

The Influence Effect of Digital Economy on China's Import and Export Trade Development

Wenyi Gao¹, Yu Xia¹, Yan Guo², Jing Wu³, Min Pang^{1,*}

¹ School of Economics and Management, Southwest Petroleum University, Chengdu, 610500, China

² PetroChina Kunlun Gas Co., Ltd. Tianjin Branch, Tianjing, 300450, China

³ Finance Department of Southwest Petroleum University, Chengdu, 610500, China

* Corresponding author

Abstract: In today's era of deep integration of globalisation and digitisation, the digital economy is reshaping the world's economic landscape at an unprecedented speed, and with the development of the digital economy, its impact on import and export trade is gradually unfolding. In this context, this study comprehensively explores the linear effect, non-linear effect and sub-geographical characteristics of the digital economy driving the development of China's import and export trade based on China's inter-provincial panel data from 2012-2021, which shows that: the digital economy can significantly promote the development of China's import and export trade, but in the eastern region, the promotion effect of the digital economy is not obvious; the digital economy on the development of China's import and export trade has a Non-linear dynamic impact, the impact is specifically manifested as positive marginal efficiency increment, and there is obvious spatial heterogeneity, that is, there are differences in the impact effect on different regions; further research found that the non-linear impact of the digital economy on the development of import and export trade will be subject to the constraints of its own development history and the regional gross domestic product per capita.

Keywords: Digital economy; Import and export trade; Inter-provincial panel data; Threshold effect.

1. Introduction

As a new type of economic form, the digital economy has had a profound and far-reaching impact on China's import and export trade by virtue of its strong innovation driving force. From the data in recent years can be seen, in 2021 China's digital economy services import and export trade value of 359.69 billion U.S. dollars, an increase of more than 22% year-on-year, the scale of net exports of digital services is a year-on-year increase of more than 100%; 2023 China's total import and export value of a small increase in the scale of the digital economy has reached 53.9 trillion yuan. This fully demonstrates that the digital economy has played an important role in promoting and facilitating the development of import and export trade, and this impact is expected to continue to strengthen with the further development of the digital economy in the future. The central government attaches great importance to this, and has introduced a number of policies in recent years to further develop the role of the digital economy in promoting import and export trade through the formulation of rules in the digital field and the expansion of international cooperation. In this context, it is of great theoretical significance and practical value to explore in depth the specific effects and internal influence mechanisms between the digital economy and import and export trade, and to clarify how to better utilize the development dividend of the digital economy to boost the sustained and rapid development of import and export trade.

2. Literature Review

Digital economy is a product of the digital era, as an emerging term, in recent years is gradually attracting attention, most of the existing research on the digital economy is mainly

focused on the determination of the digital economic system and its development process analysis. Yuan Pengyan et al. start from four key dimensions-digital infrastructure, digital technology application, digital innovation, and the scale of digital industry-to construct a set of comprehensive indicator system to comprehensively measure the degree of development of digital economy. On this basis, Wang Shanguo further refines the assessment perspective of the digital economy, and he measures and analyses in-depth the development of the digital economy in each region of China between 2011 and 2020 from four dimensions, including the foundation of the digital economy development and the development environment. Wang Jun et al. used the entropy method and combined with the Dagum Gini coefficient to construct the digital economy indicator system, which covers four key dimensions such as digital economy development carriers, digital industrialisation, etc., to analyse in detail the development of the digital economy in each region of China between 2013 and 2018, revealing the differences in the development of the digital economy in each region while discussing in depth the reasons behind them, and providing new references for the evaluation of the digital economy indicator system and data to provide a new reference.

Meanwhile, with the booming development of the digital economy, scholars at home and abroad have conducted relevant research on the role mechanism of the digital economy in different regions to play an effective role. Cao Biao et al. proposed that the trade in producer services has a significant promotion effect on economic growth, in contrast to the trade in consumer services, which has an inhibiting effect on economic growth, in addition, different regions also show obvious heterogeneity in spillover effects. Gaoxin et al. reveal the effect of digital technology on industrial structure in the Yangtze River Delta region by analysing the inter-

provincial panel data of the region, and also point out the significant regional heterogeneity of the influence of digital technology and import and export trade on the effect of industrial structure, stressing that the effects of the role of these factors may vary in different regional contexts, and this study is of good reference significance for this paper. Regarding the theoretical explanation of the role of the digital economy in import and export trade, most scholars point out that the digital economy can promote the increase of trade scale and the enhancement of trade efficiency by reducing trade costs and optimising the allocation of resources. Yingping Fu pointed out in the study, the development of the digital economy helps to reduce the loss of export efficiency, thus enhancing export efficiency, this enhancement is mainly achieved through two mechanisms: one is to optimise resource allocation, and the other is to reduce trade costs.

Most of the current scholars study the import and export trade is more inclined to a certain industry's import and export trade influencing factors and even China's import and export trade as a whole influencing factors, on the digital economy and China's import and export trade correlation research literature is a little lack of information, the digital economy and import and export trade development between the impact of the effect of the study is a rare corner. In view of this, this study hopes to start from the impact effect of digital economy on import and export trade, based on the systematic elaboration of the theoretical mechanism of digital economy affecting the development of import and export trade, take the panel data of 30 provinces (autonomous regions and municipalities directly under the central government) from 2012 - 2021 as samples, adopt Driscoll-Kraay standard error correction regression analysis and threshold panel technique to comprehensively explore the digital economy. We use Driscoll-Kraay standard error-corrected regression analysis and threshold panel technique to comprehensively explore the linear effect, non-linear characteristics and sub-geographical characteristics of the digital economy driving the development of China's import and export trade, and on the basis of which, we will give policy insights.

3. Theoretical Analysis and Research Assumptions

3.1. The Linear Influence Mechanism of Digital Economy on China's Import and Export Trade Development

The digital economy systematically promotes the development of import and export trade by virtue of the four essential features of time and space, open sharing, data creation and interconnection. First, breakthrough in time and space: realize the free allocation of human, technical and material resources across fields through market mechanism, and enhance the efficiency of resource utilization and value creation. Second, open sharing mechanism: connecting different regions, reducing trade search costs and compliance costs, alleviating the problem of asymmetric supply and demand information, and enabling consumers to obtain goods at lower prices. Third, data creation function: integrating fragmented knowledge into organized data, providing power support for innovation in various industries. Fourth, the interconnection effect: broadening global communication channels, building digital trading platforms to replace traditional intermediaries, directly connecting supply and

demand, lowering the threshold of foreign trade, balancing the supply and demand of the market, and creating opportunities for the marginalized groups in traditional international trade to participate. The synergy of the four features continuously empowers the development of import and export trade. Based on the above theoretical mechanisms, the following research hypotheses are proposed.

Hypothesis 1: The digital economy has a significant role in promoting the development of China's import and export trade.

3.2. Non-linear Influence Mechanism of Digital Economy on China's Import and Export Trade Development

The digital economy has a non-linear dynamic impact on the development of import and export trade, and as the scale of the digital economy's own development gradually expands, its facilitating effect on the development of import and export trade will also be gradually magnified. From a macro perspective, the digital economy takes digital resources as the core driving factor, and promotes the development through scale effect: at the initial stage, the investment cost of infrastructure and talent training is high, and the return cycle is long, which restricts the development of regions with low economic scale; however, as the scale of users expands, the marginal cost of e-commerce, online payment and other hardware facilities continues to decline, and the marginal return of enterprises increases; in the late stage of development, the digital dividend is gradually released, and high-tech and policy resources are accelerated into various links, which promotes economic growth. In the late stage of development, the digital dividend is gradually released, high-tech, policy resources to accelerate the integration of various links, promote economic growth at the same time, the sharing economy, the platform economy and other new forms of business iteration, industrial cross-fertilization and boundary blurring accelerate, the depth of the development of digital dividends to further strengthen the digital economy on the import and export trade role of the pull, and ultimately the formation of the "input - scale - gain" of the positive cycle, promoting the development of trade. The positive cycle of "input - scale - benefit" is eventually formed, which promotes the significant increase in the growth rate of trade development. Based on this, the following research hypotheses are proposed.

Hypothesis 2: The digital economy has a positive marginal efficiency incremental non-linear impact on the development of China's import and export trade.

3.3. Regional Heterogeneity Characteristics of the Promoting Effect of Digital Economy on China's Import and Export Trade Development

A number of scholars have pointed out in their studies that there are differences in the possible impacts of different geographical gaps in China on various aspects such as import and export trade. In China, the technology spillover effect triggered by import trade presents a complex double-threshold characteristic of the technology potential difference, specifically, in the coastal areas where the technology level is already in a leading position, due to the relatively small technology potential difference with the international frontier, resulting in the technology spillover effect brought by import

trade is not very significant; on the contrary, in the inland areas where the technology lags behind in an relative way, in order to effectively absorb and make use of the international technology. On the contrary, in order to effectively absorb and make use of international technological spillovers, inland areas with relatively backward technology, it is necessary to focus on strengthening the accumulation and enhancement of human capital, so as to strengthen the absorption and transformation capacity of advanced technology, and ultimately realise technological breakthroughs and development. Similarly, the impact of the development of digital economy on industrial structure shows geographical differences. Specifically, in the eastern and central regions, digital infrastructure plays a more significant role in promoting the optimisation and upgrading of industrial structure; while in the western region, compared with the construction of digital infrastructure and the process of digital industrialisation, industrial digitalisation plays a more prominent role in promoting the optimisation and upgrading of industrial structure. Based on this, the following research hypotheses are proposed.

Hypothesis 3: There are differences in the promotion effect of digital economy on China's import and export trade in different regions.

4. Research Design

4.1. Model Construction

In order to test the influence effect of digital economy on the development of China's import and export trade, this paper incorporates the digital economy into the research framework of import and export trade development for analysis, and constructs the linear regression model as follows:

$$LNTMX_{it} = \alpha_0 + \alpha_1 DIG_{it} + \sum \beta_j x_{jit} + u_i + \varepsilon_{it} \quad (1)$$

In equation (1), i represents the region, t represents time; $LNTMX$ is the explanatory variable, representing the volume of import and export trade; DIG is the core explanatory variable, representing the digital economy; x_{jit} represents each of the control variables used in the study; α_0 is the intercept term; u_i is the individual fixed effect; and ε_{it} is the random perturbation term.

In-depth research, we examine the network effect of digital economy on China's import and export trade development by drawing on Hansen's (1999) panel threshold model, so as to explore the nonlinear dynamic characteristics of digital economy-driven China's import and export trade development, and construct the model as follows.

$$LNTMX_{it} = \varphi_0 + \varphi_1 DIG_{it} \times I(Adj_{it} \leq \theta) + \varphi_2 DIG_{it} \times I(Adj_{it} > \theta) + \varphi_c Z_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

In equation (2), Adj_{it} is the threshold variable, and $I(-)$ is the indicator function that takes the value of 1 or 0, which is 1 if it satisfies the condition in parentheses, and 0 otherwise. equation (2) considers the single threshold situation, and can be further expanded to the multi-threshold according to the steps of the econometric test of the sample data, as the following model:

$$LNTMX_{it} = 1DIG_{it} \cdot I(DIG_{it} \leq \gamma_1) + 2DIG_{it} \cdot I(\gamma_2 \geq DIG_{it} > \gamma_1) + \dots + n + 1DIG_{it} \cdot I(DIG_{it} > \gamma_n) + \sum \beta_j x_{jit} + u_i + \varepsilon_{it} \quad (3)$$

In equation (3), $\gamma_1 \sim \gamma_n$ is n thresholds, and $I(-)$ is the indicator function that takes the value of 1 when the conditions in parentheses are satisfied, and 0 otherwise.

4.2. Variable Setting and Data Sources

4.2.1. Core explanatory variables

Digital Economy (DIG). This study refers to different digital economy index systems in the literature, and on the basis of existing research results, a total of 19 relevant data indicators from three dimensions of digital economy infrastructure, digital industrialisation and industrial digitisation are used to construct a comprehensive assessment and evaluation index system for digital economy, and the entropy method is used to determine the weight of each indicator, and the weight of each indicator is calculated to obtain the total of 30 provinces and municipalities in China in the period of 2012-2021 (relevant data of Tibet is missing, so it is chosen to be excluded). (Tibet relevant data is missing so choose to exclude) of the digital economy development level of the comprehensive score, the specific indicators are shown in Table 1 below, to the digital economy (DIG) as an explanatory variable.

Table 1. Digital economy evaluation index system

First-level indicators	Secondary Indicators	Data source
Digital economy infrastructure	Number of mobile phone subscriptions per 100 people (Households per 100 people)	China Statistical Yearbook
	Number of Internet Users as a Percentage of Resident Population (%)	China Statistical Yearbook
	Density of fibre-optic cable lines (km/km ²)	China Statistical Yearbook
	Density of mobile phone base stations (pcs/sq km)	China Statistical Yearbook, China Information Industry Yearbook
	Density of Internet Broadband Access Ports (pcs/km ²)	China Statistical Yearbook
	Per capita fixed asset investment in information transmission, computer services and software industry (yuan/person)	China Statistical Yearbook
Digital Industrialisation	Total Telecommunications Business per Capita (yuan/person)	China Statistical Yearbook
	Total Postal Services per Capita (yuan/person)	China Statistical Yearbook
	Express Delivery Volume (10,000 pieces)	China Statistical Yearbook
	Revenue of Electronic Information Manufacturing Industry (RMB million)	Ministry of Industry and Information Technology of the People's Republic of China, China Information Industry Yearbook
	Number of Enterprises in Electronic Information Manufacturing Industry (nos.)	Ministry of Industry and Information Technology of the People's Republic of China, China Information Industry Yearbook
	Software Business Revenue (RMB million)	Statistical Yearbook of China's Electronic Information Industry
	Number of Employees in the Information Transmission, Software and Information Technology Service Industry (10,000)	China Statistical Yearbook, China Tertiary Industry Statistical Yearbook
Industrial Digitisation	Number of Websites Owned by Enterprises (number)	China Statistical Yearbook
	Share of enterprises with e-commerce trading activities (%)	China Statistical Yearbook
	E-commerce Transaction Value; F- (RMB billion)	China Statistical Yearbook
Development Level of Digital Inclusive Finance	Digital Finance Coverage Breadth Index	Digital Finance Research Centre of Peking University
	Depth of Use of Digital Finance Index	Digital Finance Research Centre, Peking University
	F-Digital Finance Digitisation Degree	Digital Finance Research Centre, Peking University

4.2.2. Explained Variables

Total import and export trade (LMTMX). The explanatory variable is the total import and export trade of 30 provinces and municipalities in China from 2012 to 2021 (in billions of yuan) taking the first-order logarithm.

4.2.3. Threshold variables

Gross domestic product per capita (EGDP). Considering the economic aspects, the per capita GDP (billion yuan/million people) of each province and city is selected as the threshold variable in the study.

4.2.4. Control variables

(1) Consumption potential (LNAW). The study adopts the first-order logarithm of regional per capita wage (yuan) in each province and city to indicate the consumption potential of each province and city.

(2) Urbanisation level (UR). The study uses the proportion of urban population in the total population at the end of the year to indicate the level of urbanisation.

(3) Foreign Trade Dependence (FTD). The study adopts the share of export trade volume in the local GDP to indicate the foreign trade dependence.

(4) Transport accessibility (LNTR). The study adopts the first-order logarithm of the urban road freight volume measure to represent the degree of transport convenience.

(5) Total Foreign Investment (LNFDI). The study adopts the first-order logarithm of total foreign investment as total

foreign enterprise investment.

In order to deeply reveal the impact effect of digital economy on the development of China's import and export trade and its differences between provinces and regions, under the principle of ensuring the availability, scientificity and validity of the data, this paper selects the relevant statistical data during the period of 2013-2022, and the raw data are mainly obtained from the China Statistical Yearbook of each year, the CSMAR database, the statistical yearbook of each province, the China Information Industry Yearbook, China Internet Development Status Statistical Report, China E-commerce Report, Peking University Digital Inclusive Finance Index Report, etc. Some of the missing data are filled in by interpolation method.

5. Empirical Analysis

5.1. Descriptive Statistics

Descriptive statistics are first carried out on the sample to understand the basic situation of each variable. The results are shown in Table 2 below.

Table 2. Descriptive statistics of variables

Variable	Obs	Mean	Std. dev.	Std. dev.	Std. dev.
LNTMX	300	8.1061	1.5807	3.1335	11.3212
DIG	300	0.1260	0.1101	0.0157	0.6466
EGDP	300	6.0186	2.9034	1.9667	18.3997
UR	300	0.5940	0.1188	0.3641	0.8960
FTD	300	0.1236	0.1355	0.0042	0.7254
LNFDI	300	8.7350	1.4418	5.1851	12.6516
LNTR	300	11.3618	0.8634	8.8203	12.6610
LNAW	300	11.1168	0.3270	10.5019	12.1790

5.2. Benchmark Regression Analysis

Through the preliminary analysis found that the research panel data has heteroskedasticity, serial autocorrelation and cross-section correlation, so refer to the research model of Li Fengliang et al. (2020), this study uses the Driscoll-Kraay standard error for correction, while the F-test, LM-test, and Hausman-test all rejected the original hypothesis, and the test results are shown in the following Table 3, and finally select the fixed effects model for empirical analysis.

Table 3. Model test results

F test		LM test		Hausman test	
Statistics	Pvalue	Pvalue	Pvalue	Pvalue	Pvalue
52.46	0.0000	668.08	0.0000	31.57	0.0000

Table 4. Benchmark regression results of digital economy affecting high-quality development

	(1)	(2)
	LNTMX	LNTMX
DIG	2.001*** (7.93)	1.478*** (5.20)
UR		-0.525 (-0.93)
FTD		3.682*** (20.63)
EGDP		0.0964*** (16.94)
LNFDI		0.123*** (5.53)
LNTR		0.259** (2.90)
LNAW		-1.316** (-3.06)
Constant term	7.854*** (215.83)	17.34** (3.96)
Sample size	300	300
Year fixed	YES	YES
Province Fixed	YES	YES

Note: t statistics in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

Table 4 reports the benchmark results of the digital economy on the development of China's import and export trade. Models 1 and 2 are the regression results after considering the control variables and without considering the control variables, respectively, and it is found that the digital economy variables are significantly positive in both cases and pass the significance level of 1 per cent, which indicates that the digital economy is able to drive the development of

China's import and export trade in a significantly positive direction, thus verifying that Hypothesis H1 is valid. In order to further verify whether the conclusions of the baseline regression analysis are reasonable, two methods are utilised to conduct the test: first, the lagged period of the digital economy is used as an instrumental variable for the explanatory variables, and IV estimation is applied to solve the endogeneity problem. Second, the data from 2014-2020 are selected for re-regression analysis. The test results are shown in Table5, and the regression results show that the digital economy variables are significantly positive at the statistical levels of 5% and 1%, confirming that "the digital economy can significantly promote the development of China's import and export trade" and that the conclusion is robust.

Table 5. Conclusion test of baseline regression analysis

	(3)		(4)
	LNTMX		LNTMX
LDIG	1.075** (2.57)	DIG	1.481*** (4.62)
UR	-0.844*** (-2.34)	UR	-0.407 (-0.70)
FTD	3.250*** (14.24)	FTD	3.790*** (20.55)
EGDP	0.0968*** (13.84)	EGDP	0.0964*** (15.52)
LNFDI	0.121*** (5.39)	LNFDI	0.124** (3.93)
LNTR	0.288* (2.30)	LNTR	0.226** (2.55)
LNAW	-1.483** (-2.78)	LNAW	-0.224* (-1.95)
Constant term	19.30** (3.42)	Constant term	5.980** (4.43)
Sample size	270	Sample size	300
Year fixed	YES	Year fixed	YES
Province Fixed	YES	Province fixed	YES

Note: t statistics in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

5.3. Analysis of the Non-Linear Impact of The Digital Economy on The Development of China's Import and Export Trade

Considering the network effect of the digital economy and the establishment of Metcalfe's law of increasing "marginal effect" (Zhao Tao et al., 2020), this study adopts the panel threshold regression model to conduct empirical tests to analyse whether there is a non-linear effect of the digital economy on the development of China's import and export trade. Before estimating the threshold model, the panel threshold existence test is firstly carried out based on the method of Hansen (1999), using the "self-help method" (bootstrap) to repeatedly sample 1000 times, and the test results show that the threshold variables of the digital economy significantly pass the single-threshold test, and do not pass the double-threshold and triple-threshold tests, while the threshold variables of transportation significantly pass the single-threshold test, and do not pass the double-threshold and triple-threshold tests, while the threshold variables of

transportation significantly pass the double-threshold test. The test results show that the digital economy threshold variable significantly passed the single-threshold test, but not the double-threshold and triple-threshold tests, while the transport convenience threshold variable significantly passed the double-threshold test. On the basis of this test, the regression model with the corresponding number of thresholds is set, and the regression results in Table 6 are obtained. It can be seen from the analysis results, the digital economy as a threshold variable, with the continuous development of the digital economy, the spillover effect of the digital economy shows a significant positive and "marginal effect" increasing non-linear characteristics, thus confirming the establishment of hypothesis 2; in the model of the per capita GDP as a threshold variable (6), the per capita GDP on the development of China's import and export trade is significantly lower than the threshold variable, the per capita GDP on the development of China's import and export trade. In the model (6) with GDP per capita as the threshold variable, the impact of GDP per capita on the development of China's import and export trade increases with the value, from a significant negative impact to a non-significant negative impact to a significant positive impact.

Table 6. Regression results of the threshold model of the impact of the digital economy on the development of import and export trade

Variables		Threshold variable	
		(5) Dig	(6) EGDG
Threshold	q1	0.1129	4.0653
	q2		5.6743
Dige - I(Th≤q ₁)		-1.01 (0.8842)	-5.79*** (1.1069)
Dige - I(q ₁ <Th<q ₂)		1.11** (0.5056)	-0.81 (0.8388)
Dige - I(Th≥q ₂)			1.51** (0.5480)
Control Variables		YES	YES
Number of years		10	10
Number of provinces		30	30
F		14.82	23.26

Note: t statistics in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

Meanwhile, Table6 reports the results of the non-linear characterisation of the digital economy on the development of China's import and export trade under the heterogeneous constraints of economic external factors. When GDP per capita is used as the threshold variable, the relationship between digital economy and China's import and export trade development shows "from significant negative to non-significant negative to significant positive", which indicates that small economic growth cannot play a role in promoting the digital economy on China's import and export trade, and even inhibit the import and export trade, while when the economic development has reached the threshold variable, the digital economy has a negative impact on China's import and export trade. Inhibitory effect, and when the economic development to a certain scale in order to begin to play the role of the digital economy to promote the development of import and export trade.

5.4. Analysis of Regional Heterogeneity of Digital Economy's Promotion of China's Import and Export Trade

The 30 provinces and cities are divided into eastern, central and western regions according to their geographical locations, and the results of the regression analysis show that there is obvious regional heterogeneity in the influence of the digital economy on the development of China's import and export trade. Models 7, 8, and 9 report the regression analysis results of the three sub-regional samples in turn, as shown in Table7. The analysis results show that the impact coefficients and utility of the digital economy have significant differences in the three different regions, and the impact of the digital economy variables on the import and export trade in the central and western regions is significantly positive, which indicates that in the central and western regions, the digital economy has a significant role in promoting the development of the import and export trade. However, in the eastern region, the coefficient of digital economy is positive but does not reach the significant level, which indicates that the promotion effect of digital economy on the development of import and export trade has not been fully demonstrated in this region.

Table 7. Results of benchmark regression analysis by region

	(7) East	(8) Central	(9) West
	LNTMX	LNTMX	LNTMX
DIG	0.359	0.753**	3.425***
	(1.55)	(0.68)	(2.15)
FTD	-0.240	13.639***	11.375***
	(-1.19)	(7.51)	(5.76)
UR	1.280**	-1.249	-1.90
	(2.52)	(-1.64)	(-1.72)
EGDP	0.019***	0.208***	0.348***
	(3.41)	(6.74)	(4.91)
LNFDI	0.054	0.108	0.213*
	(1.87)	(1.24)	(2.12)
LNAW	0.094	-0.569	-1.797**
	(0.16)	(-1.07)	(-2.62)
LNTR	0.294**	0.148	0.148 -0.344*
	(3.17)	(1.39)	(-2.14)
Constant term	3.684	10.132	27.212***
	(0.50)	(1.76)	(4.67)
Sample size	110	80	110
Year fixed	YES	YES	YES
Province Fixed	YES	YES	YES

Note: t statistics in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

From the regional level analysis, the introduction of the variable DIG2=DIG*DIG to examine the non-linear characteristics of the sub-regional digital economy on import and export trade, in terms of the East and Central regions, the non-linear characteristics of the digital economy on the development of import and export trade and the national level to maintain consistency with the level of the digital economy, with the level of digital economic development, the impact of its impact on the development of import and export trade from a significant negative to a significant positive direction, presenting a "Positive U-shaped characteristics"; the western region of the non-linear characteristics of the impact is completely opposite to the national level, showing an

"inverted U-shaped characteristics", the results of the analysis are shown in Table 10 below.

Table 8. Analysis of the non-linear characteristics of the digital economy on import and export trade by region

	(10) East	(11) Central	(12) West	(13) National
	LNTMX	LNTMX	LNTMX	LNTMX
DIG2	-1.958*** (-4.23)	-85.351** (-3.27)	74.164** (2.53)	-2.104** (-2.48)
DIG	1.480*** (4.46)	23.073*** (3.70)	-19.159 (-1.83)	3.319*** (5.29)
FTD	-0.459* (-1.85)	15.595*** (7.00)	10.513** (5.00)	3.420*** (15.46)
UR	1.491** (2.44)	-1.263* (-2.12)	-2.145** (-2.28)	-0.477 (-0.89)
EGDP	0.141** (2.37)	0.226*** (6.28)	0.319*** (4.25)	0.089*** (19.69)
LNFDI	0.046 (1.54)	0.100 (1.19)	0.272** (2.79)	0.122*(**) (5.65)
LNAW	0.089 (0.16)	-0.362 (-0.75)	-1.270 (-1.71)	-1.284** (-3.17)
LNTR	0.236*** (3.34)	0.102 (0.90)	-0.372** (-2.65)	0.251** (3.02)
Constant term	4.248 (0.61)	7.686 (1.36)	22.227** (3.20)	17.035*** (4.08)
Sample size	110	80	110	300
Year fixed	YES	YES	YES	YES
Province Fixed	YES	YES	YES	YES

Note: t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6. Research Conclusions and Policy Implications

Based on the theoretical foundation of the systematic elaboration of the effect of digital economy on the development of China's import and export trade, this paper selects the inter-provincial panel data from 2012-2021 and comprehensively analyses the linear impact, non-linear characteristics and sub-geographical characteristics of the digital economy on the development of China's import and export trade by means of empirical analyses, and the main conclusions are as follows: first, the digital economy can significantly promote the development of China's import and export trade. Second, the digital economy on the development of China's import and export trade shows a non-linear dynamic effect, and the two show a positive trend of increasing marginal benefits. Thirdly, the impact of the digital economy on the development of import and export trade will be different because of geographical differences, linear promotion effect in the middle, western region is significant, in the eastern region is not significant; East, central region of the non-linear dynamic effect and the overall trend of the country in line with the overall trend, are showing a "positive U-type" characteristics, the western region is the opposite. The western region, on the contrary, shows an "inverted U-shaped" characteristic.

Based on the above conclusions, the following policy

recommendations are given:

(1) All regions should attach great importance to the cultivation and introduction of digital economy talents, and establish a sound talent cultivation system and innovation incentive mechanism. By strengthening education and training, encouraging innovation and entrepreneurship, and supporting cooperation between industry, universities and research institutes, they should cultivate a group of high-quality digital economy talents with international perspectives and innovation capabilities.

(2) Each region in accordance with the actual situation of the development of their own digital economy, do not blindly formulate strategies: the central and western regions still need to vigorously develop the digital economy infrastructure, improve the scale of the regional digital economy to promote the development of import and export trade; the eastern region is not a significant role in promoting the development of the traditional economic forms and new economic forms, innovation and construction of new forms of digital trade. Therefore, it is more necessary to deal with the development of traditional and new economic forms, innovatively construct new forms of digital trade, and continuously explore better development modes under the condition of perfect infrastructure to give full play to the marginal incremental effect of digital economy.

(3) In the long run, the development of import and export trade will get better and better with the development of digital economy. All regions should proactively promote the in-depth integration of digital technology and traditional import and export trade, encourage enterprises to participate in the innovation of trade mode by using digital technology, improve the efficiency of supply chain management, reduce the transaction cost, and gradually enhance the competitiveness of import and export trade.

(4) Co-operation brings win-win situation, attaches importance to regional co-ordinated development, strengthens inter-regional economic co-operation and exchanges, promotes balanced regional development of digital economy, and promotes the overall enhancement of regional import and export trade by using the driving effect of digital economy. Coordinated regional development not only helps to narrow the regional development gap, but also forms a synergy through regional cooperation to jointly promote the growth of import and export trade.

Acknowledgements

Sichuan Petroleum and Natural Gas Development Research Center: Research on Investment Risk Management Model of Shale Gas Development Project (Project No.: 2025SY019)

References

- [1] YUAN Pengyan, ZHANG Qin, GUAN Xiang. Research on the measurement of the development level of China's digital economy [J]. Times Economy and Trade, 2024, 21(08):24-26.
- [2] WANG Shan-Gao. Digital economy and high-quality development of agriculture: impact effects and path of action [J]. Statistics and Decision Making, 2024, 40(06):21-26.
- [3] WANG Jun, ZHU Jie, LUO Xi. Development level and evolution measurement of China's digital economy [J]. Research on Quantitative and Technical Economics, 2021, 38(7):17.

- [4] Cao Biao, Liao Libing. Structure of trade in services and economic growth [J]. *World Economic Research*, 2014(1):6.
- [5] Gao Xin, Fang Minjie. Digital Transformation, Import Trade and Industrial Structure Upgrading--Taking the Yangtze River Delta Region as an Example [J]. *National Circulation Economy*, 2022(29):87-90.
- [6] Fu Yingping. Research on the impact of the development level of China's digital economy on export efficiency [D]. Hubei Normal University, 2024.
- [7] Han Xianfeng, Liu Juan, Li Boxin. Research on the heterogeneous dynamic effect of "Internet +" driven regional innovation efficiency [J]. *Journal of Management*, 2020, (05): 87-96.
- [8] Ma Dongdong, Ning Zhaoshan. Digital economy, factor allocation and manufacturing quality upgrading [J]. *Economic System Reform*, 2020, (03): 24-30.
- [9] Wang Ying, Yang Hang, Li Bo. Import Trade, Digital Empowerment and Residents' Consumption Upgrading - An Empirical Analysis Based on Provincial Panel Data [J]. *Research on Business Economics*, 2023, (05):118-122.
- [10] HE Shuquan, ZHAO Jingyuan, ZHANG Runqi. The level of digital economy development, trade costs and trade in value added [J]. *International Economic and Trade Exploration*, 2021, 37(11):4-19.
- [11] Huining, Liu Xinxin. The influence effect of Internet development on China's regional innovation capacity [J]. *Social Science Research*, 2020, (06): 30-37.
- [12] Wen Jun, Yan Zhijun, Cheng Yu. Research on the effect of digital economy-driven innovation - regression based on inter-provincial panel data [J]. *Economic System Reform*, 2020, (03): 31-38.
- [13] WANG Weiling, WANG Jing. Research on the trend of China's digital economy development and promotion policies [J]. *Economy vertical and horizontal*, 2019, (01): 69-75.
- [14] Shen Neng, Li Fu. Technological Potential Difference, Import Trade Spillovers and Spatial Differences in Productivity--A Test Based on Double Threshold Effect [J]. *International Trade Issues*, 2012, (09):108-117.
- [15] Li YJ, Han P. The Impact of Digital Economy Development on the Optimisation and Upgrading of China's Industrial Structure - An Empirical Analysis Based on Provincial Panel Data [J]. *Research on Business Economy*, 2021, (06):183-188.
- [16] Hansen B E. Threshold Effect in Non-Dynamic Panels: Estimation, Testing, and Inference [J]. *Journal of Econometrics*, 1999, 93 (02): 345- 368.
- [17] Li Fengliang, Wang Yuqi. An Empirical Study on the Impact of the Scale of Postgraduate Education on Economic Growth--Based on Country-Specific Panel Data [J]. *China Higher Education Research*, 2020, (08):43-49.
- [18] Zhao T, Zhang Z, Liang Shangkun. Digital Economy, Entrepreneurial Activity and High Quality Development - Empirical Evidence from Chinese Cities [J]. *Management World*, 2020, 36(10):65-76.