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# Research on the influence mechanism and effect of digital transformation on the high-quality development of textile industry

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**SUMMARY:** *Taking the balanced panel data of 30 provinces in China from 2012 to 2023 as samples, a comprehensive evaluation system of high-quality development and digital transformation of the textile industry is constructed. The two-way fixed effects, instrumental variables, threshold regression, mechanism test and adjustment effect model are used to systematically investigate the influence effect and mechanism of digital transformation on high-quality development of the textile industry. The results show that digital transformation significantly promotes the high-quality development of the textile industry, the benchmark regression coefficient is 0.2013, and the coefficient after endogenous treatment is 0.4020. The effect is more significant in the eastern region and regions with high informatization, high labor size and high economic development level. The threshold value of digital transformation is 0.1773, and the threshold value of financial development is 5.4656, indicating that digital empowerment has stage and conditional characteristics. Both technological innovation and industrial structure upgrading constitute effective transmission paths, and the role of technological innovation is stronger. Environmental regulation and government support can further strengthen the promotion effect of digital transformation. The research results provide an empirical basis for the collaborative upgrading of digital, intelligent and green textile industry.*

***KEYWORDS:*** *Digital transformation; Textile industry; High-quality development; Technological innovation*

## 1 Introduction

Textile industry is not only an important basic industry of national economy, but also a key link in the construction of green manufacturing and modern industrial system. With the continuous promotion of green and low-carbon transformation, the accelerated reconstruction of the division of labor of the global industrial chain and the gradual weakening of the cost advantage of traditional factors, the textile industry has become an inevitable trend from scale expansion to quality improvement. In this context, digital transformation is transforming from an auxiliary tool to a core force that reshapes industrial organization, production mode and value creation logic. Xu et al. (2023) found that digital transformation can improve the sustainable performance of manufacturing enterprises through ecological innovation [1]. Yang et al. (2023) pointed out that digital transformation can promote low-carbon technology innovation by means of dynamic capabilities [2]. Lin et al. (2025) show that digital transformation of traditional manufacturing enterprises and environmental responsibility

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strengthening have a synergistic relationship [13]. According to the research of Zhou and Shao (2025), the linkage of digital transformation and manufacturing service will further affect the carbon emission performance of enterprises [14]. It can be seen that digital transformation has become an important realization path for the textile industry to improve quality and efficiency, green upgrading and cultivate new quality productivity.

From the technical basis, big data, artificial intelligence, industrial Internet of things, industrial Internet and platform systems are accelerating the embedding into the textile production and supply chain operation process. Hamann-Lohmer et al. (2023) pointed out that digital transformation will reshape the collaborative relationship and information interaction mechanism in the manufacturing network [3]. Che et al. (2023) found that digital transformation can improve product quality through organizational transparency [5]. Ghafoori et al. (2024) show that data-driven digital transformation is inseparable from the support of organizational culture and data governance capabilities [6]. Belhadi et al. (2024) believe that data-driven transformation contributes to carbon transparency and carbon neutrality of supply chain [7]. Franco et al. (2024) and Song et al. (2024) pointed out from the perspectives of resource orchestration and digital supply chain, respectively, that digital technology can enhance supply chain integration and reduce the risk of disruption under uncertain environment [10, 11]. Compagnucci et al. (2025) emphasized from the perspective of platform research that the digital transformation of manufacturing increasingly depends on the support of B2B platforms and collaborative networks [16]. At the same time, Rocha et al. (2024) studied the composition of digital transformation readiness of large manufacturing enterprises [17], Hansen et al. (2025) pointed out that the digital promotion of small and medium-sized enterprises is still restricted by organizational, resource and path obstacles [18]. Hassan et al. (2025) and De Felice et al. (2025) further show that digital technology, Internet of things and circular supply chain model have begun to play a key role in the green transformation of the textile industry [19, 20]. This is also in line with the technical observations in the paper regarding the Industrial Internet of Things, textile dedicated robots, and blockchain and industrial Internet to improve supply chain transparency and collaboration.

Existing studies have discussed the economic consequences of digital transformation from different dimensions, but there is still room for further expansion. Dabić et al. (2023) studied the impact of digital transformation on new product development performance from the perspective of collaborative allocation of open innovation and absorptive capacity [4]. Wu et al. (2024) found that different enterprise sizes, product innovation capabilities and production types can significantly affect the effect of manufacturing digital transformation [8]. Merin-Rodriganez et al. (2024) pointed out that business model innovation plays a mediating role between digital transformation and enterprise performance [9]. Xu et al. (2024) show that digital transformation can enhance enterprise resilience [12]; Xu et al. (2025) further revealed the conditional mechanism of digital transformation to promote technological innovation performance [15]. In general, the existing literature focuses more on the innovation performance, resilience improvement or platform governance at the enterprise level, and still pays insufficient attention to the high-quality development effect of the textile industry, a typical traditional manufacturing industry, at the meso industry level. It is not enough to reveal the difference in the role of regional differences, informatization foundation, labor force scale and economic development level under heterogeneous conditions. There is also a lack of unified identification of the transmission relationship and boundary effect among technological innovation, industrial structure upgrading, environmental regulation and government support.

Based on this, this paper focuses on the main line of "digital transformation - technology empowerment - high-quality development effect", combines the provincial panel data from 2012 to 2023, and systematically identifies the direct impact, heterogeneity differences, nonlinear characteristics and mechanism paths of digital transformation on the high-quality development of the textile industry. In terms of structure, this paper firstly analyzes the mechanism of digital transformation to promote the high-quality development of the textile industry, then constructs the index system and measurement model, and further carries out empirical analysis from the levels of benchmark regression, endogenism, robustness, threshold effect, mechanism test and adjustment effect. Finally, it puts forward the policy enlightenment for the collaborative upgrading of digital, intelligent and green textile industry.

# 2 Analysis of the mechanism of digital transformation to promote the high-quality development of textile industry

## 2.1 The overall logic of digital transformation to promote the high-quality development of textile industry

The core of digital transformation to promote the high-quality development of the textile industry does not lie in the replacement of traditional operations by a single technical tool, but in the reconstruction of the operation logic of production decision-making, equipment control, resource allocation and industrial collaboration with data elements as the link. Specifically, at the data-driven decision-making level, enterprises rely on big data, cloud computing and intelligent analysis systems to collect and dynamically identify order demand, raw material consumption, process parameters, quality fluctuations and energy consumption emissions in real time, so as to improve the accuracy of business judgment, process optimization and market response. At the control level of equipment networking, the industrial Internet of Things connects key equipment such as spinning, weaving, printing and dyeing and finishing to a unified platform to realize state perception, remote monitoring, fault early warning and process linkage control. With intelligent robots and automatic execution units, production continuity and product consistency can be significantly enhanced. At the level of resource allocation optimization, the digital system can coordinate the scheduling of raw materials, energy, labor, equipment and logistics, reduce ineffective consumption and process redundancy, and promote efficiency improvement and green transformation. At the level of industrial collaborative innovation, industrial Internet, blockchain and platform system connect research and development, procurement, manufacturing, warehousing, sales and other links, and enhance information transparency, supply chain collaboration and innovation diffusion ability. Its overall function logic is shown in Figure 1. Digital transformation thus promotes the evolution of the textile industry to the direction of high efficiency, high added value, green and synergy.

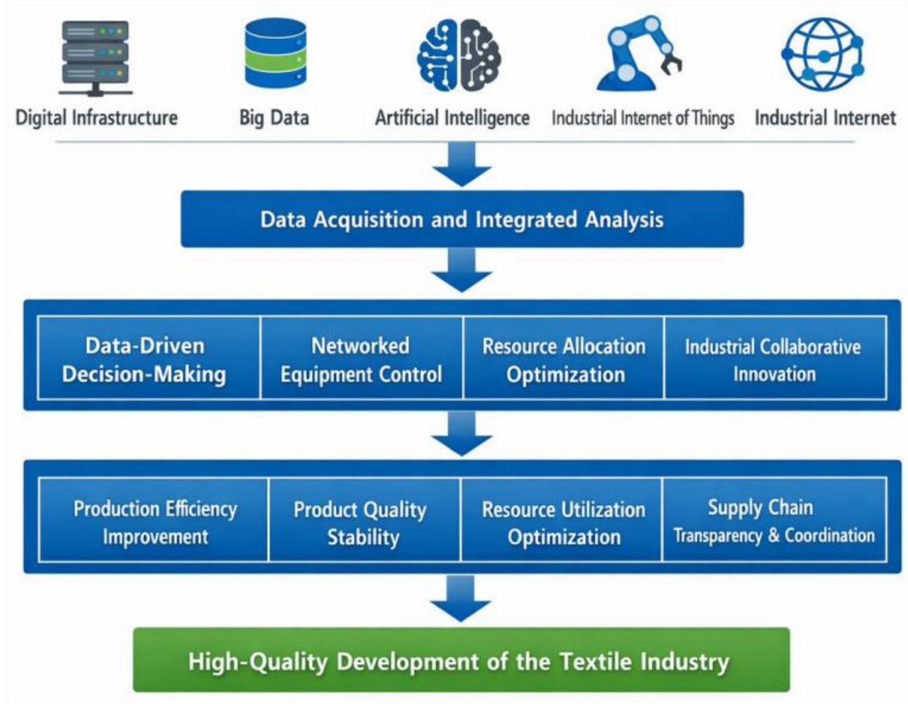


*Figure 1: The overall logic of digital transformation to promote high-quality development of the textile industry*

## 2.2 Empowering paths for embedding computer technology into production systems

Computer technology embedded in textile production system is not a simple digital superposition of existing processes, but through the reconstruction of five levels of perception, connection, analysis, control and collaboration, which promotes a systematic change in the operation mode of spinning, weaving, printing and dyeing, logistics and supply chain. In the process of spinning and weaving, the big data platform aggregates and analyzes the order structure, raw material batch, equipment speed, tension change and yield in real time, which provides a basis for production scheduling optimization, process parameter adjustment and abnormal identification. Artificial intelligence algorithm is used to further predict the breakage rate, defect distribution and equipment fluctuation, so as to improve production continuity and quality stability. In the printing and dyeing link, the industrial Internet of things connects the dyeing and finishing equipment, sensors and control terminals to a unified network to realize online monitoring and closed-loop adjustment of parameters such as temperature, humidity, flow rate, color difference and energy consumption. With intelligent equipment, the manual intervention error can be reduced and the process consistency can be enhanced. In the logistics and warehousing link, industrial Internet and intelligent scheduling system can link raw material warehousing, work-in-process circulation, finished product distribution and order delivery, shorten turnaround time and improve response speed. At the supply chain collaboration level, blockchain and platform system connect procurement, production, warehousing, transportation and sales data, and enhance quality traceability, information transparency and collaborative supporting capabilities.

## 2.3 The transmission mechanism of technological innovation and industrial structure upgrading

The deep role of digital transformation in the high-quality development of the textile industry is mainly carried out along the two paths of technological innovation and industrial structure upgrading. First, digital technology continues to drive process innovation, equipment upgrading and high-end product research and development by embedding it into R&D, production and quality control processes. Big data, cloud computing and artificial intelligence can carry out high-frequency identification and intelligent analysis of order characteristics, process parameters, energy consumption level and quality defects, and provide data support for new process test, parameter optimization and anomaly correction. At the same time, the linkage application of digital system and intelligent equipment can promote the upgrading of textile equipment from traditional mechanical control to CNC, intelligent and flexible direction, thereby improving production accuracy, stability and automation level. On this basis, digital technology can also promote the development of smart textiles, functional new materials and differentiated products, and enhance the added value of products and market competitiveness. Secondly, by changing the way of resource flow and the structure of value creation, digital transformation promotes the extension of the textile industry from pure manufacturing to high added value, service and personalized customization. The penetration of digital technology has made the collaboration between cotton spinning, chemical fiber, printing and dyeing, clothing and other sub-links closer, and the allocation of resources has changed from extensive dispersion to accurate matching. At the same time, new models such as digital design, flexible manufacturing, brand operation, online collaboration and on-demand customization continue to develop, promoting the industry to evolve from standardized production to "manufacturing + service" integration. Therefore, the digital transformation not only enhances the technology density of the textile industry, but also promotes the extension of its value chain position from low-end processing to high-end links such as R & D design, brand service and personalized supply.

## 2.4 The influence mechanism of financial conditions, environmental regulation and government support

Whether digital transformation can form sustainable empowerment in the textile industry depends not only on the internal technical foundation of the enterprise, but also on the joint influence of external factors such as financial conditions, environmental regulations and government support. The level of financial development is directly related to the ability of enterprises to implement digital transformation and technology adoption. When promoting industrial Internet access, intelligent equipment update, industrial software deployment, data platform construction and supply chain system collaboration, the textile industry usually faces the realistic constraints of high initial investment, long construction cycle and lagging revenue recovery. If the financial supply is insufficient, the financing cost is high or the risk sharing mechanism is not perfect, it is difficult for enterprises, especially small and medium-sized enterprises, to continue to promote the transformation of intelligent manufacturing, and it is difficult for digital technology to be extended from local application to system integration. In contrast, a higher level of financial support can improve the availability of funds and enhance the investment ability of enterprises in big data, artificial intelligence, industrial Internet of things and platform systems, so as to improve the depth of digital diffusion and application intensity. At the same time, through energy consumption constraints, emission standards and green production requirements, environmental regulations force enterprises to embed digital monitoring, intelligent control and clean technology into key links such as spinning, weaving, printing and dyeing, and promote the collaborative upgrading of green and intelligent. Government support, through technical subsidies, tax incentives, special funds and demonstration project construction, reduces the threshold of enterprise digital transformation, mitigates trial and error costs and transformation risks, and accelerates the diffusion and application of advanced technologies in all links of the industrial chain. As a result, financial conditions determine the technology investment capacity, environmental regulations shape the pressure of green upgrading, and government support strengthens technology diffusion and system implementation. The function logic is shown in Figure 2.

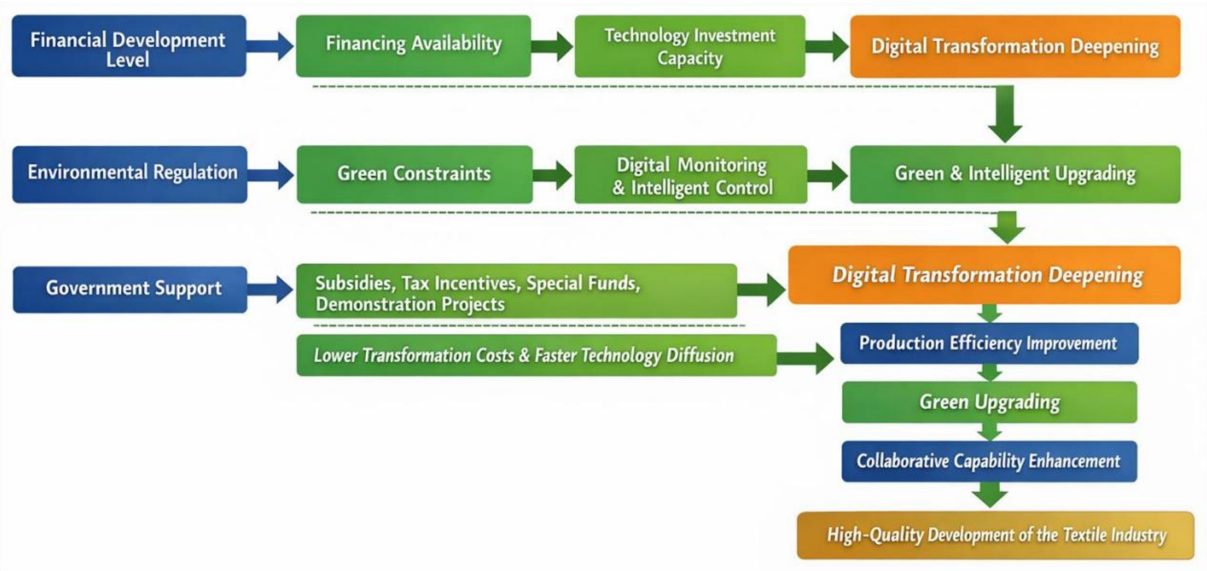


*Figure 2: The role of financial conditions, environmental regulations and government support in enabling high-quality development of the textile industry through digital transformation*

# 3 Research design

## 3.1 Model setting

### 3.1.1 Baseline regression model

In order to identify the direct impact of digital transformation on the high-quality development of the textile industry, this paper constructs a two-way fixed effect model for benchmark estimation. The inter-provincial textile industry has strong differences in industrial base, resource endowment, digital infrastructure, technology absorption capacity and institutional environment. Such differences are usually relatively stable, and if not controlled, it is easy to interfere with the identification of the net effect of digital transformation. At the same time, macroeconomic fluctuations, industrial policy adjustment, digital technology diffusion and green transformation process will have a common impact on all regions during the study period, so it is necessary to include regional fixed effects and year fixed effects at the same time to improve the reliability of parameter estimation. Combined with the research theme of this paper, digital transformation is not only reflected in the general economic changes, but also reflected in the comprehensive embedding degree of computer technologies such as big data analysis, industrial Internet access, industrial Internet of things perception, software system deployment and intelligent equipment upgrading in the textile industry. Based on this, the baseline regression model is set as follows.

$$TIQ_{it} = \alpha_0 + \alpha_1 DT_{it} + \alpha_2 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Among them, $TIQ_{it}$ represents the high-quality development level of the textile industry in the ith province in the t year, $DT_{it}$ represents the level of digital transformation, $X_{it}$ is the control variable matrix, mainly including the level of urbanization, the intensity of scientific research investment, the level of human capital and the degree of opening to the outside world. Let $\mu_i$ denote region fixed effects, $\lambda_t$ denote year fixed effects, and $\varepsilon_{it}$ be a random disturbance term. The core coefficient α1 is used to describe the influence direction and effect strength of digital transformation on the high-quality development of the textile industry. If $\alpha_1$ is significantly positive, it indicates that the diffusion of computer technology represented by data-driven decision-making, equipment networked control, intelligent manufacturing and platform collaboration can effectively improve the resource allocation efficiency, product quality stability, innovation output capacity and green development level of the textile industry. This model is used later in the empirical identification of direct effects of digital transformation.

### 3.1.2 Threshold regression model

The impact of digital transformation on the high-quality development of the textile industry does not necessarily change linearly. For the textile industry, digital technology embedding often has obvious stage characteristics: When digital infrastructure, industrial Internet access ability, data acquisition density and software system deployment level are low, computer technologies such as big data analysis, industrial Internet of things perception, intelligent scheduling and equipment collaborative control can only stay at the local application level, and their driving effect on production efficiency, quality stability and resource allocation optimization is relatively limited. When the level of digitalization reaches a certain stage, the flow of data elements, equipment interconnection and platform synergy effects are gradually released, and the empowering path of digital transformation will shift from single-point application to system integration. At the same time, the level of financial development will also affect the ability of enterprises to invest in intelligent equipment, industrial software, platform systems and green digital transformation, and then change the strength of digital transformation. Based on this, this paper uses the panel threshold regression model to identify the threshold of digital transformation itself and the threshold of financial development level. The model is set as follows:

$$\mathrm{TIQ_{it}} = \beta_0 + \beta_1 \mathrm{DT_{it}} \mathrm{I}(\mathrm{q_{it}} \leq \gamma) + \beta_2 \mathrm{DT_{it}} \mathrm{I}(\mathrm{q_{it}} > \gamma) + \beta_3 \mathrm{X_{it}} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

Here, $\mathrm{TIQ_{it}}$ represents the high-quality development level of the textile industry in the ith province in the t year, $\mathrm{DT_{it}}$ represents the level of digital transformation, $\mathrm{X_{it}}$ is the control variable matrix, $\mathrm{q_{it}}$ is the threshold variable, γ is the threshold value to be estimated, I(·) is the indicative function, $\mu_i$ and $\lambda_t$ represent the region fixed effect and year fixed effect, respectively. Let εit be the random disturbance term. When qit takes the level of digital transformation, it is used to identify the threshold effect formed by the development stage of digital transformation itself. When qit takes the level of financial development, it is used to test the impact of changes in external financing conditions on the intensity of digitization empowerment. The model can describe the marginal effect differences of digital transformation under different development intervals and financial support conditions, so as to identify its nonlinear influence characteristics.

### 3.1.3 Mediation effect model

In order to identify the internal transmission path of digital transformation affecting the high-quality development of the textile industry, this paper constructs an intermediary effect model, and conducts a quantitative test on the two mechanisms of technological innovation and industrial structure upgrading. The role of digital transformation in the textile industry is not limited to directly improving efficiency and quality, but also promoting process optimization, intelligent equipment transformation and high-end product research and development through the deep embedding of computer technologies such as big data analysis, artificial intelligence assisted decision-making, industrial Internet collaboration and intelligent equipment upgrading. And further drive the industrial structure from traditional processing and manufacturing to high value-added, service and personalized customization direction extension. Based on this, technological innovation and industrial structure upgrading are set as mechanism variables, and the impact of digital transformation on mechanism variables is investigated respectively, as well as the impact of digital transformation on the high-quality development of textile industry after the inclusion of mechanism variables. The model is set as follows:

$$M_{it} = \delta_0 + \delta_1 DT_{it} + \delta_2 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \tag{3}$$

$$TIQ_{it} = \theta_0 + \theta_1 DT_{it} + \theta_2 M_{it} + \theta_3 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \tag{4}$$

Among them, $M_{it}$ represents the mechanism variable, and takes technological innovation and industrial structure upgrading respectively in the specific estimation. $DT_{it}$ denotes the level of digital transformation; $X_{it}$ is the control variable matrix; Let $\mu_i$ and $\lambda_t$ denote the region and year fixed effects, respectively, while $\varepsilon_{it}$ is a random disturbance term. The first equation is used to test the influence of digital transformation on mechanism variables, and the second equation is used to test the direct effect of digital transformation and the influence of mechanism variables on the high-quality development of textile industry after controlling mechanism variables. If $\delta_1$ and $\theta_2$ are significant at the same time, it means that the digital transformation can be transmitted to the high-quality development of the textile industry through the corresponding mechanism variables. The model can reveal the internal mechanism of digital transformation to promote the high-quality development of textile industry from the two dimensions of technological innovation strengthening and industrial structure optimization.

### 3.1.4 Regulation effect model

In order to identify the influence of external conditions on the strength of digital transformation, this paper constructs a regulatory effect model, and integrates environmental regulation and government support into a unified analysis framework. The implementation effect of the digital transformation of the textile industry depends not only on the internal technical foundation and resource allocation ability of the enterprise, but also on the joint influence of institutional constraints and policy environment. Through emission constraints, energy consumption control and green governance requirements, environmental regulations encourage enterprises to embed digital monitoring, intelligent control and clean production systems into key links such as spinning, weaving, printing and dyeing, so as to enhance the role of digital transformation in promoting resource utilization efficiency, green production capacity and high-quality industrial development. Government support is mainly through technical subsidies, financial support, tax incentives and digital demonstration project construction, to reduce the initial investment pressure and transformation risk of enterprises in industrial Internet access, industrial Internet of things deployment, intelligent equipment update and platform system construction, and then strengthen the diffusion of digital technology and system integration effect. Based on this, this paper introduces the interaction term of digital transformation and adjustment variable on the basis of the benchmark model to test the difference of digital transformation affecting the high-quality development of textile industry under different external conditions. The model is set as follows:

$$TIQ_{it} = \rho_0 + \rho_1 DT_{it} + \rho_2 ER_{it} + \rho_3 (DT_{it} \times ER_{it}) + \rho_4 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (5)$$

$$TIQ_{it} = \eta_0 + \eta_1 DT_{it} + \eta_2 GS_{it} + \eta_3 (DT_{it} \times GS_{it}) + \eta_4 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (6)$$

Among them, $ER_{it}$ represents the level of environmental regulation, $GS_{it}$ represents the strength of government support, $DT_{it} \times ER_{it}$ and $DT_{it} \times GS_{it}$ represent the interaction terms between digital transformation and environmental regulation and government support respectively, and the meanings of the remaining variables are consistent with the previous paper. In the model, $\rho_3$ is used to characterize the regulatory effect of environmental regulation on the impact of digital transformation on the high-quality development of the textile industry, and $\eta_3$ is used to characterize the regulatory effect of government support. If the coefficient of the interaction term is significantly positive, it means that the corresponding external conditions can strengthen the empowering effect of digital transformation. If the coefficient of the interaction term is insignificant or significantly negative, it indicates that this external condition fails to effectively amplify the promoting effect of digital transformation. Through this model, the external conditions and mechanisms of digital transformation to promote the high-quality development of the textile industry can be identified from the two dimensions of green system constraints and policy support environment.

## 3.2 Variable definition and index system construction

### 3.2.1 Explained variable: high-quality development level of textile industry

The high-quality development level of the textile industry is used to describe the comprehensive output state after digital transformation. Considering that the textile industry has the characteristics of process manufacturing, equipment dependence, energy consumption constraint and product iteration, a single index is difficult to reflect the true upgrading degree. Therefore, this paper constructs a multi-dimensional comprehensive evaluation system, and uses the entropy method for objective weighting and index synthesis. Specifically, the dimension of economic benefit reflects the profitability and operation quality of the industry, the dimension of resource allocation efficiency describes the matching state of capital occupation and labor output, the dimension of innovation capability measures the intensity of R&D investment and the transformation level of new products, and the dimension of green development identifies the input status of energy consumption, wastewater discharge and environmental protection governance. The system can simultaneously characterize the change characteristics of the textile industry in terms of efficiency improvement, technological progress, green constraints and value creation, and better adapt to the connotation of high-quality development under the background of digital, intelligent and green collaborative evolution. The relevant index system is shown in Table 1.

*Table 1: Index system of high-quality development level of textile industry*

| Primary Indicator | Secondary Indicator | Measurement Method | Attribute | Weight |
|---|---|---|---|---|
| Economic Performance | Main Business Profit Margin | Operating Profit / Main Business Revenue | Positive | 0.007 |
| | Profitability | Total Profit / Main Business Revenue | Positive | 0.005 |
| Resource Allocation Efficiency | Asset-Liability Ratio | Total Liabilities / Total Assets | Negative | 0.001 |
| | Labor Productivity | Industrial Added Value / Average Number of Employees | Positive | 0.326 |
| Innovation Capability | Innovation Input | R&D Expenditure / Main Business Revenue | Positive | 0.262 |
| | Innovation Output | New Product Sales Revenue | Positive | 0.249 |
| | Energy Use Intensity | Total Energy Consumption / Industrial Added Value | Negative | 0.006 |
| Green Development | Wastewater Emission Intensity | Total Wastewater Emissions / Industrial Added Value | Negative | 0.004 |
| | Environmental Protection Investment | Completed Investment in Industrial Pollution Control | Positive | 0.140 |

### 3.2.2 Core Explanatory variable: Level of digital transformation

The level of digital transformation is used to describe the embedding strength and system diffusion degree of computer technology in the textile industry. Considering that digital transformation involves network connection, data processing, platform application and innovation support, this paper constructs a comprehensive evaluation system from three dimensions of digital infrastructure, digital application level, digital finance and innovation environment, and uses the entropy method to measure the index. In the digital infrastructure dimension, long-distance fiber optic cable, broadband port, broadband user and other indicators are selected to characterize data transmission and equipment interconnection capabilities. In the dimension of digital application level, indicators such as e-commerce, corporate websites, software product revenue and employment in software information service industry are selected to reflect platform operation, software deployment and information service support capabilities. The digital finance and innovation environment dimension is used to characterize the digital financing support and technology diffusion environment. The relevant index system is shown in Table 2.

*Table 2: Indicator system of digital transformation level*

| Primary Indicator | Secondary Indicator | Tertiary Indicator | Attribute | Weight |
|---|---|---|---|---|
| Digital Infrastructure | Network Infrastructure | Length of Long-Distance Optical Cable Lines | Positive | 0.040 |
| | | Number of Internet Broadband Access Ports | Positive | 0.061 |
| | | Number of Internet Broadband Access Users | Positive | 0.065 |
| | | Capacity of Mobile Telephone Exchanges | Positive | 0.051 |
| | Communication Service Penetration | Mobile Telephone Penetration Rate | Positive | 0.025 |
| | | Per Capita Total Telecommunication Services | Positive | 0.132 |
| Digital Application Level | E-commerce Development Level | E-commerce Sales | Positive | 0.057 |
| | | E-commerce Purchases | Positive | 0.062 |
| | | Number of Enterprises Engaged in E-commerce Transactions | Positive | 0.109 |
| | | Number of Websites per 100 Enterprises | Positive | 0.013 |
| | Digital Software Application | Software Product Revenue | Positive | 0.190 |
| | | Number of Employees in Software and Information Technology Services | Positive | 0.123 |
| Digital Finance and Innovation Environment | | Breadth of Digital Financial Coverage | Positive | 0.028 |
| | Digital Financial Development Environment | Depth of Digital Financial Usage | Positive | 0.023 |
| | | Degree of Digitalization of Digital Finance | Positive | 0.020 |

### 3.2.3 Mechanism variables: technological innovation and industrial structure upgrading

In order to identify the internal transmission process of digital transformation affecting the high-quality development of the textile industry, this paper sets technological innovation and industrial structure upgrading as mechanism variables. Technological innovation mainly reflects the capability change of industry in process improvement, equipment upgrading and new product development after digital technology embedding. Considering the continuous availability of segmented innovation data of the textile industry at the provincial level, this paper uses the number of authorized invention patent applications to represent the level of technological innovation, so as to characterize the regional innovation output capacity and its supporting role in the technological progress of the textile industry. The upgrading of industrial structure mainly reflects the evolution of textile industry from traditional processing and manufacturing to the direction of high added value, high technology content and service. This paper uses the ratio of the added value of the tertiary industry to the added value of the secondary industry to measure, in order to identify the optimization trend of resource allocation and value creation structure.

#### 3.2.4 Threshold variables, adjustment variables and control variables

In order to identify the internal transmission process of digital transformation affecting the high-quality development of the textile industry, this paper sets technological innovation and industrial structure upgrading as mechanism variables. Technological innovation mainly reflects the capability change of industry in process improvement, equipment upgrading and new product development after digital technology embedding. Considering the continuous availability of segmented innovation data of the textile industry at the provincial level, this paper uses the number of authorized invention patent applications to represent the level of technological innovation, so as to characterize the regional innovation output capacity and its supporting role in the technological progress of the textile industry. The upgrading of industrial structure mainly reflects the evolution of textile industry from traditional processing and manufacturing to the direction of high added value, high technology content and service. This paper uses the ratio of the added value of the tertiary industry to the added value of the secondary industry to measure, in order to identify the optimization trend of resource allocation and value creation structure.

### 3.3 Data source and preprocessing

The sample data mainly come from China Statistical Yearbook, China Industrial Statistical Yearbook, China Science and Technology Statistical Yearbook, Peking University Digital Financial Inclusion Index, and statistical yearbooks and statistical bulletins of various provinces. The above data can systematically cover the high-quality development, digital transformation, financial development, environmental regulation, government support and control variables of the textile industry, and meet the needs of multi-dimensional measurement and measurement identification in this paper.

In terms of data preprocessing, the linear interpolation method is used to fill in the missing values in individual years, so as to maintain the continuity of the time series and the integrity of the sample structure. For the two types of comprehensive indicators of high-quality development level and digital transformation level of the textile industry, the entropy method is used to perform objective weighting and index measurement, so as to reduce the deviation caused by subjective weighting and improve the stability and comparability of the index synthesis results. In the process of measurement estimation, Stata 16.0 software is used to complete the parameter estimation and robustness test of two-way fixed effect, threshold regression, mediation effect and adjustment effect models, so as to ensure the standardization of the empirical analysis process and the reliability of the result identification.

## 4 Empirical results and mechanism testing

### 4.1 Analysis of benchmark regression results

To investigate the direct impact of digital transformation on the high-quality development of the textile industry, this paper uses a two-way fixed effects model to conduct benchmark regression, and the results are shown in Table 3. Column (1) only includes the core explanatory variable digital transformation, and the regression coefficient is 0.3836, which is significant at the 1% level, indicating that there is a significant positive correlation between digital transformation and high-quality development of the textile industry. In column (2), after adding control variables such as urbanization level, scientific research investment intensity, human capital level and degree of opening to the outside world, the coefficient of digital transformation is 0.2013, which is still significant at the 1% level, indicating that after controlling regional heterogeneity, time effect and other influencing factors, the promotion effect of digital transformation on the high-quality development of the textile industry is still stable.

*Table 3: Baseline regression results*

| variables | (1) | (2) |
|---|---|---|
| | TIQ | TIQ |
| DT | 0.3836*** | 0.2013*** |
| | (0.0523) | (0.0662) |
| UR | | 0.2325 |
| | | (0.1703) |
| RD | | 0.8701 |
| | | (1.0229) |
| HC | | -3.9662*** |
| | | (1.1712) |
| OPEN | | -0.0002*** |
| | | (0.0000) |
| _cons | 0.0291*** | 0.0726 |
| | (0.0077) | (0.0793) |
| Fixed year | Yes | Yes |
| Individual fixation | Yes | Yes |
| N | 360 | 360 |
| $R^2$ | 0.445 | 0.494 |

Standard errors in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01

This result shows that the improvement of digital infrastructure, the deepening of digital application and the optimization of digital finance and innovation environment can improve the production efficiency, quality stability and resource allocation ability of the textile industry through computer technology embedding paths such as big data analysis, industrial Internet access, industrial Internet of things perception, software system deployment and intelligent equipment upgrading. And then promote the high-quality development of the industry. The benchmark regression results show that digital transformation has become an important driving force for the collaborative evolution of the textile industry from traditional extensive growth to efficiency improvement, innovation enhancement and green.

## 4.2 Test for endogeneity

Considering that there may be a bidirectional causal relationship between digital transformation and high-quality development of the textile industry, directly using the fixed effect model for estimation may still be affected by endogenous bias interference. In order to improve the reliability of the identification results, this paper uses the instrumental variable method for two-stage least squares estimation. Based on the existing research ideas, the interaction term between the number of telephone calls in 1984 and the number of Internet users in the previous year is selected as an instrumental variable to enhance the correlation between the instrumental variables and digital transformation. On this basis, a two-stage regression analysis is carried out.

*Table 4: Results of the endogeneity test*

| variables | (1) | (2) |
|---|---|---|
| | Stage 1 regression | Stage 2 regression |
| IV | 1.6558*** | |
| | (0.2529) | |
| DT | | 0.4020** |
| | | (0.1700) |
| UR | -0.1301 | 0.2892 |
| | (0.2325) | (0.4563) |
| RD | 5.7129*** | -0.5908 |
| | (1.5716) | (2.4370) |
| HC | -2.3630 | -3.0442 |
| | (1.4926) | (2.3719) |
| OPEN | -0.0001* | -0.0001 |
| | (0.0001) | (0.0001) |
| Kleibergen-Paap rk LM statistic | 7.263*** | |
| Kleibergen-Paap rk Wald F statistic | 42.868<br>(16.38) | |
| Fixed year | Yes | Yes |
| Individual fixation | Yes | Yes |
| N | 360 | 360 |
| $R^2$ | 0.969 | 0.479 |

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results are shown in Table 4, and the regression coefficient of the instrumental variables in the first stage is 1.6558 and significant at the 1% level, indicating that the selected instrumental variables have a strong correlation with digital transformation. At the same time, the Kleibergen-Paap rk LM statistic is 7.263, which is significant at the 1% level, indicating that the model does not have unidentifiable problems. The Kleibergen-Paap rk Wald F statistic is 42.868, which is significantly higher than the critical value of 16.38 corresponding to the 10% bias level, indicating that there is no weak instrumental variable problem. The second stage regression results show that after controlling for endogeneity, the regression coefficient of digital transformation is 0.4020, and it is significant at the 5% level. The sign of the coefficient is consistent with the baseline regression, and the value is higher than the estimated result in the baseline regression. The results show that after excluding the potential endogenous interference, the promotion effect of digital transformation on the high-quality development of the textile industry is still robust. In terms of technical implications, the embedded computer technologies such as industrial Internet access, data analysis capability enhancement, software system deployment and intelligent equipment upgrading do not only appear in tandem with industrial upgrading, but can have a relatively stable and significant role in promoting the high-quality development of the textile industry.

## 4.3 Robustness check

In order to test the stability of the benchmark regression results, this paper carries out the robustness test from five aspects: index replacement, extreme value treatment, sample interval adjustment, explanatory variable lag and extended control variable. The results are shown in Table 5.

*Table 5: Results of the robustness test*

| variables | (1) Replace X with the PCA index | (2) 1% tail reduction | (3) Samples after 2021 were excluded | (4) X lag one stage | (5) Adding control variables |
|---|---|---|---|---|---|
| DT | | | 0.2329*** | | 0.1608** |
| | | | (0.0510) | | (0.0667) |
| L.DT | | | | 0.1570** | |
| | | | | (0.0728) | |
| DT_pca | 0.0089* | | | | |
| | (0.0049) | | | | |
| DT_w | | 0.2132*** | | | |
| | | (0.0643) | | | |
| UR | 0.1914 | 0.2046 | 0.0813 | 0.2315 | 0.1223 |
| | (0.1710) | (0.1608) | (0.1385) | (0.1921) | (0.1703) |
| RD | 1.5117 | 1.0356 | 1.0941 | 1.4183 | 1.2071 |
| | (1.0142) | (0.9584) | (0.8070) | (1.0892) | (1.0049) |
| HC | -4.4773*** | -3.7597*** | -1.0965 | -4.8691*** | -3.5662*** |
| | (1.1632) | (1.1025) | (0.9452) | (1.3314) | (1.1582) |
| OPEN | -0.0002*** | -0.0001*** | -0.0001*** | -0.0002*** | -0.0001*** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| IT | | | | | 0.0054 |
| | | | | | (0.0137) |
| IND | | | | | -0.0404 |
| | | | | | (0.0664) |
| LAB | | | | | 0.1447*** |
| | | | | | (0.0353) |
| EG | | | | | -0.0598** |
| | | | | | (0.0284) |
| _cons | 0.1374* | 0.0776 | 0.0571 | 0.1094 | -0.4127 |
| | (0.0773) | (0.0751) | (0.0662) | (0.0913) | (0.3220) |
| Fixed year | Yes | Yes | Yes | Yes | Yes |
| Individual fixation | Yes | Yes | Yes | Yes | Yes |
| *N* | 360 | 360 | 270 | 330 | 360 |
| $R^2$ | 0.485 | 0.517 | 0.537 | 0.453 | 0.521 |

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In the test of replacing the core explanatory variables, the digital transformation index was reconstructed by principal component analysis with a regression coefficient of 0.0089 and significant at the 10% level. After bilateral 1% tail reduction for digital transformation, the regression coefficient is 0.2132, which is significant at the 1% level. After adjusting the sample period to 2012-2020, the coefficient of digital transformation is 0.2329, which is still significant at the 1% level. After the one-stage lag of digital transformation is included in the model, the coefficient of the lag term is 0.1570, which is significant at the 5% level. After further adding the control variables such as informatization level, industrialization level, labor level and economic development level, the coefficient of digital transformation is 0.1608, and it is significant at the 5% level.

The above test results show that under different measurement methods, sample processing methods and model setting conditions, the estimated coefficient of the digital transformation variable always maintains a significant positive characteristic, indicating that the benchmark regression conclusion has strong stability. Therefore, it can be concluded that the promotion effect of digital transformation on the high-quality development of textile industry is not caused by extreme value disturbance, sample interval change, dynamic lag influence or omission of control variables, and the relevant conclusions have good reliability.

## 4.4 Heterogeneity analysis

In order to further identify the difference in the role of digital transformation under different development conditions, regional heterogeneity and factor endowment heterogeneity are unified into the analysis framework, and the results are shown in Tables 6 and 7, respectively.

*Table 6: Results of the regional heterogeneity test*

| variables | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Western region | Central Region | Eastern region | Northeast China |
| DT | -0.2399 | -0.3598** | 0.5266*** | -0.8563 |
| | (0.2453) | (0.1571) | (0.0771) | (0.5347) |
| UR | -0.4684 | -0.1603 | 0.0440 | -2.6296*** |
| | (0.5515) | (0.4049) | (0.2340) | (0.8479) |
| RD | 0.3745 | 0.3845 | 2.1103* | 2.2102 |
| | (3.2977) | (1.6580) | (1.1474) | (3.0239) |
| HC | -3.1140 | -3.1043** | -3.7955* | 14.8445*** |
| | (2.1601) | (1.2597) | (2.2107) | (3.0718) |
| OPEN | -0.0003 | -0.0002 | -0.0001 | -0.0006*** |
| | (0.0002) | (0.0002) | (0.0001) | (0.0002) |
| _cons | 0.3949 | 0.2660 | 0.1187 | 1.3422** |
| | (0.2483) | (0.1740) | (0.1162) | (0.4814) |
| Fixed year | Yes | Yes | Yes | Yes |
| Individual fixation | Yes | Yes | Yes | Yes |
| $N$ | 132 | 72 | 120 | 36 |
| $R^2$ | 0.357 | 0.774 | 0.789 | 0.893 |

Standard errors in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01

*Table 7: Results of the heterogeneity analysis*

| | Information grouping | | Labour Force Division | | Economic Development Unit | |
|---|---|---|---|---|---|---|
| variables | (1) | (2) | (3) | (4) | (5) | (6) |
| | Low informatization | High informatization | Low labor force | High labor force | Low economy | High economy |
| DT | 0.0825 | 0.4249*** | -0.0799 | 0.4120*** | -0.1636 | 0.3097*** |
| | (0.1069) | (0.0974) | (0.1492) | (0.0536) | (0.1234) | (0.0555) |
| UR | 0.2818 | 0.1179 | -0.5196 | 0.2111 | 0.3279 | -0.8333*** |
| | (0.2716) | (0.2424) | (0.3238) | (0.1532) | (0.2927) | (0.1631) |
| RD | -0.4305 | -0.3179 | 1.2479 | 2.3582*** | 0.4239 | 4.7876*** |
| | (1.6472) | (1.2906) | (2.2717) | (0.7703) | (1.3773) | (1.0428) |
| HC | -3.3622* | -5.0274*** | -6.5065*** | -0.5892 | -2.1910 | 0.1844 |
| | (1.7231) | (1.6416) | (1.9454) | (1.0544) | (1.8019) | (1.0527) |
| OPEN | -0.0001 | -0.0001 | -0.0001* | -0.0001*** | -0.0001 | -0.0001** |
| | (0.0001) | (0.0001) | (0.0001) | (0.0000) | (0.0001) | (0.0000) |
| _cons | 0.0291 | 0.1382 | 0.5190*** | -0.0584 | -0.0386 | 0.4330*** |
| | (0.1172) | (0.1192) | (0.1539) | (0.0670) | (0.1370) | (0.0771) |
| Fixed year | Yes | Yes | Yes | Yes | Yes | Yes |
| Individual fixation | Yes | Yes | Yes | Yes | Yes | Yes |
| *N* | 180 | 180 | 180 | 180 | 180 | 180 |
| $R^2$ | 0.374 | 0.655 | 0.544 | 0.700 | 0.296 | 0.832 |

Standard errors in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01

The regional grouping results show that there are obvious spatial differences in the promotion effect of digital transformation on the high-quality development of the textile industry. The regression coefficient of the eastern region is 0.5266, and it is significant at the 1% level, indicating that the region can more fully release the empowering effect of digital technology by relying on relatively perfect digital infrastructure, strong data processing capability and relatively mature industrial ecology. The coefficient in the central region was -0.3598 and significant at the 5% level, indicating that digital investment has not yet been fully transformed into high-quality development performance in the stage of industrial undertaking, factor restructuring and transformation transition. The coefficients of western and northeastern regions did not pass the significance test, indicating that under the conditions of weak digital foundation, small industrial scale or insufficient technology penetration, the promotion role of digital transformation has not yet fully appeared.

After grouping by informatization level, labor size and median economic development level, the heterogeneous characteristics of digital transformation are further verified. The regression coefficients of high informatization level group, high labor force scale group and high economic development level group were 0.4249, 0.4120 and 0.3097, respectively, and all were significant at 1% level. The estimated results of the corresponding low level group are not significant, and some coefficients are negative. The results show that the release of digital transformation effect depends on certain technical foundation and development conditions. A higher level of informatization means stronger data transmission, platform access and technology absorption capacity, a larger labor force scale helps to form intelligent manufacturing and digital system application scenarios, and a higher level of economic development can provide more sufficient financial and market support for industrial Internet deployment, software system update and intelligent equipment transformation.

## 4.5 Threshold effect analysis

In order to identify the nonlinear impact of digital transformation on the high-quality development of the textile industry, this paper uses the panel threshold model to test the digital transformation level and financial development level as threshold variables respectively, and the results are shown in Tables 8 and 9.

*Table 8: Tests for the existence of threshold effects*

| Threshold Variable | Threshold Type | F-statistic | P-value | Bootstrap Replications | 10% Critical Value | 5% Critical Value | 1% Critical Value |
|---|---|---|---|---|---|---|---|
| Digital Transformation (DT) | Single Threshold | 20.24 | 0.0900 | 500 | 19.3205 | 26.9130 | 32.6430 |
| | Double Threshold | 8.71 | 0.7200 | 500 | 15.5209 | 18.7794 | 24.4864 |
| Financial Development Level (Fin) | Single Threshold | 20.60 | 0.0967 | 500 | 20.0351 | 24.3063 | 30.4737 |
| | Double Threshold | 9.48 | 0.3167 | 500 | 19.1935 | 26.8009 | 42.8203 |

Table 8 shows that whether digital transformation or financial development level is taken as the threshold variable, the single threshold effect is significant at the 10% level, while the double threshold effect is not significant, indicating that the impact of digital transformation on the high-quality development of the textile industry has a significant single threshold feature. Specifically, when the digital transformation level was used as the threshold variable, the F-statistic was 20.24 and the P-value was 0.0900. When the financial development level is taken as the threshold variable, the F-statistic is 20.60, and the P-value is 0.0967, which all pass the single threshold test.

*Table 9: Regression results for the threshold model*

| variables | (1) | (2) |
|---|---|---|
| Control variable | Yes | Yes |
| DT (DT ≤ 0.1773) | 0.7647*** | |
| | (0.1209) | |
| DT (DT > 0.1773) | 0.5377*** | |
| | (0.0779) | |
| DT (Fin ≤ 5.4656) | | 0.3247*** |
| | | (0.0983) |
| DT (Fin > 5.4656) | | 0.4521*** |
| | | (0.0697) |
| _cons | -0.0345 | -0.0625* |
| | (0.0367) | (0.0369) |
| N | 360 | 360 |
| $R^2$ | 0.455 | 0.453 |

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9 further reveals the specific performance of the threshold effect. When the digital transformation level was used as the threshold variable, the threshold value was 0.1773. When the digital transformation level is lower than the threshold value, the regression coefficient is 0.7647, and it is significant at the 1% level. When the digital transformation level crosses the threshold value, the regression coefficient drops to 0.5377, which is still significant at the 1%

level. The results show that the promotion effect of digital transformation on the high-quality development of the textile industry has an obvious stage, and with the improvement of digital level, its marginal empowerment effect is decreasing. This means that in the initial stage of digital transformation, it is easier to bring efficiency improvement through infrastructure improvement, device networking and basic application deployment. After entering the stage of deep integration, the complexity of technology integration, organizational restructuring and process optimization increases, and the marginal gain is relatively weakened.

When the financial development level is taken as the threshold variable, the threshold value is 5.4656; When the financial development level is lower than the threshold value, the regression coefficient of digital transformation is 0.3247, and it is significant at the 1% level. When the financial development level is higher than the threshold value, the digital transformation coefficient rises to 0.4521. The results show that the level of financial development can significantly affect the release degree of digital empowerment effect, and a higher level of financial support helps enterprises to expand their investment in industrial Internet access, industrial Internet of things deployment, software system update and intelligent equipment transformation, so as to enhance the role of digital transformation in promoting the high-quality development of the textile industry. In general, the threshold effect analysis shows that digital transformation empowering the high-quality development of the textile industry has obvious stage and conditional characteristics.

## 4.6 Mechanism test: technology innovation and industrial structure upgrade

In order to further identify the internal path of digital transformation to promote the high-quality development of the textile industry, this paper unified and adjusted the original intermediary effect analysis to the mechanism test, and carried out the analysis from the technological innovation path and the industrial structure upgrading path, and the results are shown in Table 10 and Table 11.

*Table 10: Mechanism test: technological innovation channels*

| variables | (1) | (2) |
|---|---|---|
| DT | 1.1946*** | 0.1059* |
| | (0.4271) | (0.0576) |
| UR | 2.9484*** | -0.0031 |
| | (1.0982) | (0.1479) |
| RD | 15.8700** | -0.3979 |
| | (6.5966) | (0.8861) |
| HC | -11.4583 | -3.0506*** |
| | (7.5529) | (1.0091) |
| OPEN | 0.0000 | -0.0002*** |
| | (0.0003) | (0.0000) |
| lnTI | | 0.0799*** |
| | | (0.0075) |
| _cons | 6.0593*** | -0.4116*** |
| | (0.5114) | (0.0819) |
| Fixed year | Yes | Yes |
| Individual fixation | Yes | Yes |
| *N* | 360 | 360 |
| $R^2$ | 0.898 | 0.628 |

Standard errors in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01

In terms of technological innovation path, column (1) of Table 10 shows that the regression coefficient of digital transformation on technological innovation is 1.1946, which is significant at the 1% level, indicating that digital transformation significantly improves the level of regional technological innovation. Column (2) further shows that after including digital transformation and technological innovation at the same time, the regression coefficient of technological innovation on the high-quality development of textile industry is 0.0799 and significant at 1% level, and the direct effect coefficient of digital transformation is 0.1059 and significant at 10% level. Therefore, the mechanism effect of technological innovation path is 0.0954, accounting for 47.39% of the total effect. This result indicates that a considerable part of the promotion effect of digital transformation on the high-quality development of the textile industry is realized through technological innovation. The internal logic is that the embedded computer technologies such as big data analysis, industrial Internet access, software system deployment and intelligent equipment upgrading can improve the efficiency of research and development information acquisition, optimize the allocation of innovation resources, and enhance the ability of process innovation, product innovation and material innovation, thus promoting the evolution of the textile industry to the direction of technology-intensive and high added value.

*Table 11: Mechanism test: industrial structure upgrading channels*

| variables | (1) | (2) |
|---|---|---|
| DT | $0.2780^{***}$ | $0.1664^{**}$ |
| | (0.0575) | (0.0684) |
| UR | 0.0939 | 0.2207 |
| | (0.1479) | (0.1697) |
| RD | -0.0002 | 0.8701 |
| | (0.8885) | (1.0184) |
| HC | -1.2532 | $-3.8086^{***}$ |
| | (1.0173) | (1.1689) |
| OPEN | 0.0000 | $-0.0002^{***}$ |
| | (0.0000) | (0.0000) |
| lnISU | | $0.1257^{*}$ |
| | | (0.0647) |
| _cons | $0.9474^{***}$ | -0.0465 |
| | (0.0689) | (0.1000) |
| Fixed year | Yes | Yes |
| Individual fixation | Yes | Yes |
| *N* | 360 | 360 |
| $R^2$ | 0.313 | 0.500 |

Standard errors in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01

In terms of the upgrading path of industrial structure, column (1) of Table 11 shows that the regression coefficient of digital transformation on industrial structure upgrading is 0.2780, which is significant at the 1% level, indicating that digital transformation has significantly promoted the servitization and advancement of regional industrial structure. Column (2) shows that after the simultaneous inclusion of digital transformation and industrial structure upgrading, the regression coefficient of industrial structure upgrading on the high-quality development of textile industry is 0.1257, which is significant at the 10% level, and the direct effect coefficient of digital transformation is 0.1664, which is significant at the 5% level. Further calculation shows that the mechanism effect of industrial structure upgrading path is 0.0349, accounting for 17.36% of the total effect. This result shows that digital transformation can not only improve the internal production efficiency of the textile industry, but also promote the extension of the industry from pure manufacturing to "manufacturing + service". Through digital design, flexible customization, brand operation and supply chain collaboration, it can guide resources to R & D design, brand marketing and high value-added service. So as to improve the overall development quality of textile industry.

## 4.7 Regulation effect test: environmental regulation and government support

In order to further investigate the influence of external institutional environment on the effect intensity of digital transformation, this paper introduces environmental regulation, government support and their interaction terms with digital transformation based on the baseline model, and the results are shown in Table 12.

*Table 12: Results of the moderating effect*

| | Level of government support | | Environmental regulation | |
|---|---|---|---|---|
| variables | (1) | (2) | (3) | (4) |
| | No interaction terms | Interaction term included | No interaction terms | Interaction term included |
| DT | 0.2364*** | 0.4668*** | 0.1671** | 0.2983*** |
| | (0.0651) | (0.1156) | (0.0688) | (0.0871) |
| c_GS | -0.3531*** | -0.1913* | | |
| | (0.0847) | (0.1077) | | |
| UR | 0.0915 | -0.0087 | 0.2815 | 0.1684 |
| | (0.1694) | (0.1733) | (0.1720) | (0.1769) |
| RD | 1.5510 | 1.8074* | 0.7939 | 0.8249 |
| | (1.0105) | (1.0086) | (1.0204) | (1.0126) |
| HC | -3.7119*** | -3.9810*** | -4.4065*** | -4.2797*** |
| | (1.1435) | (1.1403) | (1.1938) | (1.1857) |
| OPEN | -0.0001*** | -0.0001** | -0.0002*** | -0.0001*** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| DT×GS | | 1.5662** | | |
| | | (0.6518) | | |
| c_ER | | | 1.5165* | 4.8181*** |
| | | | (0.8615) | (1.6061) |
| DT×ER | | | | 31.8472** |
| | | | | (13.1150) |
| _cons | 0.1191 | 0.1562** | 0.0652 | 0.1041 |
| | (0.0781) | (0.0791) | (0.0792) | (0.0802) |
| Fixed year | Yes | Yes | Yes | Yes |
| Individual fixation | Yes | Yes | Yes | Yes |
| *N* | 360 | 360 | 360 | 360 |
| $R^2$ | 0.521 | 0.529 | 0.499 | 0.508 |

Standard errors in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01

The results of the adjustment effect of government support show that after adding the interaction term, the coefficient of digital transformation is 0.4668, and it is significant at 1% level, and the coefficient of the interaction term DT×GS is 1.5662, and it is significantly positive at 5% level. The results show that government support can significantly strengthen the role of digital transformation in promoting the high-quality development of the textile industry. The reason is that policy tools such as financial subsidies, tax incentives, project support and digital demonstration projects can help reduce the upfront costs and implementation risks of enterprises in industrial Internet access, industrial Internet of things deployment, software system update and intelligent equipment transformation, so as to enhance the implementation effect of digital technology diffusion and system integration.

The regulatory effect of environmental regulation is also significant. After adding the interaction term, the coefficient of digital transformation is 0.2983, which is significant at the 1% level, and the coefficient of the interaction term DT×ER is 31.8472, which is significantly positive at the 5% level. The results show that environmental regulation can effectively strengthen the role of digital transformation in promoting the high-quality development of the textile industry. The internal mechanism is that emission constraints, energy consumption control and green governance requirements encourage enterprises to embed digital monitoring, intelligent control and clean production systems into key links such as spinning, weaving, printing and dyeing, and promote green process improvement and resource efficiency improvement through real-time identification and dynamic adjustment of energy consumption, material consumption and emission data. And then realize the collaborative promotion of digital empowerment and green upgrading.

# 5 Research conclusions and technical implications

The results show that digital transformation has a significant role in promoting the high-quality development of the textile industry. In the baseline regression, the regression coefficient of digital transformation is 0.2013, and it is significant at the 1% level. After introducing the instrumental variable to control the endogeneity, the coefficient increased to 0.4020, indicating that the positive effect of digital transformation had strong robustness. Heterogeneity analysis showed that the effect was significantly different in different regions and development conditions. The regression coefficient of the eastern region was 0.5266, and the regression coefficients of the high informatization, high labor force scale and high economic development level groups were 0.4249, 0.4120 and 0.3097, respectively. It shows that the release of digital empowerment effect depends on strong technical foundation and resource support. The threshold effect test further found that the threshold value of digital transformation was 0.1773 and the threshold value of financial development was 5.4656, indicating that the digital empowerment had significant stage and condition. The mechanism test shows that both technological innovation and industrial structure upgrading constitute effective transmission paths, in which the effect of technological innovation mechanism is 0.0954, accounting for 47.39% of the total effect, and the effect of industrial structure upgrading mechanism is 0.0349, accounting for 17.36% of the total effect. The interaction terms of environmental regulation and government support are all significantly positive, indicating that the external institutional environment can strengthen the promotion effect of digital transformation.

Based on the above conclusions, the digital upgrading of the textile industry should be more prominent in the technical system construction and scene landing orientation. The construction of textile industry Internet platform, industry data center and key link perception network should be accelerated, the collaborative deployment of industrial software, equipment networked control system and production execution system should be strengthened, and the deep embedding of big data analysis, intelligent scheduling, online quality inspection and energy consumption monitoring in spinning, weaving and printing and dyeing links should be promoted. At the same time, the integrated development of intelligent manufacturing and green manufacturing should be promoted, and the quality stability, resource utilization efficiency and green production level should be improved by relying on digital monitoring, intelligent control and clean technology. In addition, differentiated digital technology deployment strategies should be implemented according to the digital foundation, industrial scale and development conditions of different regions.

There is still room for further expansion of this research. Limited by data availability, the current analysis is mainly based on provincial panel data, which has not yet fully revealed the micro differences of digital technology embedding at the enterprise level. Subsequent research can introduce digital text data of enterprise annual reports, industrial Internet platform data, equipment networking operation data and supply chain collaboration data to build a multi-source heterogeneous data analysis framework, so as to enhance the recognition depth of digital transformation process characteristics, technology path differences and dynamic evolution mechanism.

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