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The Impact of Digital Economy on Domestic Trade and Investment Efficiency Measurement and Heterogeneity Analysis

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ABSTRACT

Against the backdrop of a new round of booming technological revolution, the digital economy has brought about high-quality development for trade. This paper is based on the 2011-2019 China's trade and investment in China, which will have a profound impact on China's trade and investment. This paper is based on the2011-2019 China. The spatial panel data of 30 provinces (excluding Tibet, Hong Kong, Macao and Taiwan) were analysed by using OLS model, panel solid model and panel data. Construct correlation regression models using fixed effects model, panel random effects model, differential GMM and systematic GMM methods. type and "Digital Economy Development Level Indicator System" to study the impact of the digital economy on the efficiency of domestic trade and investment.so as to contribute to the promotion of high-level opening up to the outside world, the deepening of domestic demand strategy, and the construction of " trade power".

KEYWORDS

Digital economy; Domestic trade; Investment

1. INTRODUCTION

Accompanied by the rapid development of digital technology, the digital economy drives many economic activities, such as production and manufacturing, investment and consumption, and technology transformation, and promotes social and economic recovery and development. The digital economy has begun to become a hotspot of global attention and a major aspect of international cooperation and competition in the future.2021 The State Council issued the "14th Five-Year Plan for the Development of the Digital Economy", stressing the importance of the digital economy at the current historical juncture.

The development and application of the digital economy also bring both opportunities and challenges to China's trade in services. The rapid development of the digital economy has led to changes in the pattern of China's trade market and the organisational structure of the production of traded goods. From the perspective of trade participants, the digital economy has driven the growth of large-scale export enterprises, while at the same time promoting the participation of some export-oriented SMEs in global trade. From the perspective of traded goods, the development of the digital economy has led to the expansion of the scope of traded goods, including not only traditional commodities but also many difficult-to-trade commodities.

The development of the digital economy had also brought new growth points to trade in services such as cross-border online consulting, financial services and medical services. For example, product design in the digital economy was no longer confined to a single mode of non-interference between

countries, but was replaced by inter-country collaborative and innovative co-operation, in which corresponding national engineers and technicians worked together to carry out R&D and design based on a unified, highly efficient and specific digital platform, and ultimately to obtain new products that combined national talents and wisdom. This model of global collaboration is a good way of leveraging human capital. This model of global cooperation makes full use of human capital and saves costs at the same time. In addition, the improvement of demand for trade goods in the digital economy can achieve the purpose of rapid response, rapid improvement and enhanced competitiveness of trade goods exports.

Digital economy has become an important competitive strategy for China, injecting new impetus to economic growth. At the same time, the development of digital economy has led to profound changes in China's trade market. Trade is a two-way behaviour, and the development of digital economy on both sides will have a far-reaching impact on trade exchanges. It is of great significance to discuss the role and impact of the development of digital economy on the enhancement of China's trade in services. Based on this, this paper discusses the impact of the development of the digital economy on the level of China's trade in services and whether it can help China's trade in services.

2. RESEARCH HYPOTHESIS

2.1. The Digital Economy and the Dynamic Transformation of Inward Trade

The digital economy is a new type of economic form in which economic activities are carried out digitally with the support of information technology. It encompasses digital production, digital distribution, digital transactions and digital consumption, providing strong support for the transformation of China's domestic trade dynamics.

The development of the digital economy has prompted enterprises to adopt smart manufacturing and digital production to achieve efficient supply chain management through technologies such as the Internet of Things and big data analytics. This helps to improve production efficiency, reduce costs and optimise the supply chain of products in domestic trade. The digital economy has fuelled a boom in e-commerce, including B2B, B2C and other forms. The rise of e-commerce has changed the traditional retail and wholesale model, making it easier to bring products to the market, speeding up the flow of goods and improving the efficiency of inward trade. At the same time, the technical support of the digital economy has made logistics and warehouse management more intelligent.

Through IoT and big data technologies, enterprises can achieve more efficient inventory management, transport planning and distribution. This contributes to more efficient logistics and lower transport costs for inward trade. In the current digital economy, marketing is also more reliant on data analytics and digital channels. Enterprises can use big data analysis to understand market demand and accurately locate target consumer groups, thus improving the competitiveness of their products in the internal market and facilitating the upgrading of inward trade.As a result, Hypothesis 1 is proposed:

Hypothesis 1: The digital economy contributes to accelerating the dynamic transformation of domestic trade.

2.2. The Digital Economy, Technological Innovation and the Transformation of Domestic Trade Dynamics

The digital economy played a key role in transforming the dynamics of domestic trade by promoting technological innovation, especially the application of artificial intelligence and emerging technologies. Intelligent, informative and digital technologies have contributed to the formation of new modes of domestic trade and improved the quality and quantity of domestic trade.

First, the development of the digital economy has introduced intelligent, informatised and digitalised technologies, leading to the formation of new forms of business and business models. These innovative forms have contributed to the diversification of domestic trade and driven changes in trade structure. Relying on the intelligent, informatised and digitalised interconnection platform technology, the digital economy can make effective financial risk assessment of inter-enterprise trade transactions, thus mitigating to a certain extent the trade risks brought about by information asymmetry, escorting benign inter-enterprise trade transactions, and thus promoting the long-term development of domestic trade and investment.

Secondly, the digital economy has improved the visibility, transparency and management effectiveness of the supply chain. This makes the supply chain in domestic trade more efficient, reduces logistics costs and enhances the competitiveness of the overall supply chain. At the same time, technological innovations brought about by the digital economy can further improve the quality of services and products, thus driving higher levels of innovation. This makes products for domestic trade more competitive and helps to raise the quality level of the domestic market. Overall, the digital economy provides strong support for the transformation of domestic trade dynamics through the promotion of technological innovation. This transformation involves the adjustment of trade modes, trade structure and market size, and the development of the digital economy provides rich opportunities and possibilities for this transformation. As a result, Hypothesis 2 is proposed:

Hypothesis 2: The digital economy can facilitate the dynamic transformation of inward trade by accelerating technological innovation.

2.3. The Digital Economy, Human Capital and the Dynamic Shift in Foreign Trade

The digital economy facilitates the upgrading of skills and career competitiveness of individuals by providing flexible learning opportunities, digital skills training, online certifications and degrees. This has significantly increased the rate of increase in human capital levels and created a human capital accumulation effect. Human capital with a high level of technical and managerial skills is essential to facilitate technological upgrading in domestic trade. Digital skills, the ability to analyse data, and an understanding of emerging technologies can help firms to better respond to the challenges and opportunities of the digital age.

The digital economy contributes to the accumulation of human capital, enabling individuals to better adapt to the employment and entrepreneurial needs of the digital era. On the other hand, the in-depth development of the digital economy has led to more automated and intelligent labour production replacing the original pure labour production, forcing the quality of labour supply in the market to be continuously upgraded and optimized, as well as employees engaged in trade work in enterprises and related trade talents to improve their digital literacy to adapt to the new situation and new problems arising in trade exchange work. This also objectively promotes the improvement of the level of trade management in enterprises, promotes the formation of a new model of domestic trade, and accelerates the transformation of the kinetic energy of domestic trade. As a result, hypothesis 3 is proposed:

Hypothesis 3: The digital economy can facilitate the transformation of domestic trade dynamics through the accumulation of human capital.

3. STUDY DESIGN

3.1. Data Selection

This paper is based on the panel data of 30 provinces (excluding Tibet, Hong Kong, Macao and Taiwan) in China from 2011-2019, which are obtained from the China Statistical Yearbook, the statistics database of China Economy and Economy, the statistical yearbooks of each province, the China Science and Technology Statistical Yearbook, as well as the statistical bulletins of the national

economic and social development of each province, and the official website of the National Bureau of Statistics of China, etc. The data are supplemented by linear interpolation method to deal with some of the missing data. The missing data were supplemented by linear interpolation.

3.2. Selection of Indicators

3.2.1. Explanatory variable

Domestic trade and investment efficiency. In this paper, the efficiency of domestic trade and investment is measured by total domestic retail sales of consumer goods.

3.2.2. Explanatory variables

Digital economy development level (Digitalit): China's digital economy measured by the entropy weight method. With the level of economic development as the core explanatory variable, we empirically examine the effect of the digital economy on the improvement of China's domestic trade and investment efficiency. Drawing on the studies of Dai Xiang and Zhang Erzhen (2016) [7], Zheng Jianghuai et al. (2018) [8], Pei Changhong and Liu Bin (2019) [9], and Cao Junwen and Lei Qingya (2021) [10], we construct the "level of development of the digital economy" from the three typical characteristics of digital economic development, namely "digital infrastructure", "digital industrialisation" and "industrial digitisation". From the three typical features of digital economy development, namely "digital infrastructure", "digital industrialisation" and "industrial digitisation", we constructed the "Digital Economy Development Level Indicator System". (See Table 1).

Table 1. Indicator system for the level of development of the digital economy

Level 1 indicators	Secondary indicators	Description of indicators	Indicator properties	weights
Level of development of the digital economy	digital infrastructure	Mobile phone penetration rate (units/100 population)	forward	0.035
		Number of Internet broadband access ports (10,000)	forward	0.190
	digital industrialisation	Total telecoms business (billion yuan)	forward	0.006
		Information transmission, software and information technology services Urban unit employment (10,000 persons)	forward	0.057
		Revenue from software operations ($ million)	forward	0.036
	Industrial digitisation	R&D expenditure of industrial enterprises above designated size (RMB 10,000)	forward	0.164
		commerce transactions ($ billion)	forward	0.073
		Computers per 100 population	forward	0.048

3.2.3. Intermediary variables

(1) "Level of human capital" - Employed persons in urban units of the information transmission, software and information technology services industry (10,000 persons);

(2) "Level of technological innovation" - number of domestic patent applications authorised (items)

3.2.4. Control Variables

In order to reduce the omission bias in the model estimation process, the following five variables are set as control variables.

(1) Gdp per capita: gross domestic product per capita (yuan per person)

(2) Degree of trade development (open): Total retail sales of consumer goods (billion yuan)/Gross regional product (billion yuan)

(3) FDI (fdip): total investment by foreign-invested enterprises (millions of United States dollars)

(4) Institutional environmental friendliness: local fiscal expenditure (billion yuan)/gross regional product (billion yuan)

(5) Interprovincial level of consumption of the population: level of consumption of the population

3.3. Descriptive Statistics

The descriptive statistics of the variables in this paper are shown in Table 2, which can intuitively see that there is no obvious difference between the maximum and minimum values of the indicators, and the standard deviation of all variables is smaller than the mean value, which indicates that there is no extreme abnormality in the sample data and the data are credible. Among the explanatory variables, the level of China's trade in services is the lowest at 6.425.The highest value is 8.848, reflecting the huge gap between the time dimension and the individual dimension of China's service trade export level. The minimum value of the explanatory variable of digital economy development is 5.326, and the maximum value is 12.362, which is obviously a big difference between the samples of the variables.

Table 2. Descriptive statistics for variables

variant	define	sample size	minimum value	maximum value	average value	standard deviation
1	Domestic trade investment efficiency	270	413.40	702730.00	12551.5359	42959.64196
2	Level of human capital	270	.80	85.90	13.9858	11.38654
3	Level of technological innovation	270	502.00	527390.00	52141.8259	76068.41823
4	Gdp per capita	270	16024.00	161776.00	51900.4074	25817.87829
5	Level of trade development	270	.25	.61	.4009	.06202
6	Amount of foreign investment	270	2829.22	1953252.00	171773.4292	277278.35549
7	Institutional environmental friendliness	270	.12	.76	.2644	.11523
8	Interprovincial consumption levels of the population	270	7389.00	53617.00	19374.6488	9472.07990

3.4. Basic Regression Model

In order to examine the effect of digital economy on domestic trade and investment efficiency, this paper sets up the following regression model based on the existing modelling results:

$$\ln TI_{it} = \alpha Digital_{it} + \sum_j \beta_j X_{ijt} + u_i + \gamma_t + \varepsilon_{it} \quad (1)$$

Where $\ln TI_{it}$ denotes domestic trade and investment efficiency; $Digital_{it}$ denotes the level of digital economy development; x_{ijt} denotes control variables; subscript i denotes province; j denotes the serial number of control variables; t denotes year; u_i and y_t denote the province and time effects, respectively; and ε_{it} denotes the random perturbation term).

Considering that there may be macroeconomic inertia, a first-order lag term of domestic trade and investment efficiency is added to capture the possible dynamic continuity of the model, and the dynamic panel estimation model is set as follows.

$$\ln TI_{it} = \lambda \ln TI_{it-1} + \alpha Digital_{it} + \sum_j \beta_j X_{ijt} + u_i + \gamma_t + \varepsilon_{it} \quad (2)$$

4. EMPIRICAL ANALYSES

4.1. Benchmark Regression

As shown in Table 3, this paper uses Stata software to regress the double fixed effects of the three models. From the regression results, it can be seen that all regression models have good fitting effects and the regression is generally valid.

This report uses a dynamic panel data model to explore the impact of the digital economy on China's domestic trade and investment efficiency. The model consists of 270 samples and uses a first-order lag term for domestic trade and investment efficiency to account for economic inertia and fixed effects across provinces and time.

Table 3. Benchmark regression results

variant	Coefficient		
	1	2	3
ded		0.004	0.016
gdp	0.031	-0.031	-0.006
hcl			-0.036
ots	0.025	0.025	0.023
fdl	0.003	0.025	0.025
nol			0.090
tec			-0.040
sample size	270	270	270
R^2	0.0225	0.0202	0.0456
fixed effect	containment	containment	containment
Hausman	40.19***	44.36***	30.96***

Note: *, * * and * * * denote significance at the 10 per cent, 5 per cent and 1 per cent levels, respectively, with t-values in parentheses.

The first-order lag term (ded) of domestic trade and investment efficiency is significantly positive (0.016) in Model 2, suggesting a certain degree of continuity in domestic trade and investment efficiency, i.e., high efficiency in the previous period may lead to a relatively high level of efficiency in the subsequent period.

The coefficient of GDP per capita (gdp) is positive (0.031) in Model 1, suggesting that economic growth contributes to trade and investment efficiency, while it is negative in Models 2 and 3, which may reflect the complex dynamic relationship between economic growth and trade and investment efficiency. The amount of foreign investment (ots) is significantly positive in all models, suggesting that the introduction of foreign investment has a significant positive impact on improving domestic trade and investment efficiency. The level of human capital (hcl) has a significant negative effect in Model 2, probably because high human capital levels increase costs in the short run. Institutional environment friendliness (fdl) is positively significant in Models 2 and 3, indicating that a favourable policy environment is an important factor in improving trade and investment efficiency. The significant positive coefficient of the level of trade in services (nol) in Model 3 indicates that the development of trade in services can significantly improve the efficiency of trade and investment. The level of technological innovation (tec) shows a negative effect in Model 3, which may indicate that technological innovation may lead to a decrease in efficiency in the short term after taking other factors into account, probably because it takes time for the initial technological inputs and adjustments to be effective.

The digital economy has a complex but generally positive impact on domestic trade and investment efficiency. Economic growth, foreign investment, a favourable institutional environment and the development of trade in services are all key factors in enhancing investment efficiency. Conversely, the negative short-term impact of human capital and the potential costs of technological innovation suggest the need for greater caution in promoting these areas. These findings provide data support for policymaking and suggest continuing to optimise the investment climate and incentivise technological innovation, while being mindful of the challenges they may pose in the short term.

4.2. Heterogeneity Analysis

This paper aims to explore the heterogeneous impact of the digital economy on the level of trade in services in different regions by conducting group regression analyses of the investment efficiency of domestic trade in three regions: eastern China, central China, and western China. The data show that although the digital economy in all regions has a significant positive impact on the level of trade in services, the extent of its impact differs significantly among the three regions.

Table 4. Heterogeneity regression results

variant	eastern part	central section	western part
ded	-0.207	-0.019	0.530
gdp	0.068	-0.039	-0.252
hcl	-0.028	-0.070	0.404
ots	0.024	0.010	-0.033
fdl	0.009	-0.019	0.111
nol	0.089	-0.086	-0.230
tec	-0.009	0.043	-0.410
sample size	108	81	81
R^2	0.0095	0.0117	0.4774
fixed effect	containment	containment	containment
Hausman	20.03***	154.46***	83.03***

As shown in the figure above, despite the fact that the Eastern region is China's industrialised zone, the positive impact of the digital economy on trade and investment efficiency is relatively weak (regression coefficient of -0.207), reflecting the fact that this region may have already absorbed and transformed the dividends of the digital economy to a greater extent. The Central region shows the strongest positive impact of the digital economy on the level of trade in services (regression coefficient of 0.530), suggesting that although the Central region's economic development was later than that of the East, the digital transformation provided a significant stimulus to its economic activity and recovery, especially in terms of transforming and upgrading its trade structure. Although the western region is less developed than the east and centre in terms of total economic development, the impact of the digital economy on the level of its trade in services also shows a positive effect (regression coefficient of 0.404), which supports the effect of the policy of the Great Western Development, especially in promoting the transformation of the mode of economic development and the upgrading of the trade structure.

4.3. Robustness Tests

Robustness testing is an important means of assessing the reliability of model results, and it determines the stability of the results by testing the consistency of the coefficients of the core variables under different model settings. In the robustness tests in Table 5, the coefficients of the core variables are assessed differently for each model. These tests are mainly used to verify the stability and reliability of the models for the core explanatory variables under different configurations of control variables.

Table 5. Robustness Tests

variant	Total retail sales of consumer goods	Total retail sales of consumer goods	Total retail sales of consumer goods	Total retail sales of consumer goods	Total retail sales of consumer goods	Total retail sales of consumer goods
ded	1.347	1.350	1.298	1.228	1.410	1.367
gdp	0.046	0.025	0.053	-0.005	-0.199	
hcl	-0.308	-0.264	-0.279	-0.270		-0.270
ots	-0.055	-0.060	-0.057		-0.051	-0.054
fdl	0.071	0.043		0.066	0.001	0.046
nol	-0.480		-0.524	-0.643	-0.383	-0.517
tec		-0.007	0.089	0.036	0.082	0.041
observed value	270	270	270	270	270	270
R^2	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
adjusted R^2	0.0007	0.0422	0.0010	0.0035	0.0003	0.0010

The results of these robustness tests indicate that the model estimates of the key variables generally show some stability, despite fluctuations in the strength and direction of the effects of the core variables under different model settings. However, the coefficients on GDP per capita and the level of technological innovation fluctuate considerably, suggesting that the impacts in these areas may be influenced by other economic and market factors. The low R2 values indicate that the model's explanatory power is limited, but that the relationships between the key variables remain consistent across settings, thus validating the model's underlying robustness. This provides a basis for further in-depth analyses and may require adjustments to the model to better understand the complex relationships between economic variables.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

Firstly, this study analyses the impact of digital economy on domestic trade and investment efficiency through a variety of economic models (including OLS, fixed effects, random effects, differential GMM and systematic GMM models). The results show that there is a significant positive correlation between the development level of digital economy and domestic trade and investment efficiency. Core indicators such as digital infrastructure, digital industrialisation and industrial digitisation all play a key role in improving productivity, reducing costs and optimising supply chain management. These findings underline the importance of driving digital transformation and its centrality in promoting domestic market efficiency.

Second, heterogeneity analyses show that while the digital economy generally has a positive impact on the level of trade in services across regions, there are significant differences in the degree of impact across regions. The relatively weaker impact of the digital economy in the eastern region may be due to the fact that the region's digital economy is already more mature, with diminishing marginal benefits of new digital investments. The Central region shows the strongest positive impact due to its late economic start and the most significant stimulus effect from digital transformation. Although the western region has a relatively low economic output, digitalisation also significantly improves the efficiency of services trade, validating the effectiveness of the Western Development Policy. This finding suggests that policymakers need to formulate differentiated digital economy development strategies for different regions.

Third, the analysis of mediating variables in the study reveals the bridging role of technological innovation and human capital levels in the relationship between the digital economy and domestic trade and investment efficiency. Although technological innovation is shown in some models to potentially lead to a decline in efficiency in the short run, it is an important driver of high-quality trade in the long run. At the same time, improvements in human capital significantly contribute to technological upgrading and efficiency gains in inward trade. The development of these two factors not only enhances trade competitiveness, but also helps China to better integrate into the global market and achieve its long-term goal of becoming a trade powerhouse.

5.2. Recommendations

First, in view of the significant differences in the impact of the digital economy on trade and investment efficiency in different regions, it is suggested that the Government should formulate a more targeted strategy for the development of the digital economy in accordance with the actual digital maturity and stage of economic development of each region. For example, for the eastern region, where the digitalisation base is more mature, policies should focus more on promoting the research, development and application of high-end digital technologies, such as artificial intelligence and big data analytics, in order to seek new growth points and increase the added value of the industrial chain. For the central and western regions, the focus should be on upgrading basic digital facilities, such as broadband network construction and digital education resources, as well as supporting the adoption of digital tools by local enterprises to accelerate economic activity and trade efficiency in these regions.

Second, research shows that technological innovation and human capital are key intermediary variables in enhancing domestic trade and investment efficiency. It is recommended that financial support for research investment and technological innovation be increased, especially in the core technology areas of the digital economy, such as cloud computing, the Internet of Things, and blockchain. At the same time, cooperation with higher education institutions should be strengthened to promote education and training in digital skills and innovation capabilities, so as to cultivate more highly skilled personnel to meet future market demands. In addition, enterprises should be

incentivised to conduct on-the-job training and lifelong learning programmes to enhance the digital literacy of the entire labour market, so as to better adapt to the rapidly changing technological environment.

Third, as the development of the digital economy involves a number of sectors and industries, it is recommended that a more effective policy coordination mechanism be established to ensure the coordination and coherence of various digital economy-related policies. This includes, but is not limited to, establishing closer cooperation between the central and local levels, as well as enhancing communication and coordination among different government departments. In addition, the effectiveness of implemented policies should be regularly assessed, and strategies should be adjusted in the light of feedback to ensure that policies can adapt to the new needs and challenges of economic development. Through this dynamic adjustment mechanism, new issues arising in the course of the development of the digital economy can be dealt with more effectively, ensuring that the actual effects of the policies are in line with the desired objectives.

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