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# Digital Transformation, Resource Allocation and Innovation Performance：Evidence from China

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# Digital Transformation, Resource Allocation and Innovation Performance：Evidence from China

**Abstract:** In the context of the digital economy, digital transformation has become an important engine of structural upgrading for enterprises. Based on resource orchestration theory, we take Chinese A-share listed companies from 2007 to 2023 as samples to empirically investigate the impact of digital transformation on innovation performance from the perspective of resource allocation. The findings reveal that digital transformation can promote the improvement of innovation performance, and the effects are more pronounced in large-scale enterprises. The allocation of capital, knowledge, labor, and technological resources plays a mediating role in the impact of digital transformation on innovation performance. Further analysis reveals that the digital transformation of enterprises has significant positive effects on joint innovation and substantive innovation, and is also conducive to improving the quality of innovation. This study enriches the research on the relationship between digital transformation and innovation performance, provides targeted and differentiated guidance for enterprises to formulate digital transformation strategies, and also offers empirical evidence for policymakers to optimize digital economy policies.

**Key Words:** Digital Transformation; Innovation Performance; Resource Allocation

## 1. Introduction

Innovation is the fundamental driver of long-term economic growth and national competitiveness. Currently, digital technologies are profoundly reshaping the global financial landscape and industrial ecosystem, and digital transformation has become the core pathway for enterprises to drive innovation and strengthen core competitiveness (Verhoef et al., 2021). While enterprises' digital transformation still faces numerous challenges. For instance, SMEs are constrained by high computing costs and inadequate data channels, the hidden costs associated with digital

transformation, such as ongoing training, cybersecurity, and technological iteration, prevent enterprises from fully capturing digital dividends (Vial, 2019). Large enterprises, however, are constrained by the inefficient coordination of internal resources, which limits the effectiveness of large-scale digital technology applications(Kulichyova & Batolas, 2025). How to enable enterprises to achieve efficient resource allocation through digital transformation, enhance innovation performance, and gain sustainable competitive advantages has become a critical issue requiring urgent attention amid the ongoing advancement of the global digital economy.

Although existing studies have confirmed that digital transformation has a significant impact on innovation performance, the specific form of the relationship between the two remains undetermined. Scholars generally recognize the innovative empowerment value of digital transformation, believing that it can not only accelerate the flow of information across entities, enhance the efficiency of the utilization of individual resources, help enterprises accurately capture market demands, and provide guidance for product and service innovation (Lyytinen et al., 2016; Nambisan et al., 2017); but also promote the automated reconfiguration of internal processes, assist enterprises in upgrading their operation, management and innovation models, reduce redundancies and costs, and shorten the innovation implementation cycle (Yoo, et al., 2010; Verhoef et al., 2021; Sirmon, 2021). However, some scholars have found that the relationship is complex and nonlinear. When the degree of transformation reaches a relatively high level, it may inhibit innovation due to organizational inertia, resource misallocation, and rising management costs (Henderson & Clark, 1990; Christensen, 1997; Tushman & Anderson,1986). In addition, some scholars have expanded the perspective of transmission paths and pointed out that digital transformation can provide support for corporate innovation activities through indirect channels such as alleviating financial constraints (Wang et al., 2025; Li & Xie, 2025), improving corporate governance (Yang et al., 2024) and enhancing organizational absorptive capacity (Zhan & Li, 2024). In terms of resource pathways, some studies focus on organizational resources and find that digital transformation can enhance corporate resilience by improving the efficiency of internal resource allocation and boosting

organizational agility (Helfat & Peteraf, 2015; Agarwal & Helfat, 2009). Others shift their focus to technological and knowledge resources, proposing that digital transformation can enable process optimization, facilitate knowledge sharing, and enhance the quality of innovation (Agarwal & Helfat, 2009). Still, other studies expand the scope to resource integration, suggesting that it can facilitate the integration of traditional and digital elements and optimize the process of knowledge creation(Lavie, 2002).

The existing literature holds significant reference value, yet there remains room for further in-depth exploration. First, existing studies have revealed multiple results regarding the relationship between enterprise digital transformation and innovation performance, including positive effects and nonlinear effects. However, no consistent conclusion has been reached. The reason might be that the sample enterprises were not differentiated. Further clarification is needed to understand the deep-seated relationship between digital transformation and innovation performance. Second, regarding the impact mechanism of digital transformation on innovation performance, most studies focus on perspectives such as corporate governance and enterprise capabilities, while lacking in-depth exploration from the perspective of resource allocation. Even the limited existing relevant studies mostly start from single types of resources, such as knowledge and technology, and lack analysis on the coordinated allocation of multiple resources, including capital, knowledge, technology, and human resources, making it difficult to explain the impact of resource allocation on innovation performance fully.

In fact, digital technology not only changes business processes but also the underlying logic of resource flow. The digital transformation of enterprises breaks the inherent routes of traditional resource allocation through the “breaking down of walls” and “reconstruction” by algorithms. By optimizing the allocation of capital, knowledge, labor, and technological resources, it provides impetus and guarantee for enterprise innovation. Therefore, this study takes Chinese listed companies as samples and analyzes the impact and mechanism of enterprise digital transformation on innovation performance from the perspective of resource allocation.

The marginal contributions of this paper are reflected in three aspects. Firstly, it

explores the action mechanism of corporate digital transformation on innovation performance from the perspective of resource allocation, reveals the path that digital transformation enhances innovation performance through optimizing resource allocation, and deepens the driving logic of corporate innovation in the digital economy era. Secondly, it breaks the traditional research's sole focus on measuring innovation performance, adding heterogeneity tests of the impacts of digital transformation on enterprise innovation types and innovation quality. It is a deep and comprehensive exploration of the impact of digital transformation on enterprise innovation. Thirdly, by conducting a stratified analysis of transformation differences among enterprises with varying scales and ownership natures, it provides targeted and differentiated digital transformation strategies for enterprises and offers a reliable basis for optimizing digital economy policies.

## 2. Theory and Hypotheses

### 2.1 The Impact of Digital Transformation on Innovation Performance

Resource Orchestration Theory emphasizes that the allocation and utilization of corporate resources and capabilities are critical (Sirmon et al., 2011). Enterprises can seize and leverage opportunities to establish competitive advantages by effectively orchestrating resources and capabilities(Amit et al., 2017). Digital transformation is inherently a higher-order process of resource orchestration. Managers achieve a leap in innovation performance by structuring digital resources, bundling digital and traditional resources to form new digital capabilities, and ultimately leveraging these capabilities in the marketplace.

Digital transformation refers to the process of integrating internal and external resources through the construction, transformation, coupling and coordination of digital technologies, thereby achieving a systematic reconfiguration of production models, service systems and operational architectures(Karim, & Capron, 2016; Helfat & Peteraf, 2014). Enterprise digital transformation enhances innovation capabilities and competitiveness. First, resource piecing together, reorganization， and

redistribution are the starting points for enterprises to carry out innovation under constraints. Digital transformation breaks spatial limitations, facilitates the flow of internal and external knowledge, and promotes the sharing of technology, thereby accelerating the innovation process. Second, corporate digital transformation can optimize resource allocation efficiency, reduce redundant expenditures, lower cost stickiness, and free up more resources for research and development, thereby enhancing innovation performance (Lyytinen et al., 2016). Third, digital transformation helps to optimize business processes, reshape business models, facilitate enterprises' integration into the global innovation network, and drive the transformation of modular products and organizational structures, enhance production efficiency and competitiveness, and stimulate enterprises' innovation capabilities (Zhuo & Chen, 2023; Zhu & Iansiti, 2019). Therefore, the following hypothesis is proposed:

H1: Digital transformation promotes the improvement of enterprise innovation performance.

## 2.2 The Impact Mechanism of Digital Transformation on Corporate Innovation Performance

The theory of strategic dynamics posits that in a volatile business environment, there is no single fixed strategy or resource allocation method that can ensure enterprises' long-term survival and development (Maritan & Lee, 2017). Over time, enterprises will continuously adjust their strategic posture, and also undergo significant changes in resource allocation decisions, such as capital investment and capital structure, personnel adjustments, etc(Crossland et al., 2014). Adjusting and optimizing the allocation of key strategic resources during the innovation process is an important way for enterprises to maintain long-term competitive advantages.

### 2.2.1 Capital Resources

Corporate digital transformation enhances innovation performance by optimizing capital resources. First, it alleviates financing constraints and provides stable financial support for innovation activities by improving information transparency and attracting external investment. As the core driving force for enterprises to achieve technological

breakthroughs and build competitive advantages, innovation activities are characterized by high investment, long cycles, and high risks (Grant, R. M., 1996). Digital transformation reduces information asymmetry among market participants by enhancing information penetrability and transparency (Muneer et al., 2025), allows external financial institutions to assess enterprises' operating conditions and credit risks accurately. The improvement in information transparency and financial resource matching facilitates dynamic alignment between the supply and demand sides of financial resources, shortens the capital acquisition cycle for enterprises' R&D innovation and equipment upgrading, and thus supports the improvement of innovation performance (Zhu & Yu, 2024). Second, by leveraging big data analysis and intelligent algorithms, enterprises can enhance their internal control, monitor the usage of funds by each business department, promote the unified and efficient allocation of organizational funds, and optimize the utilization efficiency of internal capital within the enterprise. Finally, the reasonable transparency of operational data and moderate disclosure of financial information reduce the motivation of management to act in their own interests, minimize the impact of agency problems on capital (Lu et al., 2025), curb adverse selection and moral hazard issues, effectively avoid the risk of enterprises falling into financial distress, and provide financial guarantee for corporate innovation. Therefore, Hypothesis 2 is proposed:

H2: Digital transformation enhances corporate innovation performance by improving the allocation of capital resources.

**2.2.2 Knowledge Resources**

Knowledge is the engine driving economic growth. Enterprise innovation activities are essentially a process of deconstructing, reorganizing, and creating value from diverse knowledge. Their effectiveness is highly dependent on the internal knowledge stock and the integration and utilization of interdisciplinary knowledge (Griliches, 1998; Hiebeler, 1996; Nonaka, Takeuchi, 1995; Ştefan et al., 2024). However, the inherent internal sharing nature of knowledge resources not only enhances the collaborative effect of knowledge but also gives rise to the costs of enterprises' acquisition and integration of knowledge, which results in enterprises often facing high expenditures of human, material and financial resources during the

process of identifying and absorbing external knowledge resources, which severely restrict corporate innovation (Paavola et al., 2004; Rybnicek & Königsgruber, 2019; Robertson et al., 2023).

Digital transformation drives enterprises to establish a dynamic knowledge management system, breaking the knowledge silos within traditional organizational structures and facilitating the free flow and collaborative innovation of knowledge among departments and at different levels. The establishment of a digital knowledge-sharing platform enables enterprises to achieve real-time updates, accumulation, and reuse of knowledge, thereby forming a virtuous cycle of knowledge spiral ascent and continuously optimizing the organization's knowledge resource structure. This structural optimization is not only reflected in the growth of internal knowledge reserves but also in the diversification, complementarity, and innovation, which provide a more solid intellectual foundation for enterprise innovation activities (Chen et al., 2024;Gold et al., 2001). Therefore, Hypothesis 3 is proposed:

H3: Digital transformation enhances the innovation performance by optimizing the structure of their knowledge resources.

**2.2.3 Labor Resources**

Digital transformation increases the demand for highly skilled talents in enterprises, promotes the increase of human resource investment and system optimization, and provides support for the innovation and development of enterprises. First, digital transformation drives the optimization and upgrading of production technologies. Given the complementary effects of factor inputs, when enterprises increase their investment in technology, they will also correspondingly increase their input of factors for highly skilled workers. Sustained human capital investment not only enriches employees' knowledge and enhances their capabilities but also promotes knowledge sharing and restructuring among teams, effectively stimulating innovative behavior (Sheehan et al., 2025). Second, Digital transformation achieves intelligent matching of labor demand by establishing vertical supply chains and horizontal industrial ecosystem platforms. Enterprises can promptly release job requirements and conduct semantic analysis matching with the talent pool. Talent

suppliers can also present their skill sets through digital portraits. This two-way information connection effectively reduces the search, friction, and transaction costs in the labor market and avoids research and development delays caused by talent mismatches. Finally, the application of digital technologies replaces routine and repetitive jobs, reduces demand for low-skilled workers, creates new high-skill employment opportunities, and consequently increases demand for highly skilled talent. This shift in labor demand—toward highly skilled talent and away from low-skilled roles—drives enterprises to optimize their human capital structure, enhance productivity, and boost innovation performance (Babina et al., 2024; He & Chen, 2024). Therefore, we propose the following hypothesis:

H4: Digital transformation enhances innovation performance by optimizing the composition of a firm's labor resources.

**2.2.4 Technological Resources**

Schumpeter's innovation theory posits that technology is a crucial factor of production, and technological innovation can enhance productivity and stimulate economic growth (Schumpeter, 1934). From the perspective of upgrading technological resources, digital transformation encourages enterprises to increase investment in cutting-edge technologies, enhancing innovation performance through technology integration and process reconstruction (Schneider et al., 2024; Wang & Zhang, 2025). At the level of technological resource sharing, digital platforms can facilitate inter-enterprise technology sharing and cooperation, break down technological barriers between enterprises, improve the efficiency of knowledge flow and innovation synergy, enhance enterprises' technological innovation capabilities, and promote the formation of a technology sharing and cooperation ecosystem (Dosi, 1982). Meanwhile, through in-depth technological exchanges and cooperation with external institutions, enterprises can build an extensive technological cooperation network, effectively integrate external innovation resources, and provide strong support for their own sustainable development (He & Chen, 2024; Bican et al., 2017). Digital platforms enable the efficient sharing of resources; through multi-node factor allocation methods, enterprises can reduce the cost of technological imitation. Leading enterprises on the nodes can set an example for small and medium-sized

enterprises, narrow the technological gap between enterprises, and mitigate the innovation differentiation caused by the digital divide. In other words, digital transformation can narrow the technological gap between enterprises and promote improvements in overall innovation performance (Tsou & Chen, 2023; Fang & Liu, 2024). Thus, the following hypothesis is proposed:

H5: Digital transformation drives the improvement of innovation performance by facilitating the upgrading and sharing of technological resources.

# 3. Research Design

## 3.1 Data and Sample

Chinese listed companies have been implementing the new enterprise accounting standards since 2007. To avoid the impact of accounting standard changes on the research results, we selected Chinese A-share listed companies from 2007 to 2023 as the research sample. The research data mainly came from the China Research Data Service Platform (CNRDS) and the CSMAR database. To obtain robust results, the following samples were excluded: (1) financial enterprises. (2) *ST, ST, and PT enterprises. (3) enterprises that do not meet the accounting standards, namely those with total assets, operating income, sales revenue, intangible assets, etc., less than zero. Finally, 36,387 annual sample observations were obtained. At the same time, to eliminate the influence of extreme values, perform Winsorization at the 1% and 99% levels for all continuous variables.

## 3.2 Variables

(1) Dependent Variable

Corporate Innovation Performance (inno). Corporate innovation performance refers to the improvement in performance brought about by technological progress or the enhancement of innovation capabilities, which can be directly reflected in the number of patents. Referring to the methods of Li et al. (2023), Ahuja & Katila(2001), innovation performance is measured by the number of patent applications.

(2) Independent Variable

Digital Transformation (digital). Drawing on the method of Wu et al. (2021), we use text analysis to measure corporate digital transformation. The measurement steps are as follows: ① Extract keywords related to digital transformation from the annual reports of sample enterprises, covering five categories, including artificial intelligence, big data, cloud computing, blockchain, and digital technology application. ② Calculate the total word frequency of digital transformation keywords appearing in the enterprise annual reports. ③ To avoid the right-skewed distribution characteristic of such data, take the natural logarithm of the total word frequency obtained in the first step to derive the corporate digital transformation index.

(3) Mediating Variable

Capital Factor Allocation (tSA). Following the approaches of Hadlock and Pierce (2010) and Li and Xie (2025), the capital allocation efficiency is constructed by the Theil index. Specifically, the SA index is used to measure the financing constraints of enterprises, and a capital allocation efficiency index is constructed. The smaller the tSA value is, the smaller the gap in financing constraints among enterprises is, and the more effective the capital allocation is.

$$tSA_{jt}=\frac{1}{n_{jt}}\sum_{i=1}^{n_{jt}}\frac{sa_{ijt}}{\overline{SA_{jt}}}\log\left(\frac{sa_{ijt}}{\overline{SA_{jt}}}\right) \quad (1)$$

where:

$$SA=-0.737Size+0.043Size2-0.040Age \quad (2)$$

Here, n denotes the number of enterprises in industry j in year t. Since the SA index is a negative value, its absolute value is taken. A larger SA index indicates that the enterprise is confronted with more severe financing constraints. Size represents the enterprise scale, and Age represents the firm's age.

Knowledge Resource Allocation (incite). Drawing on the methodologies of Jung et al. (2024), Wang et al. (2020), and Jaffe et al. (1993), knowledge resource allocation is measured by the number of patent citations of an enterprise (Incite).

Labor Resource Allocation (ttec). The Theil index is adopted to construct the labor factor allocation efficiency, and the labor factor allocation index is expressed as:

$$ttec_{jt} = \frac{1}{n_{jt}} \sum_{i=1}^{n_{jt}} \frac{technical_{ijt}}{\overline{Tech_{jt}}} \log\left(\frac{technical_{ijt}}{\overline{Tech_{jt}}}\right)$$

（3）

In the formula, technicality refers to the proportion of technical personnel of enterprise i in industry j and year t, which reflects the level of high-quality labor force owned by the enterprise. Techjt denotes the average proportion of technical personnel in industry j in year t. ttecjt represents the dispersion degree of technical personnel in industry j in year t. A smaller Theil indicates smaller talent gaps between enterprises and higher efficiency in labor resource allocation.

Technical Resource Allocation (gaptfp). Following the approach of Aghion et al. (2005), technical resource allocation is measured using inter-firm technological gaps. The inter-firm technological gap variable is constructed as:

$$gaptfp = TFP_{ft} - TFP_{it}TFP_{ft} \quad （4）$$

where TFP denotes the total factor productivity of the frontier firm within the industry, TFP denotes the total factor productivity of other firms within the industry, and gaptfp represents the relative technological gap between firm i and frontier firm f. Following the methodology of Schumpeter (1934), we estimate firm TFP using a C-D production function and a simple linear estimation approach.

(4) Control Variables

Following Shen and Zhang(2018), Wu et al. (2024), this study controls for several variables influencing corporate innovation output, including firm and CEO characteristics. These encompass firm age, firm size, firm leverage, firm growth, board size, the degree of equity checks and balances, the proportion of independent directors, CEO tenure, CEO shareholding, dual roles, and the nature of property rights. Specific variables and definitions are presented in Table 1.

Table 1 Variable Definitions

| Variable Type | Variable Name | Variable Definition |
|---|---|---|
| Dependent Variable | Innovation performance （inno） | ln(Number of Enterprise Patent Applications+1） |
| Independent Variable | Digital transformation （digital） | ln(Frequency of Digital Keywords Extracted from Enterprise Annual Reports+1） |
| Mediating | Capital factor allocation（tsa） | Capital allocation efficiency measured by the Theil Index |

| | | |
|---|---|---|
| Variable | Knowledge resource allocation（incite） | ln(Number of Enterprise Patent Citations+1) |
| | Labor resource allocation （ttec） | Labor factor allocation efficiency constructed by the Theil Index |
| | Technology resource allocation（gaptfp） | Technological gap between enterprises |
| Control Variable | Firm age （age） | ln(Years from Enterprise Establishment to the Current Year+1) |
| | Firm size（size） | ln(Total Assets at the End of the Period+1) |
| | Leverage（lev） | Total Liabilities / Total Assets |
| | Firm growth（opicrt） | Operating revenue growth rate, calculated as (Current Period Operating Revenue - Adjusted Operating Revenue of the Same Period Last Year) / Adjusted Operating Revenue of the Same Period Last Year × 100% |
| | Return on assets（roa） | Enterprise return on assets |
| | Equity balance degree （shrholder3） | Sum of shareholding ratios of the top three major shareholders |
| | Proportion of independent directors（indrcrat） | Ratio of independent directors to the total number of directors |
| | Ceo tenure（renqi） | ln（CEO Tenure+1） |
| | Ceo-chairman duality （cmgm） | Dummy variable: 1 if the CEO also serves as the chairman of the board, 0 otherwise |
| | Property right nature（state） | Dummy variable: 1 for state-owned enterprises, 0 for non-state-owned enterprises |

## 3.3 Model Construction

To examine the impact of digital transformation on corporate innovation performance, the model is constructed as follows:

$$innovation_{it} = \beta_0 + \beta_1 digital + \sum \beta_2 controls_{it} + \mu_t + \lambda_i + \varepsilon_{it} \quad (5)$$

where i and t denote the enterprise and year respectively; innovation represents corporate innovation performance; digitalit denotes digital transformation; controls refers to a set of control variables, including firm age, firm size, enterprise leverage, return on assets, equity balance degree, etc.; μ is the time-fixed effect; λ is the industry-fixed effect; and ε denotes the random disturbance term.

To further analyze the transmission path through which digital transformation

affects innovation performance, Models (6)–(7) are constructed as follows:

$$median_{it} = \beta_0 + \beta_1 digital + \sum \beta_2 controls_{it} + \mu_t + \lambda_i + \varepsilon_{it} \quad (6)$$

$$innovation_{it} = \beta_0 + \beta_1 digital + \beta_2 median_{it} + \sum \beta_3 controls_{it} + \mu_t + \lambda_i + \varepsilon_{it} \quad (7)$$

where median represents the mediating variables, including the allocation of capital, labor, knowledge, and technological resources.

# 4. Empirical Results Analysis

## 4.1 Descriptive Statistics and Correlation Analysis

### 4.1.1 Descriptive Statistics

The descriptive statistics are presented in Table 2. The mean corporate innovation performance is 2.673, with a minimum of 0 and a maximum of 9.380, indicating substantial disparity across the sample. For digital transformation, the mean value stands at 1.395, ranging from 0 to 5.159. In addition, the descriptive statistics of firm age, leverage ratio, firm growth, and other variables all indicate significant differences among the sample enterprises.

Table 2 Descriptive Statistics of Main Variables

| | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Innovation Performance | 2.673 | 1.720 | 0 | 9.380 |
| Digital Transformation | 1.395 | 1.421 | 0 | 5.159 |
| firm age | 31.695 | 5.832 | 2 | 51 |
| Leverage | 0.440 | 0.206 | 0.053 | 0.929 |
| Firm Growth | 27.901 | 1017.222 | -130.916 | 149715.600 |
| Board Size | 2.329 | 0.248 | 1.609 | 2.944 |
| Return on Assets | 4.213 | 5.791 | -20.18 | 19.930 |
| Equity Balance Degree | 0.350 | 0.148 | 0.089 | 0.747 |
| Independent Director Ratio | 38.765 | 9.269 | 0 | 62.500 |
| CEO-Chairman Duality | 0.320 | 0.467 | 0 | 1 |
| Nature of Property Rights | 0.343 | 0.475 | 0 | 1 |

### 4.1.2 Correlation Analysis

In the correlation test (see Table 3), the correlation coefficients are generally appropriate, with no excessively large values. Thus, further regression analysis can be conducted. Meanwhile, the correlation coefficient between corporate digital transformation and innovation performance is significantly positive, which preliminarily verifies that corporate digital transformation has a significant positive correlation with the improvement of innovation performance. Nevertheless, further empirical tests are still required.

Table 3 Correlation Analysis

| | Innovation Performance | Digital Transformation | firm age | Leverage | Firm Growth | Board Size | Return on Assets | Equity Balance Degree | Independent Director Ratio | CEO-Chairman Duality | Nature |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Innovation Performance | 1 | | | | | | | | | | |
| Digital Transformation | 0.224*** | 1 | | | | | | | | | |
| firm age | 0.114*** | 0.187*** | 1 | | | | | | | | |
| Leverage | 0.019** | -0.096*** | -0.173*** | 1 | | | | | | | |
| Firm Growth | -0.011** | -0.006 | 0.003 | 0.005 | 1 | | | | | | |
| Board Size | 0.068*** | -0.010* | -0.095*** | 0.134*** | -0.007 | 1 | | | | | |
| Return on Assets | 0.056*** | -0.043*** | 0.035*** | -0.361*** | -0.003 | -0.080*** | 1 | | | | |
| Equity Balance Degree | -0.030*** | -0.129*** | 0.011** | 0.070*** | 0.004 | -0.005 | 0.127*** | 1 | | | |
| Independent Director Ratio | -0.010** | -0.004 | 0.028*** | -0.041*** | -0.003 | -0.079*** | 0.027*** | 0.010** | 1 | | |
| CEO-Chairman Duality | 0.054*** | 0.144*** | 0.191*** | -0.144*** | -0.001 | -0.097*** | 0.023*** | -0.068*** | 0.012** | 1 | |
| Nature of Property Rights | -0.068*** | -0.184*** | -0.264*** | 0.287*** | -0.011** | 0.254*** | -0.096*** | 0.254*** | -0.093*** | -0.327*** | 1 |

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels,respectively.

## 4.2 The Impact of Digital Transformation on Innovation Performance

This paper employs panel data for analysis, and the results of the Hausman test reject the null hypothesis, indicating that the fixed-effects model should be adopted for empirical analysis. The empirical test is conducted considering the time and industry fixed effects, and the results are presented in Table 4.

Column 2 of Table 4 reports the effects of control variables on corporate innovation performance. Among these variables, firm age, leverage ratio, board size, return on assets, CEO-chairman duality, and nature of property rights all show a significantly positive correlation with innovation performance. The proportion of independent directors is significantly negatively correlated with innovation performance, meaning that enterprises with a lower proportion of independent directors tend to have higher innovation performance. Firm growth and the degree of equity balance show no direct correlation with digital transformation. Column 3 reports the regression results of the impact of digital transformation on innovation performance, the coefficient of digital transformation on innovation performance is 0.05, which is statistically significant at the 1% level. This finding confirms that digital transformation facilitates innovation performance, thereby supporting Hypothesis H1.

Table 4 Results of the Impact of Digital Transformation on Innovation Performance

| | Innovation Performance M1 | Innovation Performance M2 |
|---|---|---|
| Digital Transformation | | 0.050*** （4. 72） |
| Firm age | 0.105* （1.83） | 0.105* （1.83） |
| Leverage | 0.743*** （10.57） | 0.730*** （10. 37） |
| Firm Growth | 0 （0. 13） | 0 （0.10） |
| Firm Size | 0.128*** （2. 92） | 0.122*** （2.77） |
| Return on Assets | 0.011*** （6. 36） | 0.011*** （6. 16） |
| Equity Balance Degree | -0.033 (-0.30) | -0.000 (-0.00) |
| Independent Director Ratio | -0.002* (-1.93) | -0.001* (-1.67) |
| CEO-Chairman Duality | 0.054** （2.13） | 0.051** （2. 01） |
| Nature of Property Rights | 0.113** | 0.109** |

| | | |
|---|---|---|
| | （2.36） | （2. 28） |
| Constant Term | 0.500***<br>（4. 11） | 0.488***<br>（4. 00） |
| Year Fixed Effects | Controlled | Controlled |
| Industry Fixed Effects | Controlled | Controlled |
| Number of Samples | 36387 | 36387 |
| $R^2$ | 0.14 | 0.151 |

**Note**: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, with t-values in parentheses.

## 4.3 Robustness Tests

(1) Alternative Variables

In the baseline regression, the level of digital transformation is measured by taking the natural logarithm of the frequency of digital keywords, which may be affected by the length of annual report texts. For the robustness test, the proportion of target keywords appearing in the “Discussion and Analysis” section of corporate annual reports is used to measure the level of digital transformation. The results, presented in Table 5, are consistent with the baseline findings.

(2) Time Sensitivity Test

Given the periodicity and long-term nature of technological innovation activities, the impact of digital transformation on innovation performance is likely to lag. To eliminate the influence of time trends on the results, the innovation performance variable is treated with a one-period lag. The results, shown in Table 5, confirm the robustness of the baseline conclusions.

(3) Sample Period Adjustment

The research sample in this paper covers A-share listed companies in China from 2007 to 2023. Given the 2008 financial crisis and its subsequent impacts, this test excludes enterprise data from 2008 to 2010 and re-conducts the robustness test using data from 2011 to 2023. The results, reported in Table 5, are consistent with the baseline results.

(4) Endogeneity Test

Drawing on the research by Liu et al. (2021), this paper uses the one-period lagged digital transformation as an instrumental variable and conducts a two-stage

regression analysis. The results, presented in Table 5, are consistent with the baseline findings.

Table 5 Robustness Tests

| | Innovation Performance | | | |
|---|---|---|---|---|
| | Alternative Variables | Lag Effect Test (1-Period Lag) | Sample Period Adjustment | 2SLS Instrumental Variable |
| Digital Transformation | 0.055*** （4.87） | 0.047*** （2.93） | 0.059*** （3.15） | 0.048*** （3.71） |
| Control Variables | Controlled | Controlled | Controlled | Controlled |
| Year Fixed Effects | Controlled | Controlled | Controlled | Controlled |
| Industry Fixed Effects | Controlled | Controlled | Controlled | Controlled |
| Constant Term | 0.610 （3.61） | 1.047** （5.37） | -0.575 （-1.58） | 0.759 （4.87） |
| $R^2$ | 0.125 | 0.174 | 0.175 | 0.129 |

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, with t-values in parentheses. All 2SLS instrumental variables pass the under-identification test and weak identification test.

## 4.4 Mechanism Test

Based on theoretical analysis, this paper examines the underlying mechanisms through which digital transformation influences corporate innovation performance from the perspective of capital, labor, knowledge, and technology factor allocation.

Empirical results are presented in Table 6. After controlling for firm age, firm size, firm leverage ratio, and profitability, while accounting for time and industry fixed effects, digital transformation exhibits a significant positive impact on innovation performance ($\beta_1$=0.050, p<0.001). The positive effect of digital transformation on innovation performance suggests that digital transformation can substantially enhance a firm's innovation capabilities.

Further tests were conducted to examine the impact of digital transformation on the allocation of capital, labor, knowledge, and technology. The results show that digital transformation has a significant positive impact on capital factor allocation ($\beta_2$ = 0.114, p < 0.001), labor factor allocation ($\beta_2$ = 0.435, p < 0.001), knowledge factor

allocation ($\beta_2$= 0.977, p < 0.001), and technology factor allocation ($\beta_2$ = 0.297, p < 0.001). These results show that digital transformation improves the allocation of capital, labor, knowledge, and technology factors, indicating that digital transformation can optimize the allocation of multiple key resources. A joint analysis of digital transformation and capital factor allocation was then performed. The results demonstrate that capital factor allocation has a significant positive impact on innovation performance ($\beta_4$=0.023, p<0.001), while the impact of digital transformation on innovation performance remains statistically significant ($\beta_3$=0.038, p<0.001). However, $\beta_3<\beta_1$ (i.e., 0.038 < 0.271), suggesting that capital factor allocation plays a partial mediating role between digital transformation and innovation performance, thus verifying Hypothesis H2.

Similarly, the partial mediating roles of labor, knowledge, and technology factor allocation in the relationship between digital transformation and innovation performance are all verified, which supports Hypotheses H3, H4, and H5.

Therefore, digital transformation enables enterprises to effectively integrate internal resources, optimize the allocation of resources, and thereby enhance their innovation performance.

Table 6 Results of the Mediating Role of Resource Allocation in the Relationship between Digital Transformation and Innovation Performance

| | inno（1） | tSA（2） | inno（3） | incite（4） | inno（5） | ttec（6） | inno（7） | gaptfp（8） | inno（9） |
|---|---|---|---|---|---|---|---|---|---|
| digital | 0.050***（4.72） | 0.114***（3.22） | 0.038***（3.51） | 0.435***（4.32） | 0.034***（2.85） | 0.977***（2.76） | 0.041***（2.69） | 0.297***（93.38） | 0.028**（2.08） |
| tSA | | | 0.023***（8.64） | | | | | | |
| incite | | | | | 0.012***（9.53） | | | | |
| ttec | | | | | | | 0.002***（5.21） | | |
| gaptfp | | | | | | | | | 0.073***（2.68） |
| Control Variables | Control | Control | Control | Control | Control | Control | Control | Control | Control |
| Year Fixed Effects | Control | Control | Control | Control | Control | Control | Control | Control | Control |
| Industry Fixed Effects | Control | Control | Control | Control | Control | Control | Control | Control | Control |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Constant Term | 0.488***（4.00） | -0.793*（-1.94） | -4.218***（-9.12） | -2.287*（-1.92） | -4.218***（-9.12） | -9.263**（-2.26） | 0.384***（3.02） | 0.232***（6.28） | 0.463***（3.77） |
| Number of Samples | 36387 | 15326 | 15316 | 10512 | 10511 | 15294 | 15284 | 16793 | 16783 |
| R2 | 0.151 | 0.005 | 0.156 | 0.029 | 0.155 | 0.006 | 0.154 | 0.708 | 0.153 |

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, with t-values in parentheses.

# 5. Further Analysis

## 5.1 Enterprise Heterogeneity Test

### 5.1.1 Firm Scale

The scale of an enterprise is closely related to the organization of innovation resources and the aggregation of elements. The promotion of digital transformation across enterprises of different scales may lead to heterogeneous impacts on innovation performance. The median of annual industry enterprise scale is taken as the benchmark, enterprises above the median are considered large enterprises and recorded as 1; those below the median are considered small enterprises and recorded as 0. Then the impact of digital transformation on innovation performance of different enterprise scales is analyzed taking firm age, profitability, leverage ratio, and equity balance degree as control variables. The results are shown in Table 7.

The results indicate that digital transformation has a positive impact on innovation performance of large-scale enterprises, and the effect passes the significance test at the 1% level. However, for small-scale enterprises, the effect of digital transformation is no longer significant. Therefore, digital transformation significantly enhances innovation performance in large enterprises, but has a limited effect on small enterprises. This discrepancy may stem from large enterprises possessing relatively greater surplus resources, more substantial market influence, and more robust internal R&D capabilities and risk management capacity, thereby amplifying the impact of digital transformation on innovation performance.

### 5.1.2 Enterprise Nature

The nature of ownership has a significant impact on the way enterprises allocate

resources, the principal-agent relationship, and the corporate governance structure, and is also a key factor contributing to the differences in technological innovation behaviors between state-owned enterprises and private enterprises (Wen & Feng, 2012). This study further explores the differences in the impact of enterprise digital transformation on innovation performance under different ownership forms. The empirical results (Table 7) show that the digital transformation of both state-owned enterprises and non-state-owned enterprises is positively correlated with innovation performance, and both have passed the significance test at the 1% level. Therefore, digital transformation has a significant positive promoting effect on the innovation performance of both state-owned enterprises and non-state-owned enterprises.

Table 7 Heterogeneity Test of the Impact of Enterprise Digital Transformation on Innovation Performance

| | Innovation Performance | | | |
|---|---|---|---|---|
| | firm size | | firm size | |
| | Small-Scale | Large-Scale | State-Owned Enterprises | Non-State-Owned Enterprises |
| Digital Transformation | 0.023<br>（1.50） | 0.044***<br>（2.78） | 0.060***<br>（3.25） | 0.048***<br>（3.75） |
| Control Variables | Controlled | Controlled | Controlled | Controlled |
| Constant | 0.610***<br>（3.65） | 1.057***<br>（5.57） | 0.494**<br>（2.40） | 0.751***<br>（4.90） |
| Year Fixed Effects | Controlled | Controlled | Controlled | Controlled |
| Industry Fixed Effects | Controlled | Controlled | Controlled | Controlled |
| Number of Samples | 8349 | 7651 | 6557 | 9880 |
| R2 | 0.125 | 0.177 | 0.180 | 0.132 |

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, with t-values in parentheses.

## 5.2 Analysis of Innovation Heterogeneity

### 5.2.1 Independent Innovation and Collaborative Innovation

Based on the different ways of innovation, enterprise innovation can be classified

into independent innovation and joint innovation. It is assumed that these two forms together constitute enterprise innovation (Zheng et al., 2024). Drawing on the research of Song et al. (2022), the number of patents independently applied for by enterprises is used to measure the independent innovation of enterprises, while the number of patents jointly applied for by enterprises is used to measure the joint innovation of enterprises. Meanwhile, in order to eliminate the problem of right-skewed distribution of patent data, the number of patents applied for by the enterprise in the current year is incremented by 1 and then logarithmically processed. The empirical test is conducted, and the results are presented in Table 8.

The results show that the impact of enterprise digital transformation on independent innovation is significantly positive, and the impact of digital transformation on joint innovation is also significantly positive.

The reason may lie in the fact that the widespread application of digital technologies enables entities located in different regions to jointly participate in the entire product development process through virtual environments, which breaks the constraints of time and space on cross-regional collaboration among enterprises, effectively addresses the distance barriers to joint innovation among geographically dispersed entities, creates new opportunities for collaborative innovation and fosters more instances of cross-regional joint innovation. Therefore, digital transformation exerts a more substantial influence on joint innovation.

**5.2.2 Substantive Innovation and Strategic Innovation**

During the implementation of technological innovation in enterprises, due to differences in innovation motivations, they may exhibit "high-level and high-difficulty" substantive innovations, or "focus on quantity but neglect quality" strategic innovations(Zhang et al., 2024). To examine the specific impact of digital transformation on innovation, this paper further categorizes the patents applied by enterprises into invention patents and utility model patents(Li & Zheng, 2016). Specifically, substantive innovation is measured by the number of invention patent applications filed by enterprises. In contrast, strategic innovation is measured by the number of utility model patent applications filed by enterprises. An empirical test is conducted, and the results are presented in Table 8.

The results show that digital transformation has a significant positive impact on substantive innovation, but has no effect on strategic innovation. Therefore, compared with strategic innovation, the facilitating effect of digital transformation on substantive innovation is more pronounced. That is, digital transformation is more conducive to driving enterprises to undertake high-quality, high-risk substantive innovation activities, rather than merely pursuing strategic innovation behaviors focused on quantity growth.

Table 8 Heterogeneity Test of the Impact of Enterprise Digital Transformation on Innovation

| | Innovation Performance | | | |
|---|---|---|---|---|
| | Independent Innovation | Collaborative Innovation | Substantive Innovation | Strategic Innovation |
| Digital Transformation | 0.044***<br>（4.09） | 0.071***<br>（7.87） | 0.091***<br>（9.59） | 0.014<br>（1.37） |
| Control Variables | Controlled | Controlled | Controlled | Controlled |
| Constant | 0.451***<br>（3.58） | -0.228**<br>（-2.18） | -0.022<br>（-0.20） | 0.024<br>（0.20） |
| Year Fixed Effects | Controlled | Controlled | Controlled | Controlled |
| Industry Fixed Effects | Controlled | Controlled | Controlled | Controlled |
| Number of Samples | 16437 | 16437 | 16437 | 16437 |
| $R^2$ | 0.141 | 0.069 | 0.137 | 0.149 |

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, with t-values in parentheses.

## 5.3 Innovation Quality Effects

The report of the 20th National Congress of the Communist Party of China proposed pursuing a path of high-quality development, stating that “high-quality development is the primary task in building a modern socialist country in all respects.” Public attention toward corporate innovation activities has also gradually shifted from the quantity of innovation to its quality. Can digital transformation enhance the

quality of innovation?

According to the resource allocation theory, the digital transformation of enterprises has enhanced the allocation efficiency of key resources, such as information and capital, thereby fully unleashing their potential for value creation. In this process, enterprises use digital technologies and equipment to alleviate financial constraints, enhance organizational resilience, and strengthen risk-taking capabilities, thereby providing strong support for enterprise innovation and upgrading (Zahra & George, 2002). Therefore, digitalization can improve the quality of enterprise innovation.

Drawing on the methodologies of Dan Zhang et al. (2023) and Li & Zhang (2025), this paper measures innovation quality by the number of citations received by the invention patents filed and authorized by enterprises in subsequent years. A regression analysis is conducted, and the results are presented in Table 9.

The results indicate a significantly positive relationship between corporate digital transformation and innovation quality, suggesting that digital transformation can enhance innovation quality.

Further heterogeneity tests were conducted on firm size and enterprise nature. The results demonstrate that digital transformation exerts a positive effect on the improvement of innovation quality in large-scale enterprises. In contrast, its impact on innovation quality of small-scale enterprises is not significant. Additionally, digital transformation plays a significantly facilitating role in enhancing the innovation quality of both state-owned enterprises and non-state-owned enterprises.

Therefore, in the process of advancing digital transformation, emphasis should be placed on improving innovation quality. In particular, we should support the leading role of large-scale enterprises in digital transformation, while providing more resources and policy support for small-scale enterprises, to promote the high-quality development of the overall innovation ecosystem.

Table 9: Test Results on the Impact of Enterprise Digital Transformation on Innovation Quality

| | Innovation | Innovation Quality |
|---|---|---|

| | Quality | firm size | | Enterprise Nature | |
|---|---|---|---|---|---|
| | | Small-Scale | Large-Scale | State-Owned Enterprises | Non-State-Owned Enterprises |
| Digital Transformation | 0.107***<br>（7.11） | 0.019<br>（0.80） | 0.133***<br>（6.24） | 0.093***<br>（3.42） | 0.110***<br>（5.93） |
| Control Variables | Controlled | Controlled | Controlled | Controlled | Controlled |
| Constant Term | 2.395***<br>（13.46） | 2.460***<br>（9.03） | 3.072***<br>（11.81） | 2.475***<br>（8.07） | 2.564***<br>（11.36） |
| Year Fixed Effects | Controlled | Controlled | Controlled | Controlled | Controlled |
| Industry Fixed Effects | Controlled | Controlled | Controlled | Controlled | Controlled |
| Number of Samples | 10161 | 4732 | 892 | 3766 | 6395 |
| R2 | 0.277 | 0.303 | 0.281 | 0.237 | 0.297 |

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, with t-values in parentheses.

## 6. Conclusions and Recommendations

### 6.1 Conclusions

This paper studies the impact of digital transformation on enterprise innovation performance from the perspective of resource allocation using data of Chinese A-share listed companies from 2007 to 2023. The research findings show:

(1) Digital transformation exerts a significant overall enabling effect on innovation performance. And this promotional effect is pronounced only in large-scale enterprises. Constrained by resource limitations and barriers to digital technology adoption, small-scale businesses have yet to demonstrate a pronounced innovation-enabling effect from digital transformation. Both state-owned and non-state-owned enterprises can achieve enhanced innovation performance through digital transformation.

(2) Digital transformation indirectly affects enterprises' innovation performance by optimizing the allocation of capital resources, enhancing the allocation of knowledge resources, improving the allocation of labor resources, and optimizing the

allocation of technological resources.

(3) The impact of digital transformation on innovation performance varies significantly. Digital transformation has a significant positive impact on independent innovation and collaborative innovation. Compared with strategic innovation, digital transformation has a more significant promoting effect on substantive innovation.

(4) Digital transformation can enhance the quality of innovation. Digital transformation has an impact on large-scale enterprises, but has no significant impact on small-scale enterprises. It has significant impacts on both state-owned enterprises and non-state-owned enterprises' innovation quality.

## 6.2 Recommendations

For enterprises, firstly, it is necessary to strengthen the awareness of the digital transformation strategy and place it at the core of the strategy. Different strategies should be adopted based on the differences in enterprise scale. Large-scale enterprises should deepen digital application to tap into innovation potential, while small-scale enterprises should start from key business processes to promote digitalization to enhance operational efficiency and lay the foundation for innovation. Secondly, optimize the resource allocation system. Reasonably allocate capital, knowledge, and labor resources according to the transformation needs. For example, increase investment in digital research and development, establish a knowledge sharing platform, and conduct digital training for employees. Thirdly, enhance the awareness of innovation quality orientation and clarify the innovation goals. Build a complete evaluation system to assess innovation outcomes from multiple dimensions, guiding innovation activities towards high-quality development.

For the government, firstly, introduce tax incentives and financial subsidy policies, establish a special fund for digital transformation, and focus on supporting the digital transformation of small-scale enterprises and traditional industries, alleviating their financial pressure for digital transformation. Secondly, strengthen the construction of digital infrastructure, enhance the development of 5G, Internet of Things, cloud computing, etc., expand network coverage, improve quality, reduce enterprise operating costs, and create a fair transformation environment. Thirdly,

build a platform for industry-university-research cooperation to promote digital technology research and development cooperation and knowledge transfer, encourage industry organizations to hold exchange activities, share experience cases, promote enterprise cooperation and innovation, and build a favorable innovation ecosystem.

### 6.3 Research Prospects

Although this study has yielded specific findings, there is still room for improvement.

This study only selected data from Chinese A-share listed companies, which leads to sample limitations. Subsequent research may expand the sample to include non-listed companies, small and medium-sized enterprises, and characteristic enterprises across different industries, thereby covering a broader range of enterprises and enhancing the generalizability of the research conclusions.

The time span of this study is limited. Future research can establish a long-term follow-up mechanism to continuously observe the process of enterprise digital transformation and analyze the dynamic changes in the impact of digital transformation on innovation performance at different stages, thereby providing enterprises with a more timely and forward-looking decision-making basis.

Further explore the in-depth mechanisms through which digital transformation affects enterprise innovation performance. For example, investigate how digital transformation indirectly affects innovation performance through corporate culture reform, organizational structure adjustment, and other paths.

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## Data Availability：

The raw and cleaned panel data used in this study, together with variable definition documents, data processing rules, and Stata statistical codes, are provided as supplementary materials accompanying this article. All data and codes are publicly available for the purpose of peer review and replication. No restrictions apply to the access of these research materials.

## ETHICAL APPROVAL :

This article does not contain any studies with human participants performed by any of the authors.

## INFORMED CONSENT:

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