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Original Paper

Research on the Impact of Artificial Intelligence on Innovation Performance

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Abstract

As the "main battlefield" for the development of artificial intelligence technology, artificial intelligence companies bear the important mission of the development and growth of artificial intelligence. This paper uses Shenzhen and Shanghai A-share listed companies from 2011 to 2022 as a research sample to examine the impact of artificial intelligence technology on corporate innovation performance. The results show that artificial intelligence technology can significantly promote the improvement of corporate innovation performance, and the conclusion still holds after a series of robustness tests; heterogeneity tests show that the role of artificial intelligence technology in promoting corporate innovation performance is more significant in state-owned enterprises and enterprises with a high degree of digital transformation.

Keywords

artificial intelligence, innovation performance, degree of digital transformation

Introduction

In today's era of rapid technological change, artificial intelligence, as the core driving force leading a new round of scientific and technological revolution and industrial transformation, is affecting all areas of social economy at an unprecedented speed and breadth. In particular, in terms of innovation performance, the introduction and application of artificial intelligence has not only brought revolutionary changes to enterprises and organizations, but also injected new vitality into the innovation ability and development potential of the entire society (Chen, Liu, & Wang, 2024).

With the continuous breakthroughs in technologies such as big data, cloud computing, and machine learning, artificial intelligence has become an important engine to promote innovation and development. As an important indicator to measure the innovation ability and competitiveness of an organization or enterprise, the improvement of innovation performance is of great significance to the long-term

development of enterprises and society. In this context, exploring the impact of artificial intelligence on innovation performance not only helps us to deeply understand the mechanism of artificial intelligence, but also provides an important reference and reference for enterprises and organizations to apply artificial intelligence technology in innovation practice.

Artificial intelligence provides strong support for innovation activities through its powerful data processing, learning and decision-making capabilities. On the one hand, artificial intelligence can analyze and mine massive amounts of data to discover the patterns and trends hidden behind the data, providing new ideas and methods for innovation. On the other hand, artificial intelligence can also simulate human thinking and behavior, providing intelligent assistance and decision-making support for innovation activities. These advantages have led to an increasingly widespread application of artificial intelligence in the field of innovation, which has had a profound impact on improving innovation performance (Pu, 2023).

However, the impact of artificial intelligence on innovation performance is not achieved overnight, and we need to continuously explore and improve it in practice. Therefore, this article aims to systematically sort out the impact mechanism of artificial intelligence on innovation performance and analyze its application in different fields and scenarios, in order to provide useful inspiration and suggestions for enterprises and organizations to apply artificial intelligence technology in innovation practice. At the same time, this article also hopes to attract the attention and thinking of more scholars and practitioners, and jointly promote the in-depth application and development of artificial intelligence in the field of innovation.

1. Theoretical Analysis and Research Hypothesis

The impact of AI on innovation performance is mainly transmitted through the channel of R&D investment. On the one hand, the rapid development of AI has greatly increased the R&D investment of enterprises. First, AI can conduct in-depth data analysis on market trends, consumer demand, technological development, etc., and predict future development directions and potential opportunities. This predictive ability can help enterprises identify new areas and technologies that are worth investing in R&D, thereby increasing R&D investment (Xu, Li, & Guo, 2024). For example, by analyzing consumer purchasing behavior and preferences, AI can predict the types of products or services that may become popular in the future. Enterprises can adjust their R&D strategies accordingly and increase R&D investment in related fields . Secondly, AI can optimize the R&D process, reduce unnecessary links and repetitive work, and improve R&D efficiency. By introducing methods such as agile development and iterative development, combined with the automation and intelligent characteristics of AI, enterprises can obtain R&D results faster, thereby increasing their confidence in R&D investment (Li, Ye, & Pan, 2023). In addition, through precise investment and strategy adjustment, AI can improve the return on R&D investment and allow enterprises to see the value and effect of investment. This can further stimulate the motivation of enterprises to increase R&D investment (Li, 2023). At the same time,

AI can provide enterprises with an innovative environment and platform to encourage employees to actively participate in innovation activities. By establishing innovation funds and reward mechanisms, companies can stimulate employees' innovative spirit and creativity and increase their investment in R&D. Finally, AI can help companies establish broader external partnerships, establish close partnerships with universities, research institutes, and other companies, and share resources and experiences. This kind of cooperation can bring more R&D resources and innovation support to companies, reduce R&D costs, and improve R&D efficiency (Chen & Cai, 2022).

On the other hand, the increase in R&D investment further improves the innovation efficiency of enterprises. First, the increase in R&D investment enables enterprises to have more resources for the research and development and innovation of new technologies, which helps enterprises accumulate more technical reserves and patents. The enhancement of technical strength not only improves the market competitiveness and performance of enterprises, but also lays a solid foundation for the long-term development of enterprises in the future (Jin, Sun, & Jin, 2024). Second, the increase in R&D investment helps enterprises attract and cultivate more R&D talents and establish a more complete R&D team. These talents have rich innovation experience and professional knowledge, and can better promote the innovation activities of enterprises and improve innovation performance . In addition, the increase in R&D investment also provides enterprises with more innovation resources and support, such as advanced R&D equipment, high-quality materials and accessories, which help to improve the innovation ability of enterprises (Ding & Ke, 2024). In addition, the increase in R&D investment enables enterprises to respond to market demand and technological changes more quickly and develop more competitive new products and services. The development of new products and services not only increases the revenue source of enterprises, but also enhances the brand image and market position of enterprises (Li, 2024). At the same time, the increase in R&D investment helps enterprises to form unique technical advantages and product advantages, thereby gaining competitive advantages in the market. This competitive advantage can help enterprises attract more customers and market share, and improve their profitability and market position (Ren, 2024). Finally, increasing R&D investment helps enterprises to form a more positive innovation culture and atmosphere. This culture and atmosphere can stimulate employees' innovative spirit and creativity, making them more willing to participate in innovation activities, thereby improving the innovation performance of enterprises (Yang & Jia, 2024). Therefore, based on the above analysis, this paper proposes the following hypothesis:

H: Artificial intelligence significantly improves corporate innovation performance

2. Study Design

2.1 Sample Selection and Data Sources

This study selected Shenzhen and Shanghai A-share listed companies from 2011 to 2022 as the research sample, and the original data mainly came from the CSMAR database. In addition, financial listed companies, ST and *ST companies, companies listed for less than one year, and observations

with missing variable data were excluded, and finally 19,822 company-year observations were obtained . In order to eliminate the interference of extreme values on the regression results, this paper winsorized all continuous variables at the 1% level.

2.2 Variable Definition

2.2.1 Explained Variables

Innovation performance (Pat). Scholars usually measure innovation performance in two ways: the number of patent applications and the number of patent authorizations. This paper refers to the approach of Su et al. (2023) and chooses the total number of patent applications to measure the innovation performance of enterprises. In the empirical test, the total number of patent applications is added by 1 and then the logarithm is taken to avoid heteroscedasticity problems.

2.2.2 Explanatory Variables

Artificial Intelligence (AIT). This article measures AI technology by taking the logarithm of the frequency of the sub-indicators of AI technology appearing in the report.

2.2.3 Control Variables

With reference to relevant research literature, the following control variables are selected: firm age (FirmAge), firm size (Size), debt-to-asset ratio (Lev), proportion of independent directors (Indep) , equity balance (Balance), Tobin's Q value (TobinQ) and proportion of institutional investors' holdings (INST) .

Table 1. Variable Definition Table

Variable Types	Variable Name	Variable Symbols	definition
Explained variable	Innovation Performance	Pat	The number of patent applications + 1 and then take the natural logarithm
Explanatory variables	Artificial Intelligence Technology	AIT	The frequency of the sub-indicators of artificial intelligence technology in the report is taken in logarithm
Control variables	Company age	FirmAge	The difference between the current year and the founding year
	Enterprise scale	Size	The natural logarithm of the total assets of the enterprise at the end of the period
	Assets and liabilities	Lev	The ratio of total liabilities to total assets at the end of the year
	Proportion of independent directors	Indep	Proportion of independent directors on the board of directors

	Equity Balance	Balance	The second largest shareholder's shareholding ratio divided by the largest shareholder's shareholding ratio
	Tobin's Q	TobinQ	The ratio of an asset's market value to its replacement value
	Shareholding ratio of institutional investors	INST	The proportion of total shares held by institutional investors

2.3 Model Setting

In order to examine the impact of artificial intelligence technology on corporate innovation performance, this paper constructs a regression model (1) to test hypothesis H:

$$ROA_{i,t} = \beta_0 + \beta_1 HNEPU_{i,t} + \beta_2 Controls_{i,t} + \mu_i + \lambda_i + \varepsilon_{i,t} \quad (1)$$

Among them, Controls represents the control variables, μi represents the year fixed effect, λi represents the industry fixed effect, and ε_i, t represents the regression residual.

3. Empirical Results and Analysis

3.1 Descriptive Statistics

Table 2 reports the descriptive statistics of the variables. From the table, we can see that the standard deviation of artificial intelligence technology (AIT) is 0.841, and the difference between extreme values is large, indicating that there are significant differences in artificial intelligence technology each year, which may have a significant impact on corporate innovation performance. At the same time, the maximum value of corporate innovation performance (Pat) is 7.318, and the minimum value is 0, indicating that there are significant differences in the innovation performance levels of various companies , which is researchable. The results of other control variables are generally consistent with the results of Chen (2024), and will not be discussed in detail here.

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std.	Min	Max
AIT	19822	0.435	0.841	0	4.111
Pat	19,822	2.031	2.116	0	7.318
FirmAge	19,822	2.837	0.369	0.693	3.689
Size	19,822	21.96	1.227	19.31	27.3
Lev	19,822	0.375	0.195	0.026	1.073
Indep	19,822	37.55	5.33	25	60
Balance	19,822	0.386	0.285	0.00399	1

TobinQ	19,822	2.046	1.213	0.611	9.614
INST	19,822	0.409	0.256	0.000484	0.96

3.2 Correlation Coefficient Analysis

The correlation coefficients between the variables are shown in Table 3. It can be found from Table 3 that artificial intelligence technology (AIT) and enterprise innovation performance (Pat) are significantly negatively correlated at the 1% level, which preliminarily supports hypothesis H. In addition, the absolute values of the correlation coefficients between other variables are basically lower than 0.6, indicating that there is no serious multicollinearity problem between the variables. Combined with the variance inflation factor index after regression, the adverse effects of multicollinearity on the regression results are basically eliminated.

Table 3. Correlation Coefficient Table

	AIT	Pat	FirmAge	Size	Lev	Indep	Balance	TobinQ	INST
AIT	1								
Pat	0.080***	1							
FirmAge	0.103***	-0.015**	1						
Size	0.020***	0.283***	0.200***	1					
Lev	-0.071***	0.114***	0.144***	0.541***	1				
Indep	0.047***	0.013*	0.003	0.035***	0	1			
Balance	0.082***	-0.043***	-0.021***	-0.098***	-0.108***	-0.018**	1		
TobinQ	0.050***	-0.029***	-0.017**	-0.262***	-0.229***	0.016***	0.027***	1	
INST	-0.075***	0.187***	-0.012*	0.387***	0.200***	-0.055***	-0.151***	0.014**	1

3.3 Benchmark Regression Analysis

Table 4 shows the baseline regression results of model (1). Column (1) shows the regression results of artificial intelligence technology (AIT) and enterprise innovation performance (Pat) when no control

variables are added ; Column (2) is the result obtained by adding control variables to the regression of column (1) ; Column (3) shows the regression results of artificial intelligence technology (AIT) and enterprise innovation performance (Pat) when no control variables are added but industry and time are controlled ; Column (4) shows the regression results after adding control variables and controlling industry and time . It can be seen from the table that regardless of whether control variables are added and industry and year are controlled, the coefficient of artificial intelligence technology (AIT) on enterprise innovation performance (Pat) shows a significant positive correlation at the 1% level, which shows that the development of artificial intelligence technology is one of the reasons for promoting the improvement of enterprise innovation performance .

Table 4. Basic Regression Results

	(1)	(2)	(3)	(4)
	Pat	Pat	Pat	Pat
AIT	0.2017 ***	0.2148 ***	0.2708 ***	0.1918 ***
	(11.3181)	(12.4421)	(12.3325)	(9.1493)
FirmAge		-0.4303 ***		-0.1869 ***
		(-10.7821)		(-4.0914)
Size		0.5022 ***		0.5677 ***
		(32.7593)		(34.9255)
Lev		-0.4067 ***		-0.5873 ***
		(-4.6072)		(-6.4444)
Indep		0.0010		0.0005
		(0.3766)		(0.1870)
Balance		-0.1147 **		-0.1456 ***
		(-2.2572)		(-2.9148)
TobinQ		0.0567 ***		0.0322 **
		(4.5754)		(2.4431)
INST		0.6960 ***		0.7112 ***
		(11.2016)		(11.4293)
_cons	1.9430 ***	-8.1131 ***	1.4426 ***	-10.5358 ***
	(115.1753)	(-24.5554)	(5.2561)	(-24.0754)
N	19822	19822	19822	19822
adj. R^2	0.006	0.101	0.062	0.153

3.4 Stability Analysis

3.4.1 Replacement of Explanatory Variables

There are many ways to measure innovation performance. This paper measures innovation performance by taking the logarithm of the number of patents obtained domestically and regresses the results. The regression coefficient of artificial intelligence is 0.2367, which is still significantly positive at the 1% level, indicating that the research results are robust.

3.4.2 Explanatory Variables Lagged One Period

Considering that there is a certain lag in the impact of artificial intelligence technology on corporate innovation performance, which may affect the regression results, a regression analysis is conducted by treating artificial intelligence technology with a one-period lag. The results are shown in column (2) of Table 5. The regression coefficient is still significantly positively correlated at the 1% level . The coefficients of the other variables have changed slightly, but remain consistent with the previous conclusions.

3.4.3 Control Variable Increase and Decrease Method

This paper chooses to increase the management expense ratio (Mfee) and the proportion of funds occupied by major shareholders (Occupy) as control variables to strengthen the control over the impact on innovation performance. The regression results are shown in column (3) of Table 5. The regression coefficient of artificial intelligence is 0.2152, which is still significantly positive at the 1% level, indicating that the research results of this paper are robust.

Table 5. Stability Test

	(1)	(2)	(3)
	Pat2	Pat	Pat
AIT	0.2367 ***		0.2152 ***
	(20.6959)		(12.4675)
L.AIT		0.1941 ***	
		(8.9129)	
FirmAge	-0.2183 ***	-0.5244 ***	-0.4303 ***
	(-8.2584)	(-10.1827)	(-10.7818)
Size	0.0320 ***	0.5011 ***	0.5009 ***
	(3.1474)	(26.7806)	(32.6744)
Lev	-0.4276 ***	-0.3685 ***	-0.3208 ***
	(-7.3122)	(-3.3733)	(-3.5545)
Indep	0.0007	0.0017	0.0013
	(0.3801)	(0.5155)	(0.4833)
Balance	0.0295	-0.1459 **	-0.1130 **

	(0.8775)	(-2.3756)	(-2.2241)
TobinQ	0.0163 **	0.0535 ***	0.0579 ***
	(1.9868)	(3.6341)	(4.6742)
INST	0.1707 ***	0.8052 ***	0.6852 ***
	(4.1488)	(10.4881)	(11.0205)
Mfee			0.0009
			(1.2330)
Occupy			-3.1801 ***
			(-4.4555)
_cons	0.4317 **	-7.8037 ***	-8.0914 ***
	(1.9726)	(-18.9663)	(-24.4840)
N	19822	14095	19808
adj. R^2	0.029	0.100	0.102

3.5 Further Analysis: Heterogeneity Test

3.5.1 Heterogeneity of Property Rights

There may be differences in R&D investment and resource allocation between enterprises with different ownership characteristics. Some enterprises tend to have more government support and financial resources, which helps them make greater investments in the R&D and application of artificial intelligence technology. In contrast, non-state-owned enterprises may face greater financing pressure and market competition, which may affect their investment in artificial intelligence technology and innovation motivation. Therefore, this paper divides the sample into state-owned enterprises and non-state-owned enterprises for comparative regression. The results are shown in columns (1) and (2) of Table 6. The artificial intelligence coefficient in the state-owned enterprise group is 0.2387, which is greater than the coefficient of the non-state-owned enterprise group, indicating that in state-owned enterprises, artificial intelligence technology can more significantly promote the improvement of corporate innovation performance.

3.5.2 Degree of Digital Transformation

Companies with a high degree of digital transformation usually have more complete digital infrastructure and data analysis capabilities, which enables them to use artificial intelligence technology for innovation more effectively. For example, through technologies such as automated workflows, big data analysis, machine learning, and natural language processing, these companies can more quickly identify market trends and consumer needs, and optimize product development and marketing strategies accordingly. In contrast, companies with a low degree of digital transformation may be limited by technology and resources and find it difficult to fully utilize the advantages of artificial intelligence technology for innovation. This paper uses the median degree of digital transformation as the boundary and divides the companies into high and low degree groups for

comparative regression. The results are shown in columns (3) and (4) of Table 6. In the group with a high degree of digital transformation, the coefficient of artificial intelligence technology is higher, at 0.4330, which is greater than 0.1776, indicating that companies with a high degree of digital transformation are more able to use artificial intelligence technology to promote the improvement of corporate innovation performance.

Table 6. Heterogeneity Test

	(1) Non-state-owned enterprises	(2) State-owned enterprises	(3) Low level	(4) High degree
AIT	0.2229 ***	0.2387 ***	0.1776 ***	0.4330 ***
	(5.7713)	(12.3835)	(8.6368)	(2.6142)
FirmAge	-0.4752 ***	-0.4080 ***	-0.5483 ***	-0.3649 ***
	(-6.4557)	(-8.5496)	(-8.7695)	(-7.2193)
Size	0.5893 ***	0.3961 ***	0.4706 ***	0.5302 ***
	(22.2430)	(19.7811)	(21.5031)	(25.0214)
Lev	-0.3272 **	-0.5807 ***	-0.4647 ***	-0.3051 ***
	(-2.0540)	(-5.3554)	(-3.5267)	(-2.6497)
Indep	0.0001	-0.0011	0.0064 *	-0.0079 **
	(0.0306)	(-0.3317)	(1.6923)	(-2.0944)
Balance	-0.0745	-0.0518	-0.1886 ***	-0.0417
	(-0.7759)	(-0.8613)	(-2.5989)	(-0.5998)
TobinQ	0.0625 **	0.0703 ***	0.0522 ***	0.0489 ***
	(2.3293)	(5.0441)	(3.0877)	(2.6893)
INST	0.5124 ***	0.5523 ***	0.7499 ***	0.6589 ***
	(3.3920)	(7.8434)	(8.3544)	(7.8311)
_cons	-9.7035 ***	-5.8282 ***	-7.1618 ***	-8.6737 ***
	(-17.2073)	(-13.4464)	(-14.8543)	(-19.0845)
N	5872	13950	11012	8810
adj. R^2	0.148	0.056	0.083	0.122

4. Conclusions and Suggestions

This paper uses Shenzhen and Shanghai A-share listed companies from 2011 to 2022 as research samples to examine the impact of artificial intelligence technology on corporate innovation performance. The research results show that artificial intelligence technology can significantly promote the improvement of corporate innovation performance, and the conclusion still holds after a series of

robustness tests; heterogeneity tests show that the role of artificial intelligence technology in promoting corporate innovation performance is more significant in state-owned enterprises and enterprises with a high degree of digital transformation.

Based on the above research conclusions, the following are corresponding policy recommendations: First, increase investment in the research and development of artificial intelligence technology . The government should encourage and increase investment in the research and development of artificial intelligence technology, and provide sufficient financial support for the technological innovation of enterprises. Establish scientific research projects and plans related to artificial intelligence technology, attract more scientific research institutions and enterprises to participate, and form an integrated innovation system of production, learning, research and application. Second, optimize the policy environment and promote the application of artificial intelligence technology . Simplify the approval process of artificial intelligence technology and lower the threshold for enterprises to apply new technologies. Provide incentives such as tax incentives and loan support to encourage enterprises to actively adopt artificial intelligence technology and improve innovation performance. Third, support state-owned enterprises in using artificial intelligence technology . Given that state-owned enterprises have performed more significantly in promoting innovation performance through artificial intelligence technology, the government should pay special attention to and support the development of state-owned enterprises in the field of artificial intelligence. Provide targeted training and guidance to help state-owned enterprises better understand and apply artificial intelligence technology and promote their transformation and upgrading.

Fourth, promote digital transformation and improve the overall level of the industry . Encourage enterprises to accelerate the pace of digital transformation, improve the level of informatization, and create favorable conditions for the application of artificial intelligence technology. Provide consulting, training and financial support for digital transformation to help enterprises solve problems and difficulties encountered in the transformation process. Fifth, strengthen talent training and introduction . Increase the training of talents in the field of artificial intelligence and improve the quality and quantity of talent supply. Introduce outstanding artificial intelligence talents at home and abroad to provide intellectual support for enterprises and scientific research institutions.

Sixth, establish a risk prevention mechanism for the application of artificial intelligence technology . While promoting artificial intelligence technology, we should also pay attention to the risks and challenges it may bring, such as data security and privacy protection. Establish a sound risk prevention mechanism to ensure the healthy, safe and sustainable development of artificial intelligence technology. Seventh, strengthen international cooperation and exchanges. Actively participate in international cooperation and exchanges in the field of artificial intelligence, learn from international advanced experience and technology. Promote international cooperation projects in artificial intelligence technology and enhance China's international influence and competitiveness.

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