How Does Digital Finance Affect the Development of China's Technology Market? An Empirical Study Based on China's Province-Level Data

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Abstract. Digital finance (DIF) has advanced rapidly over recent years, and it is worth exploring whether it can benefit China's technology market (TEM). Based on China's provincial panel data from 2011 to 2020, this paper empirically studies the impact and regional heterogeneity of DIF on China's TEM development by using a two-way fixed effects (TWFE) model. The results show that: (1) DIF has a significant positive impact on China's TEM development; (2) The coverage breadth, use depth and digitization degree of DIF all have a significant positive impact on China's TEM development, but the influence decreases in order; (3) The role of DIF in promoting the TEM in the underdeveloped regions of the central and western regions is significantly stronger than that in the eastern regions, and it is heterogeneous in different dimensions. The research conclusions of this paper will provide a reliable theoretical basis and policy implications for promoting the development of China's TEM.

Keywords: Digital finance · technology market · two-way fixed effects model · regional heterogeneity

1 Introduction

The 20th National Congress of the Communist Party of China proposed to deeply implement the innovation-driven development strategy, improve the scientific and technological innovation system, and accelerate the realization of high-level scientific and technological self-reliance and self-improvement. In the past decade, China's emerging frontier technology has continuously spawned new industries and new formats, which not only promoted the upgrading and development of the manufacturing industry, made the scale of new energy vehicles and new display industries rank first in the world, but also accelerated the application of supercomputing, big data, and blockchain, driving the vigorous development of artificial intelligence and digital economy. However, the development of China's technology market (TEM) today is far from enough, and there is still plenty of room for improvement. On the one hand, compared with the international TEM, the development of China's TEM is still in its infancy, and there are problems such as

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insufficient supply, insufficient demand, and low added value of technology. Although China's TEM has grown significantly in recent years, it still accounts for only a very small proportion of the transaction size compared to the global TEM, which is very inconsistent with China's second largest economy in the world [1]. On the other hand, compared with other domestic production factor markets, the development of China's TEM is obviously lagging behind. In 2021, the turnover of China's TEM accounted for only 3.26% of GDP, far lower than the proportion of total retail sales of consumer goods in the product market in the same year to 38.54% of GDP, and lower than the proportion of social financing to GDP in the capital market of 27.40%.

In contrast, the development trend of digital finance (DIF) in recent years is very ideal. According to the Peking University's Digital Financial Inclusion Index [2], China's DIF continued to develop at an average annual growth rate of 32.17% between 2011 and 2020. In addition, as the world's largest e-commerce market, China is a leader in both Internet finance innovation and digital economy. As an emerging financial model that organically combines information technology and traditional finance, DIF realizes the functions of financial integration, payment and settlement and information intermediary in virtue of mobile Internet, blockchain, big data and other digital technologies. DIF can not only reduce financing costs [3, 4] and alleviate financing constraints [5–7], thereby enhancing the efficiency of capital allocation and further promoting technical innovation of enterprises, it can also effectively improve the "financial mismatch" [8] and information asymmetry problems [9] existing in traditional finance, and drive the upgrading of industrial structure and promote the optimization of consumption structure [10], which has a positive effect on driving economic development [11, 12] and promoting technological innovation [13, 14].

Based on the significant difference between the development of China's TEM and DIF, the question arises: can DIF promote the development of China's TEM? Are there regional heterogeneities in the effects on regions at different levels of the economy? However, there are still three shortcomings in relevant research: First, in terms of content, the literature on how DIF affects the development of China's TEM is relatively rare, and the existing research on DIF mainly focuses on the impact on the efficiency of technological innovation, while the macro-level research on the development of the TEM is insufficient. Second, in terms of perspective, most scholars take the technological innovation and development of an industry or enterprise in China as the research object, while few scholars stand in the macro perspective of China's TEM development, and for regions of different economic levels, study the regional heterogeneity of the impact of DIF on the development of their TEMs. Third, in terms of methods, the research methods selected in the existing literature have certain limitations and have room for further expansion. In order to make up for the above shortcomings, this paper uses the TWFE model, IV-2SLS and other methods, uses China's province-level data from 2011 to 2020, and takes Peking University's Digital Financial Inclusion Index [2] and Technology Market Turnover as the main measurement indicators, to empirically explore how DIF affects China's TEM development, and examines the influence of three different dimension indexes of DIF on the development of the TEM, then compares and analyzes the three sets of data in the eastern, central and western regions to investigate whether there is regional heterogeneity in the impact of DIF on the TEM in regions with different

economic levels. This paper aims to enrich the theoretical research related to DIF and TEM, and has certain enlightenment and reference significance for promoting China's TEM development.

2 Literature Review and Research Hypotheses

Through sorting out the existing literature, it is found that there is a lack of research on the impact of DIF on the development of the TEM, most of the existing research has focused on the influence of financial development on technological innovation and the relationship between the impact of DIF on technological innovation.

In view of the research on the relationship between financial development and technological innovation, many scholars have concluded through empirical analysis that financial development can promote technological innovation. From different perspectives of financial development, the existing research can be roughly divided into three aspects: financial scale, financial structure and financial efficiency. In terms of financial scale, Lv Chengchao et al. [15] believe that the role of China's financial development in accelerating the efficiency of technological innovation is mainly due to the expansion of financial development scale rather than the optimization of financial structure and the improvement of financial market efficiency. In terms of financial structure, Lin Peng et al. [16] found through comparative analysis of different financial development models that the continuous optimization of financial structure and the complementary advantages of financial development models can greatly promote technological innovation and development. In terms of financial efficiency, Li Linhan et al. [17] studied the threshold characteristics of financial development efficiency on technological innovation and Yuan Feifei et al. [18] studied the spillover effect of financial development on technological innovation efficiency, both of which proved that financial efficiency can obviously promote technological innovation.

In view of the research on the relationship between DIF and technological innovation, from both macro and micro perspectives, scholars have proved the role of DIF in promoting technological innovation. From a macro perspective, research on China's provincial panel data: Nie Xiuhua et al. [13] used data of 31 provinces in China from 2011 to 2018 to verify the driving effect of DIF on the improvement of regional technological innovation level and spatial spillover effect. From a micro perspective, research on the data of an industry or enterprise in China: Du Li et al. [14] use the data of China's high-tech industry from 2011 to 2019, empirically found that the growth of DIF can positively boost the improvement of technological innovation efficiency in high-tech industries; Gao Yuying et al. [19] took the data of A-share non-financial non-real estate listed companies in Shanghai and Shenzhen from 2015 to 2020 as a sample, and concluded through empirical analysis that the development of DIF can promote enterprise technological innovation.

Based on this, some scholars have researched the influence mechanism of "DIF can promote technological innovation and development". First, in terms of cost, Tu Yongmei et al. [3] and Zhang Yanyan et al. [4] both proposed that compared with the traditional inclusive financial model, digital inclusive finance uses digital technology to effectively reduce the costs of financial services, production, operation and innovation

subjects, increase the supply of technological innovation funds, improve the innovation environment, and thus improve the efficiency of technological innovation. Second, in terms of funds, whether it is the research of Wan Jiayu et al. [5] on the data of listed enterprises in China, or the research on the data of small and medium-sized enterprises by Liu Li et al. [6] and Liang Bang [7], it verifies that DIF can effectively alleviate financing constraints, broaden financing channels, improve capital allocation efficiency, and further promote enterprise technological innovation. Third, in terms of supervision, Tang Song et al. [8] believe that the progress of DIF can effectively improve the problems of "stage mismatch", "field mismatch" and "attribute mismatch" in traditional finance, and DIF can establish a risk control system through big data to supervise funds, thereby alleviating the information asymmetry between the credit parties and promoting the enhancement of enterprise technological innovation efficiency. Therefore, compared with traditional finance, DIF can stimulate technological innovation and development by reducing financing costs, alleviating financing constraints, and improving mismatches.

To sum up, this paper proposes the hypothesis H_1.

H_1: DIF has a significant positive impact on China's TEM development.

For regional heterogeneity, some scholars' studies at different levels have shown that there are differences in the impact of DIF on regional TEMs at different economic levels. At the industry level, Du Li et al. [14] empirically concluded that the coverage breadth of DIF does not have obvious influence on the technological innovation efficiency of high-tech industries in the eastern region, but has a certain role in promoting the central and western regions. At the enterprise level, Liu Li et al. [6] verified that DIF can boost technological innovation of SMEs by alleviating financing constraints, and has a more significant impact on the economically underdeveloped central and western regions. At the macro level, Tang Song et al. [8] believe that in regions with relatively weak financial development levels, DIF can exert a stronger positive influence on enterprise technological innovation. However, contrary to the above views, Nie Xiuhua and other scholars [13] have shown that the direct and indirect "incentive effects" and spatial spillover effects of DIF on the level of technological innovation in the eastern region are more significant than those in the central and western regions.

Based on the above research, this paper proposes a hypothesis H_2.

H_2: There is regional heterogeneity in the influence of DIF on TEM development in regions with different economic levels.

3 Empirical Design

3.1 Model Building

In this paper, a two-way fixed effects (TWFE) model is constructed to examine the impact of DIF on the development of China's TEM. The specific measurement model is as follows:

$$Tech_{it} = \alpha_0 + \alpha_1 Digi_{it} + \sum\nolimits_{j=2} \alpha_j Control_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

Among them, $Tech_{it}$ is the explained variable, indicating the level of TEM development of the province i in the t period; $Digi_{it}$ is the explanatory variable, indicating the

level of DIF development of the province i in the t period; $Control_{it}$ is a series of control variables; μ_i represents the entity fixed effect, that is, the province i does not change over time; γ_t represents the time fixed effects; ε_{it} is the stochastic disturbance term. If the hypothesis H_1 is true, that DIF has a significant positive impact on China's TEM development, then α_1 should be significantly positive.

3.2 Variable Description

1. Explained variables

The level of TEM development: Since the exchange of technology commodities can well measure the level of TEM development [20], this paper uses Technology Market Turnover (*Tech*) as the explained variable in benchmark regression analysis, in units of 100 million yuan. In addition, for the TEM transactions, this paper uses the Number of Contracts in the Technology Market Output Region (*TeOut*) and the Number of Contracts in the Technology Market Input Region (*TeIn*) as proxy variables for the development level of TEM for robustness testing.

2. Explanatory variables

The level of DIF development: In this study, the Digital Financial Inclusion Index [2] (*Digi*), jointly compiled and released by the Digital Finance Research Center of Peking University and Ant Group, is used as the core explanatory variable. In order to further explore the influencing factors, this paper measures the level of DIF development from three dimensions: Coverage Breadth of DIF (*Breadth*), Depth of Use of DIF (*Depth*), and Digital Level of Financial Inclusion (*Level*). Among them, the coverage breadth of DIF can be regarded as a precondition; The depth of use of DIF indicates the actual use of DIF by payment, credit, insurance, investment and other businesses; The digital level of financial inclusion corresponds to the underlying conditions.

3. Control variables

In order to reduce the bias of missing variables in the model estimation, the following indicators are selected as the control variables: (1) Investment Scale (*Invest*): the proportion of total fixed asset investment in GDP in each province; (2) Trade Openness (*Trade*): the proportion of goods imported and exported by each province to GDP; (3) Infrastructure Construction (*Infra*): the ratio of the sum of railway operating mileage and road mileage of each province to the area covered by the province; (4) Proportion of Secondary Industry (*SecIndus*): the proportion of secondary industry is used to measure the low level of industrial structure; (5) Degree of Urbanization (*Urban*): the proportion of the urban population.

3.3 Data Description

This paper selects the balanced panel data of Chinese mainland 30 provinces from 2011 to 2020 (due to the serious lack of data in Tibet, it is not included in the statistics, and does not include data from Hong Kong, Macao and Taiwan) as a research sample, and uses the provincial data of various variables to explore the impact of DIF on China's TEM development. The relevant variable data to measure the development level of the TEM are derived from the China Statistical Yearbook and China Statistical Yearbook on

Table 1. Descriptive statistics for variables

Variables	Observations	Mean	Standard deviation	Minimum	Maximum
Digi	300	217.25	96.97	18.33	431.93
Tech	300	416.32	819.35	0.57	6316.16
TeOut	300	1.18	1.60	0.00	8.45
TeIn	300	1.17	1.28	0.10	6.73
Breadth	300	198.01	96.33	1.96	397.00
Depth	300	212.04	98.11	6.76	488.68
Level	300	290.24	117.64	7.58	462.23
Invest	300	79.30	25.78	21.00	147.95
Trade	300	25.26	26.73	0.71	145.74
Infra	300	9730.03	5174.68	916.24	22227.18
SecIndus	300	43.13	8.77	15.80	59.00
Urban	300	59.01	12.22	35.03	89.60

Science and Technology; The relevant variable data to measure the development level of DIF comes from the Measuring China's Digital Financial Inclusion: Index Compilation and Spatial Characteristics [2]; The control variable data are all from the China Statistical Yearbook over the years.

Table 1 shows the variable descriptive statistical results for the full sample data. Among them, the mean value of the core explanatory variable *Digi* is 217.25, the maximum value is 431.93, and the minimum value is 18.33, indicating that the overall development level of DIF is good, but the development level in some provinces is low. Among the explained variables, the mean value of *Tech* is 416.32 and the standard deviation is 819.35, denoting that the average TEM turnover of each province from 2011 to 2020 is 41.632 billion yuan, and the development level of TEM is quite different. Among the control variables, there are also different degrees of differences between provinces in terms of *Invest*, *Trade*, and *Infra*, etc.

4 Empirical Results Analysis

4.1 Benchmark Regression Analysis

This paper adopts a TWFE model, taking *Digi* and *Tech* as the core explanatory variable and explained variable, respectively, to examine the impact of DIF on the development of China's TEM. The benchmark regression results are shown in Table 2. From column (1) to (4), after gradually adding control variables, the regression coefficient of the *Digi* is always significantly positive at the level of 1%, signifying that DIF has a significant positive role in facilitating the development of China's TEM, that is, the hypothesis H_1 is true.

Table 2. Benchmark regression results

Variables	(1)	(2)	(3)	(4)
Digi	23.664*** (9.41)	20.064*** (7.31)	21.294*** (7.64)	16.849*** (6.10)
Invest		−1.177 (−0.83)	−1.332 (−0.96)	0.784 (0.57)
Trade		−11.479*** (−3.70)	−9.813*** (−3.16)	−0.773 (−0.23)
Infra			−0.092*** (−3.49)	−0.062** (−2.40)
SecIndus			5.479 (0.71)	19.763** (2.55)
Urban				−80.166*** (−5.49)
Time effect	Control	Control	Control	Control
Area effect	Control	Control	Control	Control
_cons	−816.626*** (−7.10)	−239.466 (−1.32)	200.121 (0.46)	3252.484*** (4.70)
R^2	0.528	0.556	0.577	0.621
Obs	300	300	300	300

Note: ***, **, * denote significant at the level of 1%, 5% and 10%, respectively. The numbers in parentheses are t or z values. The same below.

It can be seen that DIF can promote TEM development. The main reason is that DIF can provide good financial support and financial services for the TEM, effectively alleviating financing constraints. In addition, by integrating and regulating information flow and cash flow through big data, it solves the problem of information asymmetry, and improves the efficiency of financial allocation and technological innovation, thereby promoting TEM development. At the same time, as a financial format that integrates technical means, DIF is essentially an information network platform for technical exchange, so the development of DIF can directly stimulate the vitality of the TEM.

4.2 Dimensional Analysis

Since the level of DIF development can also be measured from three different dimensions: *Breadth*, *Depth* and *Level*, this paper analyzes the impact of DIF on TEM development from three dimension indexes of DIF. The regression results are shown in Table 3. The empirical results show that the coefficients of *Breadth*, *Depth* and *Level* are significantly positive, and the size decreases in order, indicating that the three dimension indexes of DIF have significant promoting effects on China's TEM development. Among them, *Breadth* has the greatest impact, followed by *Depth*, and *Level* has the smallest impact.

It can be seen, the growth of DIF can greatly promote the development of China's TEM, but there are differences in the impact of DIF on TEM development in different dimensions. The improvement of the coverage breadth of DIF as an important prerequisite represents the increase in the supply of DIF services; The increase in the depth of use of DIF represents the increase in the actual demand for DIF, indicating the increase in the actual use of DIF by payment, credit, insurance, investment and other businesses; The increased digitalization of financial inclusion as a potential condition means increased access to financial services. With the continuous improvement of the breadth, depth of use and digital level of DIF, DIF provides more convenient financial services and more financing support for the TEM, so that the technological innovation environment of enterprises has been continuously improved, thereby effectively promoting China's TEM development.

Table 3. Regression results of DIF indexes in different dimensions

Variables	(1)	(2)	(3)
Breadth	9.123** (2.23)		
Depth		8.982*** (5.73)	
Level			4.335*** (4.40)
Invest	2.993** (2.15)	1.106 (0.81)	1.829 (1.32)
Trade	−2.867 (−0.80)	−1.514 (−0.45)	−3.929 (−1.15)
Infra	−0.040 (−1.49)	−0.055** (−2.13)	−0.044* (−1.69)
SecIndus	27.811*** (3.38)	27.175*** (3.58)	25.043*** (3.17)
Urban	−117.329*** (−7.51)	−66.517*** (−4.24)	−82.774*** (−5.38)
Time effect	Control	Control	Control
Area effect	Control	Control	Control
_cons	4931.345*** (6.57)	2362.381*** (3.12)	3493.692*** (4.87)
R^2	0.574	0.615	0.597
Obs	300	300	300

4.3 Regional Heterogeneity Analysis

This paper divides 30 provinces into eastern, central and western regions according to the difference in economic level, and verifies the regional heterogeneity of the impact of DIF on the development of regional TEMs at different economic levels by comparing and analyzing the three sets of data. The regression results of *Digi* in different regions are shown in Table 4. The empirical results show that the regression coefficients of *Digi* in the central and western regions are significantly positive, while the coefficient of *Digi* in the eastern region is positive, but it does not pass the significance test, indicating that there is regional heterogeneity in the impact of DIF on TEM development in regions with different economic levels. Among them, DIF has a significant role in promoting TEM development in the central and western regions, while the promotion effect on the development of the TEM in the eastern region is not significant. Therefore, the hypothesis H_2 is true.

It can be seen that DIF can show a stronger driving effect of technological innovation in the underdeveloped central and western regions. Due to the relatively active TEM in the eastern region and abundant financial resources, the development of information technology and finance has reached a high level, so that the role of DIF in promoting TEM development in the eastern region has been released, so the impact effect is not significant. In contrast, in the economically underdeveloped central and western regions, the TEM and financial development level are relatively backward, so that the development of DIF can more effectively stimulate the vitality of the local TEM, thereby greatly promoting TEM development. As a result, the impact of DIF on the TEM in different economic levels is different.

Table 4. Regression results of *Digi* in different regions

Variables	Eastern	Central	Western
Digi	7.716 (1.13)	15.432*** (4.89)	15.241** (2.52)
Invest	−2.775 (−0.86)	3.380*** (3.01)	0.051 (0.03)
Trade	−3.920 (−0.66)	27.879** (2.36)	24.665*** (3.36)
Infra	−0.207** (−2.46)	0.043* (1.78)	−0.063** (−2.35)
SecIndus	54.035** (2.57)	11.800** (2.03)	−11.211 (−1.15)
Urban	−76.089** (−2.58)	−144.083*** (−5.94)	47.123 (1.33)
Time effect	Control	Control	Control
Area effect	Control	Control	Control

(*continued*)

Table 4. (*continued*)

Variables	Eastern	Central	Western
_cons	4831.309*** (2.70)	5145.937*** (4.83)	−1804.381 (−1.29)
R^2	0.696	0.755	0.547
Obs	120	90	90

In addition, this study explores the regional heterogeneity of the influence of DIF on TEM development from three dimensions. The empirical results are shown in the appendix. It can be seen from Table 5 that the regression coefficient of *Breadth* is significantly positive in the eastern and central regions and negative in the western region, indicating that the coverage breadth of DIF has a positive impact on the development of TEMs in the eastern and central regions with rich financial resources, while there is a negative impact on the economically backward western regions. Because even if the coverage of DIF in backward regions is increased, it is difficult to obtain DIF support through a single factor [11], and instead wastes resources.

It can be seen from Table 6 that the regression coefficient of *Depth* is significantly positive in the central and western regions, but has no significant impact in the eastern

Table 5. Regression results of *Breadth* in different regions

Variables	Eastern	Central	Western
Breadth	15.844* (1.75)	9.519** (2.16)	−23.240*** (−3.47)
Invest	−4.089 (−1.22)	4.472*** (3.25)	3.619** (2.26)
Trade	−4.833 (−0.86)	8.700 (0.70)	22.487*** (3.18)
Infra	−0.272*** (−3.24)	0.079*** (3.00)	−0.060** (−2.42)
SecIndus	45.334** (2.08)	17.154*** (2.64)	−1.753 (−0.18)
Urban	−85.768*** (−3.00)	−132.208*** (−4.06)	101.846*** (2.68)
Time effect	Control	Control	Control
Area effect	Control	Control	Control
_cons	6218.804*** (3.88)	4380.092*** (3.06)	−4055.857*** (−2.68)
R^2	0.702	0.688	0.580
Obs	120	90	90

Table 6. Regression results of *Depth* in different regions

Variables	Eastern	Central	Western
Depth	0.009 (0.00)	12.089*** (5.79)	12.689*** (5.15)
Invest	−2.384 (−0.73)	3.118*** (2.92)	−0.613 (−0.40)
Trade	−6.251 (−1.03)	30.071*** (2.69)	13.789* (1.98)
Infra	−0.232*** (−2.73)	0.037 (1.63)	−0.078*** (−3.35)
SecIndus	62.532*** (3.13)	12.320** (2.24)	−0.627 (−0.07)
Urban	−83.487*** (−2.70)	−114.093*** (−5.57)	96.270*** (2.92)
Time effect	Control	Control	Control
Area effect	Control	Control	Control
_cons	5738.357*** (2.92)	3663.678*** (4.23)	−4180.706*** (−3.14)
R^2	0.692	0.779	0.646
Obs	120	90	90

region, indicating that the depth of use of DIF has a more significant role in facilitating the development of TEMs in the economically underdeveloped central and western regions.

It can be seen from Table 7 that the regression coefficient of *Level* is only significantly positive in the central region, while it has a positive impact in the eastern and western regions, but it does not pass the significance test, indicating that the digital level of inclusive finance can show a stronger driving effect of technological innovation in the central region.

Therefore, there is regional heterogeneity in the impact of DIF on the development of regional TEMs at different economic levels, and there are also obvious differences in the impact of DIF indexes on regional technological development in different dimensions.

4.4 Robustness Test

In this study, a set of robustness tests are used to verify the robustness of the benchmark regression results, and the empirical results are shown in Table 8.

1. Replace the explained variable

Since the number of contracts in the TEM output and input regions can also better reflect the TEM transactions, this paper replaces the explained variable *Tech* with *TeOut* and *TeIn* as proxy variables for the level of the TEM development for robustness testing. The results of the estimates are shown in columns (1) and (2) in Table 8. The empirical results indicate that the regression coefficients of the *Digi* are significantly positive at

Table 7. Regression results of *Level* in different regions

Variables	Eastern	Central	Western
Level	2.316 (0.95)	2.945** (2.61)	2.260 (1.58)
Invest	−2.078 (−0.64)	2.298* (1.76)	1.619 (0.95)
Trade	−5.080 (−0.88)	16.995 (1.32)	28.084*** (3.84)
Infra	−0.193** (−2.11)	0.092*** (3.98)	−0.055* (−1.99)
SecIndus	58.832*** (2.94)	11.226* (1.70)	−11.534 (−1.15)
Urban	−80.753*** (−2.78)	−90.943*** (−3.90)	48.503 (1.32)
Time effect	Control	Control	Control
Area effect	Control	Control	Control
_cons	5119.362*** (2.96)	2678.266*** (2.71)	−1742.691 (−1.21)
R^2	0.695	0.697	0.522
Obs	120	90	90

the 1% level, signifying that using different TEM development level indicators will not change the empirical results of DIF variables, and DIF still has a significant positive impact on China's TEM development, consistent with the previous conclusion.

2. Lag explanatory variable

Considering the lag of the mechanism, this paper treats the core explanatory variable *Digi* with a lag of one period and a lag of two periods, respectively, and the results are shown in columns (3) and (4) in Table 8. The empirical results indicate that the coefficients of DIF variables in the lag I and lag II are significantly positive, denoting that the treatment method considering lag will not change the empirical results, and DIF still has a significant positive role in driving China's TEM development, consistent with the previous conclusion.

3. IV-2SLS

Considering the temporal correlation and path dependence of DIF, this study adopts the Instrumental Variable Method and the Two Stage Least Square Method (IV-2SLS) to test the endogeneity, sets the *Digi* as the endogenous explanatory variable, and selects the first-order lag term of the endogenous variable as the instrumental variable. The regression results are shown in column (5) in Table 8. It can be seen from the empirical results: First, the Kleibergen-Paap rk Wald F statistic that tests the "weak instrumental variable" is 153.315, which is significantly greater than the bias value of 16.38 at the 10% level, so the null hypothesis is rejected, that is, there is no weak instrumental variable.

Table 8. Regression results of robustness tests

Variables	(1) *TeOut*	(2) *TeIn*	(3) Lag I	(4) Lag II	(5) IV-2SLS
Digi	0.027*** (5.34)	0.020*** (4.90)	16.295*** (5.48)	12.660*** (3.44)	23.639*** (4.44)
Invest	−0.001 (−0.20)	0.000 (0.21)	2.358* (1.74)	3.638** (2.55)	−0.155 (−0.14)
Trade	0.012* (1.95)	−0.009* (1.72)	−4.173 (−1.14)	−8.534** (−2.04)	−3.179 (−0.58)
Infra	−0.000 (−0.66)	−0.000 (−0.59)	−0.066** (−2.42)	−0.074** (−2.42)	−0.073*** (−2.98)
SecIndus	0.034** (2.33)	0.017 (1.51)	21.580** (2.55)	22.082** (2.34)	8.475 (0.98)
Urban	−0.008 (−0.29)	0.010 (0.47)	−79.267*** (−5.26)	−84.907*** (−5.06)	−67.472*** (−3.65)
Time effect	Control	Control	Control	Control	Control
Area effect	Control	Control	Control	Control	Control
_cons	−1.590 (−1.23)	−0.969 (−0.94)	3337.032*** (4.36)	4027.015*** (4.40)	2373.457 (1.17)
R^2	0.395	0.488	0.621	0.598	0.928
Obs	300	300	270	240	270

Second, the number of instrumental variables selected in this paper is exactly equal to the number of endogenous variables, so there is no over-identifying problem. Third, the regression coefficient of the *Digi* concerned in this paper is significantly positive at the 1% level, so there is no endogenous problem, and DIF still has a significant positive role in facilitating China's TEM development, consistent with the previous conclusion.

In conclusion, DIF has a significant positive influence on China's TEM development, and the research conclusion has strong robustness.

5 Conclusion and Enlightenment

In order to systematically explore the impact of DIF on China's TEM development and regional heterogeneity, this paper uses a TWFE model based on China's province-level data from 2011 to 2020 for empirical testing. The results of the study prove that: First, DIF has a significant positive impact on China's TEM development, and the robustness of the conclusion is verified by IV-2SLS and other methods. Second, from the perspective of dimensions, the breadth of coverage, depth of use and degree of digitization of DIF have all significantly promoted China's TEM development, so the development of DIF can greatly promote China's TEM development. In terms of their impact on TEM development, the coverage breadth of DIF is the strongest, the depth of use is the second, and the degree of digitization is the weakest. Third, from the perspective of different regions,

the impact of DIF on TEM development in regions with different economic levels has regional heterogeneity, which has a significant role in promoting TEM development in the central and western regions, while the promotion effect on TEM development in the eastern region is not significant, and there are also obvious differences in the impact of DIF indexes of different dimensions on regional technology development.

Based on the above conclusions, the policy enlightenments proposed in this study are as follows.

First, comprehensively develop DIF from multiple dimensions. Whether for countries or regions, it is necessary to increase the promotion of DIF, improve the DIF system conducive to promoting technological development, and give full play to the advantages of DIF in corporate financing, such as low cost, convenience and accuracy, so as to increase the efficiency of financial resource allocation and technological innovation. Due to the promotion of the TEM by the three dimensions of the DIF index, DIF can be developed from the following aspects: The first is to expand the coverage of DIF by strengthening the construction of financial data centers and computing centers and optimizing the allocation of financial resources; The second is to stimulate the potential of the depth of DIF use by enriching the types of DIF products and encouraging the diversified development of DIF platforms; The third is to improve the digitalization of inclusive finance by promoting the application of digital technology in financial scenarios and increasing the supply of DIF services.

Second, use DIF technologies and means to promote TEM development. If we want to give full play to the role of DIF in promoting the TEM, we must jointly promote the application of digital technology through the efforts of many parties. For enterprises, it is necessary to actively introduce information technologies such as blockchain, cloud computing, big data and artificial intelligence to improve technological innovation capabilities, and at the same time use technical means to monitor and measure innovation results, and expand financing channels through DIF platforms to reduce financing costs and improve the environment for technological innovation; For financial institutions, it is necessary to strengthen the supervision of DIF business, improve the risk prevention and control system, and ensure the security and stability of financing channels, so as to provide users with reliable financial support and accelerate the pace of technological innovation; For the market, it is necessary to continuously improve the national technology trading network system and strengthen the support of digital technology for market construction, so as to reduce transaction costs and improve market transparency, further inspire the vitality of technology transactions and advance the development of the TEM.

Third, strengthen policy support and improve institutional design. Due to the regional heterogeneity of the influence of DIF on the TEM, governments need to formulate differentiated regional development policies to balance regional differences. First of all, the government should strengthen support for economically underdeveloped areas, and provide financial, human and policy assistance to the central and western regions in the construction of information technology infrastructure and the popularization and promotion of DIF. By enhancing the accessibility of financial services and optimizing the development environment of DIF, backward regions can achieve leapfrog development. Second, the government should promote technical exchanges between the eastern region and the central and western regions, and give full play to the demonstration and driving

role of the eastern region in the central and western regions, so as to accelerate technology diffusion. In addition, the government should improve the design of the incentive system for the flow of scientific and technological talents, and strengthen the spatial flow of innovative talents, technology, information, capital and other innovative elements to relieve the current situation of uneven development of China's interregional DIF and TEM. In addition, the government ought to improve the incentive system design for the flow of technical talents, and strengthen the spatial flow of innovative talents, technology, information, capital and other innovative elements to alleviate the current imbalance in the development of DIF and TEMs between regions in China. At the same time, local governments should actively respond to the call of the central government, formulate development policies appropriate to the local area, take DIF as an important driving force for the development of the local TEM, and rationally allocate financial resources, so as to promote the vigorous development of the TEM.

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