ISSN: 2688-9323

# Research on the Impact of Digital Economy on Green Innovation of Manufacturing Enterprises

Xingchang Li[1, a], Lelin Zhang[1,2]

[1] School of Finance, Faculty of economics and management, Qilu University of Technology (ShandongAcademy of sciences), Jinan, Shandong 250100, China

[2] Shandong Future Digital Technology Co., Jinan, Shandong, China

[a]lxcdyx2023@163.com

## Abstract

**The purpose of this study is to investigate the impact of digital economy on green innovation of manufacturing enterprises, this paper takes China's A-share listed companies as a sample, and adopts entropy method to measure the digital economy, which is measured by taking the logarithm of the total number of green patent applications of manufacturing enterprises. The fixed effect model is utilized for testing. The results show that the digital economy can enhance the green innovation ability of manufacturing enterprises. In addition, the digital economy has a more significant impact on the green innovation of manufacturing enterprises in the eastern region of China, while the impact on the central and western regions is relatively small. This finding highlights the important role of digital economy in promoting green innovation of manufacturing enterprises. For manufacturing enterprises, actively exploring the development path of digital economy and strengthening the application of digital technology can help to enhance green innovation capability and sustainable development. At the same time, the government and relevant stakeholders should also increase support for the development of the digital economy and promote the integration of digital technology and green development, in order to promote the green transformation and sustainable development of the manufacturing industry.**

## Keywords

**Digital Economy; Manufacturing Firms; Green Innovation; Heterogeneity Analysis.**

## 1. Introduction

With global climate change and energy security becoming increasingly urgent, the low-carbon economy has become a trend in global development. China's rapid economic growth, urbanization and industrialization are advancing, however, the problem of environmental pollution is also becoming more and more serious, and therefore needs to be improved urgently. The manufacturing industry, as one of the major energy consumers, is a key area of concern for realizing the goal of "double carbon". The contradiction between China's rapid economic growth and environmental pollution is a major challenge facing society today. Enterprises play an important role in the development of the market and should take the responsibility of harmonizing economic development and ecological environment protection.[1] In the field of environmental protection, enterprises carry out green innovation. In the field of environmental protection, enterprises carrying out green innovation can not only effectively reduce the negative impact of the production process on the environment, but also promote the differentiation of green products to compete.so as to obtain market advantages[2] . Reid & Miedzinski (1996) proposed that the green technological innovation of the enterprise is crucial to the development of the enterprise, and it can enhance the eco-efficiency and realize the

ISSN: 2688-9323

optimal allocation and effective use of resources.[3] Reid & Miedzinski (1996) suggested that green technological innovation of enterprises is crucial to enterprise development, which can enhance ecological efficiency and realize optimal allocation and effective utilization of resources. However, enterprises' green technology innovation faces many challenges, such as uncertainty, market imperfection and huge capital investment. These high-risk characteristics bring many difficulties for enterprises' green innovation. On the one hand, there is an obvious contradiction between the traditional environmental regulation measures that make enterprises more passive in environmental management and the optimized allocation of innovation resources that require enterprises to be more active in development.[4]. On the other hand, compared with the general innovative products, the innovative products are more difficult to develop. On the other hand, compared with the general innovation products, the research and development of green innovation patented products need to invest a large amount of capital investment, high risk and low success rate.[5] On the other hand, compared with general innovative products, the research and development of green innovative patented products require a large amount of capital investment, high risk and low success rate. Therefore, in-depth exploration of factors favorable to enterprise green innovation is crucial to enhance the high-quality development of China's economy.

With the continuous development of computer technology, emerging production methods such as digital technology-driven are receiving widespread attention. And the rapid development of the digital economy is conducive to enhancing the green innovation ability of enterprises[6]. From the overall perspective, digital economy is of great significance in promoting the rational distribution and efficient utilization of resources.[7] From a holistic perspective, the digital economy is important for promoting rational distribution and efficient utilization of resources, and the digital economy can solve the problem of green innovation of enterprises, and the in-depth application of information technology to the level of micro-enterprises can help to alleviate the agency problem and enhance the effectiveness and accuracy of decision-making[8].

This paper selects A-share listed manufacturing enterprises from 2013 to 2022 as the research object, aiming to analyze the impact of digital economy on green innovation of manufacturing enterprises. The focus of the study includes: first, verifying whether the digital economy significantly enhances the green innovation capability of manufacturing enterprises; second, exploring the factors affecting the green innovation of manufacturing enterprises; and finally, the conclusions of the study will provide a theoretical basis for the government to formulate and implement green innovation strategies.

## 2. Theoretical Analysis and Research Hypothesis

### 2.1. Theoretical Analysis

In terms of the influencing factors of green innovation, it has been pointed out that the determinants of green innovation of enterprises mainly cover three dimensions: the supply side, the demand side, and the regulatory and political influences[9]. On the supply side, Bixin et al[10] found that the inflow of foreign direct investment (FDI) positively promotes the input of green patent innovation factors in the manufacturing industry. Wang Hui et al[11] concluded that the intensity of firms' investment in R&D has a significant positive impact on green innovation.

### 2.2. Research Hypothesis

With the rapid development of the digital economy, information technology is gradually penetrating the enterprise level. It has prompted the organizational management form of enterprises to tend to flatten, which is not only conducive to the sharing of information between different departments, but also to achieve the complementarity of professional knowledge.

ISSN: 2688-9323

With the help of horizontal information sharing mechanism, enterprises can improve the decision-making efficiency and effectiveness of green innovation from a holistic perspective[12]. In addition, In the era of digital economy, the establishment of an urban big data platform can improve the transparency of corporate information, reduce the impact of agency problems on enterprises, and thus improve the level of internal governance.[13] The green technological innovation of enterprises has a high level of risk. Due to the high risk of corporate green technology innovation, which may adversely affect revenue, corporate management usually avoids venturing into the field of green innovation when considering the sensitivity of compensation performance. The digital economy, as a new financial form, effectively compensates for the shortcomings of the traditional financial market by establishing a perfect financial infrastructure to meet the financial service needs of social groups. First, in terms of breadth of coverage, the digital economy establishes an extensive network of electronic accounts through the Internet platform, which breaks the geographical restrictions, expands the coverage of

financial services and improves the level of financial services. Second, in terms of depth of use, the digital economy has promoted the development of integrated businesses such as digital payment and online lending, facilitated the innovation and integration of business models, and effectively lowered the threshold and cost of services for small and micro enterprises and low-income groups[14] . Based on this, this paper puts forward the following hypotheses:

H1: Digital economy has a significant positive impact on green innovation in manufacturing companies.

The digital economy is able to assess the credit and risk of enterprises based on platform data, reduce the degree of information asymmetry, optimize the allocation of resources, alleviate the financing constraints of enterprises, and help them obtain sufficient funds to achieve the goal of sustainable development. With technologies such as big data and blockchain, the digital economy is able to access a large amount of data at low risk and low cost, helping to absorb and integrate more capital [15]. By acquiring a large amount of information on both the supply and demand sides of funds through digital technology, financial institutions are able to gain a deeper understanding of the financial and non-financial situation of the demand side of funds, and realize rapid fund matching (Yu Lianchao et al. 2019)[16] , so as to provide financial security for the enterprise's green technological innovation. Wan Jiayu et al. (2020) proposed that the support of information technology enables digital finance to reduce the redundant costs of enterprises in the investment and financing links and promote the efficient allocation of resources, effectively alleviating the financing constraints faced by enterprises[17]. In summary, this paper puts forward the following hypotheses.

H2: The development of the digital economy promotes green innovation in firms mainly by alleviating financing constraints.

## 3. Research Design

### 3.1. Data Sources

This paper selects A-share listed manufacturing enterprises from 2013-2022 as the research object, and the data are mainly from CSMAR database and China Urban Statistical Yearbook. To ensure the rigor of the study, this paper excludes ST, ST*, and companies with missing financial data, and shrinks all variables to obtain a final data sample of 15,274 manufacturing enterprises.

### 3.2. Description of Variables

#### 3.2.1. Explained Variables

Existing studies usually assess an enterprise's green innovation from the perspective of inputs or outputs, and this paper also draws on this logic. Since it takes a certain amount of time for

ISSN: 2688-9323

an enterprise's green technological innovation to go from initiation to output, this paper selects the logarithm of the total number of green patent applications as a proxy variable for an enterprise's green innovation from the perspective of green innovation inputs.

### 3.2.2. Explanatory Variables

This paper refers to Zhao Tao (2020)[18] et al. to measure the level of digital economy development in terms of digital financial inclusion and Internet development. Specific indicators include: Beida Digital Inclusive Finance Index, computer services, the proportion of software employees, the per capita volume of telecommunication services, the number of cell phones per 100 people, and the number of computers in use per 100 people The entropy method is used to measure.

### 3.2.3. Control Variables

In this study, a series of control variables are introduced, taking into account the impact of city-level and firm-level factors on the findings. ①Firm size (size), the study shows that the size of the firm has an important impact on firm innovation. (Wenjing Lai and Manny Zheng[19] , 2016). Large enterprises usually maintain the level of technological development through stable R&D investment to ensure sustainable development. Therefore, in this paper, the total assets of enterprises are selected to take the logarithm to measure the size of enterprises. ②Firm age (lnage), studies show that the age of a firm usually reflects its maturity level, and mature firms have a higher sense of innovation (Jie Zhang et al. 2015[20]; Han Chao and Sang Ruicong, 2018[21]). In this paper, we select the time of listing of enterprises and take the logarithm to measure. ③Corporate liabilities (lndebts), corporate liabilities reflect the market's evaluation of corporate creditworthiness (Meuleman and Maeseneire,2012[22]; Wang just et al, 2017[23]). Referring to the existing literature, this paper selects the ratio of the current year's loan amount to total assets to measure corporate liabilities. ④Capital intensity, as capital intensity involves the impact of industrial structure changes and economic development (Yu Yongze and Zhang Shaohui, 2017[24]; Jin Gang and Shen Kunrong, 2018[25]), this paper selects the ratio of industrial structure to GDP to measure capital intensity. ⑤Relevant variables at the city level. This paper controls the city-level GDP per capita (lngdp) and industrial structure ratio. ⑥Control the environmental regulation variable (lnSO2) at the city level. Referring to Dong Zhiqing and Wang Hui (2019), using pollutant emissions per unit of economic output to measure[26], using sulfur dioxide emissions and taking the logarithm (lnSO2) to represent other environmental regulations.

**Table 1.** Description of variables

| variable name | Variable Description |
|---|---|
| Digital | Measuring the Digital Economy with the Entropy Approach |
| inno | Logarithmic total green applications |
| size | Logarithmic total assets of the enterprise |
| lnage | The length of time a company has been on the market and measured logarithmically. |
| lndebts | Ratio of loan amount to total assets for the year |
| lngdp | gdp taking logarithms |
| cap | Industrial structure to GDP ratio |
| $lnSO_2$ | Sulfur dioxide emissions in logarithmic terms |

### 3.2.4. Measurement Models

The purpose of this paper is to explore whether the digital economy promotes green technological innovation in manufacturing firms. This paper examines the impact of the digital economy on green innovation in manufacturing firms by constructing a benchmark regression.

ISSN: 2688-9323

$$Lninnoi,t = \alpha + \beta Digitalm, t + yXi, t + \varphi i + \delta t + \varepsilon i, t \quad (1)$$

where Lninnoi,t denotes the logarithm of the total number of corporate green patents of manufacturing firms at year t, Digital denotes the digital economy, Xi, t represents the control variables, and φi and δt are firm fixed effects and year fixed effects, respectively. The core variable of interest in this paper is the coefficient of Digital. Ifβis significantly positive, then it indicates that the digital economy has a significant positive impact on green innovation in manufacturing firms.

## 4. Empirical Results and Analysis

### 4.1. Descriptive Statistics

Table 1 shows the descriptive statistics of each major variable. During the sample period, the mean value of total green patent applications of listed enterprises is 0.5224062, the maximum value is 4.025352, and the minimum value is 0. This indicates that the total number of green patent applications of manufacturing enterprises is generally low, and there are significant differences in the level of green innovation among different enterprises.

**Table 2.** Results of descriptive statistics of variables

| variant | observed value | average value | (statistics) standard deviation | minimum value | maximum values | upper quartile |
|---|---|---|---|---|---|---|
| Digital | 15274 | 0.3251623 | 0.2289689 | 0.0610798 | 0.997939 | 0.2942677 |
| inno | 15274 | 0.5224062 | 0.9200163 | 0 | 4.025352 | 0 |
| size | 15274 | 22.19289 | 1.195818 | 0.08448 | 25.76029 | 22.02144 |
| age | 15274 | 1.975503 | 0.9720736 | 0 | 3.332205 | 2.197225 |
| lndebts | 15274 | 0.0104478 | 0.0760575 | -0.2356101 | 0.294854 | 0 |
| lngdp | 15274 | 10.73274 | 0.7084328 | 8.229106 | 11.76849 | 10.78012 |
| cap | 15274 | 2.199768 | 1.856822 | 0.7892357 | 13.83121 | 1.557269 |
| $lnSO_2$ | 15274 | 2.47279 | 1.47128 | -1.966113 | 5.06903 | 2.503243 |
| RD2 | 15274 | 5.046012 | 4.381344 | 0.01 | 26.57 | 4.03 |

### 4.2. Impact of the Digital Economy on Green Innovation in Business

Table 3 presents the results of the empirical tests of the benchmark relationship between the digital economy and firms' green innovation. The level of firms' green innovation is measured by taking the logarithm of the total number of firms' green patent applications, while the regression analysis controls for individual firm and year fixed effects, as well as separate individual firm fixed effects and year fixed effects. In columns (1), (2), and (3) of Table 3, the digital economy is significantly positive at the 5%, 1%, and 5% levels, respectively, indicating that the development of the digital economy has a significant positive impact on the green technological innovations of manufacturing firms. In other words, the higher the level of digital economy development, the higher the level of green innovation of manufacturing enterprises, thus verifying hypothesis H1.

The control variables of enterprise size are significant at the 1% level, and enterprise age and debt are significant to some extent, which indicates that enterprise size, age, and debt have a certain impact on enterprise green technological innovation and are consistent with theoretical expectations. The industrial structure variable in column (2) of Table 3 is significant at the 5% level, which indicates that as the proportion of the secondary industry increases, the green technological innovation of enterprises is adversely affected. Although the upgrading of

ISSN: 2688-9323

industrial structure has the potential to promote the level of green technology innovation in manufacturing enterprises, this potential has not yet been fully released.

**Table 3.** Impact of the digital economy on firms' green innovation: benchmark regression results

| | (1) lninno | (2) lninno | (3) lninno |
|---|---|---|---|
| Digital | 0.718** | 0.229*** | 0.739** |
| | (0.357) | (0.084) | (0.325) |
| lnsize | 0.084*** | 0.197*** | 0.090*** |
| | (0.023) | (0.010) | (0.023) |
| lnage | -0.024 | -0.042*** | -0.034* |
| | (0.022) | (0.011) | (0.020) |
| lndel | 0.098*** | 0.106*** | 0.099*** |
| | (0.033) | (0.039) | (0.034) |
| lngdp | -0.037 | 0.009 | -0.011 |
| | (0.077) | (0.034) | (0.061) |
| cap | -0.038 | -0.030** | -0.049 |
| | (0.039) | (0.014) | (0.040) |
| $lnso_2$ | 0.016 | 0.024* | -0.024* |
| | (0.020) | (0.013) | (0.013) |
| RD2 | 0.004 | 0.013*** | 0.004 |
| | (0.073) | (0.002) | |
| vintages | containment | fluid | containment |
| | | | |
| corporations | containment | containment | fluid |
| | | | |
| _cons | -1.246 | -4.075*** | -1.385* |
| | (0.969) | (0.435) | (0.811) |
| N | 15264 | 15264 | 15264 |
| $R^2$ | 0.0551 | 0.1709 | 0.0380 |

Note: ***, **, * represent 1%, 5%, 10% level of significance, respectively. Same as below.

## 4.3. Endogenous Problems

In order to cope with the possible endogeneity problem in the model, this paper refers to the related literature and adopts the method of lagging one period to deal with it. As shown in Table 4, the lagged one-period digital economy variable is significantly positive at the 5% level. This indicates that the positive impact of the digital economy on the total number of green patent applications is still significant after considering the potential endogeneity problem.

ISSN: 2688-9323

**Table 4.** Endogeneity test results

| | (1)<br>lninno |
|---|---|
| L. Digital | 0.635**<br>(0.282) |
| lnsize | 0.069***<br>(0.024) |
| lnage | -0.049<br>(0.038) |
| lndel | 0.093***<br>(0.035) |
| lngdp | -0.006<br>(0.079) |
| cap | -0.026<br>(0.038) |
| $lnso_2$ | 0.006<br>(0.025) |
| RD2 | 0.004<br>(0.003) |
| _cons | -1.071 (0.997) |
| Enterprise/Year | containment |
| N | 12621 |
| $R^2$ | 0.0369 |

## 4.4. Robustness Tests

### 4.4.1. Replacement of Explanatory Variables

**Table 5.** Robustness test results

| | (1)<br>Lninno |
|---|---|
| Digital | 0.758*<br>(0.400) |
| lnsize | 0.084***<br>(0.023) |
| lnage | -0.025<br>(0.022) |
| lndel | 0.098***<br>(0.033) |
| cap | -0.037<br>(0.038) |
| $lnso_2$ | 0.019<br>(0.020) |
| RD2 | 0.004<br>(0.003) |
| _cons | -1.093<br>(0.962) |
| Enterprise/Year | containment |
| N | 15264 |
| $R^2$ | 0.0490 |

ISSN: 2688-9323

In order to enhance the stability of the model, this paper changes the number of cell phones per 100 people and the number of computers per 100 people measuring the digital economy index to the number of cell phones per capita and the number of computers per capita. The results are shown in Table 5, the digital economy as an explanatory variable is still significantly positive at the 10% level, consistent with the previous results.

### 4.4.2. Random Sampling

In order to enhance the stability of the model, this paper refers to the relevant literature and conducts the regression again by randomly selecting 70% of the data, and the results are shown in Table 6, the explanatory variables are still significantly positive at the 5% level.

**Table 6.** Robustness test results

| | (1)<br>lninno |
|---|---|
| Digital | 0.785**<br>(0.326) |
| lnsize | 0.091***<br>(0.025) |
| lnage | -0.018<br>(0.025) |
| lndel | 0.257***<br>(0.070) |
| Lngdp | -0.007<br>(0.088) |
| cap | -0.042<br>(0.040) |
| $lnso_2$ | 0.026<br>(0.022) |
| RD2 | 0.002<br>(0.003) |
| _cons | -1.722<br>(1.078) |
| Enterprise/Year | containment |
| N | 10683 |
| $R^2$ | 0.0548 |

## 4.5. Financing Constraints

Studies have shown that the digital economy meets the financial needs of more enterprises by lowering the threshold for financing and expanding the scope of services, thereby creating more opportunities for innovation. The digital economy attracts idle funds and enhances the vitality of the capital pool by utilizing big data, blockchain and other information technologies. Based on the above logic, this paper refers to Wen Zhonglin et al.(2004)[27] The mediation effect test procedure proposed by Wen Zhonglin et al. (2004) is tested, and the results are shown in Table 7, the digital economy is significantly positive at 5% level, indicating that the digital economy can effectively alleviate the financing constraints of manufacturing enterprises, which is consistent with the above theoretical logic, so the hypothesis H2 is established.

ISSN: 2688-9323

**Table 7.** Results of Financing Constraints Test

| | (1)<br>lninno |
|---|---|
| Digital | 0.727**<br>(0.359) |
| SA | 0.600***<br>(0.231) |
| lnsize | 0.081***<br>(0.023) |
| lnage | 0.005<br>(0.022) |
| lndel | 0.113***<br>(0.033) |
| lngdp | -0.035<br>(0.077) |
| cap | -0.037<br>(0.037) |
| $lnso_2$ | 0.017<br>(0.020) |
| RD2 | 0.004<br>(0.003) |
| _cons | 0.936<br>(1.227) |
| Enterprise/Year | containment |
| N | 15264 |
| $R^2$ | 0.0053 |

# 5. Heterogeneity Analysis

## 5.1. Heterogeneity Analysis of High-Tech and Non-High-Tech Enterprises

**Table 8.** Results of heterogeneity analysis

| | (1)Non-high-tech enterprises | (2) High-tech enterprises |
|---|---|---|
| | lninno | lninno |
| Digital | 0.628* | 0.457 |
| | (0.379) | (0.307) |
| lnsize | 0.030 | 0.120*** |
| | (0.028) | (0.031) |
| lnage | -0.020 | -0.044 |
| | (0.035) | (0.029) |
| lndel | 0.069* | 0.132** |
| | (0.041) | (0.052) |
| lngdp | -0.020 | -0.112 |
| | (0.100) | (0.112) |
| cap | -0.020 | -0.172** |
| | (0.028) | (0.070) |
| $lnso_2$ | -0.019 | 0.035 |
| | (0.026) | (0.026) |
| RD2 | 0.004 | 0.003 |
| | (0.004) | (0.004) |
| _cons | -0.149 | -0.917 |
| | (1.304) | (1.293) |
| Enterp rise/Year | set rigidly in place | set rigidly in place |
| N | 6292 | 8972 |

ISSN: 2688-9323

As an important vehicle for the close integration of science and technology and the economy, high-tech firms play a key role in national science and technology strategies. These firms usually have high levels of digitization and well-developed infrastructures, and thus they tend to have a high potential for innovation. Although non-high-tech firms are relatively less innovative, they can improve their operational efficiency and innovation capabilities by improving their investment, management, and production models, which can lead to significant improvements and make it easier for them to undergo digital transformation. Therefore, we expect the impact of the digital economy on the green innovation of non-high-tech firms to be more significant. In order to re-test the impact of the digital economy on firms' green innovation, we divide the firms in the full sample into two groups, high-tech manufacturing firms and non-high-tech manufacturing firms, based on the national identification criteria available for high-tech and non-high-tech firms. Table 8 shows that the digital economy has a greater impact on the green technology innovation of non-high-tech enterprises, which is significantly positive at the 10% level, while it has a smaller impact on high-tech enterprises.

### 5.2. Heterogeneity Analysis of the East and West Regions

Given the vastness of China and the uneven distribution of resources, there are significant differences in the level of economic development between different regions. In order to explore the impact of the digital economy on enterprise green innovation, this study divides the analysis area into two regions, the east and the central and western regions, according to the geographic location and with reference to the relevant literature. The results of the study are shown in Table 9, compared with the eastern region, the impact of the digital economy on the green innovation of manufacturing enterprises is more significant.

**Table 9.** Heterogeneity analysis test results

| | (1)<br>Eastern<br>lninno | (2)<br>Midwest lninno |
|---|---|---|
| Digital | 0.496** (0.220) | 0.332 (0.498) |
| lnsize | 0.089*** (0.017) | 0.085*** (0.025) |
| lnage | -0.012 (0.020) | -0.084** (0.034) |
| lndel | 0.094** (0.047) | 0.093 (0.076) |
| lngdp | -0.055 (0.091) | -0.008 (0.090) |
| cap | -0.107* (0.055) | -0.047 (0.037) |
| $lnso_2$ | 0.044** (0.017) | -0.028 (0.038) |
| RD2 | 0.004 (0.003) | 0.003 (0.004) |
| _cons | -1.121 | -1.041 |
| | (1.112) | (1.080) |
| N | 10721 | 4489 |

## 6. Conclusion and Recommendations

### 6.1. Conclusion

Driven by new technologies, the digital economy has developed rapidly and effectively solved the problem of enterprise financing constraints, thus promoting the green innovation activities of enterprises. This study empirically examines the mechanism of digital economy's role in green innovation of manufacturing enterprises with the sample of A-share listed manufacturing enterprises from 2013 to 2022.

ISSN: 2688-9323

The results of the study show that digital economy significantly promotes the level of green innovation of enterprises, and it incentivizes enterprises to carry out green innovation activities through the mechanism of reducing financing constraints. Further research shows that the digital economy has a more significant impact on the green innovation of non-high-tech manufacturing enterprises, while the impact on high-tech manufacturing enterprises is smaller. The digital economy has a greater impact on the green technological innovation of manufacturing enterprises in the eastern region, while it has a smaller impact on the green technological innovation of manufacturing enterprises in the central and western regions.

### 6.2. Policy Recommendations

This paper makes the following recommendations for the impact of the digital economy on green innovation in manufacturing firms:

(1) Digital transformation: Encourage enterprises to accelerate the pace of digital transformation, especially non-high-tech manufacturing enterprises, in order to gain more momentum for green innovation. Through the application of digital technology, financing constraints can be effectively reduced and enterprises can be stimulated to carry out green innovation activities.

(2) Industrial classification support: For high-tech manufacturing enterprises, although the impact of the digital economy is relatively small, there should be continuous attention to their green innovation needs and corresponding support policies should be provided to ensure their better achievements in sustainable development.

(3) Strategies for regional differentiation: For manufacturing enterprises in the eastern region, the focus should be on supporting their green technological innovation, as the impact of the digital economy on these enterprises is more significant. For manufacturing enterprises in the central and western regions, it is necessary to explore feasible support policies more in accordance with local conditions in order to promote the pace of their green technological innovation.

## References

[1] LI Wei-An ZHANG Yao-Wei ZHENG Min-Na et al. Research on Green Governance of Chinese Listed Companies and Its Evaluation [J]. Management World, 2019, 35 (05): 126-133+160.

[2] LI Qingyuan XIAO Zehua. Heterogeneous Environmental Regulatory Tools and Corporate Green Innovation Incentives-Evidence from Green Patents of Listed Firms [J]. Economic Research, 2020, 55 (09): 192-208.

[3] Huang J W , Li Y H .Green Innovation and Performance: the View of Organizational Capability and Social Reciprocity[J].145(2):1-16.

[4] GUO Hai, SHEN Rui, WANG Donghan et al. Research on the "Double-edged Sword" Effect of Organizational Legitimacy on Corporate Growth [J]. Nankai Management Review, 2018, 21 (05): 16-29.

[5] Rezende L D A , Bansi A C , Rodrigues Alves M F ,et al. Take your time: examining when green innovation affects financial performance in multinationals[J]. Journal of Cleaner Production, 2019, 233(OCT. 1):993-1003.

[6] Zou Yaqing. Status quo and reform of enterprise business management mode in the background of economic structure transformation [J]. Marketing World, 2020, (44): 154-155.

[7] Teng Lei, Ma Degong. Can digital finance promote high-quality development? [J]. Statistical Research,2020, 37 (11): 80-92.

[8] Ferraris A, Mazzoleni A , Devalle A ,et al. Big data analytics capabilities and knowledge management: impact on firm performance[J].Management Decision, 2019, 57(8):1923-1936.

[9] Jens H .Determinants of Environmental Innovation - New Evidence from German Panel Data Sources[J].SSRN Electronic Journal, 2006.DOI:10.2139/ ssrn.879707.

ISSN: 2688-9323

[10] BI Kexin,WANG Yuhan,YANG Zhaogun. Impact of innovation resource input on green innovation capacity of green innovation system - An empirical study based on the perspective of manufacturing FDI inflow [J]. China Soft Science, 2014, (03): 153-166.

[11] WANG Hui,WANG Shuqiao,MIAO Zhuang et al. Heterogeneous Threshold Effect of R&D Investment on Green Innovation Efficiency-An Empirical Study Based on Chinese High-Tech Industries [J]. Research Management, 2016, 37 (02): 63-71.

[12] Wei Z , Sun L .How to leverage manufacturing digitalization for green process innovation: an information processing perspective[J].Industrial Management & Data Systems, 2021, ahead-of-print (ahead-of-print).DOI:10. 1108/IMDS-08-2020-0459.

[13] SHI Dachan,DING Hai,WEI Pingping. Can smart city construction reduce environmental pollution [J]. China Industrial Economy, 2018, (06): 117-135.

[14] Zhai, Huayun,Lewis. Research on the relationship between digital financial development, financing constraints and corporate green innovation [J]. Science and Technology Progress and Countermeasures, 2021, 38 (17):116-124.

[15] TANG Song,WU Xuchuan,ZHU Jia. Digital Finance and Corporate Technological Innovation – Structural Characteristics, Mechanism Identification and Effect Differences under Financial Regulation [J]. Management World, 2020, 36 (05): 52-66+9.

[16] YU Lianchao,BI Xi,ZHANG Weiguo. Construction of Green Transformation Evaluation System for Industrial Enterprises [J]. Statistics and Decision Making, 2019, 35 (14): 186-188.

[17] Wan Jiayu, Zhou Qin, Xiao Yi, "Digital Finance, Financing Constraints and Corporate Innovation, "Economic Review, 2020, (01): 71-83.

[18] ZHAO Tao,ZHANG Zhi,LIANG Shangkun. Digital Economy, Entrepreneurial Activity and High Quality Development - Empirical Evidence from Chinese Cities [J]. Management World, 2020, 36 (10): 65-76.

[19] Lai, Wenjing,Manny Zheng. Inflation expectations, firm growth and business investment [J]. Statistical Research, 2016, 33 (05): 34-42.

[20] Zhang J,Wei ZQ. Can Digital Economy Drive Low-Carbon Transformation of Household Consumption? --Based on empirical evidence from Chinese household tracking surveys [J]. Modern Finance and Economics (Journal of Tianjin University of Finance and Economics), 2023, 43 (09): 3-19. DOI:10.19559/j.cnki.12-1387.2023.09.001.

[21] Han Chao,Sang Ruicong. Enterprise product switching and product quality improvement under environmental regulation constraints [J]. China Industrial Economy, 2018, (02): 43-62.

[22] Meuleman M , Maeseneire W D .Do R&D Subsidies Affect SMEs' Access to External Financing?[J]. Research Policy, 2008, 41(3).

[23] Wang Gang,Xie Fuji,Jia You. A Reexamination of R&D Subsidy Policy Incentive Mechanism - Based on the Examination of External Financing Incentive Mechanism [J]. China Industrial Economy, 2017, (02) :60-78.

[24] Yu Yongze,Zhang Shaohui. Urban house price, purchase restriction policy and technological innovation [J]. China Industrial Economy, 2017, (06): 98-116.

[25] Jin Gang, Shen Kunrong. Beggar-thy-neighbor or neighborly? --Environmental Regulation Enforcement Interactions and Urban Productivity Growth [J]. Management World, 2018, 34 (12): 43-55.

[26] DONG Zhiqing, WANG Hui. The "local-neighborhood" green technology progress effect of environmental regulation [J]. China Industrial Economy, 2019, (01): 100-118.

[27] WEN Zhonglin,HOU Jetai. Comparison and Evaluation of Hidden Variable Interaction Effect Analysis Methods [J]. Mathematical Statistics and Management, 2004, (03): 37-42.