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Research on the Synergistic Development of Digital Economy, Science and Technology Innovation and Regional Business Environment

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Abstract: *Based on the provincial panel data, and with science and technology innovation as the mediating variable, the study analyzes the relationship between the digital economy, science and technology innovation, and the regional business environment and the internal mechanism from both theoretical and empirical dimensions. The study finds that: the digital economy has a direct effect on the regional business environment; it can not only promote the development level of science and technology innovation but also promote the optimization of the regional business environment through the enhancement of science and technology innovation; heterogeneity analysis shows that the optimization of local business environment by digital economy is more obvious in the western and northeastern regions than in the central and eastern regions.*

Keywords: *Digital Economy, Science and Technology Innovation, Rregional Business Environment*

1. Introduction

The current economic situation is becoming increasingly complex, and the digital economy, which relies on data elements and Internet platforms to become a key form of productivity organization, represents a significant breakthrough in optimizing the regional business environment and stimulating market vitality[1]. As the embodiment of the core competitiveness of the region, China is moving towards the goal of socialist modernization after the completion of poverty alleviation, and urgently needs to consolidate the cornerstone of the business environment in order to achieve high-quality development[2]. And in recent years, although China's business environment has achieved remarkable results[3], it is still a bit far from the first-class level.

Existing studies emphasize that digital governance and government reform are the core paths, and the practical level finds that the reform of “management and service”, which aims at reshaping the relationship between government and enterprises, is the key initiative, and the construction of digital government has been proved to be able to significantly bridge the regional development gap [4]. As the first driving force of economic development, science and technology innovation play an important role in today's important stage of digital transformation. From the perspective of innovation input and output, the digital economy can enhance the green science and technology innovation output of enterprises through the path of business environment construction[5]. Other scholars believe that digital finance enhances the tendency of enterprises' breakthrough innovation by optimizing the regional business environment[6].

It can be seen that the relationship between the digital economy, science and technology innovation, and the business environment is closely linked. Still, most of the existing studies have empirically explored the optimization mechanism of the regional business environment from the macro background of the digital economy. Little literature has studied the impact mechanism of the digital economy on the regional business environment with science and technology innovation as the intermediary. Based on this, this paper innovatively integrates the three into a unified framework to empirically test the intermediary role of science and technology innovation in the digital economy's impact on regional business environment, to provide a new perspective for the optimization of regional business environment, and to promote China's economic high-quality development with practical significance.

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2. Theoretical analysis and research hypotheses

2.1 Digital economy and regional business environment

As a more advanced economic form, the digital economy has a spillover effect, which accelerates the transformation of economic structure and optimizes the regional business environment at the same time.First, the digital economy improves the regional market environment. On the one hand, digital economy can promote the sharing of information elements and reduce the transaction costs due to information asymmetry[7]. On the other hand, digital economy improves resource allocation efficiency through intelligent big data analysis[8]. Secondly, through the construction of digital government, it improves government efficiency, creates an efficient and clean governmental environment, and effectively promotes the efficiency of public services as well as the refinement of social governance[9]. Third, through the smart approval and other technologies to reduce the unproductive expenditure of enterprises, to create a fair and transparent legal environment. Therefore, this paper proposes the hypothesis:

H1: The digital economy has a significant positive role in promoting the regional business environment.

2.2 Digital economy, science and technology innovation and regional business environment

Emerging digital technologies drive the scientific and technological revolution and industrial change, making the digital economy a new engine for China's economic growth. Through digital industrialization and industrial digitization, it improves the supply system of industrial chain, provides more possibilities for innovation activities, and optimizes the allocation of enterprise factors and improves the efficiency of enterprise research and development (R&D)[10], which in turn improves the level of regional scientific and technological innovation[11].

Science and technology innovation to the market value as a criterion, to promote the sustainable development of science and technology innovation can not only improve the infrastructure and other hard business environment, but also enhance the institutional culture and other soft business environment, which constitutes the key path to optimize the business environment of the digital economy[12]. Research shows that the digital economy can significantly improve enterprise innovation performance, and promote the continuous optimization of the business environment[13]. Based on the above analysis, this paper puts forward the hypothesis:

H2: The digital economy promotes the optimization of the regional business environment through scientific and technological innovation.

3. Research Design

3.1 Variable Measurement and Description

3.1.1 Explained variable: regional business environment (BE)

This paper uses China's sub-provincial marketization index to measure the regional business environment, which covers five sub-dimensions: legal and institutional environment, development of market intermediary organizations, development of factor markets, development of product markets, development of the non-state economy, and the relationship between the government and the market, and is derived from China's marketization index database.

3.1.2 Explanatory variables: digital economy (DE)

The digital economy is measured in two dimensions: Internet development and digital financial inclusion: the former is represented by four indicators, namely, the percentage of employees, broadband/mobile phone penetration rate, and per capita telecom services; the latter is measured using Peking University's Digital Financial Inclusion Index, which is ultimately synthesized into a composite development index through principal component analysis. Data from China Urban Statistical Yearbook

3.1.3 Mediating variable: science, technology and innovation (STI)

This paper measures the level of regional science and technology innovation from the dimensions of input and output: the input side covers the proportion of R&D personnel, R&D expenditure and local

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financial expenditure on science and technology of industrial enterprises above large scale; the output side includes the number of patents authorized and the sales revenue of new products of enterprises above large scale. The entropy method is used to integrate the above five indicators to form a comprehensive index, and the data are from the China Regional Economic Statistics Yearbook and the National Bureau of Statistics.

3.1.4 Control variables

To ensure the robustness of the research results, this paper selects five aspects as control variables, namely, the current status of economic development, the loan-deposit ratio, the economic growth rate, the urban registered unemployment rate, and the degree of inflation, and uses the Gross Regional Product (GRP) as the representative of the current status of economic development, the Loans from Banking Financial Institutions/Deposits from Banking Financial Institutions as the loan-deposit ratio, and the Gross Regional Product Index-1 as the economic growth rate, respectively, Consumer price index represents the degree of inflation. The above relevant raw data are from the China Financial Yearbook and the National Bureau of Statistics. In addition, all empirical models control for the effects of year and province to eliminate the bias of year and city on the estimation results.

3.2 Empirical Model Setting

To test research hypothesis 1, this paper constructs a time-area two-way fixed-effects model for the impact of the digital economy on the regional business environment:

$$BE_{it} = \alpha_0 + \alpha_1 DE_{it} + cX_{it} + u_i + v_t + \varepsilon_{it} \quad (1)$$

In model (1), BE is the explanatory variable representing the regional business environment, the core explanatory variable DE is the level of regional digital economy development, the coefficient α1 is the core parameter of this study, i.e., the impact effect of the digital economy on the regional business environment, X denotes a variety of control variables that may affect the development of the regional business environment, ui is the province fixed effect, it is the year fixed effect, and εit is the model's random error term. To examine the impact of science and technology innovation on the business environment, this paper constructs a two-way fixed model with science and technology innovation as the explanatory variable:

$$BE_{it} = \beta_0 \ + \beta_1 STI_{it} + cX_{it} + u_i + v_t + \varepsilon_{it} \quad (2)$$

Where STI is the level of regional science and technology innovation development, and other variables have the same meaning as in model (1). In order to further test whether the digital economy acts on the regional business environment through science and technology innovation, this paper constructs model (3) and model (4) to examine the influence path of the digital economy on the regional business environment, the specific regression model is as follows:

$$STI_{it} = \eta_0 + \eta_1 DE_{it} + cX_{it} + u_i + v_t + \varepsilon_{it} \quad (3)$$

$$BE_{it} = \gamma_0 + \gamma_1 DE_{it} + \gamma_2 STI_{it} + cX_{it} + u_i + v_t + \varepsilon_{it} \quad (4)$$

Model (3) is used to examine the impact of the digital economy on science and technology innovation, and model (4) is the direct effect of the digital economy on the regional business environment after considering the impact of science and technology innovation. Model (1) is the total effect of the impact of the digital economy on the regional business environment.

4. Empirical results and analysis

4.1 Descriptive statistics

Considering the availability of data and the fluctuation of the general environment due to force majeure factors from the end of 2020 to 2023, and to avoid possible unnecessary errors in the empirical results, this paper adopts the panel data of 31 provinces or cities (excluding Hong Kong, Macao, and Taiwan) from 2011 to 2020. The descriptive statistics of the main variables are shown in Table 1.

Table 1: Descriptive statistics

Variable	Meaning	Mean	Standard	Min	Max
BE	Business environment	7.734	2.191	-0.161	11.934
DE	digital economy	0.594	0.065	0.486	0.886

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STI	Science, technology and innovation	0.234	0.181	0.031	1.000
SED	Current state of economic development	24084.850	20640.140	611.500	110760.900
LDR	Loan-to-deposit ratio	0.787	0.154	0.246	1.216
EGR	Economic growth rate	106.913	2.917	94.000	115.400
UUR	Urban registered unemployment rate	3.242	0.638	1.200	4.600
IL	Level of inflation	102.511	1.171	100.600	106.300

4.2 Benchmark regression analysis

Since this paper takes short panel data, the model needs to be tested with the Hausman test to determine whether random effects or fixed effects are used. After the test Prob>chi2=0.0000, which indicates that the original hypothesis should be rejected, and this paper should use the fixed effect model.

In the benchmark regression results in Table 2, column (1) represents the analysis of the impact of the core explanatory variable Digital Economy on the explanatory variable Doing Business without adding any control variables, and the regression result is (22.584***) indicating that Digital Economy and Doing Business are positively significant at the 1% level. Column (2) represents the baseline regression of digital economy and business environment after adding control variables that may have an impact on business environment, and it can be seen that the regression result is (19.561***), which is still positively significant at 1% level, and the coefficient size does not change much, which initially indicates that the regression result is very robust under different settings, and thus confirms that digital economy has a significant positive business environment promotion effect in the region, and hypothesis H1 is established. Promotion effect, hypothesis H1 is established.

Table 2: Benchmark regression results of the digital economy on business environment

	(1)	(2)
	BE	BE
DE	22.584***	19.561***
	(7.093)	(10.492)
	(-2.885)	(2.105)
Controls	Yes	Yes
province	Yes	Yes
year	Yes	Yes
N	310.000	310.000
R^2	0.224	0.634

Note: *p<0.1, **p<0.05, ***p<0.01; values in parentheses are t-values. Same below.

4.3 Intermediation mechanism test

Theoretical analysis shows that the digital economy optimizes the business environment by enhancing regional science and technology innovation. The regression results in Table 3 confirm that the digital economy has a significant positive effect on both STI (19.561***) and BE(0.199***) at the 1% level; when both digital economy and STI are introduced to explain the business environment, they are significantly positive at the 5% and 1% levels, respectively, and the coefficient of the digital economy is smaller than 19.561, indicating that STI has a partially mediating effect.The Sobel test further supports the existence and significance of this partial mediating effect. further supports the existence and significance of this partial mediation effect. The results verify the hypothesis H2, that is, the digital economy optimizes the regional business environment by promoting science and technology innovation.

Table 3: Mediating mechanism test of STI on digital economy and business environment

	(1)	(2)	(3)
	BE	STI	BE
DE	19.561***	0.199***	5.780**
	(10.492)	(13.699)	(2.537)
STI			69.098***
			(9.628)
Controls	Yes	Yes	Yes
province	Yes	Yes	Yes
year	Yes	Yes	Yes
N	310.000	310.000	310.000
R^2	0.634	0.686	0.704
Sobel test	Z=7.299, Significant intermediation effects		

ISSN 2616-5902 Vol. 7, Issue 7: 28-33, DOI: 10.25236/AJBM.2025.070704

4.4 Robustness Tests

To enhance reliability given the absence of a unified digital economy (DE) measurement, this study recalculates the explanatory variable (DE2) using the entropy weight method. Table 4 shows the regression results after re-measurement, The entropy-weighted re-measurement of the digital economy (DE2) has a significant positive effect on business environment (5.169***) and science and technology innovation (0.051***) at the 1% level ,column (3) is the regression results of the mediation effect test (1.983**, 62.313***), which are positively significant at the 5% and 1% level, and are consistent with the findings of the previous study, thus indicating that the regression results are robust from that perspective.

Table 4: Test results after replacing the calculated caliber

	(1)	(2)	(3)
	BE	STI	BE
DE2	5.169***	0.051***	1.983**
	(13.328)	(15.881)	(3.551)
STI			62.313***
			(7.930)
Controls	Yes	Yes	Yes
province	Yes	Yes	Yes
year	Yes	Yes	Yes
N	310.000	310.000	310.000
R^2	0.658	0.724	0.708

4.5 Heterogeneity tests

In this paper, regression by the four major economic regions in China found that there are significant regional differences in the optimization of the digital economy on the business environment, as shown in Table 5, in addition to the eastern region of the regression results at the 5% level significantly positive, the rest of the region are at the 1% level significantly positive, and the coefficients of the West and Northeast are higher than those of the Central, the role of the more obvious. The difference stems from the fact that the digital economy in the eastern region matured earlier, and the optimization effect has reached a relatively stable state, while the central, western and northeastern regions have accelerated the development of the digital economy in recent years, and the infrastructure has been improved, and its high-speed growth has played a significant role in the enhancement of the business environment.

Table 5: Regional heterogeneity regression results

	(1)	(2)	(3)	(4)
	East	Middle	West	Northeast
DE	6.735**	47.665***	49.698***	49.950***
	(2.562)	(4.045)	(5.229)	(5.450)
Controls	Yes	Yes	Yes	Yes
province	Yes	Yes	Yes	Yes
year	Yes	Yes	Yes	Yes
N	100.000	60.000	120.000	30.000
R^2	0.021	0.474	0.158	0.525

5. Conclusions and Implications

As an emerging technological change, the digital economy is of great significance in stimulating market vitality, optimizing the regional business environment and driving economic development, while the continuous development of science and technology innovation can enhance both the hard and soft business environments. Based on the data of 31 provinces in China from 2011 to 2020, this study explores the relationship between digital economy, STI and business environment, and confirms that the digital economy has a significant positive impact on STI and business environment, and that STI plays an important positive intermediary role; at the same time, because of the weaker foundation of the digital economy in the western and northeastern regions, the business environment in these regions is more obviously optimized by the digital economy.

Based on the conclusions of the study, this paper gets the following policy and practice insights: the

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government should make every effort to develop the digital economy, strengthen the integration of digital infrastructure and the real economy, and release the digital dividend, use the digital economy to promote scientific and technological innovation and digital transformation of the city.Focusing on regional coordination, strengthening digital infrastructure in the west and northeast, using the “crowding out effect”of the digital economy to narrow the gap, and combining with the “release of services” reform, using emerging technologies to promote the digitalization of government governance, data sharing and cross-sectoral collaboration, and building a market-oriented, rule-of-law, internationalized business environment.

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