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Digital Economy, Corporate Governance and Enterprise Innovation

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Abstract: Based on the matching data of listed companies and urban digital economy from 2011 to 2019, this paper uses multiple regression model and intermediary effect model to examine the relationship between digital economy, corporate governance and enterprise innovation. The research results show that there is a positive correlation between digital economy and enterprise innovation, digital economy positively promotes the level of corporate governance, and corporate governance plays a part of the intermediary effect between digital economy and enterprise innovation.

Keywords: Digital Economy; Corporate Governance; Enterprise Innovation.

1. Introduction

Since the 18th National Congress of the Communist Party of China, innovation has always been placed at the core of the overall development of the country. The special deployment of innovation in the outline of the 14th Five-Year Plan has highlighted the unprecedented importance of innovation and the importance of promoting development through innovation. China has embarked on a new journey to fully build a modern socialist country, and scientific and technological innovation plays a very important role in the overall development of the Party and the country. In recent years, China's digital economy has developed rapidly, and the scale has been increasing year by year, which has made great contributions to the country's economic development. The state has also specially deployed the digital economy as innovation in the outline of the 14th Five-Year Plan, which emphasizes that "accelerating the construction of digital economy, digital society, digital government, and digital transformation as a whole to drive the transformation of production mode, lifestyle and governance mode ". With the vigorous development of digital economy and innovation, exploring new ways of corporate governance in the era of digital economy has become the mainstream of current development. Faced with the current business environment, enterprises need to cater to the trend of digital economy, constantly improve the corporate governance model, accelerate the transformation in the digital economy, and obtain enough competitive advantages. Corporate governance can gain better advantages for the survival and development of enterprises and market competition, and the ability of corporate governance is a gradual process of continuous and continuous adjustment, the purpose of which is to seek the path of high-quality development of enterprises. Under the business model of digital economy, digital economy not only helps enterprises to increase their performance and reduce operating costs, but also helps enterprises to improve their performance and reduce operating costs. It is also the repositioning and thinking of existing enterprise innovation and corporate governance (Meng Tao, 2021). China has been in the era of transformation from traditional economy to digital economy, and the application of digital economy in enterprise management has gradually penetrated into all aspects of enterprises. The development of digital economy provides more effective means for corporate governance and provides a good foundation for enterprise innovation. It is the current trend for enterprises to innovate by relying on digital economy. Therefore, in the digital economy, how to promote corporate governance, seek corporate governance on the basis of enterprise innovation, successful completion of digital transformation, has become an important issue faced by enterprises in the era of digital economy.

2. Literature Review and Research Hypothesis

2.1. Digital Economy and Enterprise Innovation

In the study of digital economy and enterprise innovation, existing scholars generally use the perspective of digital finance to study the impact on enterprise innovation. Taking the internal environment of listed companies as the research object, digital finance can alleviate financing constraints and information asymmetry to a certain extent and indirectly promote enterprise innovation (Zhou Zhenjiang, 2021). Further research on green innovation shows that, On the basis of alleviating financing constraints, digital finance can also play a positive role in promoting green innovation (Zhai Huayun, 2021), in addition, digital finance can promote enterprise innovation through equity pledge (Li Yukun, 2021), and digital finance can significantly promote enterprise total factor productivity on the basis of promoting innovation (Ran Fang, 2021). With the deepening of research on digital finance, the research Angle of digital economy is no longer limited to digital finance and internal issues of listed companies. Using ICS12 data report, Zhang Guosheng (2021) constructed digital empowerment index to study the impact on enterprise innovation, and concluded that digital empowerment has a positive promoting effect on enterprise technological innovation. Similarly, with the use of enterprise digital resources and information platform, Huang Jiegen (2021) constructed digital level to study the impact on enterprise innovation, and also concluded that digital level also has a positive impact on enterprise innovation; In the study of enterprise external environment, digital economy can promote enterprise innovation in both innovation

environment and market environment (Dang Lin, 2021; Hou Shiying, 2021). Most existing literatures study that digital economy plays a promoting role in enterprise innovation, but when regional digitalization indicators affect the green innovation of resource-based enterprises, there is a "∩ - shaped" influence relationship (Wang Fengzheng, 2021). However, there is also a " ∪ type" relationship between enterprise digitalization and enterprise innovation performance (Yu Feifei, 2021). Based on the existing research perspectives of digital economy and different conclusions on enterprise innovation, this paper proposes the following research hypotheses:

Hypothesis 1: Digital economy can promote enterprise innovation.

2.2. Digital Economy, Corporate Governance and Enterprise Innovation

At present, the impact of corporate governance on enterprise innovation is mostly explained from the single perspective of the board of directors, the shareholding of major shareholders, equity checks and balances, and institutional investors. For example, the board of directors can improve the transparency of corporate information to improve the efficiency of innovation. With the increase of the shareholding ratio of major shareholders, the risk characterization of innovation by major shareholders will also change and they are more inclined to support enterprise innovation. On the other hand, ownership concentration is a balancing effect, which can indirectly improve enterprise innovation (Xu Yang, 2021). Based on the governance ability of major shareholders, external major shareholders can also promote corporate innovation under the threat of exit, and its role in corporate governance is as important as that of internal major shareholders (Chen Kejing, 2021). According to existing studies on institutional investment, participation of institutional investors in corporate governance can also promote corporate innovation (Jiang Junchen, 2021). In addition, multi-angle joint analysis also has many influences on corporate innovation. For example, the study on corporate governance based on the two-power split interest rate, executive shareholding and tax burden can also promote corporate innovation (Fan Yuxian, 2021); Corporate governance capability can significantly improve the innovation behavior and efficiency of enterprises. With the development of digital economy, enterprises can use digitalization to improve their self-management mode, which can accelerate the adaptability of digital economy (Mikalef,2017).

User value dominance and alternative competition in the digital economy have become the fundamental forces of corporate governance, promoting the adaptive transformation of enterprises in the digital economy and the innovation of governance structure (Qi Yudong, 2020). In the governance structure, the digital economy has increased the ability to use information governance, which can help shareholders to supervise the behavior of the company's management to a certain extent. To restrain the hollowing out behavior of major shareholders and improve the environment of corporate governance (Wang Haifeng, 2021). The higher the degree of digitalization, the higher the level of corporate governance, and enterprises may affect their governance ability by reducing information asymmetry and managers' irrational decisions (Qi Huaijin, 2020). The digital economy can improve the organizational structure of enterprises, influence and integrate the governance system of enterprises, and objectively promote corporate governance, which will also have a positive effect on innovation and corporate performance to a certain extent (Liu Shuchun, 2021). However, existing studies also believe that the digital economy will increase the difficulty of management due to the existence of digital divide. It will also produce uncertainty effect to reduce innovation input and the necessary factors for innovation (Grewal, 2019). From the perspective of the existing role of digital economy in corporate governance, it has significantly changed management ability, management process and management efficiency, and has a significant impact on the research on the development of corporate governance in China. However, there are few relevant literatures at present, and the impact of digital economy on corporate innovation through corporate governance is a new path for high-quality development of companies. Based on the above research basis, the paper puts forward the following research hypotheses:

Hypothesis 2: Digital economy can improve corporate governance.

Hypothesis 3: Corporate governance plays an intermediary role between the digital economy and corporate innovation.

3. Research Design

3.1. Sample Selection and Data Source

This paper takes A-share listed companies from 2011 to 2019 as the research object, and matches the research data of prefecture-level cities with the data of listed companies to build panel data, which contains 17,663 research samples. The enterprise-level data came from Guotai 'an Database (CSMAR) and Wind database (Wind); Provincial and prefecture-level data are from the China Statistical Yearbook, and digital economy-related data are from the China Digital Financial Inclusion Index jointly compiled by the China Urban Statistical Yearbook, the Digital Finance Research Center of Peking University and Ant Financial Group; The samples of listed companies in the financial sector, ST, *ST and PT were excluded; And eliminate outliers and other companies with significant data gaps.

3.2. Selection of Variables

3.2.1. Explained Variable -- Enterprise Innovation

In the existing research on enterprise innovation, there are three ways to measure enterprise innovation. First, innovation input is the main innovation index, and the representative metric is R&D input (Ran Fang, 2021; Li Yukun, 2021); The second is the research on innovation output as the main innovation index, and the representative indicators are the number of patent applications or acquisitions and the sales revenue of new products (Zhai Huayun, 2021; Yu Feifei, 2021); The third is to construct the research on innovation indicators in the way of comprehensive reflection, and the representative measurement is the description of various indicators in the questionnaire survey (Zhang Guosheng, 2021) and the combination of the first two methods (Huang Jiegen, 2021; Hou Shiying, 2021). The impact of digital economy on enterprise innovation is more about the activities that promote enterprise innovation and enterprises' utilization of digital economic environment innovation. This paper uses innovation investment to measure enterprise innovation, which is more appropriate and more intuitive to reflect the degree of enterprise innovation, while patent data is more

uncertain and has a longer development cycle.

3.2.2. Explanatory Variable -- Digital Economy

In the existing researches on digital economy, scholars mostly use the Digital Financial Inclusion Index jointly compiled by the Digital Finance Research Center of Peking University and Ant Financial Services Group. The data includes provincial, city and county data as well as various categories of index attributes, with relatively comprehensive and extensive data coverage (Guo Feng, 2020); Some also use the Digital China Index of 351 cities published by Tencent Research Institute jointly with several Internet platforms (Danglin, 2021), and the proportion of assets related to the digital economy in the relevant data of the company as an indicator of the digital economy (Qi Huaijin, 2020). Based on the research methods of Zhao Tao (2020) and Liu Jun (2020), this paper measures the comprehensive development index of digital economy at the city level by combining Internet development and digital financial data. The measurement of Internet development at the city level uses the method of Huang Huiqun (2019) as reference. The four indicators of Internet penetration rate, relevant employees, relevant output and mobile phone penetration rate are adopted. The actual data corresponding to the four indicators are respectively: the number of Internet broadband access users per 100 people, the proportion of computer service and software employees in urban units, the total amount of telecom business per capita and the number of mobile phone users per 100 people. The above indicators are standardized and processed by principal component analysis to obtain the comprehensive development index of digital economy after dimensionality reduction.

3.2.3. Intermediate Variable -- Corporate Governance

In order to correspond to the comprehensiveness of digital economy indicators, this paper adopts the same comprehensive index method to measure corporate governance. Drawing on the practice of Zhou Qian (2020), this paper uses principal component analysis to construct comprehensive indicators to measure the level of corporate governance from aspects of supervision, incentive and decision-making. Executive compensation (MP) and executive shareholding ratio (MS) are selected to represent the incentive aspect of corporate governance, while institutional investor shareholding (IS) and equity balance degree (SB) (sum of shareholding ratio from the second largest shareholder to the fifth largest shareholder/ shareholding ratio of controlling shareholder) are selected to represent the supervision aspect of corporate governance. Whether the chairman and general manager are Dual represents the decision-making aspect of corporate governance. Based on the above seven indexes, the principal component analysis method is used to construct the corporate governance composite index.

3.2.4. Control Variables

Based on the correlation of the research, the paper considers the selection of control variables in two directions: for the enterprise level, the paper controls the size of the enterprise, the asset-liability ratio, Tobin's Q, the book-to-market ratio, the age of the enterprise and the nature of the equity; For the prefecture-level city level, this paper controls fiscal revenue and per capita GDP. Detailed definitions of all variables are shown in Table 1.

Table 1. Variable descriptions

Types	Name	Variables	Definitions
Explained variable	Enterprise innovation	RD	R&d expenditures as a percentage of operating revenue
Explanatory variables	Digital economy	Dig	Digital Economy Comprehensive Development Index
Mediating variables	Corporate governance	Gov	Corporate Governance Composite Index
Control variables	Business size	Size	Take the logarithm of the total ending assets of the business for the current year
	Asset-liability ratio	Lev	Ratio of total business liabilities to total assets at the end of the year
	Tobin Q	TobinQ	(Market value of outstanding shares + number of non-tradable shares x net asset value per share + carrying amount of liabilities)/ total assets
	Book-to-market ratio	BM	Book value as a percentage of total market capitalization
	Age of business	Age	Study observation year minus business establishment year
	Equity nature	Owner	Take 1 for state-owned enterprises and 0 for non-state-owned enterprises
	GDP per capita	Pcg	Take logarithm of regional GDP per capita
	Fiscal revenue	REV	Regional revenue as a percentage of regional GDP
	Regions	DQ	Provinces, autonomous regions and municipalities
	Year	Year	Year
	Industry	Ind	SEC 2012 edition Industry Classification

3.3. Model Design

$$RD_{it} = \beta_0 + \beta_1 Dig_{it} + \beta_2 Size_{it} + \beta_3 Lev_{it} + \beta_4 TobinQ_{it} + \beta_5 BM_{it} + \beta_6 Age_{it} + \beta_7 Pcg_{it} + \beta_8 REV_{it} + \varepsilon \quad (1)$$

$$Gov_{it} = \beta_0 + \beta_1 Dig_{it} + \beta_2 Size_{it} + \beta_3 Lev_{it} + \beta_4 TobinQ_{it} + \beta_5 BM_{it} + \beta_6 Age_{it} + \beta_7 Pcg_{it} + \beta_8 REV_{it} + \varepsilon \quad (2)$$

$$Gov_{it} = U_0 + U_1 Dig_{it} + U_2 Gov_{it} + U_3 Size_{it} + U_4 Lev_{it} + U_5 TobinQ_{it} + U_6 BM_{it} + U_7 Age_{it} + U_8 Pcg_{it} + U_9 REV_{it} + \varepsilon \quad (3)$$

Where RD_{it} is the explained variable, indicating enterprise innovation; Dig_{it} is the explained variable, represents the digital economy; Gov_{it} is the intermediary variable, represents corporate governance, and the others are control variables. Model (1) is used to test the relationship

between the digital economy and enterprise innovation; Model (2) is used to test the impact of digital economy on corporate governance; Model (3) is based on model (1) to add intermediary variables to test the intermediary effect of corporate governance.

4. Empirical Results Analysis

4.1. Descriptive Statistics

According to the descriptive statistics of the main variables in Table 2, the mean value of R&D innovation of enterprises is 4.71, and the maximum value of 169.43 is significantly different from the minimum value of 0. It can be seen that there are differences in the intensity of R&D innovation of enterprises, and most enterprises prefer low-input R&D innovation. The mean value of digital economy is 63.56, the maximum value is 360, and the minimum value is 0.40. There are great differences in the degree of digitalization among regions. The mean value of the corporate governance index is 0.13, and the maximum value of 3.72 is not much different from the minimum value of -3.24, which shows that there is a certain gap in the level of corporate governance.

Table 2. Descriptive statistics of main variables

Variables	N	mean	sd	min	max
RD	17663	4.71	5.72	0.00	169.43
Dig	17663	63.56	1.07	0.40	360.00
Gov	17663	0.13	1.07	-3.24	3.72
Size	17663	22.06	1.30	17.81	28.64
Lev	17663	0.40	0.21	0.01	3.92
TobinQ	17663	2.10	1.81	0.15	92.25
BM	17663	0.92	1.12	0.01	20.97
Age	17663	19.89	5.38	4.00	61.00
Pcg	17663	69818.16	28627.33	13119.00	140000.00
REV	17663	0.12	0.04	0.06	0.23

4.2. Regression Result Analysis

Table 3. Analysis of regression results

Variables	Model One RD	Model Two Gov	Model Three RD
Dig	0.011*** (12.50)	0.001*** (5.90)	0.011*** (12.18)
Gov	-	-	0.338*** (7.47)
Size	-0.206** (-4.84)	-0.401*** (-56.15)	-0.070 (-1.52)
Lev	-4.24*** (-18.45)	-0.468*** (-12.14)	-4.081*** (-17.71)
TobinQ	0.270*** (11.57)	-0.068*** (-17.29)	0.293*** (12.46)
BM	-0.077 (-1.58)	0.096*** (11.83)	-0.109** (-2.25)
Age	-0.069*** (-9.31)	-0.022*** (-18.03)	-0.061*** (-8.22)
Soe	0.083 (1.34)	0.413*** (39.68)	-0.057 (-0.87)
Pcg	-0.011 (-0.05)	0.208*** (5.64)	-0.082 (-0.37)
REV	-9.67*** (-5.46)	-1.08*** (-3.63)	-9.303*** (-5.26)
Ind	Controls	Controls	Controls
Year	Controls	Controls	Controls
N	17663	17663	17663
R-sq	0.2425	0.4022	0.2450

As can be seen from Table 3, Model 1 is the regression result of digital economy and enterprise innovation. Digital economy and enterprise innovation are significant at the level of 1%, indicating a high degree of correlation between the two, and digital economy has a significant positive impact on enterprise innovation, verifying hypothesis 1. Model 2 is the regression result of digital economy and corporate governance. Digital economy and corporate governance are significant at 1% level, and digital economy has a significant positive impact on corporate governance, which verifies hypothesis 2. In order to verify the mediating effect of corporate governance in the relationship between digital economy and enterprise innovation, Wen Zhonglin and Ye Baojuan (2014) were referred to as the mediating effect test procedure, and the regression results of Model 1 and Model 2 were combined with model 3 for analysis. Among them, the regression coefficients of the parameters to be estimated of β_1,U_1 and U_2 were significantly positively correlated at the level of 1%. Corporate governance plays a part of the mediating effect between digital economy and enterprise innovation.

4.3. Robustness Test

Table 4. Analysis of regression results with a lag of one period

Variables	Model One RD	Model Two Gov	Model Three RD
Dig	0.012*** (12.68)	0.001*** (5.90)	0.012*** (12.28)
Gov	-	-	0.433*** (8.54)
Size	-0.195*** (-4.02)	-0.401*** (-56.15)	-0.022 (-0.42)
Lev	-3.86*** (-14.78)	-0.468*** (-12.14)	-3.694*** (-14.13)
TobinQ	0.414*** (13.86)	-0.068*** (-17.29)	0.448*** (14.89)
BM	-0.062 (-1.11)	0.096*** (11.83)	-0.099* (-1.78)
Age	-0.073*** (-8.71)	-0.022*** (-18.03)	-0.064*** (-7.54)
Soe	0.108 (1.57)	0.413*** (39.68)	-0.067 (-0.94)
Pcg	-0.013 (-0.55)	0.208*** (5.64)	-0.021 (-0.89)
REV	-12.209*** (-6.09)	-1.08*** (-3.63)	-11.731*** (-5.87)
Ind	Controls	Controls	Controls
Year	Controls	Controls	Controls
N	14069	17663	14069
R-sq	0.2446	0.4022	0.2385

In order to verify the stability of the above regression results, this paper adopts the method of one-stage lag, and the original explained variable (RD) is regression after a one-stage lag. The regression results are shown in Table 4. In Model 1, the enterprise innovation with a one-stage lag is significantly positively correlated with the digital economy at the level of 1%. In Model 3, digital economy and corporate governance are also significantly positively correlated with enterprise innovation at the level of 1%, and the intermediary effect relationship is still significant. Compared with the previous regression results, the robustness test fully demonstrates the robustness of the model.

5. Conclusion and Enlightenment

Based on the macro matching data of A-share listed companies and prefecture-level cities from 2011 to 2019, this paper explores the impact of digital economy on enterprise innovation from the perspective of digital economy, and explores the path of digital economy on enterprise innovation with corporate governance as the intermediary variable. The research findings are as follows: Digital economy has a positive impact on enterprise innovation, and it will also have a positive impact on corporate governance. Corporate governance plays a part of the intermediary effect between digital economy and enterprise innovation. Based on the research in this paper, we can get the following enlightenment: First, government departments should pay attention to the influence between digital economy and enterprise innovation, further improve the development level of local digital economy, formulate relevant policies to provide more support for digital development, and digital economy is more in line with the current economic development trend, laying a better environmental foundation for enterprises. Second, enterprises should pay attention to the level of innovation, improve the ability of innovation, combined with the current trend of the development of digital economy to enhance self-innovation ability, at the same time, enterprises should improve the ability of corporate governance, and cooperate with the digital economy to promote enterprise innovation.

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