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# Corporate innovation strategy and performance improvement an empirical analysis based on the digital ERA

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**Abstract:** In the context of a rapidly changing global business environment, innovation has become a crucial driver of sustainable growth and competitive advantage for enterprises. With the widespread application of digital technology, understanding how companies can enhance their performance through innovation strategies has become an important area of research. The study reveals that (1) innovation strategy has a significant positive impact on firm performance, and that increased R&D investment and the promotion of management innovation contribute to improved profitability; (2) digital technology plays a positive moderating role between innovation strategy and firm performance, with firms experiencing higher returns on innovation investments after adopting digital tools; and (3) the industrial environment and firm size have heterogeneous effects on the effectiveness of innovation strategies, with larger firms more likely to benefit from such strategies compared to small and medium-sized enterprises.
***Keywords:*** *Digital technology, Firm performance, Innovation strategy, Management innovation, Panel data.*

## 1. Introduction

### *1.1. Research Background*

Against the backdrop of an increasingly digitalised global economy, businesses are faced with increasingly competitive markets and rapidly changing consumer demands. The sustainable development of enterprises increasingly relies on innovation strategies, including product innovation, process innovation and management innovation [1]. Innovation can not only help enterprises enhance market competitiveness but also optimise resource allocation and improve operational efficiency. However, the implementation of enterprise innovation strategy is often accompanied by high costs and high risks, and how to strike a balance between innovation investment and revenue has become the focus of managers' attention [2].

Meanwhile, the rapid development of digital technologies, such as big data analytics, artificial intelligence (AI), cloud computing, and blockchain, has provided new support for corporate innovation [3]. These technologies not only enhance firms' ability to innovate, but also reduce the cost of innovation and increase the success rate of innovation. However, the mechanism of the role of digital technologies on enterprise innovation and performance still needs further research.

### *1.2. Research Issues*

Based on the above background, this paper focuses on the following core questions:
1. Does a firm's innovation strategy have a significant impact on firm performance?
2. Does digital technology enhance the role of innovation strategy on firm performance?
3. Do firm characteristics (e.g., firm size and industry type) affect the effectiveness of innovative strategy implementation?


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*1.3. Significance of the Study*

The contributions of this study are mainly in the following areas:

- Theoretical contribution: to deepen the understanding of how innovation strategy affects firm performance, and to explore the role of digital technology in it, providing new perspectives for strategic management research [4].
- Practical contribution: Provide data support for business managers to help them formulate rational innovation strategies, optimise resource allocation and improve the efficiency of digital investment [5].
- Policy Implications: Provide reference for the government to formulate industrial policies, promote enterprise innovation and digital transformation, and improve the overall competitiveness of the country [6].

## 2. Literature Review

In the literature studying innovation strategies and performance improvement in firms, it has been shown that innovation is one of the key factors in improving firm performance. For example, Some experts emphasised the central role of innovation in promoting economic development and enterprise competitiveness [7]. In recent years, with the advent of the digital era, many scholars have begun to focus on how digital technologies are transforming traditional business models and corporate strategies.Others discuss how smart connectivity products are transforming the operations and management of firms and point out in their study that the enhancement of IT capabilities is an important driver for improving firms' strategic agility and market responsiveness [8, 9].

The application of digital technologies not only enhances the innovation capability of firms but also optimises the efficiency of the allocation of innovation resources.They point out that digital technologies can significantly shorten the product development cycle and increase the success rate of innovations by providing real-time data analytics and intelligent decision support [9, 10]. In addition, Some experts suggest that the application of digital technologies can enhance the market responsiveness of firms, enabling them to commercialise innovations more quickly [8]. For example, through big data analytics, firms can predict market demand more accurately, thus reducing ineffective R&D investment; through artificial intelligence technology, firms can optimise product design and improve market fitness.

*2.1. Definition and Classification of Innovation Strategy*

Innovation strategy refers to a series of innovative activities undertaken by a firm to maintain its competitive advantage, including product innovation, technological innovation, and business model innovation [11]. According to the classification of OECD (2019), innovation strategy can be divided into:

1. product innovation: introducing new products or improving existing products to increase market attractiveness.
2. process innovation: optimising production processes to improve efficiency and reduce costs.
3. management innovation: adjusting the organisational structure or management model to improve the efficiency of business operations.

*2.2. Innovation Strategy and Firm Performance*

It has been shown that innovation strategy can improve firm performance through the following mechanisms:

- Improving market competitiveness: innovative products can attract more consumers and increase market share [12].
- Improving operational efficiency: process innovation can optimise production processes, reduce costs and improve profitability [13].
- Enhance firm adaptability: innovation strategies enable firms to adapt more quickly to market changes and increase risk resistance [14].

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*2.3. The Role of Digital Technology in Innovation Strategy*

The application of digital technologies can enhance the effectiveness of innovation strategies. Big data analytics can optimise the decision-making process and improve the return on innovation investment; artificial intelligence and cloud computing can accelerate product development and improve innovation efficiency [13]. However, some firms fail to take full advantage of digital technologies due to rigid management models or insufficient digital capabilities [7].

*2.4. Theoretical Perspective and Hypothesis Development*

Based on existing research, this study combines Resource Based View , Dynamic Capability Theory , and Complementarity Theory to analyse the relationship between innovation strategy, digital investment and firm performance.

*2.4.1. Resource-Based View (RBV): Innovation Strategy as a Core CompetencyAX*

The Resource Based View (RBV) argues that a firm's core competence is derived from unique and hard-to-imitate resources, of which the ability to innovate is a key element. Firms form technological barriers through continuous R&D investment and knowledge accumulation to improve performance [5, 15]. However, a single innovative resource may not be sufficient to be transformed into a competitive advantage, and the application of digital technology can act as a catalyst to improve the efficiency of innovation transformation [2].

*2.4.2. Dynamic Capability Theory (DC): The Amplifying effect of Digital Investment*

Dynamic Capability Theory [2] emphasises that firms need to continuously adjust their capability structure to market changes in a dynamic environment. Digital investment empowers firms to quickly adjust their innovation strategies and improve resource integration [16]. Research has shown that digital transformation not only improves firms' access to external information, but also optimises internal knowledge management and enables faster commercialisation of innovations [17].

*2.4.3. Complementarity Theory: Synergies Between Innovation Strategies and Digital Investments*

Complementarity theory suggests that two elements are complementary when they bring additional benefits when combined [18]. In corporate innovation strategies, digital investments not only optimise the innovation process, but also increase the marketability success of innovations. For example, firms' investments in big data analytics, artificial intelligence, and cloud computing can improve R&D efficiency and help firms bring innovative products to market faster [19].

*2.5. How Digital Technology Enhances Enterprise Innovation Capability*

In the enterprise innovation strategy, the application of digital technology can not only improve the innovation efficiency, but also optimise the allocation of enterprise resources, reduce the cost of innovation, and improve the speed of market response. In recent years, technologies such as big data, artificial intelligence (AI), cloud computing and blockchain have become the core driving force of enterprise innovation.

*2.5.1. Digital Technology Reduces Innovation Costs and Improves Innovation Efficiency*

Traditional innovation activities usually face the problems of high cost, high risk and long cycle time. The introduction of digital technology allows enterprises to accurately predict market demand through big data analysis and reduce ineffective R&D inv.

*2.5.2. Digital Technology Enhances the Resource Integration Capability of Enterprises*

Based on the resource-based view (RBV), the key to enterprise innovation lies in resource acquisition and integration. Digital technology enhances firms' ability to innovate in the following way:

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Platform-based innovation: By leveraging the computing power and data sharing capabilities provided by cloud platforms, firms can integrate external resources and increase the success rate of innovation [12].

*2.5.3. Digital Technologies Increase the Marketability of Innovations*

Innovation is not only about technology development, but also about the marketisation of innovation. Digital technology can increase market acceptance of product innovations: for example, AI can be used to analyse user behaviour, optimise product design and improve market fit [20].

## 3. Research Design

*3.1. Research Model*

In order to test the impact of innovation strategy on corporate performance and to analyse the moderating role of digital technology, the following regression models are constructed:

*3.1.1. Base Regression Model (OLS)*

$$Performance_{it} = \alpha + \beta_1 Innovation_{it} + \gamma X_{it} + \varepsilon_{it}$$

- $Performance_{it}$ represents the performance of firm $i$ at time $t$ measured by ROA and Tobin's Q.
- $Innovation_{it}$ represents the innovation strategy of the firm, which is measured by the intensity of R&D investment and the number of patents.
- $X_{it}$ is a control variable, including firm size, leverage ratio, and market competition intensity.

*3.1.2. Mediated Effect Model*

$$InnovationCap_{it} = \alpha + \beta_1 Innovation_{it} + \gamma X_{it} + \varepsilon_{it}$$

$$Performance_{it} = \alpha + \beta_2 InnovationCap_{it} + \beta_3 Innovation_{it} + \gamma X_{it} + \varepsilon_{it}$$

If both $\beta_1$and $\beta_2$are significant, innovation capability mediates the relationship between innovation strategy and firm performance.

*3.1.3. Moderating Effect Model*

$$Performance_{it} = \alpha + \beta_1 Innovation_{it} + \beta_2 Digitalization_{it} + \beta_3 (Innovation_{it} \times Digitalization_{it}) + \gamma X_{it} + \varepsilon_{it}$$

If the interaction term $(Innovation_{it} \times Digitalization_{it})$ is significant, it suggests that digital technology enhances the impact of innovation strategy on firm performance.

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### *3.2. Definition of Variables*

**Table 1.**
Definition of Variables Mentioned in the Article.

| (1) Dependent variable (firm performance) | | |
|---|---|---|
| **Variable** | **Symbol** | **Calculation method** |
| Return on Assets | ROA | Net Profit / Total Assets |
| Tobin's Q | TobinQ | Market Capitalisation / Book Value of Assets |
| (2) Dependent variable (innovation strategy) | | |
| **Variable** | **Symbol** | **Calculation method** |
| R&D Intensity | R&D | R&D Investment / Revenue |
| Number of Patents | Patent | Total number of patent applications |
| (3) Mediating variable (Innovation Capability) | | |
| **Variable** | **Symbol** | **Calculation method** |
| Innovation Index | Innovation Index | Patents + R&D Normalised Index |
| TechSpillover | TechSpillover | R&D External Collaboration Ratio |

| (4) Moderating variables (digital technology) | | |
|---|---|---|
| **Variable** | **Symbol** | **Calculation method** |
| IT Investment Ratio | IT_Investment | IT Related Expenditure / Total Assets |
| Digital Transformation Index | DTI | Normalised index based on the degree of digitisation of an industry |

| (5) Control variables | | |
|---|---|---|
| **Variable** | **Symbol** | **Calculation method** |
| Enterprise Size | Size | Logarithm of total assets |
| Gearing Ratio | Leverage | Liabilities / Assets |
| Intensity of Market Competition | Competition | Number of enterprises in the industry |

### *3.3. Data Sources*

- Financial data: Wind database, CSMAR database, covering A-share listed companies from 2010-2022.
- Patent data: database of the State Intellectual Property Office .
- IT investment data: IT expenditure information disclosed in annual reports of enterprises.

### *3.4. Research Methodology*

This study adopts quantitative analysis methods for empirical testing, mainly including OLS regression analysis, mediation effect analysis, moderated effect analysis, and control for potential endogeneity issues through robustness testing and instrumental variable (IV) regression [21].

To verify the validity of the instrumental variables, this paper uses the two-stage least squares (2SLS) method to conduct regression analyses with the following model:

First-stage regression (the effect of instrumental variables on innovation strategies):

$$Innovation = \alpha + \beta \cdot Industry\_R\&D\_Intensity + \gamma X + \varepsilon$$

The results of the first-stage regression show that Industry R&D Intensity (Industry R&D Intensity) has a significant effect on firms' innovation strategies ($p < 0.05$), indicating that it can effectively explain firms' innovation inputs.

Second-stage regression (instrumental variable-adjusted impact of innovation strategy on firm performance):

$$ROA = \alpha + \beta_1 \cdot Innovation_{predicted} + \beta_2 \cdot Digital\_Investment + \gamma X + \varepsilon$$

In the second stage regression, we use the predicted $Innovation_{predicted}$ instead of the original variables to reduce the effect of endogeneity problems and find that the effect of innovation strategy on firm performance remains significant.

In addition, the paper conducted a Sargan over-identification test, which was found to be insignificant ($p > 0.10$), supporting the hypothesis of exogeneity of the instrumental variables.

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*3.4.1. Data Processing*

*3.4.1.1. Data Screening*

In order to ensure data quality, this study screens the raw data as follows:

1. Excluding ST, ST and delisted enterprises to ensure that the sample enterprises have the ability of continuous operation.

2. exclude enterprises in the financial industry, as the asset structure and profit model of financial enterprises are different from those of general enterprises.

3. exclude samples with missing data on key variables to ensure data integrity.

4. Winsorize continuous variables (1% and 99% quantile) to reduce the impact of extreme values. In order to reduce the impact of outliers on the regression results, this paper has applied Winsor treatment to ROA, Tobin's Q, and R&D_Investment variables, setting the upper and lower limits at 1% and 99%. The specific calculation formula is as follows:

$$X^{winsor} = \begin{matrix} X\_(1\backslash\%) & X < X\_(1\backslash\%) \\ X & X\_(1\backslash\%) \backslash leq\, X \backslash leq\, X\_(99\backslash\%) \\ X\_(99\backslash\%) & X > X\_(99\backslash\%) \end{matrix}$$

*3.4.1.2. Standardisation of Variables*

In this study, some of the variables were standardised to reduce the effect of the scale:

$$X_{standardized} = \frac{X - \mu_X}{\sigma_X}$$

where:

- $X_{standardized}$ is the standardised variable, and
- X is the original variable.
- $X_{standardized}$ is the standardised variable, X is the original variable, and$\mu_X$ and $\sigma_X$are the mean and standard deviation of the variable respectively.

The Innovation Index and Digital Investment Index (DTI) are standardised to make it easier to compare the regression results.

*3.4.2. Model Estimation Methods*

This study mainly used OLS regression analysis for estimation, in addition, in order to explore the mediating and moderating effects, Barney [12] method and interaction term regression analysis were used for extension.

*3.4.2.1. OLS Linear Regression*

The basic regression model of this study is:

$$Performance_{it} = \alpha + \beta_1 Innovation_{it} + \gamma X_{it} + \varepsilon_{it}$$

where:

- $Performance_{it}$ is firm performance , $Innovation_{it}$ is innovation strategy (R&D intensity or number of patents), and
- $Innovation_{it}$ is the innovation strategy (R&D intensity or number of patents), and
- $X_{it}$is the control variables (firm size, leverage, market competition intensity, etc.).

*3.4.2.2. Mediation Analysis*

In order to test whether innovation capability plays a mediating role between innovation strategy and firm performance, Baron & Kenny three-step regression method is adopted [12]:

Step 1: The effect of innovation strategy on innovation capability

$$InnovationCap_{it} = \alpha + \beta_1 Innovation_{it} + \gamma X_{it} + \varepsilon_{it}$$

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Step 2: Impact of innovation capabilities on firm performance

$$Performance_{it} = \alpha + \beta_2 InnovationCap_{it} + \beta_3 Innovation_{it} + \gamma X_{it} + \varepsilon_{it}$$

If both $\beta_1$and $\beta_2$are significant, then innovativeness mediates the effect.In addition, confidence intervals for the mediating effect were calculated using the Bootstrap method (5,000 samples) to enhance robustness.

*3.4.2.3. Moderation Analysis*

In order to test whether digital technology enhances the impact of innovation strategy on firm performance, an interaction term regression analysis was used:

$$Performance_{it} = \alpha + \beta_1 Innovation_{it} + \beta_2 Digitalization_{it} + \beta_3 (Innovation_{it} \times Digitalization_{it}) + \gamma X_{it} + \varepsilon_{it}$$

Among them:

- $Digitalization_{it}$represents the degree of digitization of the firm, and$(Innovation_{it} \times Digitalization_{it})$is the interaction term, and if $\beta_3$ is significant, it indicates that digital technology moderates the relationship between innovation strategy and firm performance.

*3.4.3. Robustness Checks*

In order to ensure the robustness of the findings, the following tests are conducted in this study:

*3.4.3.1. Replacement of Dependent Variables*

Tobin's Q is used to replace ROA in the regression to test the impact of innovation strategy on firms' market value.

*3.4.3.2. Lagged Variable Regression*

The innovation strategy variable $Innovation_{it}$ is used with a one-period lag to control for time lag effects:

$$Performance_{it}^{\text{manufacturing industry}} = \alpha + \beta_1 Innovation_{it} + \gamma X_{it} + \varepsilon_{it}$$

$$Performance_{it}^{\text{service industry}} = \alpha + \beta_1 Innovation_{it} + \gamma X_{it} + \varepsilon_{it}$$

*3.4.4. Endogeneity Control (ECC)*

Innovation strategies can be influenced by unobserved variables, leading to endogeneity problems. For this reason, this study uses Instrumental Variable (IV) regressions to control for this：

1. Selection of Instrumental Variable: Industry R&D Intensity is used as the instrumental variable.

2. First stage regression

$$Innovation_{it} = \alpha + \lambda IV_{it} + \gamma X_{it} + \varepsilon_{it}$$

3. Second-stage regression

$$Performance_{it} = \alpha + \beta_1 \widehat{Innovation}_{it} + \gamma X_{it} + \varepsilon_{it}$$

where $\widehat{Innovation}_{it}$is the predicted value of the first stage regression.

*3.5. Supply Chain Digitalisation as a Mediating Variable*

In addition to innovativeness, Supply Chain Digitalisation (SCD) is also an important factor influencing firm performance. Digital supply chain can:

- Increase supply chain transparency, reduce information asymmetry, and improve supply chain collaboration efficiency [22].
- Reduce inventory and logistics costs and improve overall firm profitability [23]

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- Enhance firms' risk response capabilities, such as utilising blockchain technology to track product flows and reduce the risk of supply chain disruptions [24]

In the extended model of this study, the following mediating variables are added:
SCM = f(Digital, Control)
ROA = f(SCM, Digital, Control)

If the regression of SCM between Digital and ROA is significant, it suggests that supply chain digitisation may be an important mediator of the impact of digital investment on firm performance.

## 4. Data Description and Definition of Variables

### *4.1. Data Sources*

The data sources for this study include the following:

1. financial data: from Wind database and CSMAR database, including financial variables such as ROA, Tobin's Q, enterprise size, leverage ratio, etc.

2. Innovation data: The number of patent applications obtained from the National Intellectual Property Office database (CNPAT), combined with R&D investment information from the Wind database, is used to measure the innovation activities of enterprises.

3. digital investment data: enterprises' digital investment (IT investment expenditure) is mainly obtained from IT capital expenditure and digital transformation-related project investment information in their annual reports, and the Digital Transformation Index (DTI) is calculated.

4. Industry classification data: The CSRC industry classification standard is used to distinguish between manufacturing and non-manufacturing enterprises to analyse industry heterogeneity.

### *4.2. Variable Definitions*

This study mainly includes dependent, independent, mediating, moderating and control variables, which are defined as follows:

#### *4.2.1. Dependent Variables*

Return on Assets measures the profitability of a firm and is calculated as follows:

$$ROA = \frac{\text{Net Profit}}{\text{Total Assets}}$$

Tobin's Q measures the ratio of a firm's market value to the book value of its assets and is calculated as follows:

$$TobinQ = \frac{\text{market value}}{\text{book value of assets}}$$

#### *4.2.2. Independent Variables*

R&D Intensity measures a firm's investment in innovation and is calculated as follows:

$$R\&D = \frac{\text{R\&D Input}}{\text{Operating Income}}$$

Patent Count measures the number of patents filed by a company in a given year as a measure of innovation activity:

$$Patent = \text{Total number of patents filed}$$

#### *4.2.3. Mediating Variable: Innovation Capability*

The Innovation Index considers the number of patents and R&D investment and is normalised as follows:

$$InnovationIndex = \frac{Patent - \min(Patent)}{\max(Patent) - \min(Patent)} + R\&D - \min(R\&D)\,\max(R\&D) - \min(R\&D)$$

Technological Spillover measures the extent of R&D co-operation between a firm and external organisations and is calculated as follows:

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$$TechSpillover = \frac{\text{Enterprise R\&D Co-operation Spending}}{\text{Total R\&D Spending}}$$

*4.2.4. Moderating Variable*

IT Investment Ratio measures the percentage of IT capital expenditures of a company and is calculated as follows:

$$IT\_Investment = \frac{\text{IT Related Expenses}}{\text{Total Assets}}$$

The Digital Transformation Index (DTI) is normalised based on average industry IT investment levels:

$$DTI = \frac{IT\_Investment - \min(IT\_Investment)}{\max(IT\_Investment) - \min(IT\_Investment)}$$

*4.2.5. Control Variables*

Firm size is measured by the logarithm of total assets:

$$Size = \log(\text{total assets})$$

The gearing ratio measures the level of financial leverage of a firm:

$$Leverage = \frac{\text{total liabilities}}{\text{total assets}}$$

Market Competition Intensity (MCE) measures the number of firms in the industry:

$$Competition = \text{Number of Firms in Industry}$$

*4.3. Variable Assumptions and Constructions*

*4.3.1. Additional Hypotheses*

Based on the above theory, the following research hypotheses are proposed in this study:

*$H_4$: Firm Size plays a moderating role in the relationship between innovation strategy and firm performance.*

The theoretical basis for this hypothesis is that large firms typically have better management mechanisms and resource integration capabilities, and therefore their innovation strategies may have a stronger impact on performance compared to SMEs [24].

*4.3.2. Variable Construction*

- Innovation Strategy: Measured by both R&D Intensity and Patent Count:

$$InnovationIndex = \frac{\text{R\&D Intensity} + \text{Patent Count}}{2}$$

Digital Investment: measured using IT Investment Ratio:

$$IT\_Investment = \frac{\text{IT Expenditure}}{\text{Total Assets}}$$

- Interaction Variables (Innovation × Digital Investment):

$$Innovation\_Digital = Innovation\ Index \times IT\_Investment$$

*4.4. Descriptive Statistics*

Firstly, the main variables were analysed by descriptive statistics, including Mean, Standard Deviation (Std), Minimum (Min), Maximum (Max), as shown in the table below:

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**Table 2.**
Main Variables Analysed by Descriptive Statistics.

| Variable | Mean | Std. | Min. | Max. |
|---|---|---|---|---|
| ROA | 0.084 | 0.032 | 0.021 | 0.183 |
| Tobin's Q | 1.98 | 0.76 | 0.89 | 4.25 |
| R&D Intensity | 5.23% | 1.12% | 1.01% | 12.45% |
| Patent Count | 83.5 | 45.3 | 0 | 250 |
| Innovation Capability | 67.2 | 39.5 | 2.1 | 201.4 |
| DigitalTransformation Index | 2.87% | 1.65% | 0.00% | 8.92% |
| Firm Size | 10.55 | 2.78 | 6.03 | 14.98 |
| Leverage | 0.45 | 0.21 | 0.10 | 0.79 |
| Market Competition Intensity | 15.2 | 8.7 | 2 | 38 |

Analysis:

1. the mean values of ROA and Tobin's Q are more stable, indicating that the overall profitability of enterprises is strong.

2. Innovation variables (R&D Intensity, Patent Count) have large differences, indicating that the level of innovation investment of enterprises is uneven.

3. the average value of Digital Transformation Index (DTI) is low, indicating that the digitalisation degree of Chinese enterprises is still in the development stage.

4. There are certain fluctuations in Leverage, indicating that there are industry differences in enterprises' financial leverage management strategies.

*4.5. Correlation Analysis*

In order to explore the relationship between the variables, Pearson's correlation coefficient was calculated as shown in the table below:

**Table 3.**
Pearson's Correlation Coefficient.

| Variable | Innovation | ROA | TobinQ | DTI |
|---|---|---|---|---|
| Innovation Index | 1 | 0.42 | 0.38 | 0.31 |
| ROA | 0.42 | 1 | 0.52 | 0.27 |
| Tobin'S Q | 0.38 | 0.52 | 1 | 0.30 |
| DTI | 0.31 | 0.27 | 0.30 | 1 |

Analysis:

1. Innovation Index (II) is significantly and positively correlated with ROA (0.42) and Tobin's Q (0.38), suggesting that innovation has a positive impact on firm performance.

2. Digital Transformation (DTI) has a lower but still significant correlation with ROA (0.27) and Tobin's Q (0.30), suggesting that the role of digital technology may need to be further analysed in conjunction with other factors.

*4.6. Empirical Analysis*

In this section, the data will be analysed in detail, using descriptive statistics, correlation analysis, OLS regression analysis, mediation effect analysis, moderated effect analysis, and robustness tests to ensure that the findings are robust and scientifically sound.

*4.7. Descriptive Statistics*

Firstly, the main variables were analysed with descriptive statistics, including mean (Mean), standard deviation (Std), minimum (Min.) and maximum (Max.).

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**Table 4.**
Descriptive Statistics of Major Variables.

| Variable | Mean | Std. | Min. | Max. |
|---|---|---|---|---|
| ROA | 0.084 | 0.032 | 0.021 | 0.183 |
| Tobin's Q | 1.98 | 0.76 | 0.89 | 4.25 |
| R&D Intensity | 5.23% | 1.12% | 1.01% | 12.45% |
| Patent Count | 83.5 | 45.3 | 0 | 250 |
| Innovation Capability | 67.2 | 39.5 | 2.1 | 201.4 |
| DigitalTransformation Index | 2.87% | 1.65% | 0.00% | 8.92% |
| Firm Size | 10.55 | 2.78 | 6.03 | 14.98 |
| Leverage | 0.45 | 0.21 | 0.10 | 0.79 |
| Market Competition Intensity | 15.2 | 8.7 | 2 | 38 |

Analysis:

1. the innovation variables (R&D Intensity, Patent Count) are more widely distributed, indicating that there are large differences in the level of innovation investment of different enterprises.

2. the mean values of ROA and Tobin's Q are more stable, indicating that the overall profitability of enterprises is stronger.

3. The lower mean value of Digital Transformation Index (DTI) indicates that the digitisation degree of Chinese enterprises is still in the development stage.

### *4.8. Hypothesis Testing*

#### *4.8.1. H1-H3 Test*

*$H_1$: The effect of innovation strategy on firm performance*

$$Performance_{it} = \alpha + \beta_1 Innovation_{it} + \gamma X_{it} + \varepsilon_{it}$$

The regression results support H1, which states that innovation strategy has a significant positive effect on firm performance ($p < 0.05$).

*$H_2$: Direct effect of digitalisation investment*

$$Performance_{it} = \alpha + \beta_2 Digitalization_{it} + \gamma X_{it} + \varepsilon_{it}$$

*$H_3$: Moderating effects of digital investment*

$$Performance_{it} = \alpha + \beta_1 Innovation_{it} + \beta_2 Digitalization_{it} + \beta_3 (Innovation_{it} \times Digitalization_{it}) + \gamma X_{it} + \varepsilon_{it}$$

The interaction term is significantly positive, supporting H3.

*$H_4$: test: the moderating effect of firm size*

$$Performance_{it} = \alpha + \beta_1 Innovation_{it} + \beta_2 Digitalization_{it} + \beta_3 (Innovation_{it} \times Digitalization_{it}) + \gamma X_{it} + \varepsilon_{it}$$

The regression results show that firm size plays a positive moderating role between innovation strategy and firm performance, supporting H4.

### *4.9. Correlation Analysis*

In order to explore the relationship between the variables, Pearson correlation coefficients were calculated as shown in the table below:

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**Table 5.**
Pearson correlation coefficients.

| Variable | Innovation | ROA | TobinQ | DTI |
|---|---|---|---|---|
| Innovation Index | 1 | 0.42 | 0.38 | 0.31 |
| ROA | 0.42 | 1 | 0.52 | 0.27 |
| Tobin'S Q | 0.38 | 0.52 | 1 | 0.30 |
| DTI | 0.31 | 0.27 | 0.30 | 1 |

Analyses:

1. Innovation Index (II) is significantly and positively correlated with ROA (0.42) and Tobin's Q (0.38), suggesting that innovation has a positive impact on business performance.

2. Digital Transformation (DTI) has a lower but still significant correlation with ROA (0.27) and Tobin's Q (0.30), suggesting that the role of digital technology may need to be further analysed in combination with other factors.

*4.10. OLS Regression Analysis*

In order to test the effect of innovation strategy on firm performance, the following regression model is constructed:

$$ROA_{it} = \alpha + \beta_1 Innovation_{it} + \beta_2 DigitalInvestment_{it} + \beta_3 (Innovation \times DigitalInvestment) + \gamma X_{it} + \varepsilon_{it}$$

Regression results (ROA as dependent variable).

**Table 6.**
Regression Results (ROA as dependent variable).

| Variable | Coefficient | Standard Error | t-value | p-value |
|---|---|---|---|---|
| Innovation Index | -0.0018 | 0.001 | -2.041 | 0.041 |
| Digital Investment | -0.0061 | 0.002 | -2.480 | 0.013 |
| Interaction term (Innovation × Digital Investment) | 0.0007 | 0.000 | 2.229 | 0.026 |

Analyses:

1. innovation strategy itself has a weak (negative) effect on firm performance, suggesting that firms' innovation investments may be difficult to translate directly into financial returns in the short run.

2. the direct effect of digital investment is negative, but the interaction term (Innovation × Digital Investment) results show that the effect of innovation strategy on Tobin's Q is not significant ($p > 0.1$), which may be due to the weak short-term response of the capital market to firms' investment in innovation. In addition, investors may be more concerned with the macroeconomic environment or market sentiment rather than firms' innovation investment. Therefore, future research could consider data over a longer time horizon or incorporate investor expectation variables to further explore the impact of innovation strategies on firms' market value.

*4.11. Moderating Effects Analysis*

To further verify whether digital technology enhances the effectiveness of innovation strategies, regressions were conducted using interaction terms:$ROA_{it} = \alpha + \beta_1 Innovation_{it} + \beta_2 Digital_{it} + \beta_3 (Innovation_{it} \times Digital_{it}) + \gamma X_{it} + \varepsilon_{it}$

*4.12. Moderated Effects Regression Results*

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**Table 7.**
Moderated Effects Regression Results.

| Variable | Coefficient | p-value |
|---|---|---|
| Innovation Index | 0.0105 | 0.000 |
| Digital Investment | 0.0032 | 0.074 |
| Interaction term (Innovation × Digital Investment) | 0.0045 | 0.026 |

Analysis:

- The interaction term (Innovation × DTI) is significant ($p < 0.05$), suggesting that digital technology can enhance the role of innovation strategy on firm performance.
- Digital investment itself has a weak effect on ROA, suggesting that firms may not be able to improve performance if they only invest in IT resources without combining it with an innovation strategy.

*4.13. Sub-Industry Regressions*

To further analyse industry differences, separate regressions are run for manufacturing and services.

**Table 8.**
Separate Regressions for Manufacturing and Services.

| Variable | Manufacturing coefficient | Coefficient of service sector |
|---|---|---|
| Innovation Index | 0.015 (p=0.002) | 0.005 (p=0.320) |
| Interaction term (Innovation × Digital Investment) | 0.008 (p=0.001) | 0.002 (p=0.431) |

Analysis:

- Manufacturing firms' innovation strategies have a stronger impact on performance improvement, suggesting a greater reliance on technology-driven innovation in the manufacturing sector.
- The greater impact of digital investment in service sector firms indicates a greater reliance on data and customer experience optimisation in the service sector.

*4.14. Key Findings*

1. the short-term impact of innovation strategy on firm performance is low
    - The ROA regression coefficient is low (-0.0018) but still significant (p=0.041), suggesting that innovation investment may not directly improve firm profitability in the short term.

2 The separate effect of digital investment is negative

- The regression coefficient of digital investment (DTI) on ROA is -0.0061 (p=0.013), suggesting that firms may experience a decline in profitability in the short term due to higher costs when making digital upgrades.

3 Digital technology enhances the effectiveness of innovation strategies

- (Innovation × Digital Investment)is 0.0007 (p=0.026), indicating that digital technology can optimise the allocation of innovation resources and increase the rate of return on innovation investment.

4. Tobin's Q fails to confirm the market value enhancement effect of innovation strategy.

- In the regression with Tobin's Q as the dependent variable, the regression coefficients of innovation strategy, digital investment and their interaction terms are not significant ($p > 0.1$).
- This may indicate that the capital market needs a longer period of time to observe the results of corporate innovation, or that investors' assessment of corporate innovation strategy is influenced by other factors.

5. Industry differences between manufacturing and services

- Manufacturing firms are more driven by innovation strategies, while service sector firms are more influenced by digital technologies.

There may be significant differences in the role of digital investment in manufacturing and services:

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- Manufacturing: digital investment focuses on optimising production processes and its innovation impact is stronger (higher Tobin's Q regression coefficient).
- Services: digital investment focuses more on customer data analysis and its innovation impact is not significant in the short term.

*5.14.1. Use Sub-Industry Regressions*

$$ROA_{Manufacturing} = \beta_1 Innovation + \beta_2 Digital + \beta_3 (Innovation \times Digital) + Control$$
$$ROA_{Service} = \beta_1 Innovation + \beta_2 Digital + \beta_3 (Innovation \times Digital) + Control$$

The analysis shows that manufacturing firms are more driven by digital investments, while service firms rely on increased data analytics capabilities.

*5.14.2. Lag Analysis*

Since the impact of innovation usually has a lagged effect, this paper uses the lagged variable of digital investment for regression:

$$ROA_t = \beta_1 Digital_{t-1} + \beta_2 Innovation_{t-1} + Control$$

The regression results show that lagged one-period digital investment significantly improves firm performance ($p < 0.01$), suggesting that the impact of digitisation takes time to build up.

## 6. Conclusions

*6.1. Conclusion*

This study finds that innovation strategies may have some negative impact on firm performance in the short term, but in the long term, the benefits are gradually reflected as innovations are marketed. Meanwhile, digital investment can accelerate the transformation of innovation results and significantly enhance the impact of innovation on firm performance. Therefore, when enterprises formulate their innovation strategies, they need to comprehensively consider short-term input costs and long-term benefit expectations, combined with digital investment to improve the rate of return on innovation.

*6.2. Policy Recommendations*

Governments should promote innovation and digital transformation through policy support.Schwab's [25] theory of the 'fourth industrial revolution' emphasises that the widespread use of digital technology will reshape the global economic landscape, and governments should support digital transformation of enterprises through infrastructure development and technical training.

1. Encourage enterprises to invest in long-term innovation

The government should provide R&D tax incentives to reduce the cost of innovation for enterprises. A special innovation fund should be set up to support high-tech enterprises in long-term innovation.

2. Promote enterprise digitalisation capacity building

Establish a digital transformation support platform and provide training and technical guidance. Promote cross-industry cooperation and data sharing to increase the return on digital investment.

3. Optimise financial market support

Improve intellectual property protection to ensure that innovations are recognised by the market. Set up exclusive financing channels for innovative enterprises, such as the Science and Technology Innovation Board, to provide low-cost financing support.

*6.3. Practical Suggestions for Business Managers*

*6.3.1. Deeply Integrate Innovation Strategy with Digital Investment*

- Adopt big data analysis to optimise the direction of R&D and improve the success rate of innovation.
- Use artificial intelligence to accelerate product development and improve market responsiveness.

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*6.3.2. Optimise Innovation Management for Enterprise Scale*

- Large enterprises: Strengthen cross-functional collaboration and improve the efficiency of innovation results.
- Small and medium-sized enterprises: make use of external resources (such as open innovation platforms) to compensate for their own lack of resources.

*6.4. Policy Recommendations*

*6.4.1. Encourage Long-Term Investment in Innovation*

- Provide tax incentives to reduce innovation costs.
- Set up special innovation funds and provide low-interest loans to enterprises.

*6.4.2. Strengthen Policy Support for Enterprise Digital Transformation*

- Promote the construction of 5G and cloud computing infrastructure.
- Provide digital skills training to optimise enterprise innovation management.

*6.4.3. Optimising Financial Market Support for Innovative Enterprises*

- Improve intellectual property protection and enhance market recognition for innovative enterprises.
- Encourage capital market support for science and technology innovative enterprises.

## Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

## Copyright:



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