

Industry-University-Research Cooperation and Firm Digital Innovation

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Abstract. With the rapid development of the digital economy, firm digital innovation has become a focal point in academic research. Nevertheless, how industry-university-research (IUR) cooperation drives firm digital innovation is rarely discussed. Employing two-way fixed effects and PSM-DID models, this study analyzes data from China's A-share listed companies from 2013 to 2023, excluding financial and real estate sectors with winsorization. This paper incorporates descriptive statistics, benchmark regression, heterogeneity assessment, mediation testing, robustness checks, moderation analysis, and endogeneity controls. Results demonstrate that IUR cooperation significantly enhances corporate digital innovation. Executive compensation incentives, capital intensity, and listing tenure exhibit significant moderating effects. These findings persist through robustness checks including lagged effects and alternative variable measurements. This research provides practical solutions for corporate digital innovation and enriches theoretical frameworks.

Keywords: Firm Digital Innovation, Industry-University-Research, Number of Years Listed, Executive Compensation Incentives.

1. Introduction

A new generation of information technology is being popularized and applied, and The New Quality Productive Forces continues to develop, making the process of Digital Transformation accelerate. However, some small and medium-sized enterprises suffer from limited product variety and significant customer loss. Therefore, digital innovation has become an inevitable path for enterprises to achieve long-term development has become a collective conclusion [1~2].

IUR cooperation can establish a close cooperative relationship among enterprises, universities and research institutions to jointly carry out scientific and technological research and development, achievement transformation, talent cultivation and other activities, which in turn can promote enterprise digital innovation and solve the difficult problems of enterprise digital transformation. In recent years, China's IUR cooperation has achieved great results, and the mode of cooperation has been constantly innovated, and there has been a certain development foundation. However, innovation capacity is insufficient, some enterprises are not enough investment in R & D, colleges and research institutions of the Insufficient innovation capacity, some enterprises have not invested enough in R&D, and the scientific research achievements of universities and research institutions are out of touch with the market demand, which makes it difficult to realize the industrialization and application.

At the policy-oriented level, Jin Huan and Niu Ziheng believe that the location-oriented policy of setting up a digital innovation pilot zone affects the level of digital innovation of enterprises by influencing their innovation structure [3]. In addition, Lv Yue and Tian Jilin argue that the Belt and Road Initiative will enhance the level of digital innovation of enterprises through three mechanisms: alleviating financing constraints, promoting collaborative innovation, and strengthening the construction of digital infrastructure [4]. At the level of industry synergy, Zhang Renzhi showed that R&D alliance, as an organizational form, promotes enterprise digital technology innovation by promoting knowledge flow and technology transfer among enterprises to optimize the allocation of innovation resources [5]. At the organizational management level, Yu Jiang et al. argued that the digital transformation strategy of an enterprise can enhances its digital innovation performance by

promoting its knowledge absorption capacity [6]. Based on the mechanism of the innovation-driven effect, Li Hepeng and other researchers believe that IUR cooperation influences the co-patenting in the biomedical industry through innovation in technology, cooperation mode and results transformation [7]. Based on the mechanism of synergistic development effect, Shen Yingchun and Pan Shuling argued that IUR cooperation influences the development of large model industries by affecting synergy benefits, knowledge contribution costs, and default benefits [8].

This study intends to adopt the two-way fixed effects model to investigate whether there is a causal relationship between IUR cooperation and firm digital innovation? If there is indeed a causal relationship between IUR cooperation and firm digital innovation, what is the influence mechanism behind it? If there is indeed a causal relationship between IUR cooperation and firm digital innovation, is there a moderating effect? Therefore, this study is expected to explore from the perspective of industrial upgrading through the mechanism of digital talent inflow, technology spillover and innovation investment, and analyze the moderating effect of related variables. Compared with the current scholars usually from the perspective of financing constraints, which is limited to the internal level of the organization, it supplements the exploration of the influence path of IUR cooperation and fills in the lack of digital innovation theory. In addition, this study is expected to analyze the heterogeneity of whether a firm is a high-tech industry versus whether it is audited by a Big 4 accounting firm on the findings. It is a step forward in further refining the research findings in the field of digital innovation compared to the previous literature that usually selects the variable of the nature of property rights.

The marginal contributions of this study are threefold. First, it pioneers the investigation of how IUR cooperation shapes firm digital innovation and its underlying mechanisms. Previous literature has either studied it from the aspect of policy incentives or explored it from the internal aspect of organizations, but failed to look at it jointly with other industries and other subjects. In this paper, we combine the dynamics of enterprises with universities and research institutions. Although limited literature addresses IUR's general impacts, none specifically targets digital innovation outcomes, underscoring this study's novelty. Second, this paper further expands and innovates in the research perspective of mechanism analysis and the selection of moderating variables. While the previous mechanism analysis tends to favor the traditional research perspective, this paper analyzes it from the perspective of industrial upgrading, which provides an innovative research path. Meanwhile, in the selection of regulating variables, the previous literature mostly selects traditional variables such as the nature of property rights, while this study incorporates executive compensation incentives as moderators, highlighting agent-level drivers in innovation governance. Third, the research in this paper also has certain practical significance to promote the deep integration of industry, academia and research, and empower the development of new quality productivity.

2. Mechanism analysis and modeling assumptions

IUR cooperation can effectively facilitate the digital talent inflow from universities to bolster innovation momentum, thus enhancing firm digital innovation. Previously, in IUR cooperation, many academic papers and patents were not fully translated into tangible productivity. However, after IUR cooperation, a large number of talents will join collaborative enterprises, enhancing their competitiveness and driving innovation. Importantly, the cooperation between academia and industry is increasingly crucial for societal development in the new era. Enterprises often form enduring partnerships with universities to demonstrate social responsibility and attract innovative resources, contributing to a positive "eyeball effect" that further elevates firm digital innovation.

IUR cooperation can effectively enhance the digital technology spillover from research institutions to reduce innovation costs, thereby boosting the level of firm digital innovation. As an advanced transformation mechanism in the new era, IUR cooperation can provide full support for enterprises' innovation activities, especially in important technological areas such as blockchain, cloud computing, and large model development. With a well-developed IUR cooperation mechanism, the alignment

between research institutions and enterprises is strengthened, making it easier to achieve precise matching between R&D technologies and the market. In the context of the high-quality development of the digital economy, the efficiency of the technological value transformation of research institutions is greatly improved, and enterprises can fully leverage cutting-edge technological achievements of research institutions, which enhances the technological transfer from research institutions. Furthermore, as enterprises adopt cutting-edge technologies, they can save on innovation costs and convert results into actual productivity, significantly enhancing digital innovation capability.

IUR cooperation can effectively enhance enterprises' investment in digital innovation, thereby stimulating their innovation potential and elevating the level of digital innovation within the firm. Through the three stages of loose collaboration, deep synergy, and full integration, a virtuous cycle of dynamic complementarity, synergy, and efficiency is formed among enterprises, universities, and research institutions. This enhances the sensitivity of enterprises to the timing of innovation. Simultaneously, with efficient connections between universities and research institutions, enterprises can strategically allocate more effective resources towards digital innovation and maximize the value of these resources. As enterprises invest effective resources at the appropriate time, their investment in digital innovation increases, subsequently promoting the level of digital innovation.

Hypothesis: In the absence of other variables, IUR cooperation exerts a substantial positive influence on firm digital innovation.

3. Variable Setting and Model Selection

3.1. Sample selection and data sources

This paper selects the data of Chinese A-share listed companies from 2013 to 2023 as the research sample and screens the sample as follows: excluding the samples of the financial industry, insurance industry, and real estate industry; excluding the samples of ST and PT companies; and finally obtaining 9653 sample observations. In order to exclude the influence of extreme values, this paper has been reduced to the 1% and 99% percentile.

3.2. Variable Definition and Measurement

Firm digital innovation is as follows. Based on the quantitative economic method of Tao Feng, the invention patents with digital innovation attributes are screened out [9]. Specifically, the text matching method is used to accurately identify key digital technology features and patent technology elements, and then screen out invention patents with digital innovation attributes. On this basis, through the construction of the "enterprise-year" panel data structure, the recognized patent data are summarized to form quantitative indicators that characterize the firm digital innovation.

IUR cooperation are as follows. Referring to the research method of Liu Feiran et al., the patent application data of all listed companies were obtained from the official website of the State Intellectual Property Office of China [10]. In order to focus on the core of technological innovation, design patents focusing only on appearance are eliminated. By presetting keywords, patents jointly applied by listed companies and universities and research institutes are categorized as IUR cooperation patents, and then the number of IUR cooperation patents is used as the IUR cooperation variable. The higher its value, the deeper the cooperation between industry, academia and research of the enterprise and the greater the impact on digital innovation.

The moderator variables are as follows: executive compensation incentives, the natural logarithm of management's total annual compensation; capital intensity, the ratio of a firm's total assets to operating revenues; Listing year, the number of years was first calculated and then the results were logarithmised to eliminate heteroskedasticity in the data.

Control variables are as follows. Size, the natural logarithm of total assets; Lev, the ratio of liabilities to assets; Roa, the ratio of total profit to average total assets; Ato, the ratio of Operating Income to Average Total Assets; Cashflow, the ratio of net cash flow from operations to assets; Fixed, the ratio of net fixed assets to assets; Board, the natural logarithm of the number of board members;

Top5, the ratio of the number of shares held by the top five shareholders to the total number of shares; Employ, the number of employees in the company.

3.3. Model building

In order to test the impact of IUR cooperation on the digital innovation of enterprises, this paper constructs the following model (1):

$$\text{Innovation}_{i,t} = \beta_0 + \beta_1 \text{Cooperation}_{i,t} + \sum \beta_k \text{Controls}_{i,t} + \text{Individual}_i + \text{Year}_t + \varepsilon_{i,t} \quad (1)$$

Among them, Innovation indicates firm digital innovation; Cooperation indicates IUR cooperation; Control indicates relevant control variables; Individual indicates individual fixed effect; Year indicates time fixed effect; ε indicates random error term.

4. Empirical results and analysis

4.1. Descriptive statistics

The results in Table 1 are described as follows. The explanatory variable "innovation" has a right-skewed distribution with a mean of 29.0276 and a standard deviation of 88.4521, which is significant. Combined with the 1% quartile (0) and 99% quartile (704), it can be seen that China's enterprise innovation investment shows a "dumbbell-type" distribution pattern. The mean value of the explanatory variable "cooperation" is 72.7874 (SD=268.0764), and its standard deviation is more than 3.68 times the mean, which indicates that there is a structural feature of the cooperation network dominated by local hub nodes. Among the control variables, the mean value of the size variable (Size) 22.1566 (SD=1.1384) is consistent with the distribution of the size of listed companies.

Table 1 Results of descriptive statistics for the main variables

	N	Mean	SD	1st Perc.	99th Perc.
Innovation	9653	29.0276	88.4521	0	704
Cooperation	9653	72.7874	268.0764	0	2000
Size	9653	22.1566	1.1384	20.1073	25.7146
Lev	9653	0.3901	0.1869	0.0601	0.8482
Roa	9653	0.04	0.0664	-0.2189	0.2062
Ato	9653	0.611	0.3337	0.1193	2.0317
Cashflow	9653	0.0498	0.0619	-0.1231	0.2206
Fixed	9653	0.1956	0.1334	0.0069	0.6154
Board	9653	2.0923	0.1929	1.6094	2.5649
Top5	9653	0.4998	0.1458	0.1993	0.8495
Employ	9653	4672.9966	8478.9698	215	57686

4.2. Benchmark regression results

Table 2 reports the results of the baseline regression, with no control variables and fixed effects added in column (1), control variables but no fixed effects added in column (2), control variables and individual fixed effects added in column (3), and control variables and two-way fixed effects added in column (4). In the above cases, the coefficients of Cooperation are all significantly positive, at least at the 1% level, confirming the existence of a positive facilitating effect of IUR cooperation on enterprises' digital innovation. Taking column (4) of Table 2 as an example, for every 1 unit increase in the coefficient of Cooperation, Innovation increases by 0.0302 units.

Table 2 Benchmark regression

	(1) Innovation	(2) Innovation	(3) Innovation	(4) Innovation
Cooperation	0.0386 ^{***} (0.00)	0.0302 ^{***} (0.00)	0.0302 ^{***} (0.00)	0.0302 ^{***} (0.00)
Size		8.3945 ^{***} (1.20)	8.3945 ^{***} (1.20)	7.0760 ^{***} (1.45)
Lev		-0.2907(4.99)	-0.2907(4.99)	-0.5589(4.99)
Roa		-10.6624(9.22)	-10.6624(9.22)	-8.1326(9.41)
Ato		7.5849 ^{***} (2.81)	7.5849 ^{***} (2.81)	6.4372 ^{**} (2.83)
Cash flow		5.5615(8.27)	5.5615(8.27)	1.8974(8.28)
Fixed		-3.9726(7.30)	-3.9726(7.30)	-1.6275(7.30)
Board		-2.3050(3.97)	-2.3050(3.97)	-1.8055(3.97)
Top5		21.4320 ^{***} (6.63)	21.4320 ^{***} (6.63)	23.5108 ^{***} (7.37)
Employ		0.0009 ^{***} (0.00)	0.0009 ^{***} (0.00)	0.0010 ^{***} (0.00)
cons	20.8890 ^{***} (1.79)	-170 ^{***} (28.45)	-170 ^{***} (28.45)	-150 ^{***} (31.95)
Year	No	No	No	Yes
Id	No	No	Yes	Yes
N	9653	9653	9653	9653
R ²	0.102	0.051	0.051	0.057

Note: Standard errors in parentheses; * p<0.1, ** p<0.05, *** p<0.01. The same as below

4.3. Heterogeneity analysis

The understanding and implementation of IUR cooperation may differ greatly among enterprises due to different audit firms, resulting in the heterogeneity of the digital innovation effect of IUR cooperation in enterprises. In this paper, based on the attributes of audit firms hired by enterprises, the sample is categorized into two groups: Big 4 audit (Big4) and non-Big 4 audit for group regression. Columns (1) and (2) of Table 3 show that industry-academia collaboration in non-Big 4 audit firms is more effective in promoting digital innovation than in Big 4 audit firms. This is because the standardized auditing requirements of Big 4 audit firms reinforce the risk aversion tendency of enterprises, resulting in management focusing more on compliance review rather than enterprise innovation in innovation decision-making. On the contrary, the relatively flexible audit model of non-Big 4 audit firms retains more flexible innovation space for enterprises, which in turn prompts management to more effectively integrate resources in IUR cooperation to promote enterprise digital innovation.

Heterogeneity tests for high-tech and non-high-tech industries show that there is a significant divergence in the driving path of IUR cooperation for firms' digital innovation. As illustrated in columns (3) and (4) of Table 3, the coefficient of IUR cooperation is found to be significantly positive in the high-tech industry group. However, this coefficient does not achieve statistical significance in the non-high-tech industry group. This is attributable to the fact that traditional industries are constrained by resource rigidity, thereby hindering the capacity of IUR cooperation to catalyse substantial innovation.

Table 3 Heterogeneity analysis

	(1) Big4	(2) Not the Big4	(3) High-tech industries	(4) Non-high-tech industries
Cooperation	0.0295(0.02)	0.0121 ^{***} (0.00)	0.0296 ^{***} (0.00)	-0.0009(0.00)
Control variable	Yes	Yes	Yes	Yes
Year/Id	Yes	Yes	Yes	Yes
N	339	9314	6621	3032
R ²	0.302	0.017	0.047	0.023

4.4. Intermediary mechanism test

In order to examine the internal mechanism of IUR cooperation affecting enterprises' digital innovation, this article builds models (2):

$$M_{i,t} = \delta_0 + \delta_1 \text{Cooperation}_{i,t} + \sum \delta_k \text{Controls}_{i,t} + \text{Individual}_i + \text{Year}_t + \varepsilon_{i,t} \quad (2)$$

Among them, M stands for three mechanism variables, referring to digital talent inflow from universities, digital technology spillover from research institutions, and digital innovation investment from enterprises. The meanings of the other variables are consistent with equation (1).

For the digital talent inflow (Dti) of universities, this paper uses the ratio of the number of firms' bachelor's and master's degree holders to the total number of firms to measure it. The test results are reported in column (1) of Table 4. The coefficient of Cooperation is significantly positive, i.e., IUR cooperation provides an important channel for talent delivery from universities. Further, the high-quality talents delivered by universities are a great motivation for firms' digital innovation.

For digital technology spillovers (Dts) from research organizations, this paper uses the ratio of R&D investment to current total assets followed by 10,000 times the logarithm. The test results are reported in column (2) of Table 4. The coefficient of Cooperation is significantly positive, i.e., firms with good performance in IUR cooperation are more advantaged in absorbing technology spillovers from research institutions. Theoretically and logically, the technology of research institutions is an important support for firms' digital innovation and has become an indispensable core resource for advancing digital innovation.

For firms' digital innovation investment (Dii), this paper dimensionless firms' R&D investment and measures digital innovation investment as a share of R&D investment to total assets. The test results are reported in column (3) of Table 4. It can be found that the coefficient of Cooperation is significantly positive, indicating that firms with the advantage of IUR cooperation can increase digital innovation investment. Digital innovation investment is an important guarantee for digital innovation.

Table 4 Mechanism tests

	(1) Dti 100	(2) lnDts 10000	(3) Dii 10000
Cooperation	0.0909*** (0.03)	0.1363** (0.07)	0.1046** (0.05)
cons	-270(551.94)	290*** (1159.66)	14000*** (890.57)
Control variable	Yes	Yes	Yes
Year/Id	Yes	Yes	Yes
N	7738	7738	7738
R2	0.143	0.038	0.189

4.5. Robustness check

It is acknowledged that the innovation of IUR cooperation is a long-term process, with the potential for patent output only materialising after many years of collaboration. The present study employs a lag effect test on the variable of IUR Cooperation to ascertain that the measurement error of this variable will not affect the research conclusion of the article. Furthermore, this paper replaces the measurement index of IUR Cooperation from a continuous variable to a discrete variable. The presence of universities and research institutes in an enterprise's joint patent applications signifies its engagement in the IUR Cooperation, which is assigned a value of 100, otherwise 0. Columns (1), (2), and (3) of Table 5 illustrate the impact of IUR Cooperation on the enterprise's digital innovations in the current year (period t+1), and in the subsequent period (period t+2), respectively. Column (4) presents the outcomes of the test following the replacement of the measurement indicator. The preceding investigation has demonstrated that IUR Cooperation continues to exert a substantial positive influence on enterprise digital innovation, and the conclusions of this study are reliable.

Table 5 Robustness tests

	(1)Innovation	(2)Innovation	(3)Innovation	(4)Innovation
Cooperation	0.0302*** (0.00)			
L.Cooperation		0.0188*** (0.00)		
L2.Cooperation			0.0066** (0.00)	
Cooperation 0/100				0.0811*** (0.01)
cons	-150*** (31.95)	-210*** (41.83)	-200*** (50.14)	-160*** (32.28)
Control variable	Yes	Yes	Yes	Yes
Year/Id	Yes	Yes	Yes	Yes
N	9653	7766	6678	9653
R2	0.057	0.038	0.034	0.037

4.6. Moderating effects test

In order to examine the relationship between executive compensation incentives, capital intensity and listing tenure in the relationship between IUR cooperation and firms' digital innovation.

Columns (1) and (2) of Table 6 verify the moderating effect of executive compensation incentives. The coefficients of Cooperation and Cooperation×Pay are significantly positive, indicating that IUR cooperation enhances the promotion of digital innovation of enterprises when executives are incentivized with remuneration. The reason for the above phenomenon is that corporate shareholders link executive compensation to digital innovation output, and high output means high compensation. Then, executives will try their best to transform resource inputs into innovation outputs, which enhances the marginal effect of IUR cooperation.

Columns (3) and (4) of Table 6 verify the moderating effect of capital intensity. The coefficients of Cooperation and Cooperation×Cap are significant and have opposite signs, indicating that firms with high capital intensity weaken the impact of IUR cooperation on firms' digital innovation. This is because high capital-intensity firms usually deposit a large amount of specialized assets, and their technological compatibility and innovation flexibility are lower.

Columns (5) and (6) of Table 6 verify the moderating effect of listing tenure. The coefficients of Cooperation and Cooperation×Listing tenure are significantly positive, indicating that IUR cooperation in firms with long listing years has a more significant role in promoting digital innovation in firms. Long-listed firms send credible commitment signals to universities and research institutions through continuous disclosure and compliance, which makes the marginal effect of IUR cooperation expand.

Table 6 Moderating effects test

	(1)Innovati on	(2)Innovati on	(3)Innovati on	(4)Innovati on	(5)Innovati on	(6)Innovati on
	Pay		Cap		Listing tenure	
Cooperation	0.0302*** (0.00)	0.0261*** (0.00)	0.0301*** (0.00)	0.0278*** (0.00)	0.0301*** (0.00)	0.0245*** (0.00)
Pay	1.3608 (0.93)	0.0434 (0.95)				
Cooperation×Pa y		0.0102*** (0.00)				
Cap			-1.2305** (0.55)	-1.6395*** (0.56)		
Cooperation×Ca p				-0.0091*** (0.00)		
Listing tenure					-1.1038 (1.93)	0.2432 (1.97)
Cooperation×Lis ting tenure						0.0117*** (0.00)
cons	-160*** (33.08)	-150*** (33.04)	-150*** (31.95)	-150*** (31.89)	-150*** (32.12)	-150*** (32.10)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes
Year/Id	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	9653	9653	9653	9653	9653	9653
<i>R</i> ²	0.057	0.062	0.058	0.061	0.057	0.058

4.7. Endogenous analysis

The review of this paper found that enterprises' digital innovation will be affected not only by the factors in the model but also by the ability of the digital platform. At the same time, a considerable part of the sample is located in provincial capital cities, which are more innovative and dynamic. Therefore, there is a certain endogeneity in the research model of this paper.

Based on the PSM-DID model, the IUR policies implemented in Jiangxi and Zhejiang provinces in 2018 are used to start the analysis. The results in Table 7 are described as follows. The Did results in columns (1) and (2) of the table are significantly positive. Columns (3) and (4) denote the results generated by the sample's dummy variable, taking values in terms of the sample's importance level and the common support hypothesis, respectively. Using nearest-neighbor matching, a control group more relevant to the experimental group is constructed, effectively solving the sample self-selection problem. The absolute value of T-stat for ATT is 2.70, which is greater than 2.58. The absolute values of post-match bias were 1%, 5%, 4.2%, 2.5%, 2.7%, 0.1%, 1.4%, 0.4%, and 0.1%, which were all less than 10%. The results show that the study's conclusions still hold.

Table 7 Endogenous analysis

	Did1	Did2	Psm-did1	Psm-did2
	(1) Ln Innovation	(2) Ln Innovation	(3) Ln Innovation	(4) Ln Innovation
Did	0.2609*** (0.07)	0.2784*** (0.07)	0.3055** (0.15)	0.2781*** (0.07)
cons	2.0813*** (0.04)	-11.8039*** (3.75)	-16.9959 (10.58)	-11.9637*** (3.78)
Control variable	NO	Yes	Yes	Yes
Year/Id	Yes	Yes	Yes	Yes
N	7606	5644	1162	5620
R2	0.033	0.064	0.145	0.066

5. Conclusions and recommendations of the study

This paper analyzes the impact of IUR cooperation on firms' digital innovation based on a research sample of A-share firms from 2013-2023 and further explores the moderating roles of executive compensation incentives, firms' capital intensity, and the uncertainty of listing years. The study finds that: ① IUR cooperation significantly improves the level of corporate digital innovation; ② Digital innovation of firms with strong executive compensation incentives, low capital intensity, and listing tenure is more affected by IUR cooperation than firms with weak executive compensation incentives, high capital intensity and short listing tenure; ③ IUR cooperation can improve the level of corporate digital innovation through the digital talent inflow, digital technology spillovers, and digital innovation investment.

Based on the conclusions of the above study, this paper draws the following recommendations:

First, enterprises should build a multi-level collaborative training system for digital talents from industry, academia, and research. The government has taken the lead in setting up a system of "special experts in enterprises" to promote enterprises' absorption of high-end talents. Schools and enterprises jointly build a talent delivery mechanism to encourage enterprises to absorb mid-range talents. Through the gradual formation of expert-led, professional talents to follow up the high-end talent system, firm digital innovation can provide inexhaustible power.

Second, enterprises should establish a technology spillover assessment and benefit-sharing platform. In response to the digital technology spillover effect of research institutions, enterprises can explore the establishment of a blockchain-enabled digital technology trading platform. Further, enterprises can also build a flexible cooperation model of "technology equity + revenue sharing + risk-sharing fund" so that enterprises and research institutions can gradually form a cooperative relationship of "sharing blessings and difficulties". Due to space limitations, this paper does not explore the evaluation model and cooperation mode in-depth, but it can provide a reference for subsequent researchers.

Thirdly, enterprises should design a dynamically adapted digital resource input mechanism. Digital innovation should not be "acute" or "grabbed in one hand" but should be invested in resources in stages, levels, and sequences. It is necessary to locate the social environment as well as the enterprise's development stage. Based on the dual life cycle theory and using the "decision-making-stage model," a dynamic digital innovation resource input mechanism is established to promote firm digital innovation.

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