

Can the Digital Economy Enhance the Investment Efficiency in The Manufacturing Industry?

-- Research Based on the Moderating Effect of the Market

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Abstract: This paper uses the A-share listed manufacturing companies in China from 2015 to 2020 as research samples, and explores the impact of the digital economy on the investment efficiency of manufacturing enterprises. In addition, this paper investigates the moderating effect of marketization on the relationship between the digital economy and investment efficiency of manufacturing enterprises. The research finds that the development of the digital economy can significantly promote the investment efficiency of manufacturing enterprises. The research conclusion remains valid even after a series of robustness tests. By introducing the moderating variable of the degree of marketization, it is found that the degree of marketization can have a positive moderating effect on the digital economy's promotion of the investment efficiency of manufacturing enterprises. Moreover, the study divided into groups of state-owned enterprises and non-state-owned enterprises and conducts further tests. The findings show that the effect of the digital economy on investment efficiency is more reflected in non-state-owned enterprises, and the moderating effect is also reflected in non-state-owned enterprises. The conclusion of the research has a policy reference value for playing the positive role of the digital economy, stimulating the development of the digital economy and promoting advanced manufacturing.

Keywords: Digital Economy, Investment Efficiency of Manufacturing Enterprises, Marketization.

1. Introduction

As the most fundamental part of the real economy, manufacturing is the foundation of the national economy. For a long time, China has played the role of "the world's factory" with the advantage of cheap labor, while most of the high added-value things have been earned by other developed countries. Currently, due to the rise in labor costs and aging problems in China, a large number of labor-intensive manufacturing industries are shifting to Southeast Asian countries where labor costs are lower. In addition, foreign technological blockades on Chinese high-end manufacturing industry have caused serious problems in the supply link of our high-end manufacturing industry. Our manufacturing industry is facing dual challenges from developed countries and developing countries. The problems of low-end lock-in, path dependency, etc., are increasingly prominent, and the dilemma of the manufacturing industry being large but not strong urgently needs to find a breakthrough.

Under the new round of technological revolution and industrial transformation, Chinese government attaches great importance to the development of the manufacturing industry. The "Made in China 2025" issued by the State Council in 2015 mentioned that the new generation of information technology and manufacturing should be deeply integrated, the industry should be transformed, and new production methods, industry forms, business models, and economic growth points should be formed. The founding conference of the Digital China Industry Development Alliance in 2019 also emphasized "advancing the profound integration of the new generation of information and communication technology with the real economy centered on manufacturing".

In the context of the global economic stagnation and the

huge downward pressure on Chinese economy, Chinese digital economy still maintains a strong development momentum. According to the data released by the China Academy of Information and Communications Technology in the "China Digital Economy Development White Paper (2021)", Chinese digital economy maintained a high growth rate of 9.7%, which is much higher than the nominal growth rate of GDP during the same period. The vigorous development of the digital economy has brought new development opportunities to our country's manufacturing industry. Digital technology has profoundly changed the ecological environment for the survival and development of manufacturing enterprises, reshaped their business models, and has a profound impact on corporate behavior.

Investment, as a key financial behavior of enterprises, is related to the future growth of enterprises. How to improve the investment efficiency of enterprises and help Chinese economy move towards a stage of high-quality development is a topic of both the theoretical and practical fields. As a rational investor, one often chooses to invest in projects with a positive net present value and gives up projects with a negative net present value. Jorgenson believes that when the marginal return on investment capital equals the marginal cost, the company can maximize its profits [1]. Due to imperfect markets and agency problems, corporate investments often deviate from the optimal state. In response to the practical issue of "digital technology empowering conventional industries", this paper analyzes the impact of digital economy development on the behavior of manufacturing enterprises from the perspective of corporate investment efficiency. Additionally, this paper also discusses the moderating effect of the external environment—market environment on the relationship between the digital economy and the investment efficiency of manufacturing enterprises.

There are three main contributions from this study. First, it provides a comprehensive measurement of the level of digital economic development at the prefecture-level city scale, using more dimensional indicators to calculate the index, which can accurately reflect the impact of the digital economy on the behavior of manufacturing enterprises. Second, from the perspective of investment efficiency, using A-share listed manufacturing companies as the research sample, it empirically analyzes the economic effects of the digital economy on manufacturing companies. The conclusions provide effective evidence to support the digital transformation of manufacturing enterprises and the continuous strengthening and expansion of the digital economy. Thirdly, few scholars have paid attention to the moderating effect of the market environment in current studies on the digital economy and corporate investment efficiency. This study attempts to start from the market environment in the external environment faced by companies, and analyze its moderating effect on the relationship between the digital economy and the investment efficiency of manufacturing enterprises.

2. Literature Review

The fourth industrial revolution, driven by digital technologies such as cloud computing, big data, and artificial intelligence, is profoundly changing all aspects of socio-economic development and continuously transforming the modes of social production. The development of the digital economy has permeated all areas of social development, influencing the economic behaviors of macro-economy, meso-industries, and micro-subject enterprises.

Previous literature on the digital economy primarily from a macro perspective, research found that the development of the digital economy can not only significantly promote total factor productivity [2-4], but also contribute to inclusive economic growth [5]. Moreover, based on data at the level of Chinese cities, research has found that the digital economy not only has spatial spillover effects and can improve the quality of urban economic development [6], but can also promote the level of regional innovation efficiency [7]. In the literature on the digital economy, there is no lack of research from the perspective of meso-industries, which has found that the digital economy can not only help promote the transformation and upgrading of industrial structures [8-9], but also promote industry growth [10]. As for the manufacturing industry, research has found that the digital economy can also promote the transformation and upgrading of the manufacturing industry [11], reduce the degree of resource misallocation in the manufacturing industry, thereby improving the efficiency of resource allocation in manufacturing [12], and enhance the competitiveness of Chinese manufacturing in the global value chain [13].

There is a lack of micro-empirical research on the digital economy and businesses. Existing literature on the relationship between the digital economy and business behavior mainly follows three research paths: (1) Research on the "direct effect" of the digital economy on business behavior, Wang Juan and Zhu Weiwu found that the digital economy can alleviate underinvestment in businesses [14]. (2) Research on whether a certain mechanism will have a "mediating effect" on the relationship between the digital economy and business behavior, He Fan and Liu Hongxia found that the digital economy can improve business performance by reducing costs, increasing resource

utilization, and driving innovation [15]. (3) Research on whether different scenarios will produce a "moderating effect" on the relationship between the digital economy and business behavior, Guo Jitao and Yao Jiacheng found that management autonomy plays a positive moderating role in the relationship between the digital economy and business risk-taking [16]. Most literature believes that the digital economy has a positive impact on the development of enterprises, but some literature also suggests that the digital economy may increase the incompatibility of new and old resources of enterprises, further increasing the operational risks of enterprises [17]. Moreover, most of the relevant studies focus on discussing the mediating effect, and few scholars consider the moderating role of the external environment on the relationship between the two. Based on this, this paper uses manufacturing companies listed on the A-share market from 2015 to 2020 as samples to study the impact of the digital economy on the investment efficiency of these firms. From the perspective of the market, which plays a decisive role in resource allocation, it investigates the moderating effect of the digital economy on the investment efficiency of manufacturing enterprises."

3. Theoretical Analysis and Research Hypotheses

In decisions about capital structure, issues such as information asymmetry, financing constraints, and principal-agent problems often affect the selection of corporate investment projects and subsequently influence investment efficiency. The impact of the digital economy on the investment efficiency of manufacturing enterprises mainly manifests in the following three aspects:

Firstly, the development of the digital economy can effectively alleviate inefficient investments caused by information asymmetry. Due to the inability of the investing entity to grasp sufficient market information, there may be errors in the judgment of investment projects, which leads to a deviation from the optimal state of investment efficiency. On the one hand, the development of the digital economy enables businesses to efficiently and quickly acquire relevant market information and precisely and rapidly make financial decisions, financial planning, and financial supervision. Furthermore, the digital transformation of enterprises can effectively break down information barriers among various functional departments of companies, making more rational decisions overall. Simultaneously, digital simulation technology is used in production and operations to recreate and predict scenarios, grasp market trends of products, and forecast the development prospects of products, thereby making more rational investment decisions. On the other hand, in the broader environment of the digital transformation of the entire manufacturing industry, each node of the industrial value chain of the manufacturing industry can better realize resource and data sharing in the industry, reduce information asymmetry between the upstream and downstream of the manufacturing industry, and thus help companies find better investment opportunities.

Secondly, the development of the digital economy can effectively alleviate inefficient investment problems caused by financing constraints. In China, most businesses still rely on traditional financial institutions for indirect financing, and banks and other traditional financial institutions are often very cautious about corporate credit business, making it very

difficult for small and micro businesses and private enterprises to get loan approvals. Furthermore, because most businesses have a short life cycle and cannot provide corresponding collateral or pledges, it is difficult for businesses to obtain the funds needed for development. With the development of digitalization, it promotes the construction of the social credit system, which significantly alleviates this financing predicament. FinTech companies use big data technology for business credit assessment, unlike the past where they stuck to collateral and financial statements to assess the credit of borrowing businesses. The social relationship network, accounting bills, payment records, public records, and even digital footprints of borrowing businesses can all serve as the basis for credit decisions. The development of the digital economy enables businesses to have diversified financing channels, increases the availability of corporate funds, and alleviates the financing difficulties of businesses.

Thirdly, the development of the digital economy can effectively alleviate inefficient investment problems caused by agency problems. With the development of the modern corporate system, the separation of corporate operating rights and ownership has led to agency problems in corporate governance. Due to the mismatch of goals between managers and shareholders, on one hand, when making investment decisions, the management may make large-scale investments disregarding cost-effectiveness principles in order to build their own business empire, resulting in over-investment of enterprises[18]; on the other hand, the management may also abandon some investments with good net present value in order to avoid risk, resulting in under-investment[19]. On the one hand, the development of the digital economy exposes all types of investment and financing decisions of enterprises to the spotlight, subject to the supervision and scrutiny of other relevant stakeholders, thus restraining the ability of managers to harm the interests of the enterprise for personal gain. On the other hand, the development of the digital economy also enables a broad range of stakeholders to participate in the company's major decisions and supervise the execution of decisions, thereby weakening the phenomenon of internal controllers in the company. Therefore, the development of the digital economy can to a greater extent curb the opportunistic behavior of managers at the expense of other stakeholders. Thus, this paper proposes the following research hypothesis:

H1: The development of the digital economy can improve the investment efficiency of manufacturing enterprises.

The external environment also affects the effect of the digital economy on corporate investment efficiency. A higher degree of marketization means a higher availability of resources such as funds, information, technology, etc., thereby improving the utilization rate of corporate resources and thereby improving corporate investment efficiency. A low degree of marketization means that information transmitted in the market may have a high risk of distortion, and the development of the digital economy cannot alleviate this type of information asymmetry problem. Due to the distortion of corporate information, external stakeholders cannot implement effective supervision based on the actual situation, which weakens the effect of the development of the digital economy in alleviating agency problems. Furthermore, due to the distortion of the market environment, financing institutions will be more careful and cautious in discerning the signals released by manufacturing enterprises, and they often adopt a cautious attitude towards the financing needs of small

and medium-sized enterprises, thereby weakening the effect of the development of the digital economy in alleviating financing constraints. Thus, this paper proposes the following research hypothesis:

H2: The degree of marketization has an important moderating role in the improvement of investment efficiency of manufacturing enterprises by the development of the digital economy, and the role of the development of the digital economy in improving the investment efficiency of manufacturing enterprises will increase with the increase of the degree of marketization.

4. Research Design

4.1. Sample selection and data sources

This paper selects A-share listed manufacturing companies as research samples, and the time range is determined to be from 2015 to 2020. According to the "2012 China Securities Regulatory Commission Industry Classification", the industry of industrial enterprises is defined and listed companies in the manufacturing industry are selected. Concurrently, this paper has processed the data selection as follows: (1) Excluding financial and insurance companies; (2) Excluding ST, *ST, PT companies; (3) Excluding companies with substantial missing data. In order to exclude the influence of outliers, the continuous variables are subjected to Winsorize treatment at the 1% percentile, and finally 9375 observations are obtained. The related financial data in this paper comes from Guotai'an database, the original data of the digital economy calculation comes from the "China City Statistical Yearbook" and the Beijing University Digital Inclusive Finance Index, the marketization degree data comes from Fan Gang's "China Marketization Index Report", and the data analysis and processing are all completed using Stata16.

4.2. Variable description

Dependent variable: Investment efficiency of manufacturing firms (EI). Referencing the Richardson model[20], the absolute value of the regression residuals obtained is used as a proxy variable for investment efficiency, as shown in model (1).

$$Inv_{i,t} = \alpha_0 + \alpha_1 Q_{i,t-1} + \alpha_2 CF_{i,t-1} + \alpha_3 Age_{i,t-1} + \alpha_4 Lev_{i,t-1} + \alpha_5 Size_{i,t-1} + \alpha_6 Roe_{i,t-1} + \alpha_7 Inv_{i,t-1} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

Here, i represents each listed company, and t represents the year. Inv is the company's investment expenditure, defined as the ratio of the net cash after the cash paid for fixed assets, intangible assets, and other long-term assets minus the cash recovered from the disposal of fixed assets, intangible assets, and other long-term assets to the total assets at the end of the period; Q represents the company's investment opportunity in the $t - 1$ year, represented by the Tobin Q value, CF is the company's cash holding in the $t - 1$ year, Age is the company's listing age in the $t-1$ year, Lev is the debt-to-asset ratio in the $t - 1$ year, $Size$ is the natural logarithm of the company's total assets at the end of the $t - 1$ year, Roe is the company's return on equity in the $t - 1$ year. In addition, year and industry dummy variables are introduced into the model to control time and industry effects, ε is the model residual, the absolute value of the residual represents investment efficiency, the larger the residual, the

more the investment level deviates from the optimal investment state, the lower the investment efficiency of the enterprise. At the same time, if the residual is less than 0, the company is considered to be under-investing; if the residual is greater than 0, the company is considered to be over-investing. In addition, this paper also uses the operating income growth rate as a proxy variable for investment opportunities, and uses the same model to obtain another measurement indicator for investment efficiency (EI2).

Explanatory variable: Level of urban digital economic development (Dig). Considering the lag effect of digital economic development on the investment efficiency of the manufacturing industry, the main explanatory variable is treated with a one-period lag (L.Dig). Referring to the measurement method of the digital economy index by Zhao Tao et al. (2020), five dimensions are selected to measure the level of digital economic development: per capita total telecommunication services, number of mobile phone users per hundred people, the proportion of employees in computer services and software industries to urban unit employees, the number of broadband internet access users per hundred people, and the China Digital Financial Inclusion Index. The entropy method in the objective weighting method is used to weight the indicators, and the digital economic development index of the prefecture-level city where the manufacturing listed company is registered is selected as the assessment of the external digital economic development level of the enterprise. Since all five dimensions are positive promotion indicator data, the processing method is as follows.

Step one, standardize the positive indicators.

$$r_{ij} = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})}$$

Step two, calculate the proportion of the j-th indicator in the i-th year.

$$p_{ij} = \frac{r_{ij}}{\sum_{i=1}^m r_{ij}} \quad (0 \leq r_{ij} \leq 1)$$

Step three, calculate the entropy weight of the j-th index.

$$e_j = -k \sum_{i=1}^m p_{ij} \cdot \ln p_{ij}$$

In the equation, the constant k is:

$$k = \frac{1}{\ln m}$$

Step four, calculate the information utility value d for the j-th index.

$$d_j = 1 - e_j$$

The information utility value of an index depends on the difference between the information entropy e_j of the index and 1. Its value directly affects the size of the weight. The larger the information utility value is, the greater the importance of the evaluation is, and thus the larger the weight is.

Step five, calculate the weights of each index.

$$w_j = \frac{d_j}{\sum_j d_j}$$

Step six, calculate the digital development index of each prefecture-level city.

$$S_i = \sum_{j=1}^m w_j r_{ij}$$

The higher the score obtained, the higher the level of digital economic development in the place where the enterprise is located.

Moderating Variable: This paper selects the degree of marketization (Mkt) as a moderating variable to study the moderating effect of digital economic development on the investment efficiency of manufacturing enterprises. Its data comes from Fan Gang's "China Marketization Index Report", but since the official data only goes up to 2016, the data afterwards is calculated based on the average growth rate of previous years. At the same time, the marketization index of the province where the listed manufacturing company is registered is used to assess the degree of external marketization where the company is located. The higher the score, the higher the degree of marketization where the company is located. The time period of the moderating variable in this paper is consistent with the core explanatory variable, so it is lagged by one period (L.Mkt).

Table 1. Variable explanation

Variables name	Variables symbol	definition
Investment efficiency of manufacturing firms	EI1(EI2)	Model (1) regression residuals, taking the absolute value
The level of digital economic development	Dig	Calculated using entropy method based on five dimensions
The degree of marketization	Mkt	Fan Gang's "China Marketization Index Report"
Company size	Size	The natural logarithm of the company's total assets at the end of the period
Financial leverage	Lev	Total liabilities divided by total assets
Return on net assets	Roa	The proportion of net profit to the total asset
Equity concentration	Share	The total shareholding percentage of the top ten shareholders
Company age	Age	The natural logarithm of the number of years the company has been listed
Free cash flow proportion	Fcf	Free cash flow divided by total assets
Fixed asset proportion	Ppe	The company's fixed assets divided by total assets
The proportion of executive shareholding	Mano	The number of shares held by the management divided by the total number of company shares
Stock return rate	Ret	The annual return rate of the company's stock considering the reinvestment of cash dividends
Audit opinion	Audit	If the audit opinion on the financial statements is a standard unqualified opinion, take 0, otherwise take 1

Control Variables: This paper also selects a series of other characteristics of enterprises at the micro level as control variables to control the potential factors that may cause the investment efficiency of enterprises. The following control variables are included: company size (Size), financial leverage (Lev), return on net assets (Roa), equity concentration (Share), company age (Age), free cash flow proportion (Fcf), fixed asset proportion (Ppe), the proportion of executive shareholding (Mano), stock return rate (Ret) and audit opinion (Audit). The definitions of the main variables are shown in Table 1.

5. Model Building

To test the impact of digital economic development on the investment efficiency of manufacturing companies, this paper builds a basic model (2) using a panel double fixed effect model. It also explores the moderating effect of the degree of marketization on the relationship between digital economy and the investment efficiency of manufacturing companies. This paper refers to the moderating effect model proposed by Wen Zhonglin for analysis [21], and includes the moderating variable and the product of the moderating variable and the explanatory variable in model (2), and builds the basic model (3). The model is set as follows:

$$EI_{i,t} = \beta_0 + \beta_1 Dig_{j,t-1} + \beta_2 control_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (2)$$

$$EI_{i,t} = \gamma_0 + \gamma_1 Dig_{j,t-1} + \gamma_2 M_{j,t-1} + \gamma_3 Dig_{j,t-1} * M_{j,t-1} + \gamma_4 control_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (3)$$

In the model, i represents the company, t represents time, j represents the prefecture-level city where the company is located, $EI_{i,t}$ represents the investment efficiency of the

company, $Dig_{j,t-1}$ represents the digital economy development index of the prefecture-level city in the previous period, and $M_{j,t-1}$ represents the moderating variable in the previous period. $control_{i,t}$ represents control variables at the micro level, μ_i represents the company's fixed effects, δ_t represents the time fixed effects, and $\varepsilon_{i,t}$ represents the random disturbance term. β_1 in model (2) represents how the digital economy affects the company's investment efficiency, and γ_3 in model (3) represents the moderating effect of the moderating variable.

6. Empirical Test

6.1. Descriptive Statistics

Table 2 reports the descriptive statistics of the main variables. From Table 2, it can be seen that the average value of EI1 is 0.042, and the median is 0.026, which means that on average, the scale of non-efficient investment in the sample accounts for 4.2% of the total assets of the company, and the median of non-efficient investment scale accounts for 2.6% of the total assets. In addition, the maximum value of EI is 0.955, and the minimum value is 0, showing that there is a significant difference in investment efficiency between manufacturing companies in China, which is consistent with the findings of Chen Yunsen and Huang Jianqiao [22]. At the same time, according to the equity nature of the company, companies are divided into state-owned enterprises and non-state-owned enterprises, resulting in 6460 observations of non-state-owned enterprises and 2915 observations of state-owned enterprises. The mean and median of EI for state-owned enterprises are both less than those for non-state-owned enterprises, indicating that overall, the investment efficiency of state-owned enterprises may be better than that of non-state-owned enterprises.

Table 2. descriptive statistics

Variables	Sample size	mean	sd	median	min	max
EI1	9375	0.042	0.060	0.026	0	0.955
EI2	9276	0.042	0.056	0.026	0	0.454
L.Dig	9375	0.205	0.118	0.169	0.038	0.552
L.Mkt	9375	8.692	1.818	9.300	-1.420	11.40
Size	9375	22.259	1.210	22.121	17.641	27.547
Lev	9375	0.412	0.198	0.400	0.012	2.123
Age	9375	2.954	0.284	2.996	1.792	3.989
Roa	9375	0.028	0.110	0.035	-2.834	0.786
Fcf	9375	0.142	0.105	0.115	0	0.922
Ppe	9375	0.212	0.140	0.186	0	0.872
Mano	9375	0.137	0.189	0.015	0	1.314
Share	9375	56.971	14.294	57.150	8.779	101.160
Ret	9375	0.135	0.602	-0.011	-0.822	14.278
Audit	9375	0.039	0.194	0	0	1

6.2. Benchmark Regression

This paper uses model (2) to conduct regression analysis on the relationship between the digital economy and the investment efficiency of manufacturing companies. First, it empirically verifies the relationship between the digital economy and the investment efficiency of manufacturing companies, and on this basis, studies the relationship between the two under different ownerships. The regression results in Table 3 show that the coefficients of L.dig for the full sample

are significantly negative at the 5% level, indicating that the development of the digital economy can improve the investment efficiency of manufacturing companies and reduce non-efficient investment, which is consistent with Hypothesis 1 of this paper. The sample is divided into groups according to the nature of property rights and regressed. The results show that: the L.dig coefficient of non-state-owned enterprises is significantly negative at the 1% level, while the L.dig coefficient of state-owned enterprises is not significant,

indicating that the effect of the digital economy on improving the efficiency of manufacturing companies is more evident in non-state-owned enterprises. On the one hand, because state-owned enterprises have factors such as political associations, they are less likely to be subject to financing constraints; on

the other hand, state-owned enterprises have a more complex governance structure, a longer chain of delegation and agency, and the phenomenon of "one dominant" is more common, which will suppress the governance effects brought about by the digital economy.

Table 3. benchmark regression

Variables	Full samples		state-owned enterprises		non-state-owned enterprises	
	EI1	EI2	EI1	EI2	EI1	EI2
L.Dig	-0.0304** (0.0127)	-0.0265** (0.0114)	-0.00043 (0.0179)	-0.00590 (0.0188)	-0.0438*** (0.0164)	-0.0368*** (0.0141)
Control Variables	control	control	control	control	control	control
Entity Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	9375	9276	2915	2855	6460	6421
R-sq	0.094	0.108	0.054	0.073	0.114	0.124

Note: ***, **, * respectively indicate significance at the levels of 1%, 5%, and 10%, same for the tables below.

6.3. Endogeneity Test

This paper uses a fixed effects model and robust standard error methods to reduce endogeneity problems, but there may still be endogeneity problems due to the bidirectional influence of the level of digital economy development and corporate investment efficiency or omitted variables. This paper attempts to use the instrumental variable method to alleviate endogeneity problems, identifying the net effect of digital economy development on the investment efficiency of manufacturing companies. This paper refers to the research method of Huang Qunhui et al.[23]. Because the previous human information transmission mainly relied on post offices, fixed telephones and other primary communication technologies, it greatly affected the construction of the digital economy infrastructure, to a certain extent, satisfying the relevance requirement of instrumental variables. In addition, the number of post offices is very difficult to directly affect the investment efficiency of manufacturing companies to a large extent, which meets the exogeneity requirement to a certain extent. Therefore, the number of post offices per million people in each city in 1984 is used as the instrumental variable of the regional digital economy development index,

and the data comes from the "China Urban Statistical Yearbook". Since this paper uses a fixed effects model, it will be difficult to measure if only the above data is used. Therefore, further referring to the practice of Nunn and Qian[24], this paper constructs the interaction term of the number of broadband access users in the previous year and the number of post offices per million people in each city in 1984, as the instrumental variable of the city digital economy development index, and conducts 2SLS estimation. The regression results are shown in Table 4. The coefficient of the instrumental variable in the first stage regression is significantly positive at the 1% level. For the selected instrumental variable, this paper uses the Kleibergen-Paap Wald rk F statistic method to test for weak instrumental variables, and uses the Kleibergen-Paap rk LM method to and uses the Kleibergen-Paap rk LM method to conduct unidentifiable tests. The test results show that the instrumental variable does not have the above two problems, and the digital economy still has a significant effect on improving the investment efficiency of manufacturing companies, verifying the robustness of the research conclusions.

Table 4. endogeneity test

Variables	First stage	Second stage	First stage	Second stage
	L.Dig	EI1	L.Dig	EI2
instrument	0.00019*** (0.00002)		0.00019***	
L.Dig		-0.350*** (0.129)		-0.355*** (0.133)
Control Variables	control	control	control	control
Entity Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Sample size	8736	8736	8640	8640
Kleibergen-Paap rk LM P		0.0000		0.0000
Kleibergen-Paap Wald rk F		81.653		77.082

6.4. Robustness Test

This paper adopts the following methods to conduct robustness tests:

1) Replace the measurement method of the dependent variable. Refer to Biddle's method[25] to measure the investment efficiency of manufacturing companies (EI3). Regression is carried out using Model (2) and grouped by property rights characteristics. The regression results are shown in column (1) of Table 5. The regression results in the full sample and non-state-owned enterprise groups are significantly negative at the 5% level, while the regression results of the state-owned enterprise group are not significant, which is consistent with the above regression results.

2) Replace the key explanatory variable measurement indicators. Use the Peking University Digital Inclusive Finance Index jointly compiled by the Peking University Digital Finance Research Center and Ant Financial Services Group, and use the digital finance usage depth index as the indicator of the explanatory variable. Regression is performed using Model (2) and grouped by different property rights characteristics. The regression results are shown in column (2) of Table 5. The regression results of the full sample group and non-state-owned enterprise group are significantly negative at the 5% level, while the regression results of the state-owned enterprise group are not significant. This is consistent with the above regression results, ensuring the robustness of the research conclusions in this paper.

Table 5. Robustness test

Variables	(1)			(2)		
	Full EI1	SOE EI2	NSOE EI1	Full EI2	SOE EI1	NSOE EI2
L.Dig	- 0.0269** (0.0127)	-0.0103 (0.0252)	- 0.0300** (0.0147)	-0.000262** (0.000121)	-0.0000172 (0.000138)	-0.000409** (0.000165)
Control Variables	control	control	control	control	control	control
Entity Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	7,483	1,780	5,703	9375	2,915	6,460
R-sq	0.085	0.075	0.092	0.094	0.054	0.115

Table 6. Mechanism test

Variables	Full samples		state-owned enterprises		non-state-owned enterprises	
	EI1	EI2	EI1	EI2	EI1	EI2
L.Dig	0.124 (0.0838)	0.138* (0.0827)	-0.00986 (0.161)	0.0759 (0.151)	0.152 (0.0981)	0.153 (0.0978)
L.Mkt	0.00657 (0.00443)	0.00596 (0.00408)	0.00428 (0.00540)	0.00384 (0.00509)	0.00811 (0.00647)	0.00783 (0.00591)
L.Dig*L.Mkt	-0.0142* (0.00764)	-0.0151** (0.00746)	0.000657 (0.0141)	-0.00753 (0.0131)	-0.0181** (0.00910)	-0.0175* (0.00900)
Control Variables	control	control	control	control	control	control
Entity Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	9375	9276	2915	2855	6460	6421
R-sq	0.094	0.109	0.055	0.074	0.115	0.125

6.5. Mechanism Test

This paper uses Model (3) to test the moderating effect of the degree of marketization, an external environment of enterprises, on the relationship between the digital economy and the investment efficiency of manufacturing enterprises, and further deeply explores the moderating effect of the degree of marketization under different property rights. The regression results are shown in Table 6. In the full sample, the interaction term coefficients of the digital economy and the degree of marketization are significantly negative at the 10% level and 5% level respectively under two different investment efficiency calculation indicators, indicating that

the degree of marketization has a moderating effect on the relationship between the digital economy and the investment efficiency of manufacturing. As the degree of marketization deepens, the role of the digital economy in improving the investment efficiency of manufacturing enterprises is enhanced. This is because the higher the degree of marketization, the more complete and real information in the market, and high-quality information can further alleviate information asymmetry and agency problems with the help of the digital economy. Furthermore, from the regression results based on the nature of property rights, the coefficient of the interaction term for the state-owned enterprise group is not significant. However, the interaction term for the non-state-

owned enterprise group is significantly negative at both the 5% and 10% levels under two different investment efficiency calculation indicators. This suggests that the moderating effect of the degree of marketization on the relationship between the digital economy and the investment efficiency of manufacturing enterprises is more pronounced for non-state-owned enterprises. This could be because state-owned enterprises bear a large number of policy burdens[26], including stabilizing economic growth, promoting local employment, and increasing government tax revenue. Compared with non-state-owned enterprises, state-owned enterprises may pay less attention to market conditions when making economic decisions.

7. Conclusion

Seizing the development opportunity of the digital economy characterized mainly by the internet, big data, and artificial intelligence, we should promote the deep integration of digital technology and the real economy, fully unleash the innovative effects of the digital economy, empower traditional industries, form new economic growth momentum, and achieve high-quality development of the real economy. This paper starts from the fact that the digital economy profoundly impacts Chinese socio-economic development, observing its influence on the behavior of micro-manufacturing enterprises. Through researching the data of A-share manufacturing enterprises from 2015 to 2020, this paper discusses the moderating effect of the degree of marketization on the relationship between the digital economy and the investment efficiency of manufacturing enterprises, based on the analysis of the impact of the digital economy on the investment efficiency of manufacturing enterprises.

The empirical results found: First, the digital economy can significantly promote the investment efficiency of manufacturing enterprises, and it is more evident in non-state-owned enterprises. Second, by introducing the moderating variable of the degree of marketization, it was found that the degree of marketization has a positive moderating effect on the digital economy promoting the investment efficiency of manufacturing enterprises. This indicates that the higher the degree of marketization, the stronger this effect. It was also found that this moderating effect is mainly reflected in non-state-owned enterprises, and its effect on state-owned enterprises is not significant.

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

(1) Continually enlarge, optimize, and strengthen our country's digital economy. Strengthen the construction of digital infrastructure, increase investment in the digital economy's internet sector, and comprehensively upgrade and transform existing communication foundations and facilities. Also, increase efforts to cultivate digital technology talents and encourage universities to offer related courses. (2) Improve the socialist market economy system, fully play the decisive role of the market in resource allocation, and promote the high-quality development of traditional industries. (3) Deepen the reform of state-owned enterprises, improve the market operation mechanism, and fully utilize the advantages of the digital economy to achieve quality improvement and efficiency.

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