



# Research on the Impact of New Quality Productive Forces on the Resilience of Innovation Ecosystem in High-tech Industries

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**Abstract.** This paper takes the innovation ecosystem of high-tech industries as the research object, and explores the impact of new quality productive forces on its resilience. Ridge regression is used for empirical analysis. The results show three points. First, new quality productive forces as a whole have a significant positive effect on the resilience of the innovation ecosystem in high-tech industries. This means that the development of new quality productive forces can effectively improve system resilience. Second, from the perspective of sub-dimensions, scientific and technological innovation input, scientific and technological innovation output and industrial development level all have significant positive effects on system resilience. Digital infrastructure has a significant negative effect on system resilience. The impact of green efficiency on system resilience is not significant. Third, according to the results of control variables, economic development level, regional innovation efficiency and opening-up degree have significant positive effects on system resilience. This shows that a sound economic foundation and an open environment provide important support for system stability. This paper reveals the mechanism of new quality productive forces on system resilience from a multi-dimensional perspective. It provides empirical evidence and policy implications for improving the resilience of innovation ecosystem in high-tech industries.

**Keywords:** New Quality Productive Forces, High-tech Industries, Resilience of Innovation Ecosystem.

## 1 Introduction

Against the background of a new round of scientific and technological revolution and industrial transformation, new quality productive forces characterized by digitalization, intelligence and green development are becoming an important force to promote high-quality economic development. The 2024 Government Work Report clearly puts forward “accelerating the development of new quality productive forces”, and emphasizes

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T. G. Guan et al. (eds.), *Proceedings of the 2026 4th International Conference on Digital Economy and Management Science (CDEMS 2026)*, Advances in Economics, Business and Management Research 392, [https://doi.org/10.2991/978-94-6239-699-9\\_49](https://doi.org/10.2991/978-94-6239-699-9_49)

promoting industrial innovation through scientific and technological innovation and improving total factor productivity. The report to the 20th CPC National Congress also requires “enhancing the resilience and security of industrial and supply chains”. The 14th Five-Year Plan for National Scientific and Technological Innovation further proposes building an open, coordinated and efficient innovation ecosystem. Under the new development pattern of dual circulation, how to improve the resilience of innovation ecosystem in high-tech industries through new quality productive forces has become an important issue related to national strategic security and industrial competitiveness.

Most existing studies discuss the impact of technological innovation or industrial structure on system resilience from a single perspective. They lack systematic analysis from the overall perspective of new quality productive forces. Therefore, this paper builds an analysis framework from five dimensions: scientific and technological input, scientific and technological output, digital infrastructure, industrial development and green efficiency. Ridge regression is used to empirically test the impact of new quality productive forces on the resilience of innovation ecosystem in high-tech industries, so as to provide empirical evidence for improving system resilience.

## 2 Research Hypotheses

New quality productive forces are mainly driven by scientific and technological innovation. They exert an important influence on the resilience of the innovation ecosystem in high-tech industries by optimizing resource allocation, promoting knowledge production and diffusion, and pushing forward the upgrading of industrial structure. New quality productive forces have multi-dimensional characteristics and cannot be fully described by a single indicator. Therefore, this study divides it into five aspects: scientific and technological input, scientific and technological output, digital infrastructure, industrial development and green efficiency to analyze its mechanism. Based on the meaning of innovation ecosystem resilience, its key points include resource redundancy against external shocks, continuous supply of heterogeneous knowledge and rapid reconstruction ability through cross-subject coordination. As an important feature of new quality productive forces, scientific and technological input can directly increase R&D funds and talent investment, and improve the efficiency of knowledge creation and transformation. Thus it can strengthen the system’s ability to resist disturbance and recover. Zeng Zhuoqi pointed out that public science and technology finance can significantly increase enterprises’ R&D funds and personnel investment, improve innovation performance and strengthen sustainable innovation supply for resilience by easing financing constraints and stimulating innovation vitality<sup>[1]</sup>. Fang Zhongxiu found that institutional environment has a significant influence on the efficiency of scientific and technological input. It can promote the development of organizational adaptability and system regeneration ability<sup>[2]</sup>. It can be seen that scientific and technological input improves the resilience of the innovation ecosystem through a positive cycle of capital, technology and institutional environment. Based on the above analysis, this paper puts forward the research hypothesis:

Hypothesis 1: The higher the level of scientific and technological innovation input, the stronger the resilience of the innovation ecosystem in high-tech industries.

Based on the mechanism of the innovation ecosystem resilience, the system relies on diverse knowledge stock, factor redundancy and coordination loops to realize a positive cycle of self-repair, adaptation and evolution when facing shocks. Therefore, higher levels of scientific and technological output, such as invention patents, academic papers, high-tech products and their commercialization, can provide alternative paths and rapid iteration capabilities to improve anti-disturbance and recovery speed. Li Hongfei pointed out that the effective transformation of scientific and technological achievements embeds new knowledge into the industrial chain, promotes the formation of new quality productive forces and optimizes resource allocation, thus strengthening system adaptability and synergy<sup>[3]</sup>. Zhu Chenxuan's research shows that although there is a time lag at the output end of the innovation ecosystem, its improvement has a continuous positive effect on the overall level of the system. The higher the output, the more stable the structure and function can be through the input-output chain<sup>[4]</sup>. It can be seen that high-level scientific and technological output can provide diverse technical paths for the system, enhance substitution ability and adaptability, and thus improve the overall resilience of the system. Based on the above analysis, this paper puts forward the research hypothesis:

Hypothesis 2: The higher the level of scientific and technological innovation output, the stronger the resilience of the innovation ecosystem in high-tech industries.

Li Shan's research shows that digital new infrastructure forms network effects and scale externality in three types of facilities: information, integration and innovation. It not only directly improves the resistance and self-repair ability of economy and industrial chain under shocks, but also shows stronger benefits after crossing the threshold and spatial spillover to neighboring areas<sup>[5]</sup>. Zhao Chunming shows that the positive effect of digital infrastructure on the resilience of industrial supply chains has been tested in many aspects. It shows fast recovery during shocks and quality improvement and structure optimization in normal periods<sup>[6]</sup>. According to existing studies, digital infrastructure is an important part of new quality productive forces. It is the basis for the innovation ecosystem of high-tech industries to resist external risks. The development of high-tech industries has higher requirements for infrastructure construction. Therefore, the improvement of resilience of the innovation ecosystem of high-tech industries depends more on the level of digital infrastructure. Based on the above analysis, this paper puts forward the research hypothesis:

Hypothesis 3: The better digital infrastructure is, the stronger the resilience of the innovation ecosystem in high-tech industries.

Wang Hongqi's research shows that when industrial development promotes ecological evolution, the system will form a positive cycle of structural support and dynamic feedback. It makes cooperation among core, complementary and application links closer and provides more alternative paths. Thus the overall resilience is improved<sup>[7]</sup>. Adner also put forward a theory of analyzing ecosystem as a structure<sup>[8]</sup>. It can be seen that industrial development level can improve the allocation efficiency and cooperation quality of innovation factors in the ecosystem. On the other hand, it enhances redun-

dancy, substitutability and reconstruction ability when the system faces shocks. Therefore, it provides continuous structural support for improving the resilience of the innovation ecosystem in high-tech industries. Based on the above analysis, this paper puts forward the research hypothesis:

Hypothesis 4: The higher the level of industrial development, the stronger the resilience of the innovation ecosystem in high-tech industries.

Chen Han's research finds that the coordination between green-oriented technological progress and environmental governance can significantly improve the stability and sustainable performance of regional innovation activities. It provides a double buffer mechanism of cost and risk for the innovation system to deal with external shocks<sup>[9]</sup>. Yang Guanhua finds that the improvement of green total factor productivity can significantly strengthen the resilience of the industrial system and has a certain spatial spillover effect<sup>[10]</sup>. It can be seen that higher green efficiency not only means lower energy consumption and emission intensity. More importantly, it reduces vulnerability under external shocks, improves recovery speed and enhances sustainable evolution ability through green technology. Thus it provides long-term and stable support for improving the resilience of the innovation ecosystem in high-tech industries. Based on the above analysis, this paper puts forward the research hypothesis:

Hypothesis 5: The higher the level of green efficiency, the stronger the resilience of the innovation ecosystem in high-tech industries.

### 3 Research Design

#### 3.1 Sample Selection and Data Sources

This study uses panel data of 31 provincial administrative units in China, excluding Hong Kong, Macao and Taiwan. Ridge regression is used for empirical analysis. Data are collected from Statistical Report on Internet Development in China, China Statistical Yearbook, China Industry Statistical Yearbook, China Energy Statistical Yearbook, China Environmental Statistical Yearbook, China Science and Technology Statistical Yearbook, China Employment Statistical Yearbook, China Labour Statistical Yearbook and other official yearbooks. The missing data are interpolated by the trend extrapolation method. AI large language models have developed rapidly in recent years. Relevant yearbook data are missing or difficult to obtain. Therefore, this study searches relevant keywords on the official website of Tianyancha and classifies data according to enterprise locations. To avoid infinite values in logarithmic calculation, all data are properly translated.

#### 3.2 Variable Definition

**Independent Variable.** The independent variable of this paper is the level of new quality productive forces. It has multi-dimensional characteristics and cannot be described by a single indicator. Therefore, it is divided into five dimensions: scientific and technological innovation input, scientific and technological output, digital infrastructure, industrial development level and green efficiency.

To show its multi-dimensional characteristics as fully as possible, the specific dimensions and measurement contents of variables are shown in Table 1.

**Table 1.** Independent Variables.

Independent Variable Dimensions	Independent Variables	Measurement Contents
Scientific and Technological Innovation Input	Number of R&D personnel	Number of R&D personnel
	R&D expenditure	R&D expenditure
Scientific and Technological Innovation Output	Patent output	Number of patent grants
	Business income of high-tech industries	Business income of high-tech industries
	Optical cable length	Optical cable length
Digital Infrastructure	Broadband ports	Number of internet broadband access ports
	Turnover of technology market	Turnover of technology market
	Internet users	Internet users (10,000 persons/households)
Industrial Development	E-commerce sales	E-commerce sales (100 million yuan)
	Energy consumption/GDP	Energy consumption intensity
	Industrial water consumption/GDP	Industrial water consumption (100 million cubic meters)
Green Efficiency	Comprehensive utilization rate of industrial solid waste	Recycling efficiency of solid waste
	Forest coverage	Forest coverage rate
	Waste gas	Emission intensity of nitrogen oxides (tons)
	Waste water	Industrial wastewater emission intensity (tons)

**Dependent Variable.** The dependent variable of this paper is the resilience of the innovation ecosystem in high-tech industries. Based on existing studies, this paper builds an index system from four dimensions: diversity, buffering, mobility and evolution. It measures system resilience comprehensively to reflect its stability, recovery ability and sustainable evolution under shocks. The specific dimensions and measurement contents of variables are shown in Table 2.

**Table 2.** Dependent Variables.

Dependent Variable Dimensions	Dependent Variables	Measurement Contents
Diversity	Number of innovation subjects	Number of high-tech enterprises Number of R&D institutions Number of colleges and universities
	Technology reserve	Number of patent grants per enterprise Scientific papers published per capita
Buffering	Knowledge reserve	Scientific works published per capita Public library holdings per capita
	Economic reserve	GDP per capita Internet penetration rate
Mobility	Information flow	Number of websites per 10,000 people Mobile internet access traffic
	Capital flow	Government R&D investment Enterprise R&D investment
	Logistics flow	Added value of transportation, warehousing and postal services
	Human resource input	Average employment of high-tech enterprises Intramural Expenditure on R&D
	Capital input	Expenditure for product development Expenditure for technological transformation
	Technology output	Number of patent applications Scientific papers published by universities Scientific works published by universities
Evolution	Economic output	Sales revenue of new high-tech products Business income of high-tech enterprises (100 million yuan) Total profit of high-tech enterprises (100 million yuan)

**Control Variables.** To reduce omitted variable bias, this paper introduces the following control variables: economic development level (measured by GDP per capita), industrial structure (measured by industrial structure upgrading index), human resources (measured by education level), regional innovation efficiency and opening-up degree (measured by total import and export volume). The specific dimensions and measurement contents of variables are shown in Table 3.

**Table 3.** Control Variables.

Control Variable Dimensions	Control Variables
Economic Development Level	Regional GDP per capita
Industrial Structure	Industrial Structure
Human Resources	Proportion of Population Receiving Higher Education
Regional Innovation Efficiency	Number of Regional Patent Applications Authorized, R&D Expenditure
Degree of Opening to the Outside World	Total Volume of Goods Imports and Exports

### 3.3 Model Specification

To test the impact of new quality productive forces on the resilience of the innovation ecosystem in high-tech industries, this paper constructs the following baseline regression model:

$$Y_i = \alpha + \beta X_i + \gamma Z_i + \epsilon_i \tag{1}$$

In this formula,  $Y_i$  represents the resilience of the innovation ecosystem in high-tech industries in region  $i$ , which is the dependent variable of this study.  $X_i$  represents the dimensional variables of new quality productive forces.  $Z_i$  is the set of control variables.  $\alpha$  is the constant term.  $\beta$  is the coefficient of the core explanatory variable.  $\gamma$  is the coefficient of the control variable, which reflects the direction and degree of the influence of each control factor on the dependent variable.  $\epsilon_i$  is the random disturbance term, used to capture the random factors that cannot be explained by the model.

## 4 Empirical Analysis

### 4.1 Regression Analysis

**Collinearity Analysis.** This study adopts the ridge regression method. This method introduces a squared penalty term of coefficients into the loss function and adds a regularization parameter  $\lambda$  to the diagonal of the  $X^T X$  matrix, thereby reducing the condition number, decreasing estimation variance and improving model robustness. Although this method introduces a certain bias, it can significantly improve the explanatory power and prediction performance of the model under severe collinearity.

To solve the problem of strong multicollinearity among independent variables, this study introduces the ridge regression method within the framework of the baseline regression model. The basic form of the model remains Model (1). The difference is that parameter estimation is no longer carried out by ordinary least squares. Instead, the estimation result is obtained by minimizing the ridge regression objective function with a penalty term added to the residual sum of squares. The formula is as follows:

$$\min_{\beta, \gamma} \left\{ \sum_{i=1}^n (Y_i - \alpha - \beta X_i - \gamma Z_i)^2 + \lambda \sum_{j=1}^k \theta_j^2 \right\}$$

Where  $Y_i$  represents the resilience of the innovation ecosystem in high-tech industries in region  $i$ ;  $X_i$  is the core independent variable, i.e., new quality productive forces, which consists of five dimensions: scientific and technological input, scientific and technological output, infrastructure, industrial development and green efficiency.  $Z_i$  is the set of control variables, including regional innovation efficiency, economic development level, industrial structure, human resource endowment and opening-up degree.  $\alpha$  is the constant term;  $\theta_j$  represents all regression coefficients excluding the intercept;  $\lambda$  is the regularization parameter of ridge regression, which is used to adjust the trade-off between bias and variance. This improved model retains the structure of the baseline regression. By penalizing regression coefficients, it reduces the instability caused by multicollinearity, thus improving the explanatory power and robustness of the model.

**K Value Selection.** In the process of parameter selection, a ridge trace plot is drawn (see Figure 1). The optimal value is determined by observing the stability of regression coefficients of explanatory variables as the ridge parameter changes. The horizontal axis represents different ridge parameter K values, and the vertical axis represents the estimated values of standardized regression coefficients.

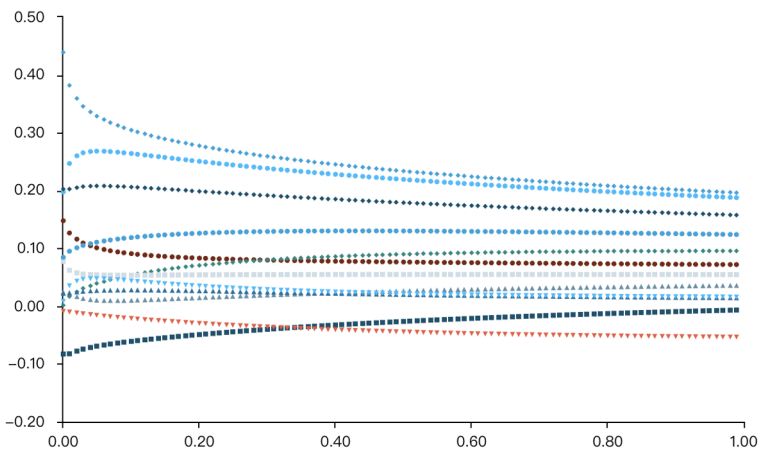


Fig. 1. Ridge Trace Plot.

The results show that when the ridge parameter K is small, the coefficients of each variable fluctuate greatly and the model stability is poor. With the increase of K value, the regression coefficients gradually become stable. When K is about 0.02, the coefficients of all variables are basically stable, indicating that the multicollinearity problem is effectively alleviated. Therefore, this paper selects K=0.02 as the optimal parameter for the ridge regression model.

**Ridge Regression Result Analysis.** In the ridge regression analysis, the K value is set to 0.020. As shown in Table 4 below, the R-squared of the model is 0.998, indicating that the explanatory power of these variables for the model reaches 99.8%. The F-test shows that the model passes the significance test (F = 778.932, p = 0.000 < 0.05). The model formula is:

$$IESR=0.003+0.221*STI+1.037*STO-0.069*INF+0.015*IND-0.095*GE+0.073*GGE+0.015*AI+0.092*RIE+0.037*EDL+0.021*IS+0.032*HR+0.138*DO$$

Among the five dimensions of new quality productive forces, the coefficients of scientific and technological input, scientific and technological output and industrial development are significantly positive. This shows that the increase in R&D resources and the output of innovation achievements have a direct effect on improving system resilience. Although the coefficient of green efficiency is in the expected direction, it is not significant, indicating that the impact of green transformation on resilience may have a lag effect. Infrastructure shows a negative impact under ridge regression, which suggests that there may be problems such as resource crowding-out and mismatch between construction and application in the short term, which need further discussion. Overall, the positive promoting effect of new quality productive forces on the resilience of the innovation ecosystem in high-tech industries is empirically supported.

**Table 4.** Ridge Regression Analysis Results.

	Non-standardized Coefficients		Standardized Coefficients	t	p	VIF value
	B	Standard Error	Beta			
Constant	0.003	0.010	-	0.308	0.761	-
STI	0.221	0.023	0.260	9.694	0.000**	6.742
STO	1.037	0.079	0.359	13.120	0.000**	7.026
INF	-0.069	0.021	-0.078	-3.299	0.004**	5.212
IND	0.015	0.024	0.017	4.622	0.000**	6.740
GE	-0.095	0.107	-0.012	-0.889	0.386	1.636
GGE	0.073	0.012	0.101	5.973	0.000**	2.673
AI	0.065	0.014	0.105	4.024	0.000**	5.537
RIE	0.092	0.020	0.116	4.705	0.000**	5.684

EDL	0.037	0.017	0.058	2.219	0.040*	6.289
IS	0.021	0.014	0.025	1.555	0.137	2.368
HR	0.032	0.019	0.043	1.685	0.109	6.130
DO	0.138	0.019	0.205	7.195	0.000**	7.619
R2	0.998					
Adjusted R-squared	0.997					
F	F(12,18)=778.932,p=0.000					

Note: Dependent variable = Resilience

\* $p < 0.05$  \*\* $p < 0.01$

## 5 Conclusions

Based on panel data of 31 provincial-level administrative regions in China, this paper uses ridge regression to empirically analyze the impact of new quality productive forces on the resilience of the innovation ecosystem in high-tech industries. The conclusions are as follows: (1) New quality productive forces overall have a significant positive effect on the resilience of the innovation ecosystem in high-tech industries, but there are obvious differences in the impact across different dimensions. Scientific and technological innovation input, scientific and technological innovation output, and industrial development level all show significant positive effects, indicating that improving the allocation efficiency of R&D resources, strengthening the transformation of innovation achievements, and promoting industrial structure optimization are key paths to enhance system resilience. (2) Digital infrastructure has a negative impact on system resilience, showing that in the short term, there may be problems such as large resource input and mismatched factor allocation, which have not yet been fully transformed into effective support for system resilience. (3) The impact of green efficiency on system resilience is not significant, which may be related to the long-term nature and lag effect of green transformation, and its effect still needs to be further released. (4) The results of control variables show that economic development level, regional innovation efficiency and opening-up degree have significant positive effects on the resilience of the innovation ecosystem in high-tech industries, reflecting the important supporting role of sound economic foundation and open environment for system stability.

Accordingly, this paper draws the following implications: (1) Strengthen scientific and technological innovation input and achievement transformation. Continuously increase investment in R&D funds and talents, optimize the structure of innovation resource allocation, and improve the mechanism for transforming scientific and technological achievements to enhance the practical application efficiency of innovation outputs, thereby improving system resilience from the source. (2) Improve the quality of digital infrastructure construction. Optimize the investment structure of infrastructure, focus on enhancing resource allocation efficiency and practical application level, avoid redundant construction and resource mismatch, and enable digital infrastructure to better serve industrial development and system resilience improvement. (3) Promote green

and low-carbon transformation. Improve the green development policy system, promote the application of resource-saving and environment-friendly technologies, and gradually release the long-term promoting effect of green efficiency on system resilience.

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