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RESEARCH ON THE INFLUENCE MECHANISM OF OPEN INNOVATION ON INNOVATION PERFORMANCE IN THE DIGITAL ENVIRONMENT

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Abstract

Under the new round of scientific and technological revolution, big data, cloud computing, blockchain, mobile Internet, artificial intelligence and other digital technologies have entered a period of unprecedented active development, which are reshaping the global economic map and industrial development structure, and also promote the enterprise management change and operation optimization. Compared with the closed innovation within the enterprise, open innovation breaks through the closed organisational boundaries of the traditional economic era, and through the strategic use of the inward-outward and By strategically using the inside-out and outside-in paths to acquire knowledge and resources outside the organisation, and combining them with the original core competencies and organisational strategies of the enterprise, open innovation enhances the internal innovation capability of the enterprise and spreads the innovation results to the external market of the organisation, in order to further enhance the dynamic adaptive capability and innovation performance of the enterprise. Although existing studies have explained the depth and breadth of open innovation and its impact on the competitive advantage of enterprises, research on the mechanism of the choice of open innovation mode on the innovation performance of enterprises in the context of digitalisation is still insufficient. This paper constructs a theoretical model of the relationship between open innovation and innovation performance in the digital environment based on dynamic capability theory, power change theory and knowledge management theory. Through questionnaire research and empirical analysis of 315 enterprises, it can be seen that: under the digital environment, inward and outward innovation has a positive and positive impact on innovation performance; digital transformation plays a significant positive moderating role between open innovation and innovation performance; and digital transformation plays a significant positive moderating role between open innovation and innovation performance; and digital transformation plays a significant positive moderating role between open innovation and innovation performance. between open innovation and innovation performance plays a significant positive moderating role.

Keywords: Open Innovation; Innovation Performance; Digital Transformation;

1. INTRODUCTION

With the rapid development of mobile Internet, IoT, 3D printing, cloud computing, and smart technologies, the innovation environment of enterprises is undergoing a huge change, and according to the prediction of IDC (International Data Corporation), the sum of global data volume will grow from 33 ZB in 2018 to 175 ZB in 2025 (Reinsel et al., 2018), signalling that human society is stepping into a new era centred on digital technology. The White Paper on the Development of China's Digital Economy (2023) released by the China Academy of Information and Communications Technology (CAICT) points out that in 2022, the scale of

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digital industrialisation in China has reached 9.2 trillion yuan, while the scale of industrial digitisation has reached 41 trillion yuan, which accounts for 18.3% and 81.7% of the digital economy, respectively, which suggests that the two-eighths ratio structure of the digital economy is relatively stable.

Against the backdrop of the rapid rise of the digital economy, it not only injects new vitality into economic growth, but also poses unprecedented challenges and requirements to the traditional economic model and industrial structure. Therefore, under the background of digitalisation, open innovation has become an inevitable choice for enterprises to cope with these changes. Open innovation can connect enterprises with external innovation resources, stimulate the internal innovation vitality of enterprises through sharing and exchange, and enhance the overall innovation capability of enterprises. Open innovation can help enterprises achieve effective use of external resources, reduce innovation costs and improve innovation efficiency by sharing resources such as R&D platforms, technologies and markets.

Against the backdrop of the digital era, traditional industrial enterprises are actively promoting digital transformation and widely applying various new digital technologies. In the context of the era of intelligent interconnection, innovation capability has become an important part of the core competitiveness of enterprises. Open innovation in the digital environment has a greater degree of freedom and flexibility compared with the traditional innovation model. In the previous innovation model, innovation is often limited by the scarcity of resources and the closed nature of knowledge and information. In contrast, in the digital environment, resources and knowledge can be more widely shared and reused, making the threshold for innovation much lower.

This open innovation model provides opportunities for more individuals to participate in innovation, and at the same time promotes the diversity and complexity of innovation. In previous studies, scholars have explored the research on the mechanism of the role of elements such as dynamic capability (Zhou Weisha et al., 2022), absorptive capability (Li Xianjun et al., 2018), and desorptive capability (Lichtenthaler, U. and Lichtenthaler, E., 2009) in open innovation on innovation performance from different perspectives, and in the study of the role of elements such as organisational flexibility (Yang Zhenning et al., 2021), institutional environment and competitive relationship (Yang Zhenning and Zhao Hong, 2020), and government-market integration (Cai Shuangli and Zhang Xiaodan, 2023) and other contexts to study the influence of their factors between open innovation and innovation performance, then, in the digital environment, from the perspective of the knowledge integration capability, what is the specific influence mechanism of the two, the current research is still not yet sufficient.

At the same time, there is also insufficient research on the situational factors in the process of enterprise digital transformation on open innovation affecting enterprise innovation performance. Therefore, exploring how open innovation affects innovation outcomes in the context of digitalisation has far-reaching practical and theoretical significance.

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2. LITERATURE REVIEW

2.1 Open innovation (OI) and innovation performance (IP)

In order to achieve the strategic vision of innovative development, firms need to break down the boundaries inherent in traditional organisations and facilitate the flow of knowledge within and outside the organisation, which is known as open innovation (Chesbrough, 2014). By adopting this strategy, firms can better stimulate their innovation capabilities, bring significant innovation effects to the company and further improve the overall performance of the company. With the rapid development of Internet technology, cloud computing technology and other emerging information technologies, the digital economy has become the mainstream mode of development in the current era (GÓMEZ.et al,2018). From the perspective of knowledge value innovation, the impact of open innovation on the innovation performance of enterprises mainly focuses on the three aspects of knowledge value identification, creation and acquisition (Wang Ju and Zeng Tao, 2011).

2.1.1 Inward-oriented innovation (In-OI) and innovation performance (IP)

Inward-oriented innovation refers to the strategic behaviours and processes by which firms systematically and purposefully integrate valuable external ideas, knowledge and technology to be utilised and assimilated within the firm, but mainly applied and commercialised within the firm (Ebersberger et al. 2021). In an open innovation environment, firms can make use of external resources to compensate for their own lack of innovation capabilities and enhance their competitive advantage. Ebersberger et al. (2012) found that inward-looking open innovation had a significant positive impact on firms' innovation outcomes by analysing data from firms in Austria and three other countries, and Gassmann et al.) findings point out that inward open innovation is beneficial for radical innovation. Laursen and Salter (2006) found through empirical research that the intensity of R&D, the breadth and depth of development positively affects the firm's innovation performance in an open innovation model. Huang and Rice (2009) argued that in the inward open innovation model, firms can significantly enhance their innovation performance by purchasing technology. In the context of digitalisation, from the perspective of capability view, inward-looking open innovation can absorb external resources such as technology, information, knowledge and talent to enhance the firm's existing capabilities. In the process of introducing such resources, enterprises can draw on their advantages and strengthen the internal transformation of the resources, so as to improve the overall capabilities of the enterprise and apply them in the future development to enhance the competitiveness and innovation performance of the enterprise. Based on the above analyses, this paper puts forward the following hypotheses:

H1: Inward-oriented innovation *(In-OI)* has a significant positive effect on innovation performance (IP).

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2.1.2 Outward-oriented innovation (Out-OI) and innovation performance (IP)

Outward-oriented innovation refers to the process by which firms commercialise their knowledge resources externally (Chesbrough & Crowther 2006). Although academics have paid significantly less attention to outward innovation than to inward innovation, and it is generally accepted that firms may face risks such as leakage of core knowledge and weakening of competitive advantage when engaging in outward innovation (Lichtenthaler 2011), the direct pathway to outward open innovation is for firms to share their knowledge resources and innovations with other organisations and receive an equivalent sharing reward from the other party receive an equivalent sharing reward from each other (Ma Wenjia et al., 2020). From one aspect, it plays a key role in setting industry standards, exploring new markets, extending the life of technology, building a firm's reputation, introducing external technologies and establishing a firm's network, thus driving the firm's innovation output (Zhang Zhengang et al., 2015). Analysed from the perspective of capabilities, the richer the technologies a firm provides externally, the better its related technologies and products can meet market demands. Enterprises obtain the new technologies they need and apply them in production through co-operation with external partners, so as to achieve the purpose of enhancing their competitive advantages. Technology transfer is the most important and challenging form of technology transaction, which requires enterprises to have high technological innovation capability. As a kind of knowledge asset, technology has strong value-addedness and tradability, and technical achievements are often regarded as intangible assets. Therefore, when an enterprise decides to sell or licence technology, this helps to enhance its internal capabilities and thus its market competitiveness. At the same time, increasing firms' internal capabilities not only enhances the efficiency of innovation, but also helps to achieve higher innovation performance. Based on the above analyses, this paper proposes the following hypotheses:

H2: Outward-oriented innovation (Out-OI) has a significant positive effect on innovation performance (IP).

2.2 Digital transformation

Digital transformation refers to the integration of various digital technologies into multiple areas such as products, operations, management, strategic thinking and business strategies in the context of an organisation's innovation journey, with the core objective of improving performance and market competitiveness and helping the organisation to move towards a deeper level of change (Yoo et al. 2012; Fichman et al. 2014; Yu Jiang et al. 2017; Liu et al. 2020). The key elements of digital transformation include three aspects: firstly, it is the extensive application of various digital technologies; secondly, it is the integration of digital technologies into every aspect of business operations and management; and the third element of digital transformation is the achievement of significant results by the business. The success of digital transformation lies not only in the application of technology, but also in how it is integrated into the daily operation of the enterprise. Considering that the dependent variable in this study is innovation performance, this finding reveals the third key element in the digital transformation process. Therefore, in assessing digital transformation, this paper will focus mainly on the first two core factors. More specifically, digital transformation is divided into

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two dimensions: the first one represents the first element, i.e. the "level of digital technology", with a special emphasis on the type and sophistication of the digital technology used; the second dimension corresponds to the second element, which can be summarised as the "scope of digitalisation". The second dimension corresponds to the second element, which can be summarised as 'scope of application', and they highlight the depth and breadth of the application of digital technologies in various innovation activities.

Contingency theory states that both the internal and external environments of an organisation affect the effectiveness of management decisions. Therefore, when making enterprise strategic decisions, the internal and external environments in which the enterprise is situated should be considered comprehensively, and a variety of factors should be integrated to determine the optimal management strategy. Based on the theory of weights and measures, the value of open innovation is closely related to the unique nature of the enterprise and the external environment in which it operates. With the spread of digital technologies such as big data, cloud computing and artificial intelligence, a new era of digital economy has been entered. In the context of digitalisation, the rapid digitisation of the processes and outcomes of innovation has created unprecedented challenges and expectations for current innovation management theories (Yoo et al., 2010; Nambisan et al., 2017). Digital transformation not only accelerates the flow of information within firms, but also expands the boundaries of innovation. Through the digital transformation process, firms' skills in data processing and resource allocation have been significantly enhanced, which has been received with better results in a number of areas such as driving innovation, aligning organisational structures and reshaping inter-organisational relationships (Millán et al, 2021).

2.2.1 Level of digitisation technology (LDT)

The level of digitisation technology represents the degree of development of the digital technology environment, and Qi, I.D. and Cai, C.W. (2020) suggest that the number, types and functions of digital technologies that a firm introduces or develops on its own determines its level of digitisation. At the same time, the high importance that firms attach to these technologies also plays an indispensable role. These digital technologies mainly cover the fields of information technology, the Internet and big data, which provide the basis for digital transformation that enterprises can use to realise their own digital transformation (Zhou, Huiwei et al., 2021). The application of digital technologies ensures that information knowledge can be generated, shared and exchanged in a low-cost, rapid and real-time manner in innovation networks. In this era of digitalisation, along with the continued advancement of big data and cloud computing technologies, these technologies have brought about sweeping socio-economic changes. This series of changes has brought about a richer and more diverse approach to open innovation, while also creating more opportunities and challenges for businesses to grow (Chesbrough ,2006). With the wide application of digital technologies such as the Internet and big data, more companies are opting for open innovation platforms or community models. Digital technologies are gradually becoming part of open innovation for companies, providing a strong backbone for companies in accessing and applying internal and

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external innovation knowledge and business resources (Zhou, Qing et al., 2020). As a result, this paper hypothesises:

H2a: The level of digitalisation technology (LDT) presents a positive moderating effect on the relationship between In-OI and IP.

H2b: The level of digitalisation technology (LDT) positively moderates the relationship between Out-OI and IP.

2.2.2 Scope of digitalisation applications (SDA)

In the open innovation process, the application of digital technologies brings obvious positive effects to the innovation activities of enterprises. Digital technology helps to break through the constraints of space and resources, thus further expanding the scope and depth of innovation. At the same time, digital technology is also an important tool that can help enterprises break through traditional thinking stereotypes and enable them to obtain more knowledge, information and experience. It helps to increase interconnectivity among enterprises, enhance the efficiency of resource utilisation and demonstrate a high degree of flexibility. At the same time, digital technology also facilitates knowledge flow and sharing, which in turn enables companies to be more innovative. These clear advantages allow companies to use their resources more efficiently when innovating, leading to better innovation results. At the same time, the new challenges posed by digitalisation also provide more opportunities for innovative firms (Kallinikos et al., 2013); in the process of open innovation, by applying cutting-edge digital technologies such as artificial intelligence, blockchain, cloud computing and big data, it is possible to significantly reduce the cost of exchanges between network members, increase the efficiency of information exchange and communication, and further expand the range and depth. Among them, artificial intelligence technology can effectively enhance knowledge acquisition and processing capabilities, while blockchain enables distributed storage and sharing of knowledge. The use of these technologies can enhance collaborative innovation among members and accelerate the pace of innovation (Lyytinen et al.,2015; Qi, I.D., and Xiao, X., 2020); and the application of digital technology can increase the diversity of resources and knowledge, thereby improving the chances of launching new products and services. This technology not only promotes the reintegration of existing products and services, but also facilitates the continuous development of corporate innovation (Yu Jiang et al., 2017), and digital technology has a significant facilitating effect in enhancing corporate innovation performance. Taken together, the application of digital technology can further strengthen the role of open innovation in promoting corporate innovation performance, which leads to the following hypothesis:

H3a: The scope of digital application (SDA) presents a positive moderating effect on the relationship between In-OI and IP.

H3b: The scope of digital application (SDA) presents a positive moderating effect on the relationship between Out-OI and IP.

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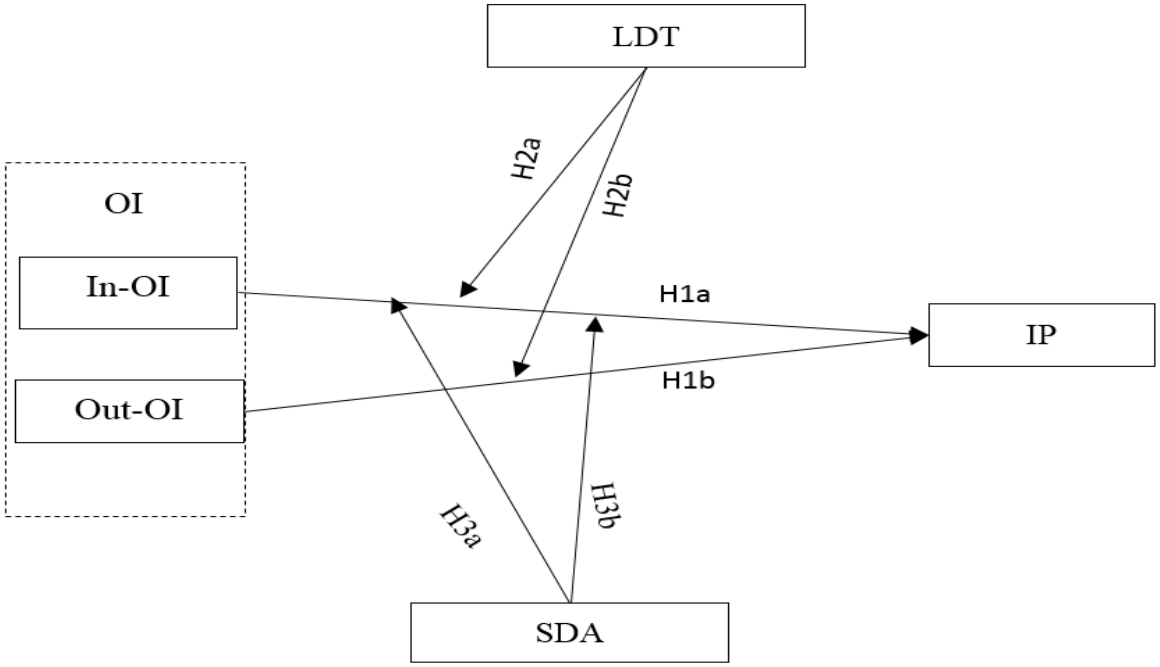
3. RESEARCH MODEL

Based on the above analyses, inward and outward innovations have a positive and positive impact on innovation performance in the digital environment; the two dimensions of digital transformation, digital technology level and digital application scope, play a significant positive moderating role between open innovation and innovation performance, respectively. Therefore, the model of this study is as follows:



4. DATA SOURCES AND RESEARCH METHODOLOGY

4.1 Data collection

In the process of selecting the research sample, this paper proposes a principle based on the objectives of the study: when an enterprise pursues sustained and large-scale R&D and innovation activities, it should set up a department dedicated to R&D and innovation within its organisation; moreover, considering that this study focuses mainly on the strategic issues of the enterprise, only those who have a certain working background or position can answer these questions more efficiently.

Therefore, in order to ensure the high quality and usefulness of the questionnaire, the research questionnaire is mainly for those middle and senior managers who have more than one year of working experience in the enterprise. In order to have a more comprehensive understanding of the R&D and innovation status of enterprises in different regions, this study purposely chose representative smart cities for data collection. These include enterprises in Beijing, Hangzhou, Guangzhou, Shenzhen, Wuxi and Zhengzhou.

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The questionnaires were distributed in a variety of ways, mainly through field visits to enterprises, commissioning classmates or friends who are studying MBA, and distributing the questionnaires online through relationships with individuals or friends. The distribution period of the questionnaire was from September 2023 to December 2023, a total of 500 questionnaires were distributed and 344 were successfully collected. After screening and excluding the invalid questionnaires, there were finally 315 valid questionnaires with a recovery rate of 63 percent.

4.2 Measurements of variables

Drawing on the theoretical perspectives of Chesbrough (2003) and Lichtenthaler (2011), this paper portrays open innovation from the perspective of the process of knowledge flow, defines open innovation as two modes of inward and outward innovation, and on the basis of this, refers to Lichtenthaler (2011) and Zhang Zhengang et al.(2015) Measurement Scale, and based on the developed scale, five for inward innovation and five for outward innovation, a total of 10 measurement questions to measure open innovation, were finally identified.

The measurement of innovation performance refers to the studies of Wu et al. (2016), chen et al. (2011), Ahuja & Katila. (2001), Qian Xihong et al. (2010), and combines them with the actual situation, using five question items to measure innovation performance.

The measurement of digital transformation refers to the studies of Yoo et al. (2012), Fichman et al. (2014), Nambisan et al. (2017), Yu Jiang et al. (2017), and Liu Yang et al. (2020), which classify digital transformation into two dimensions, namely, the level of digitalisation technology and the scope of digitalisation application.

The level of digital technology refers to the definitions of Yoo et al. (2010) and Xing Xiaoqiang et al. (2019), with appropriate additions, which are subdivided into five categories of digital technology, namely, intelligent technology, big data technology, Internet of Things technology, and cloud computing technology, with a total of five measurement items; and the scope of digital application is designed with five items, focusing on the measurement of the enterprise's mastery of digital technology and the scope of its application. The scope of digital application is designed with 5 questions, focusing on measuring the mastery of digital technology and the scope of application of enterprises.

Bernerth and Aguinis (2016) argued that the inclusion of control variables in the research model is effective in controlling the possible influence of endogenous factors on the research model. Therefore, in this study, control variables were selected to be analysed from both firm and industry levels. From the firm's perspective, the age and size of the firm are the two main control variables that are often picked in the strategic management process.

Therefore, the firm's age is taken as the firm's age from the date of its establishment to the research node (2023), and also the differences in the nature of the firm and the industry it belongs to can affect the implementation of open innovation strategies in the digital environment, so the nature of the firm is selected as a control variable, and the industry in which the firm is located is set as a control variable at the industry level.

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4.3. Common method bias assessment

Given that each questionnaire was completed by the same respondent, it was necessary to test for homoscedasticity.

This study used the Harman's one-way test (Podsakoff et al., 2003) as the main technical tool to test for common method bias. An exploratory factor analysis was conducted on all topics. The results of the analysis showed that without rotation, eight factors had eigenvalues exceeding 1.

Of these, the first factor had an explanatory power of 31.808%, which was below the critical value of 40%, and therefore there was no problem of methodological bias that might have affected the conclusions of the study.

5. RESULTS

5.1 Reliability and validity of the model

Using SPSS 22.0 software, open innovation, innovation performance, and digital transformation were tested for reliability through the values of Cronbach's alpha coefficient, and reliability index CITC. From the results in Table 5-1, the Cronbach's alpha coefficients corresponding to each variable are greater than the threshold value of 0.7, and the CITC values are greater than the threshold value of 0.5. Accordingly, it can be seen that the scales of each variable have passed the test of reliability.

Then, a validated factor analysis (CFA) was conducted using AMOS 24.0 software to test convergent validity, and discriminant validity was assessed by comparing the square root of the average extracted variance value (AVE) of a variable with the correlation coefficient of that variable and other variables.

As shown in Table 5-1, the χ^2/df values for all variables are less than 3, the fit indices CFI, NFI and GFI for all variables are greater than 0.9, and the RSMEA values are less than 0.08 (Wen Zhonglin et al., 2004), which suggests that the measurement scales fit all the variables taught well. Meanwhile, the factor loadings of the measurement questions for all variables were all over 0.7, the CR values were all higher than 0.8, and the AVE values were all higher than 0.5, which indicated that all variables had good convergent validity; according to the data in Table 5-2, it can be seen that the square root of the AVE of each variable was higher than the correlation coefficient of the variable with the others, which indicated that the scale had a good discriminant validity (Fornell & Larcker, 1981). The results indicate that the measurement scales in this chapter have good validity.

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Table 5-1: Reliability and validity of the model.

Constructs	Items	CITC	Standardized loading	Cronbach's α	AVE	CR
Open Innovation （OI） χ^2/df=1.006 RMSEA=0.004 CFI=0.993 NFI=0.980 GFI=0.981	OI1	0.759	0.828	0.875	0.584	0.875
	OI2	0.677	0.730			
	OI3	0.711	0.772			
	OI4	0.670	0.725			
	OI5	0.697	0.760			
	OI6	0.735	0.789	0.870	0.577	0.872
	OI7	0.759	0.835			
	OI8	0.699	0.768			
	OI9	0.663	0.724			
	OI10	0.620	0.672			
Innovation Performance （IP） χ^2/df=2.245 RMSEA=0.059 CFI=0.993 NFI= 0.987 GFI=0.988	IP1	0.720	0.812	0.881	0.599	0.882
	IP2	0.731	0.760			
	IP3	0.708	0.734			
	IP4	0.720	0.790			
	IP5	0.704	0.807			
Digital Transformation （DT） χ^2/df=0.900 RMSEA=0.001 CFI=1.002 NFI=0.984 GFI=0.984	DT1	0.725	0.738	0.889	0.597	0.855
	DT2	0.739	0.768			
	DT3	0.729	0.799			
	DT4	0.731	0.782			
	DT5	0.729	0.752			
	DT6	0.692	0.757	0.875	0.581	0.806
	DT7	0.696	0.777			
	DT8	0.742	0.777			
	DT9	0.707	0.786			
	DT10	0.678	0.753			

Note: Data sources are compiled for this study.

5.2 Correlation Analysis

As shown in Table 5-2, the correlation coefficients between the independent variables inward and outward innovation in open innovation and innovation performance are 0.428 and 0.366 respectively, and both are significant at the significance level of 0.01. The correlation coefficients between inward innovation in open innovation and digital technology level and digital application scope in digital transformation are 0.370 and 0.232 respectively, and both are significant at the significance level of 0.01, and the correlation coefficients between outward innovation and digital technology level and digital application scope in digital transformation are 0.407 and 0.208 respectively, and both are at the significance level of 0.01 significant. This test is is the basis for the subsequent test of causality and moderating effect among the variables. Next, the stratified regression method will be further used to explore the interaction mechanism between variables.

Table 5-2: Correlation coefficient matrix (N=315)

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	In-OI	Out-OI	IP	LDT	SDA
In-OI	**0.764**				
Out-OI	0.367**	**0.760**			
IP	0.428**	0.366**	**0.774**		
LDT	0.370**	0.407**	0.637**	**0.785**	
SDA	0.232**	0.208**	0.522**	0.558**	**0.764**
Mean	3.564	3.708	3.662	3.656	3.754
Standard deviation	1.056	1.008	1.047	1.045	0.983

Note: * represents p < 0. 1, ** represents p < 0. 05 Slant diagonal numbers are AVE square root values

5.3 Regression Analysis

5.3.1 Main effects regression

Using SPSS 22.0 software and linear least squares regression, this study provides insight into how open innovation directly affects innovation performance. As can be seen from the regression results in Table 5-3, when inward innovation is added to Model 1 (Model 2), inward innovation (β=0.430, p<0.001) has a significant positive effect on innovation performance, indicating that the higher the degree of inward innovation in the enterprise, the higher the level of innovation performance, and the F-value of Model 2 is 14.151, which is valid at the significance level of 0.01, so that the hypothesis H1a is established. According to the regression data of model 3, when adding outward innovation to model 1 (model 3), outward innovation (β=0.377, p<0.001) has a significant positive effect on innovation performance, which indicates that the higher the degree of outward innovation of enterprises, the better the level of innovation performance, and the F-value of model 3 is 10.444, which is valid at the 0.01 level of significance. Therefore, hypothesis H1b is valid.

Table 5-3: Results of regression analysis of OI on IP (N=315)

	Model1	Model2	Model3	Model4
Age	0.087 (1.278)	0.114 (1.854)	0.136* (2.153)	0.141* (2.375)
Size	0.049 (0.474)	0.027 (0.295)	-0.008 (-0.082)	-0.006 (-0.069)
Number of R&D departments	0.042 (0.386)	0.079 (0.812)	0.103 (1.023)	0.113 (1.190)
In-OI		0.430** (8.973)		0.338** (6.804)
Out-OI			0.397** (7.648)	0.268** (5.108)
R^2	0.010	0.197	0.153	0.254
Adj-R^2	-0.004	0.183	0.139	0.238
F	0.715	14.151**	10.444**	16.737**

Note: Standard errors are in parentheses, * represents p < 0. 1, ** represents p < 0.05

According to the regression data of Model 4, it can be seen that when inward and outward innovation are added to Model 1 (Model 4), both inward innovation (β=0.338, p<0.001) and

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outward innovation (β=0.268, p<0.001) have a significant positive impact on innovation performance, and also, the F value of the model is 16.737, which is valid at the significance level of 0.01. It further verified that both hypotheses H1a and H1b are valid.

5.3.2 Moderated effects regression

Table 5-4 shows the results of regression analysis of the moderating role of digital technology level in open innovation and innovation performance. In the hierarchical linear regression, firstly, model 5 is constructed by adding digital technology level to model 2, and then the regression of inward innovation and digital technology level on innovation performance is done, and the results find that both inward innovation and digital technology level can significantly and positively affect the innovation performance, and the R^2 is 0.464; then the regression of the interaction terms of inward innovation, digital technology level, inward innovation and digital technology level on innovation performance is done (model 6), and the regression results find that the interaction terms of inward innovation and digital technology level on innovation performance are significantly and positively affected. The regression results found that the regression coefficient of the interaction term of inward innovation and digital technology level on innovation performance passed the significance test, and the corresponding p-value is less than 0.01, and the R^2 increased by 0.045 compared with the first step, and the F-value of the model is significant, therefore, the moderating effect of the digital technology level on the relationship between inward innovation and innovation performance is established, i.e., digital technology level in the enterprise can positively influence the innovation performance of inward innovation and innovation performance. technology level plays a positive reinforcing role in the process of the influence of inward innovation on innovation performance, so hypothesis H2a is valid.

Add digital technology level in model 3 to construct model 7, and then do the regression of outward innovation and digital technology level on innovation performance, the results found that both outward innovation and digital technology level can positively affect innovation performance, followed by doing the regression of outward innovation, digital technology level, and the interaction term of outward innovation and digital technology level on innovation performance (model 8), and the results showed that outward innovation The regression coefficients of the interaction term of the level of digital technology and the level of digital technology on innovation performance passed the significance test and the p-value is less than 0.01, the value of R^2 increased by 0.054, and the F-value of the model is significant, so the moderating effect of the level of digital technology on the moderating effect between outward-looking innovation and innovation performance is established, which shows that the level of digital technology plays a significant positive moderating effect between outward-looking innovation and innovation performance, therefore Hypothesis H2b holds.

Table 5-4: Results of the moderating effect test for the LDT(N=315)

	Model2	Model5	Model6	Model3	Model7	Model8

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Age	0.114 (1.854)	0.121* (2.410)	0.076 (1.559)	0.136* (2.153)	0.126* (2.444)	0.104* (2.108)
Size	0.027 (0.295)	-0.004 (-0.047)	-0.010 (-0.141)	-0.008 (-0.082)	-0.015 (-0.199)	-0.017 (-0.231)
Number of R&D departments	0.079 (0.812)	0.097 (1.210)	0.083 (1.076)	0.103 (1.023)	0.102 (1.236)	0.074 (0.940)
In-OI	0.430** (8.973)	0.227** (5.375)	0.227** (5.607)			
Out-OI				0.397** (7.648)	0.150** (3.223)	0.182** (4.076)
LDT		0.557** (13.096)	0.558** (13.697)		0.583** (13.140)	0.602** (14.192)
In-OI*LDT			0.227** (5.621)			
Out-OI*LDT						0.233** (6.020)
R^2	0.197	0.464	0.509	0.153	0.436	0.490
Adj-R^2	0.183	0.453	0.497	0.139	0.424	0.478
F	14.151**	42.606**	44.537**	10.444**	38.058**	41.233**

*Note: Standard errors are in parentheses, * represents p < 0. 1, ** represents p < 0.05*

Next the moderating effect of digital application scope on the relationship between inward and outward innovation and innovation performance is done and the results of its moderating effect test are presented in Table 5-5, again the independent and moderating variables are de-centred when measuring the interaction terms.

The results found that both inward innovation (β=0.328, p<0.01) and the scope of digital applications (β=0.472, p<0.01) can significantly and positively affect innovation performance and the R2 is 0.381; moreover, the regression results found that the regression coefficients of their interaction terms on innovation performance passed the significance test (β=0.123, p<0.01), and the R2 increased by 0.014 from the first step. increased by 0.014, and the F-value of the model is significant, so the moderating effect of the scope of digital application on the relationship between inward innovation and innovation performance is established, indicating that the scope of digital application plays a significant positive moderating role between inward innovation and innovation performance, and therefore hypothesis H3a is established.

The same approach to test the interaction term between scope of digital applications and outward innovation reveals that the coefficient of the interaction term (β=0.231, p<0.01) also passes the test of significance, and Hypothesis H3b is also valid.

Table 5-5: Results of the moderating effect test for the SDA (N=315)

	Model2	Model9	Model10	Model3	Model11	Model12

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Age	0.114 (1.854)	0.087 (1.611)	0.080 (1.486)	0.136* (2.153)	0.102 (1.846)	0.086 (1.617)
Size	0.027 (0.295)	0.026 (0.323)	0.045 (0.557)	-0.008 (-0.082)	0.001 (0.006)	-0.027 (-0.331)
Number of R&D departments	0.079 (0.812)	0.095 (1.104)	0.076 (0.888)	0.103 (1.023)	0.113 (1.278)	0.108 (1.279)
In-OI	0.430** (8.973)	0.328** (7.563)	0.324** (7.547)			
Out-OI				0.397** (7.648)	0.294** (6.329)	0.291** (6.514)
SDA		0.472** (10.142)	0.471** (10.220)		0.490** (10.349)	0.508** (11.120)
In-OI*SDA			0.123** (2.750)			
Out-OI*SDA						0.231** (5.320)
R^2	0.197	0.381	0.395	0.153	0.354	0.403
Adj-R^2	0.183	0.369	0.381	0.139	0.341	0.389
F 值	14.151**	30.395**	28.047**	10.444**	26.998**	29.032**

*Note: Standard errors are in parentheses, * represents p < 0. 1, ** represents p < 0.05*

6. SUMMARY AND DISCUSSION

6.1 Summary

For the relationship between open innovation and innovation performance, this time, two hypotheses are proposed: inward innovation positively affects innovation performance and outward innovation positively affects innovation performance, and it can be seen from the empirical results that both hypotheses have been verified.

The digital context can promote the establishment of symbiotic relationship among cooperative innovation subjects and guarantee the smooth implementation of open innovation. Digital technology has the characteristics of embeddedness and permeability, and the innovation elements of different enterprises can form a closer association, which can reconstruct the interdependent relationship between organisations and form an innovation ecosystem (Liu Unloading et al., 2021). Open innovation is essentially the coordination, matching and integration of innovation resources between enterprises and partners to enhance R&D efficiency through mutual cooperation and to promote innovation results to the market in order to enhance the innovation capability of enterprises.

This paper analyses the moderating effect between open innovation and innovation performance for two dimensions of digital transformation, digital technology level and digital application scope.

The empirical results show that both digital technology level and digital application scope have significant moderating effects between open innovation and innovation performance, which is consistent with the hypothesis. Hu Qing (2020) found that digital transformation has a positive contribution to innovation and firm performance. Digital technologies enable firms to access

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external knowledge more quickly and efficiently and facilitate knowledge sharing among internal employees. This provides a broader knowledge base for open innovation. Digital transformation has continuously empowered the innovation process of enterprises, redefined the change of organisational structure, and improved the operational efficiency and performance of organisations (Liu, Yang et al., 2020). Therefore, enterprises carry out digital transformation, whether from the level of corporate governance, the level of improving the operational efficiency of the enterprise, or the interaction with external information, can strengthen the open innovation capability of the enterprise and promote the improvement of innovation performance.

6.2 Discussion

Active practice of open innovation strategies in the context of digitalisation. In the current wave of digitalisation, enterprises are facing unprecedented opportunities and challenges. In order to gain a foothold in the fierce market competition, many enterprises have begun to actively practice open innovation strategies. The open innovation strategy emphasises the use of external resources, through collaboration with external partners, to jointly promote product and technology innovation. In the digital context, the speed and scope of information dissemination have been greatly expanded. Enterprises can make use of digital platforms to attract a wide range of external innovation resources.

These platforms provide a stage for enterprises to demonstrate their innovation needs, and at the same time provide an opportunity for external innovators to showcase their talents. By collaborating with these external innovators, companies can quickly access new ideas, technologies and solutions to accelerate product iteration and optimisation. This not only improves work efficiency, but also promotes cross-cultural communication and cooperation. Practicing an open innovation strategy requires companies to break the traditional organisational boundaries and use external resources.

At the same time, enterprises also need to establish a set of effective incentive mechanisms to attract and motivate the participation of external innovators. Only in this way can enterprises make full use of external resources in the digital context to achieve faster and better product innovation.

Encourage enterprises to carry out digital transformation. Digital technology has penetrated into all areas of industrial manufacturing and daily life. Although many traditional enterprises still regard traditional production resources such as manpower and land as their core production factors and have invested heavily in information technology, these enterprises have paid relatively little attention to managing information technology resources, business transformation, and strategic joint strategies (Gupta,2018). In the context of the digital era, the core competencies of traditional enterprises have gone beyond mere product technology and manufacturing capabilities.

Therefore, enterprises need to take a series of measures to optimise and enhance the management of information technology resources, keep up with market trends and technological trends, improve the efficiency and quality of digital production, and enhance the

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quality of services in order to meet the expectations and requirements of the market (Chen Dongmei et al., 2020). Enterprises need to recognise the importance and necessity of digital transformation and make it a strategic priority for enterprise development.

6.3 Research Limitations and Research Recommendations

This study combines the methods and ideas of current academic research, constructs a mechanism model of the impact of open innovation on innovation performance in a digital environment, and carries out empirical analyses by means of questionnaires. Although the theoretical assumptions have been analysed and verified in depth to ensure their truthfulness and validity, due to the complexity of the actual problem and the limitations of personal ability, this study still has certain limitations and needs to be improved in the future.

Firstly, this study fails to comprehensively consider the interplay between inward and outward innovation and how this influence affects innovation performance. It is worth noting that the interaction between inward and outward innovation is not fixed. Considering that there are differences in inward and outward innovation across firms, these differences may have different impacts on innovation performance. Therefore, in future research work, it is necessary to study in depth the mutual influences and interaction effects between inward and outward innovation.

Secondly, constrained by the conditions of sample collection, the sample of this study comes from 315 questionnaire data, although it has met the requirements of the reliability test in the statistical sense, the sample data is cross-sectional data, which mainly relies on the subjective assessment of the participants to collect information. Measurement error is unavoidable if the mean values of the variables are on the high side, which may adversely affect the overall quality of the questionnaire.

Therefore, in the future, in-depth empirical studies can be conducted using panel data, taking into account factors such as the delayed and dynamic nature of innovation performance, in order to ensure that the study's conclusions are more accurate and enhance its robustness and generalisability.

Thirdly, this paper only considers the moderating effect mechanism of digital transformation (digital technology level and digital application scope) between open innovation and innovation performance, and between knowledge integration capability and innovation performance, and does not empirically analyse the effect of the interaction between digital technology level and digital application scope on its moderating process, and the moderating mechanism of this interaction will be added in the subsequent research.

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