Hindawi
Complexity
Volume 2022, Article ID 2552520, 15 pages
https://doi.org/10.1155/2022/2552520

Research Article

Research on the Impact of Technological Finance on Financial Stability: Based on the Perspective of High-Quality Economic Growth

Lu Shen, Guohua He, and Huan Yan

Economics and Management School, Wuhan University, Wuhan 430072, China

Correspondence should be addressed to Lu Shen; slevin@whu.edu.cn

Received 18 November 2021; Revised 15 December 2021; Accepted 30 December 2021; Published 10 January 2022

Academic Editor: A. Dionisio

This paper investigates the relationship between technological finance, high-quality economic growth, and financial stability. Based on data of 30 provinces (including autonomous regions and municipalities) collected between 2004 and 2017, this paper adopts the method of factor analysis to construct comprehensive indexes of technological finance and financial stability before calculating green total factor productivity as the index of high-quality development, using the CRS Multiplicative Model. Then it constructs the spatial SAC model and PVAR model for analyses of the just-mentioned relationship based on the total sample of the nation and regional samples in eastern, middle, and western China, respectively. The results reveal that (1) All samples, whether the total national samples or regional samples of eastern, middle, and western China demonstrate the positive influence of technological finance on high-quality economic development, with an obvious spatial spillover effect. The impact factor is the highest in the eastern region, while the western region holds the lowest factor among the three. (2) Judging by the general national sample, technological finance has an obvious negative shock effect on financial stability within a short period, but the effect gradually dwindles as time goes by. This rule applies to the sample of the eastern region, as its technological finance poses a short-time negative shock effect on financial stability, before gradually diminishing to 0. Neither western nor middle regions have displayed an obvious shock impact on financial stability.

1. Introduction

The Chinese economy has progressed from the stage of high-speed growth to a high-quality one, and the importance of sustainable economic development cannot be overemphasized for the achievement of economic transformation. The Fourteenth Five-Year Plan passed at the fifth plenary session of the 19th Communist Party of China (CPC) Central Committee proclaims "the promotion of high-quality development" as its keynote. It carries on existing policies that assert "the transformation of high-speed growth to high-quality development," demonstrating a new high level of Chinese comprehension and application of the law of economic and social development. The essence of high-quality economic growth is to increase the elementary investment-output ratio in the hope of achieving sustainable economic development with little factor input and environmental costs. Currently, the marginal utility motivated by resource factors in China is gradually decreasing. Through the investment of immaterial factors, technological innovation can boost the transformation of development towards technological advance, knowledge accumulation, and labour qualities, solving the dilemma between the labor force and resource restraints while increasing factor productivity. Hence, technological innovation is the driving force behind high-quality economic growth.

Joseph Schumpeter is one of the earliest pioneers expounding on the relationship between financial support and technological innovation in his Economic Doctrine and Method (1911)[1]. He believed that the major motivation of economic development comes from innovation, the key issue of which is to fulfill new enterprises' credit demands. Therefore, bankers play a key role in the choice of new enterprises and new technologies. Similarly, according to Hicks [2], a hundred years before James Watt's invention of the steam engine, scholars of physics were already acquainted with the knowledge of heat and pressure. The reason why the steam engine was invented in Britain and not any other countries is that Britain had a capital market of strong mobility. These two scholars revealed that technological innovation alone is insufficient for stimulating economic growth. Another prerequisite for the application of new technologies is the existence of a mobile capital market. Other scholars have researched from perspectives like diversified financial market's risk dispersion of technological innovation [3], bank's guidance of technological innovation programs [4], and financial market efficiency's improvement of technological innovation capabilities [5].

To strengthen financial support of technological innovation, the Ministry of Science and Technology published Comments on Promoting the Union of Technology and Finance for Accelerating the Application of Independent Innovation Strategy in collaboration with the Ministry of Civil Affairs, Ministry of Public Security, Ministry of Foreign Affairs, National Railway Administration, Ministry of Transport, National Health Commission, General Administration of Customs, and Civil Aeronautics Administration. Later, it issued Pilot Implementation Agenda for Promoting the Fusion of Technology and Finance in collaboration with the Ministry of Finance, the People's Bank of China, China Banking and Insurance Regulatory Commission, and China Securities Regulatory Commission. Since then "Technological Finance" has become a popular concept. Based on scholars' views, here we interpret technological finance as finance's intervention of technological innovation, manifested as a series of financial policies, tools, and systems boosting the realization of technological achievements, encouraging and directing markets, enterprises, governments, and financial institutions to fund technological innovation activities, so that financial resources would accumulate within technological enterprises. In 2020, there were 145 companies listed in the Shanghai Stock Exchange Science and Technology Innovation Board, raising a total IPO of 222.622 billion Yuan, which is 1.7 times the amount of 2019. In early 2020, the loan balance of domestic technological enterprises reached 4.1 trillion Yuan, exceeding the figure in early 2018 by 38.9%. In 2020, 2.43931 trillion Yuan were invested in scientific research across the nation, which is 55.6% more than the amount in 2016. By the end of 2020, the effective amount of invention patents in China reached 2.213 million, which doubles the amount in 2016.

The rapid development of scientific innovation effectively boosts the high-quality development of the economy. Compared with 2010, the high-tech products' export amount in 2020 has increased by 49% and reached 733.4 billion US dollars, while the technology market's business volume—2.8252 trillion Yuan—increased by six times. New service industries, including technology, information, and software service, keep growing rapidly, with the added value of strategic burgeoning industries taking up 15% of the GDP—a huge increase compared to the 4% in 2010. Meanwhile, in terms of industrial added value, the proportion of high-tech manufacturing among industrial enterprises above the designated size has increased from 9.4% (2012) to 15.1% (2020). In 2010, 52.1% of China's surface water bodies reached the level of Class III or beyond. A decade later, this figure has risen to 74.9%. In 2010, 2.185 million tons of sulfur dioxide were released as exhaust gas. In 2019, the figure dropped to 4.578 million tons, with an evident improvement in the environment. The contribution ratio of technological advances in China has risen from 43.2% (2005) to 60% (2020). China's comprehensive innovative capacity now ranks 15th in the world, as technological advance keeps boosting the nation's high-quality economic growth.

Yet the striking exclusivity of technological innovation is also worthy of our attention. Technological innovation is a long-term act involving huge investment and instability due to its immense complexity, high difficulty, and low success rate. It is wrought with risks coming from various aspects: technology, information, market, and financing. When participating in activities of technological finance, technological enterprises and financial institutions demonstrate striking information asymmetry. It is difficult for financial institutions to obtain an accurate evaluation of an enterprise's earnings persistence and credit risk in the future. Excessive nonperforming loans would lead to financial instability and economic turbulence. Thus, the development of technological finance has a "double-edged sword" impact on the real economy. On the one hand, technological finance enterprises can facilitate technological progress and industrial structure transformation and promote high-quality economic development; on the other hand, high-quality economic development does not mean financial stability. The characteristics of high risk and strong transmission of technological finance determine that increasing the scale of funds to technological finance enterprises will increase the accumulation of financial risks and affect financial stability. "Has technological finance reduced financial stability and aggravated financial systemic risks while promoting high-quality economic development?" It has become an important proposition that needs to be tested.

The report issued at the 19th National Congress of the Chinese Communist Party stresses the persistent strategy of technology-led development to accelerate the deep integration of technology and finance. Meanwhile, it also makes explicit the determination to fend against any systematic financial crisis. As technological finance takes up an even higher proportion in the financial business, some urgent issues need to be solved for the realization of healthy and sustainable development of technological finance: namely, how to achieve the coordinated linkage between technology and finance, how to curb the risks of the financial system while encouraging high-quality economic growth, and how to improve the fragile health of technological finance.

2. Literature Review

2.1. Definition of Technological Finance. The word "Technological Finance" first appeared in an announcement issued by Shenzhen Science and Technology Bureau in 1993, entitled "Technology and Finance Jointly Support High-Tech Enterprises". (In Chinese, "technological finance" and "technology (and) finance" use the same four characters.) According to Zhao [6], technological finance is a systematic and innovative arrangement of a series of financial tools, institutions, policies, and services for the purpose of promoting science and technology development, achievement transformation, and high-tech industrial development. Herrera [7] pointed out that long-term loans from banks can encourage enterprises'interest in technological innovation. Based on samples collected in Taiwan, China, Tang and Chvi [8] concluded that risk investment can facilitate technological growth. Wang and Xu [9] believed that technological finance is a systematic arrangement conducted by agents of financial resources, like government, financial institutions, and market investors, to provide all sorts of capital and financial products, policies, and services to innovative agents devoted to innovative development, achievement transformation, and industrialization, including enterprises, universities, and research institutes. It aims at an organic union of the technological innovation chain and the financial capital chain. Ang [10] adopted Korean time series data and discovered the function of financial liberalization in technological innovation. Tadesse [11] found out that a market-oriented financial system benefits technological advances. According to Zhang et al. [12], technological finance is a series of financial tools promoting science and technology development, achievement transformation, and high-tech industrial development. These tools include financial systems, policies, and services promoting industrial growth and governments, enterprises, market and social agencies funding science and technology innovation activities. In the meantime, technological finance is a key component of the financial system and national innovation system. Audretsch and Lehmann [13] concluded that venture capital tends to favor small and medium technological enterprises, and it evidently stimulates entrepreneurial development. Based on data of Italian enterprises, Benfratello [14] concluded that banking development encourages activities of science and technology innovation. Currently, scholars have not reached a consensus on the connotation of technological finance, though they do concur that the key of technological finance is its capital raising function in science and technology development. This paper interprets technological finance as policies and institutional arrangements conducted by various financial organizations and capital—such as governments and markets—to provide monetary support and financial services to activities of science and technology innovation.

2.2. Impact of Technological Finance on High-Quality Economic Growth. Studies on the impact of technological finance on a high-quality economy have led to various conclusions. He [15] believed that some factors are restraining China's high-quality economic growth to a certain extent. They include imperfection of relevant laws and regulations, insufficiency of shared service platform, monotonous fund-raising pattern, inadequate industry innovation, and absence of professional talents. Deng [16] also pointed out that current technological finance falls short of ideal policies and regimes, hence its lack of persistent innovation and the restraint over high-quality economic development. Shao and Wang [17] believed that the system of technological finance is far from perfect, as its performance has been hindered by unavailable access to venture capital. Schwartz [18] analyzed the significance of finance and technological advances in the entire economic system. Finance boosts the development of technologies and lends support to the course of high-quality economic growth. The study of commercial banks, conducted by King and Levine [19], leads to the view that banks could make use of their information edge in programme selection for risk diversification. Their funding of technology enterprises effectively supports technological innovation and optimizes the quality of economic growth. Gu and Wang [20] investigated the spatial and temporal heterogeneity of the quality effects brought by Chinese technological finance's participation in economic growth. They found out that the spatial and temporal trajectories of such quality effects are consistent with the changing level of technological finance's investment and the shifts of technology innovation capacity. Griffith et al. [21] believed that financial capital is mostly used by the enterprise for innovation and technology transfer. Using the total factor productivity as an index, they analyzed how technological progress increases the total factor productivity and subsequently stimulates high-quality economic growth. According to Zheng and Zhang [22], technological finance is of nonlinear relationship with regional technological innovation. Hsu et al. [23] classified samples into two categories: emerging economies and developed countries. Their discussion on the relationship between technological innovation and financial development leads to the discovery that the credit market and venture capital can encourage technological progress and high-quality economic growth. Zou and Ni [24] believed in the substitution effect of public technological finance. Beck et al. [25] used commercial banks' changing credit rates to evaluate the level of financial innovation. Their study leads to the conclusion that the more drastically the credit rate changes, the higher level of technological innovation for technological enterprises. Besides, enhanced enterprise productivity stimulates high-quality economic growth. Chowdhury and Maung [26] believed that the impact of innovation investment on the high-tech industry is of positive correlation with the development level of the financial market. Xu et al. [27] gave a theoretical explanation of the notable promotion mechanism behind technological finance's impact on the high-tech industry's technological innovation. For Ilyina and Samaniego [28], finance is capable of effectively allocating resources to departments of advanced technology and high productivity. Once the issue of external funding for technological innovation is settled, technological development can be further enhanced for the realization of high-quality economic growth. In his analysis of Turkey samples, Adak [29] explained how investment in technological innovation can effectively improve productivity and hence the quality of economic growth. There are also some studies evaluating the efficiency of technological finance.

2.3. Technological Finance's Impacts on Financial Stability. Technological finance benefits technological enterprises with financial capital inflow. Yet, due to the high-risk management of technological enterprises, such inflow also leads to financial instability and subsequent risks in the financial system. Technological finance is a financial resource targeting technological enterprises. Its risks come from both adjustments of financial structure and instability of the debtor. Therefore, despite its promotion of high-quality economic growth, technological finance is fraught with financial uncertainties. Scholars have yet to reach a consensus on the role played by technological finance in financial stability.

The "facilitation school" holds that financial innovation is beneficial for risk transfer and diversification [30]. Zhang [31] pointed out that the growth of technological finance could stimulate the diversified development of financial institutions'businesses, improve fund allocation and operation efficiency of financial institutions. As a result, it could effectively optimize the financial market system, improve the market's capability to defend and deal with risks and crises, reduce the likelihood of systematic financial crisis and strengthen the stability of economic growth. Zhang and Gu [32] believed that technological finance achieves coordinated development with technological innovation systems via the technicalization of new industries, thereby achieving the goal of stabilizing the macroeconomy. Drasch et al. [33] believed that an in-depth fusion of finance and technology could encourage diversification of commercial banks' business and customers and reduce bad loan ratios and systematic risks.

On the contrary, the "destruction school" holds that the purpose of financial innovation is to transfer rather than diminish systematic risks, and it would lead to more financial turmoil in times of disorderly and excessive innovation [34]. Technological enterprise, due to its inherent instability, may increase the credit risks of financial institutions, whereas the mobility and conductivity of these risks would make financial systematic risks escalate. Duffey and Saull [35] believed that, due to the information asymmetry of the market as well as the high uncertainly of technological enterprises' sustainable profitability, financial institutions cannot obtain an accurate evaluation of asset quality via core technologies. This would lead to industrial default risks and economic turbulence. Geddes and Schmidt [36] pointed out the imbalance of functional structure in the development of technological finance. This issue could be manifested as the imperfect loan model of policy-based financial institutions, which is mainly direct loans that would worsen the risks of currency mobility within banks. Yang et al. [37] indicated that, while financial innovation in the banking industry helps to fulfill business demands raised by investors and customers, thereby realizing the self-interests of the banking institutions, such innovation would also lead to risk expansion of the entire banking industry. The analysis of Jiang [38] leads to the argument that, as financial innovation evades existing risks and encourages economic growth, it also amplifies the transmission effects of financial risks and may even result in systematic financial risks.

Existing literature has examined the impacts of technological finance on high-quality economic growth and financial stability, and their achievements are of great significance, though there is still room for improvement. (1) The indexes of technological finance, high-quality economic growth, and financial stability await further refinement, while there is some confusion concerning index variants. Judging from both domestic and overseas literature, scholars hold various understandings of "technological finance, which lead to distinct constructions of the technological finance index. Technological finance emerged in China only recently and there are insufficient statistics of relevant data held by financial institutions like banks. These obstacles have troubled scholars working on technological finance. Therefore, it is of immediate significance to choose comprehensive evaluation indexes that would truly reflect the Chinese condition. (2) Existing studies of technological finance mostly focus on the theories and efficacy measurement of technological finance. Technological finance and high-quality economic growth are normally regarded as two distinct subjects for study. Literature examining technological finance tends to focus on economic growth rather than the quality of such growth, though the latter is the key to China's economic transformation. (3) Academic studies on technological finance and economic growth have not stepped beyond the topic of their relationship. So far, few have paid attention to financial risks accompanying the development of technological finance or the impacts of technological finance on financial risks. Is it true that, along with its stimulation of high-quality economic growth, technological finance has also brought down financial stability and thus worsened financial systematic risks? (4) Most of the analyses on issues related to technological finance tend to be conducted within a certain region or across the nation. Due to the lack of regional comparison, existing research achievements have neglected the spatial features of economic variables.

Therefore, this paper extends the study to the following aspects: (1) The author makes further elaboration on technological finance, high-quality economic growth, and financial stability index, thereby constructing a comprehensive evaluation index system befitting the Chinese condition and of solid reliability. (2) This paper focuses on the quality of economic development, highlighting the goal of the age—high-quality economic growth. Empirical studies of technological finance and high-quality economic growth adopt the spatial econometric model, with regional spatial interaction taken into consideration. (3) The current study incorporates the impacts of technological finance on financial stability, analyzing the shock effect brought by the former to the latter, thereby arriving at a more profound and objective examination of technological finance. (4) Based on existing research, this paper conducts both national and regional investigations on the relationship between technological finance, high-tech economic growth, and financial stability. The conclusions are generally applicable and attentive to specifics, serving as an empirical foundation for the making and application of differentiated policies.

3. Empirical Studies of Technological Finance's Impacts on High-Quality Economic Growth

3.1. Model Setup. Given the research goal of the current paper, namely to analyse the impact of technological finance on high-quality economic growth and financial stability, here the core explanatory variable is technological finance, and the explained variables are high-quality economic growth and financial stability. This section begins with the construction of an econometric model for the analysis of technological finance's impacts on high-quality economic growth. The research object covers thirty provinces (including autonomous regions and municipalities) since studies of regional economic issues could not neglect the spatial relativity of variables [39]. The method of spatial econometrics introduces the geographical location and reciprocal effects of a region into the model for the exploration of individuals' spatial changes and contributory factors within a region. Thus, this section establishes a spatial econometric model in the following form:

$$\begin{aligned} \mathrm{TFP}_t &= al_N + \rho \mathrm{WTFP}_t + \beta_1 TFI_t + \theta_1 \mathrm{WTFI}_t \\ &\quad + \beta_2 M_t + \theta_2 W M_t + \mu + \xi_t l_N + u_t, \\ u_t &= \lambda W u_t + \varepsilon_t. \end{aligned} \tag{1}$$

In formula (1), all variables are in vector form. The explained variable TFP is high-quality economic growth. TFI represents technological finance. M_t is the set of controlled variables, and W, the matrix of spatial weights.

Existing literature tends to adopt 0–1 matrix as the setup for spatial weight matrix [40], which may lead to inaccurate results. This paper adopts economic distance to construct the weight matrix of each province (including autonomous region and municipality).

3.2. Explanation of the Variables, Data Processing, and Data Source

3.2.1. Core Variable

(1) Technological Finance. The selection of technological finance indicators mainly follows the scientific principle, which means that the indicators that can truly reflect the development level of regional technological finance should be selected. Based on the main sources of funds in technological finance: government, enterprises, financial institutions, and capital markets, public technological finance, technological finance market, and technological finance output are selected as measurement indicators. Based on the works of Zou and Ni [24] and Zhang and Gu [41], this paper constructs a comprehensive index of technological finance from three aspects: public technological finance, market technological finance, and technological finance output (see Table 1). The weight construction of this comprehensive index is based on the sum of three individual index weights, constructed in accordance with the respective indexes using factorial analysis.

(2) High-Quality Economic Growth. In the new normal, total factor productivity becomes the key driving force behind China's economic growth, bearing direct correlation with the dream to achieve more sustainable and much fairer development of higher quality and more efficiency. High-quality economic development is a more efficient and sustainable development. As the cost of labor and other factors in China continues to rise, and the constraints of resources and environment are becoming increasingly tight. The extensive development model of China that relied primarily on high input, high consumption, and high pollution in the past has become unsustainable. High-quality economic development is to achieve the maximum benefit with less resource consumption and lower pollution emissions, improve input-output efficiency, and cut down energy and environmental costs. Hence, this paper selects the green total factor productivity to measure the high-quality economic development. This index is evaluated via the green total factor productivity. This paper adopts the method of the DEA-Malmquist-Luenberger Index for the assessment of green total factor productivity. This method has no restraint over the number of investment-output indexes. Construction of the output index could incorporate both desirable and undesirable outputs, along with resource and environment factors, to ensure an accurate evaluation of the high-quality economic growth index. After consulting the practice undertaken by Li et al. [42], this paper adopts the CRS Multiplicative Model of the reference set within a fixed period to measure the total factor productivity.

(3) Choice of Investment-Output Index. In this paper, investment covers three aspects, namely fixed asset investment, human capital investment, and energy investment. Calculation of the fixed asset investment is based on the work of Zhang et al. [43]. Here, we select the social fixed asset investment indicator and then calculate the capital stock of each province from 2004 to 2017 using the perpetual inventory system. The actual calculation runs as follows: $K_{it} = I_{it} + (1-\delta)K_{it-1}$ K_{it} is the capital stock of province i in the year t. I_{it} is the amount of fixed asset investment of province i in the year t. δ is the depreciation rate, here set at 6% (Hall, 1999). 2004 is the base year, and the amount of its fixed asset inventory is calculated via $K_{i0} = I_{i0}/(g+\delta)$, after consulting Coe et al. [44]. K_{i0} Is the base year's capital asset, g is the economic growth rate of that year, and δ is the depreciation rate, calculated by running deflator on each province's fixed asset investment price index of that year. The index of human capital investment is calculated based on two indicators: the amount and the quality. The amount of human capital is the sum of each province's labour force working in the primary, secondary and tertiary industries. The quality of human capital is calculated according to the years of education one has received, i.e., $S = \sum S_i L_i / \sum L_i$. In this formula, S is the maximum number of years receiving education for a given level, L is the number of people receiving each level of education. The maximum years of education for each level are, respectively, six years for primary school education, three years for both junior and senior high school education, and three years for higher education. The output index is

Table 1: Construction of technological finance index.

Grade I index	Grade II index
Public technological finance	Participants in technological activities (head) Full-time participants in reserch and experiment development (head) Organizations (number) Government funds (ten thousand yuan) Personnel involved (head/year) Spendings (ten thousand yuan)
Market technological finance	Enterprise funds (ten thousand yuan) Loans from financial institutions (ten thousand yuan) Enterprises with technological institutions (number) Enterprises with technological activities (number)
Technological finance output	Research projects in universities (number) Research projects in enterprises and research institutes (number) Domestic patents licensed (number)

judged from two aspects—the desirable and the undesirable outputs—for a more accurate evaluation of high-quality economic growth. For the desirable output, the regional total output value is adopted—as the normal practice goes—and then deflated according to the GDP deflator indicator of the corresponding year. The undesirable output selects five indicators: wastewater, chemical oxygen demand, ammonia nitrogen discharge, sulfur dioxide emission, and total dust emission. The total power emission is the sum of industrial soot (dust) emission, life-related soot (dust) emission, and industrial dust emission (see Table 2).

3.2.2. Controlled Variables

(1) Level of Economic Development (AED). The level of regional economic development plays a key role in high-quality economic growth, restraining a region's investment in improving technological innovation, humane environment, and natural environment. This paper adopts the regional GDP per capita as the proxy variable, which is deflated according to the GDP deflator index of each province.

(2) Scientific Research Investment (SRP). Endogenous growth theory maintains that scientific development motivates the development of economic society, and this paper treats the number of practitioners working in the respective fields of scientific research, technological service, and geological survey as proxy variables.

(3) Investment Rate (IRE). The ratio between the total amount of fixed asset investment and regional GDP is used as the proxy variable (see Table 3).

3.2.3. Data Source. Provincial data adopted in this section comes from China Statistical Yearbook, China Statistical Yearbook on Environment, China Statistical Yearbook on Science and Technology, the National Bureau of Statistics website, and ESP database.

Due to the data deficiency of the Tibetan Autonomous Region, its data is removed and the research samples comprise data from 30 provinces (including autonomous regions and municipalities) between the years 2005 and 2017. The few missing data is replenished using interpolation and regression.

3.3. Empirical Results and Analysis

3.3.1. Spatial Autocorrelation Test. Since this paper adopts the spatial econometric model for empirical study, we need to verify whether the data being examined is spatial dependent. This paper uses the widely adopted Moran's I Index to test the global spatial autocorrelation. The formula for this index is as follows:

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\left(x_i - \overline{x}\right)\left(x_j - \overline{x}\right)}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}}, \tag{2}$$

$S^2 = \sum_{i=1}^{n} (x_i - \overline{x})^2/n$ is the sample variance, w_{ij} is the spatial weight matrix, $S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}$ is the sum of spatial weights.

Results in Table 4 reveal that, between 2005 and 2017, the high-quality economic growth index, i.e., the Moran's I value, of 30 provinces (including autonomous regions and municipalities) have passed the significance test at 1%, 5%, and 10% levels, respectively. All the values are positive, indicating a significant spatial positive correlation among the high-quality economic growth indexes of each province (autonomous region and municipality).

3.3.2. Model Construction. First, we use the LR and Ward tests, and the results are as follows: $\text{chi2}(5) = 10.80$, $\text{Prob} > \text{chi2} = 0.0555$, $\text{chi2}(5) = 24.48$, $\text{Prob} > \text{chi2} = 0.0002$. The original hypotheses $\theta = -\beta\rho$ and $\theta = 0$ are rejected, respectively. Neither SAR nor SEM models apply to the current study. Then, we add the deviated lagging economic value and determine the applicability of SAC (SARAR) and SDM models according to AIC and BIC standards. The results demonstrate that the AIC figure has changed from 949.035 to 941.3444, and the BIC figure from 1022.871 to 987.9776. Both figures have become smaller, indicating that we should choose the spatial SAC (SARAR) model.

Results of the Hausman test are as follows: $\text{chi2}(5) = 66.93$, $\text{Prob} > \text{chi2} = 0.0000$. Therefore, we should use the fixed effects model rather than the random-effects model.

Table 2: Descriptive statistics of investment-ouput variables.

Variables	Maximum value	Minimum value	Average value	Standard deviation	Observed value
Capital stock	329849.8	2813.0	57874.8	54052.9	420
Human capital amount	6766.0	263.1	2542.5	1676.6	420
Human capital quality	11.7	6.6	8.2	0.8	420
Total energy capacity	28679.2	270.3	4936.0	4169.8	420
Electricity consumption	5959.0	68.7	1444.3	1144.9	420
Water consumption	591.3	22.1	197.5	139.6	420
Regional GDP	57212.2	438.2	11479.5	10318.8	420
Waster water	938261.0	14287.0	208367.8	166562.8	420
Chemical oxygen demand	198.3	3.9	55.3	39.8	420
Ammonia nitrogen discharge	23.1	0.5	5.8	4.2	420
Sulfur dioxide emissions	200.2	1.4	68.5	44.0	420
Total dust emission	181.7	1.6	49.2	36.2	420

Table 3: Descriptive statistics of the variables.

Variables	Signs	Maximum value	Minimum value	Average value	Standard deviation	Observed value
High-quality economic growth	TFP	22.1882	0.8925	1.9464	1.5953	360
Technological finance	TFI	4051919	2968.1640	726914.8000	540030.7000	360
Economic development level	AED	12.9060	0.6226	2.3899	4.0534	360
Research input	SRP	71.2481	1.1418	9.7345	10.9257	360
Investment rate	IRE	1.4795	0.2366	0.2351	0.7048	360

Table 4: Moran's I index test results of high-quality economic growth index.

Year	2005	2006	2007	2008	2009	2010
TFP	0.038 (0,061)	0.032 (1,037)	0.051* (1,340)	0.046* (1,330)	0.051* (1,372)	0.090* (2,010)
2011	2012	2013	2014	2015	2016	2017
0.045* (1,342)	0.064* (1,652)	0.062* (1,635)	0.057*(1.569)	0.045 (1,394)	0.024 (0,972)	0.007* (0,861)

Note: *, **, and *** represent, respectively, passing 10%, 5%, and 1% significance level test. The bracketed figure is the Z statistic value.

Based on the results of the model applicability test, this paper adopts the two-way fixed effects model.

3.3.3. Estimated Results and Analysis. This section begins with an estimation of the gross sample of 30 provinces (including autonomous regions and municipalities) in China. Since the developments of both the economy and the technological finance demonstrate obvious regional features, we divide the gross sample into three subgroups representing the eastern, middle, and western regions of China, according to the standards issued by the National Development and Reform Commission in 2003.

According to the results in Table 5, estimation of the national gross sample indicate that technological finance holds an evident positive impact over high-quality economic growth. Every time the figure representing technological finance rises by 1%, the one representing high-quality economic growth rises by 0.66413%. Estimation of the regional samples reveals that technological finance in all three regions also holds evident positive influence over the respective region's high-quality economic growth. The difference lies in the size of the impact factor. In the eastern region, technological finance proves to be a strong driving force stimulating high-quality economic growth, which increases by 1.39995% every time technological finance rises by 1%. In the middle region, high-quality economic growth rises by 0.66607% at every 1% increase of technological finance. The effect proves the be the weakest in the western region, as high-quality economic growth improves by a mere 0.17450% for the 1% rise in technological finance.

Judging from spatial interactions, both the national sample and the regional samples have demonstrated an evidently positive "spatial spillover"effect, indicating that the development of regional technological finance is positive encouragement to neighbouring regions' high-quality economic growth. This is due to the nature of technological finance as a union of technological innovation and financial assets, which can optimize resource allocation of neighbouring regions' human resources, technological resources, and capital, thus enhancing the production efficiency and economic growth there.

3.4. Robustness Test. To test the robustness of technological finance on high-quality economic growth, this section runs estimation via constructing other controlled variables. Three variables are selected: infrastructure (ARE), human capital (HCL), and industrialization level (IDL). The infrastructure adopts the road area per capita as the proxy variable. The human capital level uses the ratio of the population receiving secondary and higher education to the entire population. As for the level of industrialization, it is the ratio between the second and the third industries' production. Judging by the estimated results of the robustness test listed in Table 6, the size and significance of individual variable factors differ,

Table 5: Estimated results of the national sample and regional samples.

	Nation	Eastern region	Middle region	Western region
TFI	0.66413*	1.39995*	0.66607*	0.17450*
	(2,23)	(4,42)	(2,98)	(2,46)
AED	1.48713***	0.07335	0.28123***	0.02589
	(19,04)	(0,34)	(5,48)	(1,04)
SRP	20.11013***	−0.12962***	0.01277	−0.06155***
	(−6,10)	(−3,71)	(1,05)	(−4,63)
IRE	0.70484***	−3.10045*	0.29633	0.22115
	(56,88)	(−2,77)	(1,53)	(1,52)
C	2.25050***	2.85388***	0.03120	0.95601***
	(5,01)	(6,13)	(0,29)	(10,07)
ρ	0.57297*	1.60448***	0.79126***	0.02459***
	(2,78)	(7,62)	(3,88)	(8,79)
R^2	0.5712	0.3818	0.1522	0.5579
AdjR^2	0.5234	0.2769	0.1195	0.4875
Log$L$	−693.4250	−284.4302	34.1788	21.4707
Observed value	1950	715	520	162

Note: *, **and *** represent, respectively, passing 10%, 5%, and 1% significance level test. The bracketed figure is the Z statistic value.

Table 6: Results of the robustness test on the national sample and regional samples.

	Nation	Eastern region	Middle region	Western region
TFI	0.54003***	1.21137***	0.76516*	0.15314***
	(14,10)	(4,15)	(3,04)	(3,31)
ARE	4.40161***	−0.46620*	−0.12247*	0.03100
	(41,72)	(−2,84)	(−2,56)	(0,74)
HCL	4.40161***	0.83120*	−0.11656	0.15314***
	(41,72)	(3,13)	(−1,47)	(3,31)
IDL	1.26605***	3.16085***	0.04076	−0.61352*
	(13,37)	(3,34)	(0,93)	(−2,75)
C	2.32165***	1.60124***	0.03120	1.51499***
	(5,57)	(8,68)	(0,29)	(5,08)
ρ	0.59575*	1.60448***	0.79126***	0.02459***
	(2,99)	(7,62)	(3,88)	(8,79)
R^2	0.4485	0.5773	0.5904	0.6540
Adj R^2	0.3889	0.4831	0.5324	0.5952
Log L	−693.5411	−214.7007	12.6500	7.7109
Observed value	1950	715	520	162

Note: *, **and *** represent, respectively, passing 10%, 5%, and 1% significance level test. The bracketed figure is the Z statistic value.

whereas the core variable—spatial spillover factor of technological finance—remains the same. Therefore, the results of technological finance and high-quality economic growth prove to be relatively robust.

4. Technological Finance's Impacts on Financial Stability

The union of technology and finance is an innovation. Within a short period, constructions of financial institutions, products (services), and systems started from scratch [45]. Such construction is accompanied by diversity and uncertainty, which, in other words, mean potential risks. And this section is a study on whether technological finance and financial stability can lead to shocks. The traditional VAR model fails to take regional heterogeneity into account. PVAR model considers both temporal and geographical factors and fetches information relevant to both, thereby establishing a more valid connection between the variables.

4.1. Model Setup.

$$\mathrm{FSF}_{it} = \beta_0 + \sum_{j=1}^{p} \beta_j \mathrm{FSF}_{i,t-j} + \mathrm{TFI}_i + \varepsilon_{it}. \quad (3)$$

In formula (3), all variables are in vector form. FSF represents financial stability; TFI, technological finance; i, the region; and t, the time. p stands for the model's lag order; β_j, the regression factor of the lag endogenous variable; α_i, the individual fixed effect; and ε_{it}, the disturbance term. The PVAR model assumes that every cross-section shares an identical basic structure.

4.2. Explanation of the Variables, Data Processing, and Data Source

4.2.1. Core Variable

(1) Technological Finance. The construction of the technological finance index is the same as the explanation above.

Table 7: Construction of the financial stability index.

Construction of the financial stability index	Subindex
Status of macroeconomic growth	Economic growth rate
Macrofinancial institutions and markets	Fiscal deficit/GDP
	Total loans/GDP
	Loan balance/deposit balance
Microfinancial institutions	Property value/GDP
	Defect rate

(2) Financial Stability. Financial stability depends on both the macroscopic and the microscopic aspects [46]. Based on the work of Li [47], the financial stability index in this section is constructed as a comprehensive one joining three aspects: condition of macroeconomic growth, markets, and macrofinancial institutions, and markets and microfinancial institutions. The details are listed in Table 7. The weight is set in the same manner for the construction of the technological finance index mentioned earlier, i.e., using the factor analysis method.

4.2.2. Controlled Variable. In this section, the controlled variable adopts the investment rate (IRE), using the ratio of fixed asset investment's total amount to the regional GDP as a proxy variable.

4.2.3. Data Processing and Data Source. Data in this section comes from the wind database, China Statistical Yearbook, the National Bureau of Statistics website, and ESP database.

Due to the data deficiency of the Tibetan Autonomous Region, its data is removed and the research samples comprise data from 30 provinces (including autonomous regions and municipalities) between the years 2005 and 2017, as we did earlier. The few missing data is replenished using interpolation and regression (see Table 8).

4.3. Empirical Results and Analysis

4.3.1. Stationarity Test of the Panel Data. To avoid causing distorted results of the model estimation due to instationary data, this paper adopts the frequently adopted LLC and IPS for the panel unit root test. The results indicate that, after the first feasible region, all the data are stationary. The test results are listed in Table 9.

4.3.2. Choice of the Optimal Lag Order in the Panel VAR Model. Assessment of this model requires us to choose the optimal lag order. According to $T = 2P + 2$, the maximum number for the lag order here is 5. Here are the results running for the optimal lag order according to the AIC, BIC, and HQIC rules.

According to Table 10, in the lag order test run within the range of 1 to 5, information volumes of AIC, BIC, and HQIC are the smallest when the lag order is 4. Therefore, the optimal lag order in this model is set at 4.

4.3.3. Panel Generalized Method of Moment. This section runs a panel generalized method of moment (GMM) on the estimation of the PVAR model. With reference to Love's procedure, we run the methods of cross-section mean difference and forward difference to eliminate the estimate deviation caused by temporal effect θ and α_i .

Results of the system GMM estimation in Table 11 demonstrate the negative impact of one lagging session of technological finance on the level of financial stability, which drops by an evident 1% with a factor value of −0.15290. If technological finance lags for two sessions, there is no significant impact on financial stability. A three-session lag would lead to a positive impact at the 5% significance level, with a factor of 0.03853. Four sessions' lag has not yet been found of any significant influence.

Judging by the pulse response function graphs of the national samples, technological finance is of a significant negative shock effect on financial stability, which reaches its maximum at the third session and then gradually drops low (see Figure 1).

Results of variance analysis in Table 12 reveal that only 4.505% of the financial stability's estimated variance comes from technological finance at the 10th session, whereas the results of the variance analysis at the 20th and 30th estimation sessions are relatively the same. It suggests that after the 20th estimation session, the impact of technological finance on financial stability has become mostly stable. Judging by the results of the 10th, 20th, and 30th estimation sessions, the estimated variance of financial stability comes mainly from itself and remains stable around 92%.

According to the method selected by the gross sample PVAR model's lag order, we run the similar procedure on PVAR models of the eastern, middle, and western region samples, and finally, confirm the GMM estimate results for the 3rd, 1st, and 5th sessions are (see Table 13):

Figure 2 shows that, in the eastern, middle, and western regions, the response value of financial stability at its self-shock is positive within a short period, and then the shock gradually wanes. In the eastern region, technological finance's response to the shock of financial stability is negative within a short period, then the negative shock weakens and finishes at 0. In the middle and western regions, the shock on financial stability is barely visible. As for the impact of investment rate on financial stability, it is of little significance in the eastern and middle regions. In the western region, this impact holds positive for a short period and then weakens, demonstrating a trajectory that rises and falls and then rises again.

Table 8: Descriptive statistics of the variables.

Variables	Signs	Maximum value	Minimum value	Average value	Standard deviation	Observed value
Financial stability	FSF	1.2395	0.0811	0.1769	0.2618	360
Technological finance	TFI	4051919	2968.1640	726914.8000	540030.7000	360
Investment rate	IRE	1.4795	0.2366	0.2352	0.7048	360

Table 9: Stationarity test of the variables.

Variables	LLC	IPS	Test results
X1	1.2133	0.0778	Instationary
M	0.5835	1.9099	Instationary
X2	1.5838	3.8139	Instationary
dX1	-6.8596^{***}	-7.6467^{***}	Stationary
Dm	-5.4650^{***}	-31.9536^{***}	Stationary
dx2	-2.6030^{***}	-13.2263^{***}	Stationary

Note: *, **and *** represent, respectively, passing 10%, 5%, and 1% significance level test. The bracketed figure is the Z statistic value.

Table 10: Test restuls of the optimal lag order.

Lag	AIC	BIC	HQIC
1	10.8877	14.0853	12.1673
2	10.0873	14.1922	11.7356
3	8.17003	13.3475	10.2562
4	5.05554^{*}	11.5266^{*}	7.67156^{*}
5	108.002	116.073	111.274

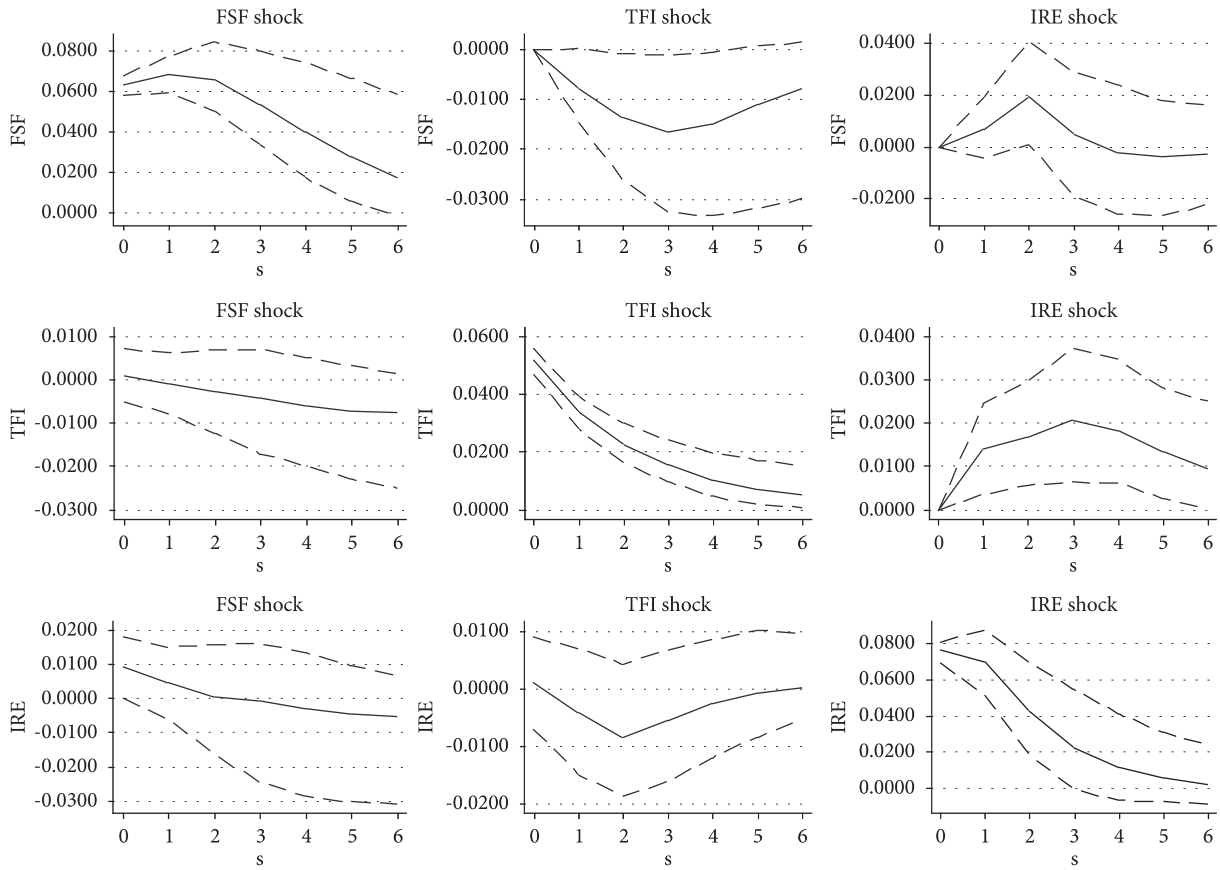
Note: *, **and *** represent, respectively, passing 10%, 5%, and 1% significance level test. The bracketed figure is the Z statistic value.

Table 11: Estimated results running system GMM.

	h_lnx1	h_lnm	h_lnx2
Lh_lnx1	1.06995^{***}(0.07144)	-0.05088^{*}(0.05165)	−0.06042(0.08648)
Lh_lnm	-0.15290^{*}(0.09043)	0.64469^{***}(0.05654)	−0.10045(0.08741)
Lh_lnx2	0.09091(0.09984)	0.18172^{**}(0.08250)	0.92139^{***}(0.13921)
L_2h_lnx1	-0.13361^{***}(0.03716)	0.01905(0.03305)	0.04137(0.03973)
L_2 h_lnm	0.00052(0.02094)	0.02127^{*}(0.01112)	−0.02587(0.01780)
L_2h_lnx2	0.09739(0.08234)	−0.06052(0.07237)	-0.26380^{***}(0.12178)
L_3h_lnx1	-0.09887^{***}(0.01927)	−0.01716(0.01741)	0.00695(0.02313)
L_3 h_lnm	0.03853^{**}(0.01592)	0.01821(0.01340)	0.07105^{***}(0.01963)
L_3h_lnx2	-0.30348^{***}(0.06751)	0.08979(0.06361)	0.05351(0.10031)
L_4h_lnx1	-0.03741^{**}(0.01611)	−0.00598(0.01301)	-0.04129^{**}(0.02018)
L_4 Lh_lnm	0.02150(0.01887)	−0.01019(0.01139)	−0.00199(0.02411)
L_4h_lnx2	0.18438^{***}(0.05134)	−0.04623(0.04635)	−0.00593(0.06092)

Note: *, **and *** represent, respectively, passing 10%, 5%, and 1% significance level test. The bracketed figure is the Z statistic value.

4.4. Robustness Test. This section replaces the investment rate index with the inflation rate since the latter proves to be of certain influence over financial stability [48]. Here we adopt the GDP deflator index as the proxy variable to examine the shock brought by technological finance on financial stability. The result does not differ much from what this thesis has presented, proving the robustness of our conclusion on the relationship between technological finance and financial stability.



Errors are 5% on each side generated by Monte-Carlo with 200 reps

Figure 1: Pulse response graphs of gross national samples.

Table 12: Variance decomposition.

	S	lnx1	lnm	lnx2
lnx1	10	0.92765	0.04888	0.02346
Lnm	10	0.04505	0.71710	0.23785
lnx2	10	0.01557	0.00937	0.97506
lnx1	20	0.92726	0.04887	0.02387
Lnm	20	0.05200	0.71145	0.23656
lnx2	20	0.01639	0.00951	0.97410
lnx1	30	0.92726	0.04887	0.02387
Lnm	30	0.05200	0.71145	0.23656
lnx2	30	0.01640	0.00951	0.97410

Table 13: GMM estimates of the eastern, middle, and western regions.

	h_lnx1 (east)	H_lnx1 (middle)	H_lnx1 (west)
L.h_lnm	−0.08076** (0.03555)	0.44397* (0.25034)	−0.21014(0.24478)
L2.h_lnm	−0.00963(0.01730)	—	−0.15406(0.11912)
L3.h_lnm	0.05437*** (0.01528)	—	0.10999* (0.06510)
L4.h_lnm	—	—	0.01101(0.03112)
L5.h_lnm	—	—	0.02764(0.02798)

Note: *, **and *** represent, respectively, passing 10%, 5%, and 1% significance level test. The bracketed figure is the Z statistic value.

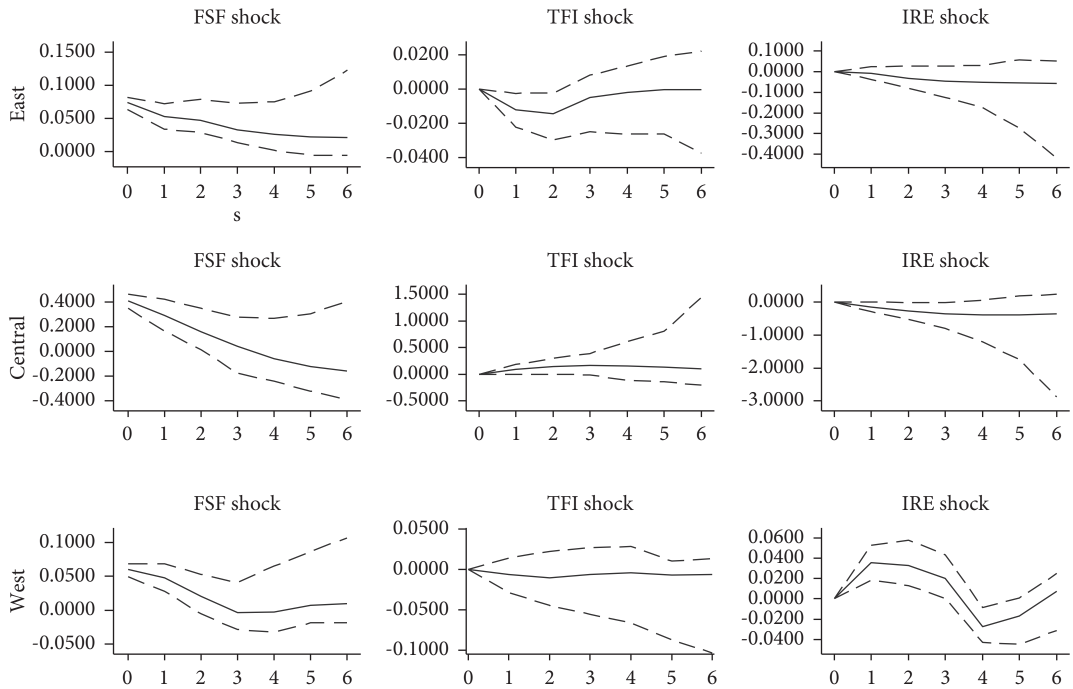


Figure 2: Pulse response of eastern, middle, and western regions' technological finance and investment rate on financial stability.

5. Conclusion and Policy Implications

Based on the panel data of 30 Chinese provinces (including autonomous regions and municipalities) between 2005 and 2017. Based on the gross national sample and the regional samples, we have analyzed the relationship between technological finance, high-quality economic growth, and financial stability both theoretically and empirically. The results demonstrate that:

(1) According to the gross national sample, technological finance holds an evident positive impact on high-quality economic growth. Every time the figure representing technological finance rises by 1%, the one representing high-quality economic growth rises by 0.66413%. The development of technological innovation is what motivates and evidently accelerates high-quality economic growth. Given its demand for sufficient funding, technological innovation can enhance its efficiency and level with increasing financial support, which would then be translated into the more effective promotion of high-quality economic growth.

(2) Empirical study on regional samples demonstrates the positive influence of technological finance on high-quality economic development in all three areas, namely China's eastern, middle, and western parts. An evident spatial spillover effect can be observed. The difference lies in the size of the impact factor: the eastern region holds the largest impact while the western region is at the bottom. Technological finance tends to accumulate in regions of high-standard economic growth and abundant financial resources. The bigger the scale of the accumulation, the more advanced innovation capacity and economic effects would become. Once a cluster centering on technological finance is formed, technological, financial capital would start to accumulate and promote high-quality economic growth. The gathering effect of technological finance is also a spillover. Mobility of factors like financial capital, talents, and techniques exert positive effects on neighbouring regions' high-quality economic growth. The extent of such spatial spillover is closely related to the level of a regions' technological financial development.

(3) Analysis of the national sample demonstrates the significant negative shock effect of technological finance on financial stability within a short period. This negative shock then gradually weakens along with the passage of time. The biggest difference between technological finance and traditional modes of finance is that the former serves technological enterprises which runs high-risk business. The high risk and contagiousness of technological finance mean that funding technological enterprises would lead to the accumulation of financial risks, and eventually affect financial stability. As the financial system becomes perfected and the risk coping capacity improves, the negative impact of technological finance over financial stability also lessens, and the financial system gradually adapts itself to the development of technological finance.

(4) In the eastern region, technological finance has an obvious negative shock effect on financial stability

within a short period, but the effect gradually dwindles as time goes by. Neither western nor middle regions have displayed an obvious shock impact on financial stability. Such regional difference suggests that financial stability is related to the level of regional development and the nature of trade. Enterprises in the middle and western regions are mostly of the traditional industry, with relatively little financial investment into the technological enterprises. Therefore, the risk thus incurred would not affect the region's overall financial system much. On the contrary, the eastern region is keen on technological innovation, with much financial investment on enterprises of technological innovation, hence the escalating financial risks.

As a financial resource devoted to the technological industry, technological finance is of great significance for China's entry into the new normal and transformation of the economic development model into high-quality economic growth. Technological finance is an ingenious child born out of the union between science and finance, yet its early stage of development is so unstable and risky that it brings a negative shock impact on financial stability. Based on the above findings, this paper proposes the following:

(1) The government should display its vigorous financial support of technological innovation, increase fiscal investment in technological enterprises and encourage social capital's participation, to perfect the service platform for technological finance. Technological finance has innovatively enriched the scope of financial products and services, alongside its promotion of macroscopic high-quality economic growth. This innovative financial service optimizes resource allocation, achieve technological advance, and satisfy the needs of all sorts of technological enterprises. Innovation in financial tools and services has also widened the scope of financial options available for investors, bringing vibrancy to the capital market and unveiling microscopic effects of economic growth. In the meantime, we should shorten the regional gap of technological finance development. Governments of all levels should attach importance to the financial support of the technological industry and implement key policies—particularly in the middle and western regions—to stimulate financial institutions' transformation for the strengthened investment of technological finance in these regions. These would help promote the development of technological industry in all regions.

(2) We should strengthen the communication and interaction among regions. Enhanced regional connectivity can help neighboring provinces and cities to follow suit and make progress together, technological finance has a spatial spillover effect, and its development is of significance to the high-quality economic growth of all regions in China. We should establish a service platform of technological finance, combine regional resources for shared information so that technological finance could be communicated. We should also strengthen the support lent by technological finance to backward regions, transmit resources of technological finance to the neighboring region as a gesture of support so that technological finance would enjoy a mobile development in all regions and stimulate their high-quality economic growth.

(3) We should strengthen the construction of the financial system to avoid financial risks. Innovative development of technological finance requires an institutional guarantee, hence the need for a fitting institutional framework. Government guidance and market operation should complement each other because the development of technological finance requires market promotion and the government supervises the procedure as the facilitator. Despite its stimulation of both technological and economic developments, the growth of technological finance, spurred by the inflation of financial capital, could also lead to a mismatch between financial resources and technological resources temporally and spatially. This would increase the overall risks of the financial system.

(4) Policies concerning the development and regulation of technology should be designed in accordance with distinct regional features. Agents involved should be regulated under perfected laws and regulations on technological finance. All regions should monitor the status of technological finance development and mend its shortcomings in time for better coordination between technological finance and high-quality economic growth. Affected by the regional levels of technological innovation and financial development, technological finance exerts heterogeneous influence over regional high-quality economic growth and financial stability. Therefore, policies on developing and regulating technological finance should also be heterogeneously arranged.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This research was financially supported by the National Social Science Fund of China, grant no. 18BJY249, and the National Social Science Fund of China (Research on the Distribution Effect of Monetary Policy and the Effective PATH to Narrow the Income and Wealth Gap, grant no. 20&ZD105).

References

[1] J. Schumpeter, *Theorie der wirtschaftlichen Entwicklung*, Springer, Boston, MA, USA, 2003.

[2] J. R. A. Hicks, *Theory of Economic History*, Oxford University Press, Oxford, UK, 1969.

[3] G. Saint-Paul, "Technological choice, financial markets and economic development," *European Economic Review*, vol. 36, no. 4, pp. 763–781, 1992.

[4] R. G. Rajan, "Insiders and outsiders: the choice between informed and arm's-length debt," *The Journal of Finance*, vol. 47, no. 4, pp. 1367–1400, 1992.

[5] V. R. Bencivenga, B. D. Smith, and R. M. Starr, "Transactions costs, technological choice, and endogenous growth," *Journal of Economic Theory*, vol. 67, no. 1, pp. 153–177, 1995.

[6] C. W. Zhao, *Sci-Tech Finance*, Science Press, Beijing, China, 2009.

[7] A. M. Herrera and R. Minetti, "Informed finance and technological change: evidence from credit relationships," *Journal of Financial Economics*, vol. 83, no. 1, pp. 223–269, 2015.

[8] M.-C. Tang and Y.-L. Chyi, "Legal environments, venture capital, and total factor productivity growth of Taiwanese industry," *Contemporary Economic Policy*, vol. 26, no. 3, pp. 468–481, 2008.

[9] H. Q. Wang and Y. L. Xu, "A measure model for synergy degree between sci-tech innovation and sci-tech finance and its application," *China Soft Science*, vol. 6, pp. 129–138, 2012.

[10] J. B. Ang, "Research, technological change and financial liberalization in South Korea," *Journal of Macroeconomics*, vol. 32, no. 1, pp. 457–468, 2010.

[11] S. Tadesse, "Innovation, information, and financial architecture," *Journal of Financial and Quantitative Analysis*, vol. 41, no. 4, pp. 753–786, 2006.

[12] M. X. Zhang, S. J. Wei, and X. L. Zhu, "Science and technology finance: from concept to theoretical system," *China Soft Science*, vol. 4, pp. 31–42, 2018.

[13] D. B. Audretsch and E. E. Lehmann, "Financing high-tech growth: the role of debt or equity. Papers on entrepreneurship," *Growth and Public Policy*, vol. 1904, pp. 1–28, 2004.

[14] L. Benfratello, F. Schiantarelli, and A. Sembenelli, "Banks and innovation: m," *Journal of Financial Economics*, vol. 90, no. 2, pp. 197–217, 2008.

[15] H. Q. He, "High-quality development of economy driven by science and technology finance: realistic predicament and path choice," *Social Sciences in Guangxi*, vol. 12, pp. 90–95, 2018.

[16] Z. M. Deng, "Difficulties and breakthroughs in high-quality development of economy driven by science and technology finance," *Scientific Management Research*, vol. 37, no. 4, pp. 146–150, 2019.

[17] C. L. Shao and L. P. Wang, "A study of the routes for technological finance development from the innovation-driven perspective," *Economic Review Journal*, vol. 11, pp. 65–69, 2016.

[18] M. Schwartz, *Evaluating Research and Development Investments in Project Flexibility, Agency and Competition*, Oxford University Press, New York, NY, USA, 2000.

[19] R. G. King and R. Levine, "Finance and growth: schumpeter might be right," *Quarterly Journal of Economics*, vol. 108, no. 3, pp. 717–737, 1993.

[20] S. Gu and S. J. Wang, "The effect of Chinese S&T financial investment to the quality of economic growth—a study based on spatiotemporal heterogeneity," *Finance and Economics*, vol. 8, pp. 30–43, 2018.

[21] R. Griffith, S. Redding, and J. V. Reenen, "Mapping the two faces of R&D: productivity growth in a panel of OECD industries," *The Review of Economics and Statistics*, vol. 86, no. 4, pp. 883–895, 2004.

[22] L. Zheng and W. K. Zhang, "The non-linear influence of tech-finance on tech-innovation—a U-shaped relationship," *Soft Science*, vol. 32, no. 7, pp. 16–20, 2018.

[23] P.-H. Hsu, X. Tian, and Y. Xu, "Financial development and innovation: cross-country evidence," *Journal of Financial Economics*, vol. 112, no. 1, pp. 116–135, 2014.

[24] K. Zou and Q. S. Ni, "Is there a substitution effect in public sci-tech finance?—evidence from 283 cities," *China Soft Science*, vol. 3, pp. 164–173, 2019.

[25] T. Beck, T. Chen, C. Lin, and F. M. Song, "Financial innovation: the bright and the dark sides," *Journal of Banking & Finance*, vol. 72, pp. 28–51, 2016.

[26] R. H. Chowdhury and M. Maung, "Financial market development and the effectiveness of R&D investment: evidence from developed and emerging countries," *Research in International Business and Finance*, vol. 26, no. 2, pp. 258–272, 2012.

[27] Y. L. Xu, Y. D. Wang, and Y. Lin, "Research on coupling coordinated degree evaluation of regional sci-tech innovation and sci-tech finance," *Science of Science and Management of S.& T.*vol. 32, no. 12, pp. 116–122, 2011.

[28] A. Ilyina and R. Samaniego, "Structural change and financing constraints," *Journal of Monetary Economics*, vol. 59, no. 2, pp. 166–179, 2012.

[29] M. Adak, "Technological progress, innovation and economic growth; the case of Turkey," *Procedia - Social and Behavioral Sciences*, vol. 195, pp. 776–782, 2015.

[30] T. Beck, O. De Jonghe, and G. Schepens, "Bank competition and stability: cross-country heterogeneity," *Journal of Financial Intermediation*, vol. 22, no. 2, pp. 218–244, 2013.

[31] L. Zhang, "Financial development, technological innovation and real economic growth—an empirical study based on spatial econometrics," *Financial Economics Research*, vol. 31, no. 1, pp. 14–25, 2016.

[32] Z. R. Zhang and G. F. Gu, "Spatial pattern of the coupling coordination between sci-tech finance and sci-tech innovation in China," *Economic Geography*, vol. 39, no. 4, pp. 50–58, 2019.

[33] B. J. Drasch, A. Schweizer, and N. Urbach, """Integrating the 'Troublemakers': a taxonomy for cooperation between banks and fintechs," *Journal of Economics and Business*, vol. 100, no. 4, pp. 26–42, 2018.

[34] W. J. Tang, S. Li, and Y. Q. Tao, "The development of digital inclusive finance and industrial structure upgrading: empirical evidence from 283 cities," *Journal of Guangdong University of Finance & Economics*, vol. 34, no. 6, pp. 35–49, 2019.

[35] R. Duffey and J. W. Saull, "Managing risk: risk assessment," *Dynamic Events and Financial Risks*, vol. 10, no. 3, pp. 219–261, 2018.

[36] A. Geddes and T. S. Schmidt, "Integrating finance into the multi-level perspective: technology niche-finance regime interactions and financial policy interventions," *Research Policy*, vol. 49, no. 6, pp. 103–115, 2020.

[37] Z. H. Yang, L. X. Chen, and Y. T. Chen, "Cross-market contagion of economic policy uncertainty and systemic financial risk: a nonlinear network connectedness analysis," *Economic Research Journal*, vol. 55, no. 01, pp. 65–81, 2020.

[38] Y. H. Jiang, "Study of the mutual transmission mechanism among financial openness, financial innovation and financial risk in China," *Social Sciences in Xinjiang*, vol. 05, pp. 30–38, 2020.

[39] J. Li, P. Chen, G. H. Wan, and C. M. Fu, "Study on the spatial correlation and explanation of regional economic growth in China—based on analytic network process," *Economic Research Journal*, vol. 49, no. 11, pp. 4–16, 2014.

[40] J. Q. Han, "Can regional financial development improve manufacturing productivity?" *Science and Technology Management Research*, vol. 14, pp. 164–173, 2019.

[41] Z. R. Zhang and G. F. Gu, "On the effect of the development of science and technology for finance on Chinese economic growth: an empirical test based on spatial econometrics model," *The Theory and Practice of Finance and Economics*, vol. 39, no. 4, pp. 112–118, 2018.

[42] Z. F. Li and X. X. Guo, "Effect and mechniamso f financial development on the rise of urban total factor productivity--from the perspective of environmental and resource restriction," *Inquiry into Economic Issues*, vol. 7, pp. 162–172, 2019.

[43] J. Zhang, G. Y. Wu, and J. P. Zhang, "The Estimation of China's provincial capital stock:1952-2000," *Economic Research Journal*, vol. 10, pp. 35–44, 2004.

[44] D. T. Coe and E. Helpman, "International R&D spillovers," *European Economic Review*, vol. 39, no. 5, pp. 859–887, 1995.

[45] M. X. Zhang, T. D. Guo, and J. F. Zhang, "Development of science and technology finance for 40 Years: analysis based on evolutionary perspective," *China Soft Science*, vol. 3, pp. 20–33, 2019.

[46] X. N. Wang and S. S. Zeng, "The impact of financial inclusion on Income inequality and financial stability—evidence from 43 countries along the "belt and road," *Research on Economics and Management*, vol. 4, pp. 25–36, 2019.

[47] X. D. Li, "Capital flows, policy uncertainty and financial stability," *Shanghai Finance*, vol. 2, pp. 30–38, 2019.

[48] Y. L. Chen, K. Song, and M. Li, "Multidimensional review of the financial crisis: cross-country evidence," *Studies of International Finance*, vol. 9, pp. 47–54, 2010.