency should be derived from the model proposed by Liu 2020 [12], which logically defines the calculation of inefficient investment via adding up investment scale, firm leverage, growth of income from major service, age of the company, stock returns, new investment together with fixed time and industry effects. The absolute value of the residuals of the calculation is obtained, and a larger value indicates a lower investment efficiency as a large absolute residual is mostly caused by over-or under-investment of the company.

The relationship between digital finance development and investment efficiency is then proposed as Equation (2):

$$IE = \alpha DFD + X\beta + industry + year + \Delta \quad (2)$$

Investment efficiency is the dependent variable, calculated before. Digital finance development is the independent variable, which is measured by the method mentioned in the previous paragraph.

Several potential controlled variables are to be determined for the regression. Firm Age measures the firm's age since its IPO, as an elder and younger companies might adopt different attitudes towards the usage of digital finance. The age is then squared to form an independent controlled variable Age-sq to test whether a quadratic relationship exists between age and the dependent and independent variables during the correlation. Firm size is measured by the level of total asset, and the larger the firm size, the higher the potential is for the firm to get access to digital finance. Firm Leverage is measured by the level of debt, in this case, Ln debt, the higher the leverage, the more eager the firm is to obtain cash inflow; therefore, their consideration over digital finance might change. Top 1 measures the share concentration for the largest shareholder in the Board, and SOE is a dummy variable that measures whether the firm is a nation-owned firm (or a public firm), an international firm, or a private firm. Board Size measures the share concentration amongst the largest shareholders within the Board of Directors, it measures the influence of the Board of Directors over the decision making and production operations of the entire company together with the Number of Independent Directors. The salary of the company measures executives' income, and ROA measures the firm's profitability. Fixed Industry Effect is considered during the calculation as Industry, and Fixed Year Effect is considered during the calculation as Year.

C. Descriptive Statistics

Before the regression, a descriptive statistic is produced for each variable to observe their basic conditions. The results of the descriptive statistics are shown in Table I below. it is obvious to observe that the IE has a relatively large range with a small mean and small standard deviation. This indicates that the majority of SMEs experience relatively high investment efficiency. The PUDFI INDEX Index shows a relatively high standard deviation, with a value of 64.1703 which indicates that the correlation of the regression line for the Index is not obvious, and the regression points plotted are relatively dispersing. The mean, standard deviation as well as the range for firm size (ln asset) and firm leverage (ln debt) are very similar to each other, indicating that the selected sample companies have similar size and leverage to each other, which means that the sample is typical in representing a particular type of company, in this case, the SME. The ROA is the variable with the highest intercorrelation, as it has the smallest standard deviation as well as the smallest range. It is followed by the Number of Independent Directors and Employee Salary, which also has a relatively small standard deviation and range. The other variables do not demonstrate obvious characteristics from the descriptive statistics.

TABLE I: DESCRIPTIVE STATISTICS FOR EACH VARIABLE

Variable	Obs	Mean	Std. Dev.	Min	Max
Investment efficiency (IE)	5096	1.7349	4.1753	.0006	36.6238
PUDFI Index	5096	191.2465	64.1703	28.98	302.9827
Age	5096	5.1517	3.2723	0	14
Age-sq	5096	37.2459	38.8556	0	196
Ln asset	5096	21.7878	.953	19.0444	26.1516
Ln debt	5096	20.6334	1.3618	17.4067	25.9776
top1	5096	34.2534	14.6142	4.15	88.92
SOE=1	5096	.1648	.3711	0	1
Foreign=1	5096	.0555	.229	0	1
Board Size	5096	8.3958	1.461	5	15
No. of Independent Directors	5096	3.0983	.4637	2	5
Ln salary	5096	14.7773	.7373	11.9685	16.9982
ROA	5096	.0471	.0626	-.3281	.2342

III. RESULT AND DISCUSSION

A. Benchmark Regression

To discover the relationship between the dependent, independent, and control variables, benchmark regressions are generated. The regression results are demonstrated in Table II below. Most of the variables show obvious significance by the end of regression. The Aggregate Index, which is the PUDFII values for each firm, shows obvious significance at the level of $p<0.01$ for both including and not-including controlled variables during the regression, with a small coefficient of 0.0008 and 0.0009 separately. This indicates that there is a significant effect from the PUDFII index on the investment efficiency and then we should reject the null hypothesis that at 0.01 significance level the coefficient for the PUDFII index is 0, indicating a positive correlation. The regression of Age and Age-sq is also significant at the level of $p<0.01$ which also indicates a positive, quadratic relationship between investment efficiency and firm age since IPO. Board Size and ROA are both significant at the level of $p<0.05$, and leverage is significant at the level of $p<0.1$, all positively correlated with investment efficiency. The correlation of firm size, share

concentration, employee salary, and the coefficient with investment efficiency is not significant and therefore the null hypothesis that these factors have a coefficient equal to 0 should be accepted. This indicates that these are the factors that have no effects during the correlation of digital finance on investment efficiency and should not be the focus of our further research.

TABLE II: BENCHMARK REGRESSION RESULTS

	(1) OLS	(2) OLS
VARIABLES	Efficient	Efficient
PUDFII Index	0.0057***	0.0030***
	(0.0008)	(0.0009)
Age		0.2024***
		(0.0467)
Age-sq		-0.0097***
		(0.0037)
Ln asset		-0.1768
		(0.1965)
Ln debt		0.2176*
		(0.1258)
top1		0.0035
		(0.0046)
SOE=1		0.0068
		(0.1878)
Foreign=1		-0.2947
		(0.2103)
Board Size		-0.1689**
		(0.0679)
No. of Independent Directors		0.3491*
		(0.1905)
Ln salary		-0.2021
		(0.1261)
ROA		-4.2454**
		(1.7000)
Coefficient	-0.2994	2.2576
	(0.2802)	(2.3696)
Observations	5,096	5,096
R-squared	0.0236	0.0409
Industry Effect	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

B. Heterogeneity Test

To test whether digital finance development could affect investment efficiencies on SMEs to a different extent depending on their company size, a heterogeneity test is performed by generating a dummy variable D, which classifies firms with total assets larger than or equal to the median value as 'Large Firms', the remaining firms are 'Small Firms'. Then the multiplication of D and the PUDFII Index is denoted as Dummy # PUDFII and is added as a second explanatory variable. If digital finance development affects differently on Large and Small Firms, the result of the test would show obvious significance in either of the significance intervals and vice versa. The result of the heterogeneity test is shown in Table III, and it is observable that after adding in the dummy variable, the PUDFII Index and Age are still significant at the level of p=0.01 with a positive coefficient, which means that there is a positive correlation between the two variables and SME investment efficiency. The profitability, calculated as ROA, Age-sq as well as the Board Size are all significant at the level of p=0.05, which means that they have direct correlations with the dependent variable. The leverage, calculated as Ln Debt, as well as the Number of Independent Directors, are significant at the level of p=0.01, which indicates direct correlations as well. Most importantly, DUMMY#PUDFII is not significant at either interval, which means that digital finance development would not exert different effects on SME investment efficiency depending on their company size.

TABLE III: HETEROGENEITY TEST RESULT

	(1) OLS	(2) OLS
VARIABLES	Efficient	Efficient
PUDFII Index	0.0057***	0.0031***
	(0.0009)	(0.0010)
Dummy	2.1917	0.6635
	(1.9613)	(2.0476)
Dummy # PUDFII	-0.0080	-0.0027
	(0.0074)	(0.0077)
Age		0.2005***
		(0.0490)
Age-sq		-0.0095**
		(0.0040)
Ln asset		-0.1711
		(0.2008)
Ln debt		0.2164*
		(0.1265)
top1		0.0035
		(0.0046)
SOE=1		0.0066
		(0.1878)
Foreign=1		-0.2951
		(0.2099)
Board Size		-0.1687**
		(0.0679)
No. of Independent Director		0.3483*
		(0.1906)
Ln salary		-0.2005
		(0.1267)
ROA		-4.2570**
		(1.7081)
Coefficient	-0.2983	2.1212
	(0.2945)	(2.3877)
Observations	5,096	5,096
R-squared	0.0238	0.0409
Industry Effect	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

IV. CONCLUSION

This paper aims to investigate the relationship between digital finance development and investment efficiency in SMEs. It uses OLS benchmark regressions to discover the correlation between investment efficiency and digital finance development as well as other controlled variables. A heterogeneity test is then performed to confirm the validity of the previous regressions. The regression results demonstrate that investment efficiency is negatively affected by the performance of digital finance and is not affected by the factor of firm size, which is a contrast to the results from previous papers. The financialization of enterprises might be

the most important factor that leads to this result. China has been promoting financialization within firms internally, causing the prosperity of digital finance while making SMEs to invest more conservatively, urging them to stabilize their financial positions instead of making new potential investments, lowering their investment efficiency.

This study could be improved by restructuring the database, as there is a high potential that a significant portion of the currently selected firms are not SMEs as they have grown to a size and that makes them no longer suitable to be defined as such. These companies might be more reliant on digital finance for their cash inflow, as they must obtain new investments regularly to finance existing and new projects which would be most efficient and cost-saving if digital finance is used. Other factors that are not considered in this studies include policy changes, external shocks, and so on. Future researches related to this area could shift focus to SMEs' detailed applications of digital finance and their performance, or the effect of digital finance development on various other factors than the controlled variables used in this paper which has a potential to cause changes in SME investment efficiency.

Conflict of Interest

This piece of work is completed via Yue Xuan as first author independently and does not have conflict of interest with any other individuals or groups.

Author Contributions

Yue Xuan is the first and only author of this paper. She suggested hypothesis, performed research and analysis, and reached conclusion without help from any other external parties.

References

[1] P. Gomber, J. A. Koch, and M. Siering, "Digital finance and FinTech: Current research and future research directions," *Journal of Business Economics*, vol. 87, pp. 537–580, 2017.

[2] Z. Lu, J. Wu, H. Li, and D. K. Nguyen, "Local bank, digital financial inclusion and SME financing constraints: Empirical evidence from China," *Emerging Markets Finance and Trade*, 2021.

[3] Fletcher School of Business, Tufts University. (2017). 2017 Digital Evolution Index (DEI). [Online]. Available: https://sites.tufts.edu/digitalplanet/files/2020/03/Digital_Planet_2017_FINAL.pdf

[4] X. Zhu, *Emerging Champions in the Digital Economy*, Shanghai Jiao Tong University Press and Springer Nature Singapore Pte Ltd., 2019.

[5] J. Li, Y. Wu, and J. Xiao, "The impact of digital finance on household consumption: Evidence from China," *Economic Modelling*, vol 86, pp. 317-326, 2020.

[6] C. Wang, "A brief definition for investment efficiency," *Productivity Research*, vol. 9, pp. 38-50, 2006.

[7] Beijing Technology and Business University Topic Group. (2021). The effect of digital finance over the operating efficiency of SMEs from the second board in Chinese stock market. *China Business and Market*. [Online]. 8. pp. 30-39. Available: https://doi.org/10.14089/j.cnki.cn11-3664/f.2021.08.003

[8] Z. Lu, J. Wu, and J. Liu, "Bank concentration and SME financing availability: the impact of promotion of financial inclusion in China," *International Journal of Bank Marketing*, vol. 38, no. 6, pp. 1329-1349, 2020.

[9] J. A. Ketterer, "Digital finance: New times, new challenges, new opportunities," Inter-American Development Bank, Institutions for Development Sector Connectivity, Markets and Finance Division, Discussion Paper No. IDB-DP-501, 2017.

[10] B. Huang, "A research on the influence of digital inclusive finance on financing constraints of SMEs," presented at the International Conference on Economic Management and Cultural Industry (ICEMCI 2019), in Advances in Economics, Business and Management Research Division, 2019.

[11] M. Siddik and S. Kabiraj, "Digital finance for financial inclusion and inclusive growth," *Digital Transformation in Business and Society*, pp. 155-168, 2020.

[12] J. Liu, "How does fiscal technology expenditure affect inefficient investment in firms?" *Contemporary Economic Management*, vol. 11, pp. 63-71, 2020.

Yue Xuan was born in Shenzhen, China on April 30th, 2000. She obtained a bachelor's degree in accounting and finance from Bayes Business School (formerly named CASS Business School), London, United Kingdom in 2021.

She interned as a researcher at Founders Securities from August to September 2021. She took part in a micro-placement and interned as project management officer at Ming-Ai Institute in June 2019. Her current research interests include digital finance, big data, investment efficiency, SME and so on.