Research On the Impact of Science and Technology Finance on New Quality Productivity: Analysis Based on Spatial Effect

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Abstract: This study investigates the driving mechanisms and spatial attributes of technology finance's role in new quality productivity, employing a panel dataset covering 30 Chinese provinces over the period 2012-2022 as the research sample. By utilizing the dynamic Spatial Durbin Model (SDM) and integrating mediating effect analysis with robustness checks, the research explores the influence pathways and spatial spillover effects of technology finance on new quality productivity. The study shows that technology finance has a significant positive direct driving effect on new quality productivity, which remains valid after robustness tests using the spatial autoregressive model (SAR) and spatial error model (SEM). Human capital plays a partial mediating role between technology finance and new quality productivity, indicating that technology finance indirectly empowers new quality productivity by enhancing human capital competitiveness. In terms of spatial effects, the influence of technology finance on new quality productivity exhibits prominent local empowerment but insufficient cross-regional spillover, and new quality productivity shows negative spatial autocorrelation, reflecting inter-regional factor suction effects. The research provides empirical references for optimizing the allocation of technology finance and promoting the coordinated regional development of new quality productivity.

Keywords: Technology Finance; New Quality Productivity; Spatial Spillover Effect; Spatial Econometric Model; Spatial Durbin Model

1. Introduction

As China enters a new era, the strategic importance of technology finance has grown significantly with the deepening implementation of innovation-driven development strategies. Looking back at its evolution, the 1985 policy announcement marked the beginning of technology finance's development. Since then, it has continuously evolved. The Central Financial Work Conference held in October 2023 explicitly proposed accelerating the construction of a financial powerhouse and advancing five key initiatives: technology finance, green finance, inclusive finance, pension finance, and digital finance. As the flagship of these five initiatives, enhancing the quality and efficiency of technology finance is not only essential for deepening financial supply-side structural reforms in the present and future, but also a top priority for supporting the high-quality development of the real economy.

Meanwhile, developing new quality productive forces as a strategic choice to break through development bottlenecks and gain the initiative in international competition has become increasingly significant. In 2023, the concept of new quality productive forces was introduced, emphasizing its "new fields of involvement, high technological content, and innovation-driven development as the key." Key conferences convened in 2024 explicitly emphasized that advancing new quality productive forces constitutes an intrinsic demand for driving high-quality development. This entails propelling industrial innovation via scientific and technological progress, while cultivating new industries, new business forms, and new growth engines through disruptive and frontier technologies. Currently, as global technological competition intensifies and domestic industrial transformation enters a critical phase, new quality productive forces have become the core driving force for addressing imbalanced and inadequate development issues and achieving qualitative changes in economic structure.

2. Literature Review

To date, a wealth of academic literature has emerged focusing on the research into science and technology finance as well as new quality productivity. The relevant literature research is generally carried out from the following two aspects, including:

The first aspect explores the influence of technology finance upon new quality productivity. Research consistently demonstrates that technology finance plays a catalytic and driving role in advancing new quality productivity. To illustrate, Zou et al. (2024) [1] found that technology finance significantly accelerates the formation of new quality productivity. Li and Cai (2024) [2] revealed that technology finance substantially enhances the development level of industrial new quality productivity, suggesting the need for deeper cross-sector integration. Jiang and Li (2025) [3] highlighted that technology finance drives the transformation from traditional agriculture to smart agriculture through four key mechanisms: enhancing human capital, transforming production materials, expanding labor scope, and reorganizing production factors.

The second aspect examines the mechanisms through which technology finance impacts new productive forces. Firstly, regarding industrial upgrading: Zhang and Lu (2024) [4] demonstrated that technology finance's robust support for high-tech enterprises and innovation projects has facilitated the upgrading of conventional industrial sectors while accelerating the advancement of nascent sectors. Secondly, in resource allocation and risk management: Wang and Zou (2024) [5] revealed that pilot programs integrating technology and finance have enhanced corporate innovation capabilities through funding support, thereby elevating regional innovation levels. Thirdly, concerning green technology innovation: Gong et al. (2023) [6] found that technology finance significantly improves urban green innovation levels by optimizing fiscal fund allocation efficiency, thereby promoting sustainable economic development. Fourthly, regarding financing constraint mitigation: Liu and Xi (2025) [7] proposed that technology finance investments positively influence the total factor productivity of sci-tech enterprises through financing constraint channels.

Current empirical studies on technology finance and new quality productivity have shown limited attention to spatial perspectives, with insufficient exploration of spatial effect decomposition. Moreover, existing research on the mechanisms of technology finance's impact on new quality productivity has neglected human capital considerations. To address these gaps, this paper makes two key contributions: First, it advances spatial perspective decomposition to broaden research scope and fill existing research gaps. Second, it introduces human capital as a mediating variable to examine how technology finance influences new quality productivity through human capital accumulation.

3. Theoretical Analysis and Research Hypothesis

3.1 Technology Finance's Direct Effect on the Advancement of New Quality Productivity

Technology finance effectively channels production factors such as capital, technology, and talent toward high-efficiency sectors, optimizing resource allocation structures and thereby enhancing overall productivity. Furthermore, by leveraging big data and artificial intelligence, it improves risk assessment and management capabilities, reduces information asymmetry, and provides more precise and efficient financial support for innovation activities. In terms of risk management, technology finance helps accumulate social savings through expanding capital sources, diversifying financing methods, improving capital accessibility, and strengthening corporate fundraising capabilities. This alleviates funding pressures faced by enterprises during innovation and provides solid capital guarantees for the growth of new productive forces. Drawing on the foregoing analysis, the present study puts forward the following hypotheses:

Hypothesis 1: Technology finance is capable of directly facilitating the enhancement of new quality productivity.

3.2 Spatial Spillover Effects of Technology Finance on the Development of New Quality Productivity

From the perspective of spatial flow patterns of production factors, technology finance-as a key vehicle for allocating innovation resources-exerts influence through spatial transmission of these factors. This sector not only empowers local new productive forces by aggregating resources in innovation-active regions, but also indirectly impacts neighboring areas' productivity through cross-regional mobility of certain elements. Based on this analysis, the present research formulates the

following hypotheses:
Hypothesis 2: Technology finance has a positive spatial effect on new quality productivity.

3.3 Indirect Impact Mechanisms of Technology Finance on the Advancement of New Quality Productivity

Through professional market analysis and value-added services, technology financial institutions can precisely channel capital to enterprises and projects with innovation potential and human capital enhancement needs. With sustained support from technology finance, companies can attract and retain more top talent, creating a talent aggregation effect. This talent concentration fosters knowledge sharing and sparks innovative thinking, further enhancing overall innovation capabilities and competitiveness. The strengthened human capital competitiveness generates greater innovation momentum and talent support for enterprises, improving production efficiency and product quality while exploring new market opportunities and profit growth points. As industries' demand for high-quality talent continues to expand, a virtuous cycle between human capital and industrial upgrading has emerged. Building upon this, the current study formulates the following research hypothesis:
Hypothesis 3: Technology finance exerts an empowering effect on new quality productivity by boosting the competitive strength of human capital.

4. Research Design

4.1 Model Construction

(1) Spatial econometric model
This study employs spatial econometric analysis to examine the impact of science and technology finance on new quality productivity. Commonly used spatial econometric models include the Spatial Durbin Model (SDM), Spatial Error Model (SEM), and Spatial Autoregressive Model (SAR).
The spatial Dubin model (SDM) is defined as follows:

$$N_{it} = \beta_0 + \rho W \cdot N_{it} + \beta_1 F_{it} + \beta_2 Control_{it} + \theta_1 W \cdot F_{it} + \theta_2 Control_{it} + \lambda W \cdot \mu_{it} + \varepsilon_{it} \quad (1)$$

N and F represent the new quality productivity index and the science and technology financ. With i and t denoting province and year. The parameters β_0, β_1, β_2 ,ρ. W denotes the spatial weight, and Control represent the coefficients to be estimated, while μ and λ denote the error term and its coefficient respectively. The random disturbance term is represented by ε.
When λ≠0 in the model and both ρ and θ are zero, the Spatial Error Model (SEM) is obtained; when ρ≠0 and both θ and λ are zero, the model degenerates into the Spatial Autoregressive Model (SAR).
(2) Spatial weight matrix
In the construction of spatial econometric models, spatial weight matrices are essential components. This paper utilizes two types of spatial weight matrices: the spatial adjacency matrix W and the economic distance matrix W1.

4.2 Indicator Selection and Explanation

4.2.1 Dependent variable
New Quality Productivity (N): The quantitative evaluation of this indicator draws on the research of Wang, (2024) [8], establishing a comprehensive assessment framework. This system focuses on three key dimensions: laborers, means of labor, and objects of labor, comprising 7 primary indicators and 14 secondary indicators. The framework ultimately calculates the New Quality Productivity Index through the entropy method.
4.2.2 Core explanatory variables
Technology Finance (F): This study adopts the research methodology of Zou and Zhou (2024) [9], establishing an evaluation framework for technology finance development from both public and market perspectives. The framework comprises two primary indicators and six secondary indicators, utilizing a combination of entropy weighting and TOPSIS model to derive the technology finance index, as shown in Table 1.
4.2.3 Mechanism variables
Drawing on existing research, human capital (HC) was selected as the control variable, with the logarithm of R&D personnel equivalent used for measurement.
4.2.4 Control variables
The study selects government intervention level (DGI), industrial structure (IS), openness to the outside world (OOW), and informatization level (II) as control variables, as shown in Table 2.

4.3 Data Sources

Given the remote geographical location of an

Autonomous Region, its statistical data may have certain deficiencies in terms of completeness and credibility. To guarantee the validity and reliability of the estimation outcomes of the spatial econometric model, the present research employed the standard handling method referenced in relevant literature of the field, thus resolving to exclude this region from the research sample. Consequently, the ultimate analytical sample comprises 30 provincial-level administrative regions in China, including provinces, autonomous regions, and municipalities directly under the Central Government., with the study's time dimension set from 2012 to 2022. The data used in this study were primarily sourced from the annual "China Science and Technology Statistical Yearbook", "China Financial Yearbook", "China High-Tech Industry Statistical Yearbook", and "China Statistical Yearbook". To maximize the retention of data information and ensure data quality, the present research utilized a hybrid of linear interpolation methods and trend projection techniques for supplementing the small number of missing data points within the dataset.

Table 1. Evaluation Index System of Science and Technology Finance

	Primary indicator	Secondary indicator	Measurement method
Tech Finance	Public Technology Finance	Technology expenditure level	Regional fiscal expenditure on science and technology/total population
		Science and technology expenditure intensity	Regional fiscal expenditure/GDP
		Departmental Support	Government RD expenditure/total population
	Market Technology Finance	Technology loan level	Tech loans by financial institutions / Total population
		Venture capital level	Venture capital/GDP
		Market Support	Enterprise RD expenditure/total population

Table 2. Control Variables

	type	weigh
controlled variable	Degree of Government Intervention (DGI)	Government expenditure as a percentage of GDP
	Industrial Structure (IS)	The ratio of added value between the tertiary industry and the secondary industry
	Openness to the World (OOW)	Total import and export volume as a percentage of GDP
	Information Level (II)	The proportion of total post and telecommunications business in GDP

5. Empirical Analysis

5.1 Spatial Autocorrelation Test

Table 3. Global Moran Index Test Table

Year	N	
	W	W1
2012	0.0737(0.1209)	0.2416***(0.0912)
2013	0.0290(0.1209)	0.2297***(0.0905)
2014	0.1212(0.1204)	0.3348***(0.0909)
2015	0.0976(0.1200)	0.2402***(0.0906)
2016	0.0644(0.1191)	0.2475***(0.0899)
2017	0.0604(0.1202)	0.2211***(0.0907)
2018	-0.0511(0.1212)	0.1670**(0.0914)
2019	0.0371(0.1190)	0.2725***(0.0898)
2020	0.1512(0.1214)	0.2880***(0.0916)
2021	0.2675**(0.1219)	0.3016***(0.0920)
2022	0.2730**(0.1221)	0.2967***(0.0921)

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

Table 3 presents the global Moran index and significance test results of new quality productivity (N) from 2012 to 2022 under two different spatial weight matrices: W (spatial adjacency matrix) and W1 (economic distance matrix).

The empirical results indicate that the new quality productivity demonstrated significant spatial proximity effects only in 2021 and 2022 under the spatial proximity weight matrix. In contrast, the Moran index of new quality productivity showed significant positive correlations in most years under the economic distance weight matrix, with the exception of 2018 which passed the 5% significance level test, while all other years met the 1% significance threshold. Therefore, future research will adopt the economic distance weight matrix for constructing spatial econometric models.

5.2 Benchmark Regression and Spatial

Durbin Model Regression Analysis

Based on the regression results in Table 4, focusing on the core variable Technology Finance (F): In column (1), the coefficient of Technology Finance (F) is 0.223 and significant at the 1% level, indicating a significant positive enabling effect of Technology Finance on local new-quality productivity. When the spatial effect is incorporated into the SDM model in column (2), the coefficient of Technology Finance (F) increases to 0.3978 while remaining significant at the 1% level. Meanwhile, the goodness-of-fit R^2 in column (2) rises sharply from 0.530 in column (1) to 0.829, demonstrating that after accounting for spatial correlation, the positive driving effect of Technology Finance on local new-quality productivity is more accurately captured, highlighting its more prominent local enabling role. Regarding spatial spillover effects, the coefficient of Technology Finance (W·F) in adjacent regions is 0.1541 but not significant, suggesting that the cross-regional spillover effect of Technology Finance has not yet been effectively utilized. Additionally, the spatial autoregressive coefficient in column (2) is-0.3166 and significant at the 1% level, indicating negative spatial autocorrelation in new-quality productivity. This implies that the enabling effect of local Technology Finance on new-quality productivity may be accompanied by a "siphon effect" on factors in adjacent regions, which partially explains the insignificant cross-regional spillover of Technology Finance. Hypothesis 1 and Hypothesis 2 are confirmed.

Table 4. Regression Results of Technology Finance on New Quality Productivity

	OLS	SDM
	(1)	(2)
	Traditional panel estimation	W1
F	0.223***(7.28)	0.3978***(7.44)
II	0.0489**(2.21)	0.3098**(2.08)
DGI	-0.0651(-1.60)	-0.0422(-0.73)
IS	-0.0893*(-1.76)	-0.0284***(-4.47)
OOW	0.144***(5.81)	0.1931***(8.41)
W·F		0.1541(0.96)
W·II		-0.4200(-1.10)
W·DGI		0.3286(1.92)
W·IS		-0.1645***(-8.91)
W·OOW		0.2659***(4.81)
rho		-0.3166***(-3.06)
constant term	-0.634***(-4.52)	0.0026***(13.19)
Fixed individual	Yes	Yes
Fixed time	Yes	Yes
r2	0.530	0.829
N	330	330

5.4 Spatial Effect Decomposition

To further identify the spatial effects of technology finance on new quality productivity, this study decomposes SDM model results to measure direct, indirect, and total effects, as shown in Table 5. The spatial effect decomposition results of technology finance (F) reveal: The direct effect coefficient of 0.3960 is significant at the 1% level, indicating that local technology finance exerts a significant positive direct empowerment effect on local new quality productivity. The indirect effect coefficient of 0.0312 is not significant, suggesting that technology finance has not effectively generated cross-regional spillover effects on new quality productivity in adjacent areas, failing to significantly drive productivity growth in neighboring regions. The total effect coefficient of 0.4272 remains significant at the 1% level, with its positive and significant nature primarily attributed to the substantial direct effect. The insignificant indirect effect does not provide additional support for the total effect, reflecting the current characteristic of technology finance's impact on new quality productivity as "primarily local empowerment with insufficient cross-regional coordination".

Table 5. Spatial Effect Decomposition

	direct effect	indigo effect	gross effect
F	0.3960*** (7.14)	0.0312 (0.25)	0.4272*** (3.63)
II	0.3186** (2.33)	-0.3952 (-1.29)	-0.0766 (-0.31)
DGI	-0.0509 (-0.79)	0.2473* (1.74)	0.1963 (1.57)
IS	-0.0204*** (-3.09)	-0.1268*** (-8.46)	-0.1476*** (-9.42)
OOW	0.1789*** (6.32)	0.1700*** (3.94)	0.3489*** (9.47)

5.5 Robustness Test

To further validate the reliability of the benchmark regression results, this study employed spatial autoregressive models (SAR) and spatial error models (SEM) as alternatives to the spatial Durbin model (SDM) for robustness testing, with the results presented in Table 6. The data in the table indicate that, compared to SDM, the regression results from SAR and SEM are generally more stable. The overall regression coefficients demonstrate that the benchmark regression results from SDM possess high reliability, thereby reconfirming the relevant hypotheses in the study.

5.6 Mechanism of Action Test

The theoretical analysis above demonstrates that enhancing human capital competitiveness serves as a crucial channel through which technology finance empowers new quality productivity. Drawing on the stepwise regression method proposed by Wen and Ye (2014) [10], we constructed a mediation effect model. The results in Table 7 reveal the following: Column (2) shows a regression coefficient of 0.726, which is significantly positive at the 1% level, indicating a substantial positive effect on human capital competitiveness. When human capital (HC) is included in Column (3), the coefficient drops to 0.126 but remains significant at the 1% level. The coefficient for human capital (HC) on new quality productivity (N) is 0.134, also significant at the 1% level. These findings confirm that human capital partially mediates the relationship between the two variables, thereby validating Hypothesis 3.

Table 6. Robustness Test Results

	W1	
	SAR	SEM
F	0.0641** (2.53)	0.0636** (2.50)
rho	-0.155 (-1.46)	
constant term	0.0131*** (12.82)	0.0132*** (12.82)
Time/Province fixed effects	yes	yes
controlled variable	yes	yes
r2	0.00428	0.00643
N	330	330

Table 7. Results of Mechanism of Action Test

	(1)	(2)	(3)
	N	HC	N
F	0.223*** (8.23)	0.726*** (9.61)	0.126*** (4.40)
HC			0.134*** (7.24)
cons	-0.634*** (-4.81)	11.90*** (12.63)	-2.231*** (-8.84)
Time/Province fixed effects	Yes	yes	yes
controlled variable	yes	yes	yes
r2	0.530	0.711	0.595
N	330	330	330

6. Conclusions and Recommendations

Based on China's provincial panel data from 2012 to 2022, this paper systematically analyzes the impact of technology finance on new quality productivity using a spatial econometric model, and draws the following conclusions: First, technology finance can directly promote the development of new quality productivity. Second, the spatial effect of technology finance on new quality productivity exhibits an unbalanced characteristic of "strong locally, weak across regions," with positive cross-regional spillover not fully realized. Third, human capital serves as an important intermediary carrier for technology finance to empower new quality productivity. Based on the above research conclusions and in combination with the current practical needs of technology finance and the development of new quality productivity, the following targeted suggestions are proposed:

(1) We will build a spatial allocation system for science, technology and finance with comprehensive coordination to break the bottleneck of cross-regional spillover.

To address the problems of insufficient overflow and "siphon effect", we should make efforts in policy coordination and factor connectivity: establish a cross-province coordination mechanism, unify the standards of science and technology enterprise identification, risk compensation and intellectual property pledge, and break down local barriers; build a national science and technology financial information platform, integrate scientific and technological innovation data, and reduce information asymmetry.

(2) Strengthen the precise empowerment of human capital by science and technology finance, and activate the efficiency of intermediary transmission.

Centering on core intermediary human capital, we will optimize the whole chain of talent support: increase the preference for vocational training to help cultivate skills for new quality productivity; introduce special incentives for high-end talents, give priority to venture capital and loan interest subsidies to science and technology innovation enterprises, and reduce the cost of attracting and cultivating talents.

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