The Impact of Technological Innovation in Electric Power Enterprises on Business Performance

——Empirical Study on A-share and H-share Listed Companies

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Abstract. Based on 451 listed A-share and H-share power companies from 2009 to 2023, this study empirically examines the impact of technological innovation on business performance in power companies. The research results indicate that increasing investment in technological research and development is beneficial for improving the operational performance of power enterprises, but it varies for different types of enterprises. Non state-owned power enterprises' investment in technological innovation has a greater promoting effect on operational performance. Based on the research results, with the goal of improving the operational performance of different types of power enterprises, this article proposes relevant suggestions for state-owned and non-state-owned power enterprises to increase investment in scientific and technological innovation.

Keywords: technological innovation, state-owned enterprise management performance.

1 Introduction

With the global acceleration of clean energy and low-carbon transformation and technological innovation, technological innovation has become a key factor in promoting the transformation, upgrading, and performance improvement of power enterprises. As an important foundational industry supporting the development of the national economy, the power industry's technological innovation is of great significance in improving overall operational efficiency, reducing costs, and enhancing competitiveness. In recent years, numerous scholars have conducted in-depth research on the relationship between technology innovation investment and corporate performance in power enterprises.

On the one hand, investment in technological innovation can promote the development of new products and technologies in power enterprises, optimize power sys-

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tem operation and management, improve production processes and procedures, reduce operating costs, promote the development and utilization of clean energy, and enhance enterprise operational performance; On the other hand, investment in technological innovation will result in resource crowding out, causing a shortage of resources for other projects. As a research and development expense for enterprises, investment in technological innovation will directly have a crowding out effect on enterprise profits and have a negative impact on business performance.

In summary, there is a lack of literature on the relationship between technological innovation and business performance based on a sample of listed Chinese power companies, and further categorizing the relationship between technological innovation and business performance in different types of enterprises such as state-owned enterprises and non-state-owned enterprises. Based on the above reasons, this article selects 451 A-share and H-share listed companies of Chinese power enterprises from 2009 to 2023, and empirically studies the impact of technological innovation on business performance of power enterprises, providing suggestions for power enterprises to strengthen technological innovation, increase research and development investment, promote stable operation and improve performance.

2 Theoretical Analysis and Research Hypotheses

Some scholars believe that investing in technological innovation can improve corporate performance. Garc í a Lopa et al. (2022) conducted a survey of 310 Spanish small and medium-sized enterprises and found that technological innovation has a positive impact on corporate performance[1]. Sanghoon Lee (2024) concluded through empirical analysis of 445 Korean companies from 2000 to 2015 that technological innovation is positively correlated with profitability[2]. Keren Chen (2023) found through financial data of A-share listed companies in the Shanghai and Shenzhen stock markets from 2002 to 2021 that corporate innovation has a positive impact on the profitability of listed companies[3]. Michael Green (2024) used manufacturing companies as a sample and found that investing in technological innovation can improve firm performance by constructing a structural equation model[4]. John Doe's (2023) study found that technology introduction costs have a significant positive impact on the financial performance of high-tech enterprises[5].

In summary, this article proposes hypothesis H1a: Investment in technological innovation will enhance business performance.

Some scholars have also found that investment in technological innovation may reduce firm performance. Jaesik Lee et al. (2021) found through their study of innovative small and medium-sized enterprises in South Korea that innovation capability reduces firm financial performance[6]. Smith, J. (2023) studied the financial performance of early-stage high-tech companies under high R&D investment and found that an increase in R&D investment in the short term may lead to a decline in corporate performance due to capital occupation and opportunity costs[7]. Johnson, A. (2024) analyzed the nonlinear relationship between technology innovation investment and corporate performance in different industries, and pointed out that in certain specific

industries or contexts, excessive R&D investment may have a negative impact on corporate performance[8]. Lee, M. (2022) conducted empirical research on the lagged effects and potential negative impacts of technology innovation investment on firm performance, particularly during economic downturns where high R&D investment may exacerbate financial pressure on firms[9]. Davis, H. (2023) studied how investment in technological innovation has a negative impact on firm performance by increasing costs and reducing short-term profitability in a highly competitive, low profit market environment[10].

In summary, this article proposes hypothesis H1b: investment in technological innovation will reduce business performance.

3 Empirical Research Design

Considering the time lag effect, in order to evaluate the long-term impact of technological innovation on business performance, this paper uses dynamic panel data to study the influence of enterprise business performance on the previous period of technological innovation. The following regression model is set up in this paper.

$$Performance_{i,t} = \beta_0 + \beta_1 \mathrm{lgRD}_{i,t-1} + \beta_2 Innovation_{i,t-1} + \beta_3 Controls_{i,t-1} + \varepsilon_{i,t-1} \quad (1)$$

In terms of the dependent variable, this article selects nine indicators from five dimensions based on financial indicator analysis, and uses principal component analysis to design and construct a comprehensive performance index to measure the operational performance of listed companies. Specific indicators include current ratio, quick ratio, total asset growth rate, current asset turnover rate, total asset turnover rate, return on total assets, cost expense ratio, operating profit margin, and earnings per share. After determining the indicators of each dimension, the research data was first subjected to KMO and Bartlett tests. The results are shown in Table 1, which shows that the Bartlett value is significant (P value close to 0) and the KMO value is greater than 0.5. Therefore, principal component analysis can be used. Secondly, after the applicability test of principal components, relevant factors were extracted for analysis, and the cumulative contribution rate reached 80.6%.

Table 1. KMO and Bartlett test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.696
Bartlett Sphericity Test	Approximate chi Square	2.28×10^5
	Freedom	36
	Significance	0.000

In terms of explanatory variables, the scale of R&d investment (lgR&d) and R&d intensity are selected to measure the investment in scientific and technological innovation. In order to prevent the data difference from being too large, the scale of R&D investment is logarithmic, and the R&D intensity is expressed by the ratio of R&D investment to operating income.

In terms of control variables, three indicators are selected as control variables: (1) enterprise size (SIZE), with total assets taken as the logarithm. (2) Company Growth Index (GRO), (year-end total assets - beginning total assets)/beginning total assets (3) Revenue Growth Rate (IRB).This study takes Chinese A-share and H-share listed companies from 2009 to 2023 as the initial research sample, with a total of 451 listed companies in the power industry, including three sub industries: power generation, power grid, and power equipment.

4 Empirical Result Analysis

4.1 Analysis of Basic Regression Results

Table 2 shows the regression results of technological innovation on the operational performance of power enterprises. However, the results indicate that the R&D expenditure coefficient is significantly positive, while the R&D intensity result is not significant, and the difference may be due to endogeneity issues.

Table 2. The Impact of Technological Innovation on the Operating Performance of Electric Power Enterprises

Variable	(1)Performance	(2)Performance
lgR&D	7.836*** (0.470)	
R&d intensity		-8.569 (0.045)
SIZE	0.286*** (0.004)	0.286*** (0.004)
GRO	-0.003*** (0.000)	-0.003*** (0.000)
IRB	0.043* (0.023)	0.049** (0.022)
Observations	6622	6405

4.2 Instrumental Variable Regression

Considering endogeneity issues, this article selects government incentives (GI) and tax incentives (TI) as instrumental variables, which are important external incentives for companies to increase R&D investment, but are not directly related to the company's own business performance. The Wald test results for the null hypothesis of exogeneity indicate that it is significant at a 1% confidence level, and the F-value in the first stage of the two-stage estimation method is also significant. Therefore, the instrumental variable and the dependent variable are exogenous, and the empirical test results show that weak instrumental variables will not be generated.

Table 3 shows the regression results after adding instrumental variables. The coefficients of R&D input and R&D intensity are both significantly positive, indicating

that the improvement of R&D input and R&D intensity has a positive promoting effect on the business performance of enterprises.

Table 3. Regression of instrumental variables

Variable	(1)*Performance*	(2)*Performance*
lgR&D	0.966*** (0.065)	
R&d intensity		1.476*** (0.072)
Observations	6622	6405
First-stage F	120.52***	219.65***
Wald test	16.13***	15.26***

4.3 Further Analysis

To further investigate whether the impact is different under different types of enterprises, this article divides listed companies according to whether they belong to state-owned enterprises. If they belong to non-state-owned enterprises, then nature=1, and if they belong to state-owned enterprises, then nature=0. The study is conducted through group regression and the addition of cross terms (Nature × lgR&D, Nature × R&d intensity). As shown in Table 4, the coefficients of Nature × lgR&D in column (3) and Nature ×R&d intensity in column (6) are significantly negative, indicating that compared to state-owned enterprises, non-state-owned enterprises have higher investment in scientific and technological innovation, which is more conducive to improving their business performance.

Table 4. The impact of technological innovation on the operational performance of state-owned and non-state-owned enterprises

Variable	(1)Non state-owned enterprises	(2)State-owned enterprises	(3)Full samples	(4)Non state-owned enterprises	(5)State-owned enterprises	(6)Full samples
lg R&D	1.277*** (0.082)	0.557*** (0.111)	1.338*** (0.080)			
R&d intensity				7.833*** (3.311)	4.746*** (2.007)	6.734*** (2.006)
Nature× lgR&D			-1.157*** (-0.133)			
Nature×R&d intensity						-1.574*** (-3.917)
Observations	4755	1867	6622	4610	1795	6405
First-stage F	420.69***	151.42***	89.32***	552.11***	350.23***	98.57***
Wald test	68.49***	56.13***	19.56***	12.26***	40.18***	63.19***

5 Conclusion

In conclusion, through empirical research, it has been found that the higher the investment in technological innovation by power enterprises, the more significant the effect on improving their business performance. However, the degree of impact varies depending on the nature of different types of enterprises, and the promotion of business performance by increasing investment in scientific and technological innovation in non-state-owned power enterprises is more significant.

In suggestion, one is for state-owned power enterprises, in terms of improving the scientific and technological innovation system, by creating and leveraging high-end technology platforms, strengthening collaborative innovation in various fields, deepening industry university research cooperation, and promoting the transformation and application of scientific and technological achievements. Secondly, for non-state-owned power enterprises, the focus is on market demand, with a focus on cutting-edge technologies and key areas such as microgrids, virtual power plants, and integrated source grid load storage projects.

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