The Influence of the Digital Economy on Innovation and Entrepreneurship Vitality: Base on the Perspective of International Trade

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Abstract. In the current wave of global technological revolution and industrial transformation, the digital economy is leading innovation and change with unprecedented vitality. Based on panel data from 29 Chinese provinces, municipalities, and autonomous regions (excluding Xinjiang, Tibet, Hong Kong, and Macau) from 2012 to 2022, this paper delves into the impact of the digital economy on the vitality of mass entrepreneurship and innovation, as well as the underlying mechanisms. Empirical results show that the digital economy significantly enhances this vitality. Specifically, its promoting effect becomes more evident when foreign trade exceeds 2.736 million US dollars, indicating a nonlinear relationship. Additionally, the influence of the digital economy on mass entrepreneurship and innovation varies regionally, with eastern regions showing a more pronounced promoting effect than central and western regions. Consequently, the paper proposes the following policy recommendations: first, strengthen digital infrastructure, reduce business entry barriers, decrease information asymmetry, and boost mass entrepreneurship and innovation vitality; second, promote deep integration of the digital economy with foreign trade by building digital trade platforms to enhance enterprises' international competitiveness; and third, develop region-specific policies to encourage balanced digital economic growth and narrow regional development gaps.

Keywords: Digital Economy; Entrepreneurship and Innovation Activity; Foreign Trade; Threshold Effect.

1. Introduction

In the current wave of global scientific and technological revolution and industrial transformation, the digital economy is leading innovation and transformation, demonstrating unprecedented vitality. According to data released by the Chinese government's official website, the added value of core digital economy industries in China accounted for approximately 10% of the country's Gross Domestic Product (GDP) in 2024. This significant proportion not only highlights the pivotal role of the digital economy in the national economy but also reflects its robust driving force for economic growth. The report of the 20th National Congress of the Communist Party of China explicitly states, "Accelerate the development of the digital economy, promote deep integration between the digital economy and the real economy, and build internationally competitive digital industrial clusters." This not only charts the course for China's digital economy development but also demonstrates the state's high-level recognition and emphasis on the strategic status of the digital economy. Against the backdrop of the ongoing global new round of scientific and technological revolution and industrial transformation, the digital economy, with its unique innovative attributes and empowering effects, has become a crucial engine driving global economic growth[17].

In recent years, digital capital and trade have become vital pillars supporting economic recovery. General Secretary Xi Jinping's strategic deployment of "promoting the construction of a strong trading nation" outlined in the report of the 19th National Congress of the Communist Party of China clarifies the direction for the transformation and upgrading of China's international trade in the new era. The "14th Five-Year Plan for High-Quality Development of Foreign Trade" issued by the Ministry of Commerce in November 2021 further emphasizes the need to "promote deep integration of digital technologies with trade development and continuously strengthen new engines for foreign trade growth," marking the formal incorporation of the digital economy into China's core strategic

framework for high-quality foreign trade development. Leveraging the digital economy, international trade has established online trading platforms such as TikTok, with new business forms and models like cross-border e-commerce and digital service trade emerging rapidly. This has spurred the proliferation of market entities and innovation activities, making Innovation and Entrepreneurship Vitality a key indicator for measuring the effectiveness of digital technology empowerment in foreign trade.

This study focuses on the interactive mechanisms between the digital economy and international trade. By analyzing the transmission pathways of Innovation and Entrepreneurship Vitality within this relationship, it not only reveals the intrinsic logic of digital technology-driven transformation in foreign trade but also provides theoretical support and practical insights for improving China's digital trade policy system and cultivating new competitive advantages in foreign trade.

2. Literature Review

2.1. Digital Economy and Entrepreneurship Vitality

Existing research indicates that the digital economy exhibits stronger geographical penetration and cost advantages, enabling it to advance inclusive finance and thereby promote economic growth (Li Jizu, 2015). The impact of the digital economy on economic development is multidimensional. From a micro-level perspective, the development of modern information networks allows enterprises to effectively reduce costs and achieve economies of scale. Leveraging these economies of scale, businesses can diversify operations and expand product variety, fostering economies of scope. Economies of scope, in turn, address diverse consumer demands through long-tail effects. These three economic effects—economies of scale, economies of scope, and long-tail effects—constitute the core economic environment of the digital economy, enhancing overall economic equilibrium. At the macro level, the digital economy drives high-quality economic development by supplying new input factors, improving resource allocation efficiency, and boosting total factor productivity (Jing Wenjun & Sun Baowen, 2019).

The digital economy promotes innovation and entrepreneurship. From a macro perspective, first, digital technologies accelerate the digital transformation of traditional industries, creating more niche market opportunities for entrepreneurs (He Xiaoyu & Chu Deyin, 2023). Second, the digital economy relies on infrastructure such as high-speed internet, cloud computing, and big data. The widespread adoption of these infrastructures reduces entrepreneurial costs and barriers, improves the business environment, expands the pool of innovators and entrepreneurs, and stimulates innovation and entrepreneurship (Zheng Wei & Lu Yuanquan, 2023).

From a micro perspective, the digital economy—powered by technologies such as big data, the internet, and cloud computing—enhances resource allocation efficiency and supply-demand matching efficiency through deep integration with various economic and social sectors. This efficient matching mechanism not only spurs innovative business models but also generates diverse employment forms and entrepreneurial opportunities. It provides rich practical scenarios and pathways for innovation and entrepreneurship activities (Zhao Tao, Zhang Zhi, & Liang Shangkun, 2020).

The digital economy empowers high-quality economic development by stimulating mass entrepreneurship (Zhao Tao, Zhang Zhi, & Liang Shangkun, 2020). Numerous scholars have conducted empirical studies using panel data at national, provincial, and prefecture-level city levels, concluding that the digital economy enhances innovation and entrepreneurship levels (Li Zhi & He Haomiao, 2021; Zou Qi & Fan Li, 2022).

2.2. Digital Economy and International Trade

Existing research indicates that the promoting role of the internet and digital technologies in international trade has achieved broad consensus. Since Rauch (2001) pioneered the theoretical framework demonstrating how network technology reduces trade search costs, Freund and Weinhold

(2002) empirically verified the scale-expanding effect of the internet on traditional trade through gravity models. Wen Jun et al. (2015) further confirmed that this effect is more pronounced in developing countries. (The critical role of the internet in facilitating trade has been substantiated by empirical studies from Rauch (2001), Freund and Weinhold (2002), and Wen Jun et al. (2015).) With the maturation of the digital economy, scholars have shifted focus to its mechanisms in promoting high-quality foreign trade development: Xu Jun and Liu Chunyan (2023) found through empirical research that digital technologies not only drive industrial structure digitization and upgrading by reconstructing trade service models and industrial chains but also reduce trade dispute incidences via traceability features of blockchain and similar technologies. Huang Xinyuan (2023) revealed in micro-level firm studies that digital technology applications enable enterprises to transcend geographical constraints, enhance export technology sophistication, and expand international market coverage.

Existing literature primarily explores the mechanisms of digital economy's impact on international trade through three pathways: First, from a supply-side perspective, the digital economy empowers foreign trade by enhancing factor allocation efficiency (Hao Sijun, 2014), promoting flexible production transformation, and optimizing global value chain division. Second, on the demand side, it manifests through precise matching of consumer demands, expansion of market scope economies, and innovation in trade models (Chao Xiaojing, Wang Chenwei, and Wang Can, 2024). Third, the digital economy fosters systemic promotion mechanisms via spatial spillover effects and institutional innovation incentives (Wang Wei, 2024).

Current scholarship has extensively investigated the intrinsic mechanisms of digital economy's impact on innovation and entrepreneurship from demand markets, entry barriers, and resource allocation efficiency. However, few studies have explored the influence of the digital economy on innovation and entrepreneurship from the perspective of international trade.

3. Theoretical Model and Research Hypotheses

Digital technology empowerment enables startups to break through resource constraints, ultimately enhancing total foreign trade volume through economies of scale and scope effects, while leveraging cross-border e-commerce platforms to promote mass entrepreneurship and innovation. On one hand, the digital economy boosts the vitality of innovation and entrepreneurship among enterprises. The continuous emergence of new foreign trade enterprises not only expands the scale of market supply entities but also reconstructs the paradigm of international competition through innovative behaviors. The trust mechanism established by blockchain technology reduces transaction costs, enabling startups to participate in global value chain divisions through digital service trade. Technology-driven product iteration systems allow startups to rapidly respond to international market demands, forming a positive cycle of "innovation input → product upgrades → market expansion." The agglomeration effect of such innovation-intensive enterprises not only enhances the differentiated competitiveness of China's export products but also drives the digital transformation of traditional enterprises through knowledge spillover effects. Based on these findings, this study proposes Hypothesis H1:

H1: The digital economy significantly enhances the vitality of innovation and entrepreneurship.

According to Metcalfe's Law of the internet, the value of a network is proportional to the square of the number of its nodes, illustrating the nonlinear growth characteristic of network value—namely, increasing marginal returns. By constructing online platforms for international trade, the digital economy strengthens economic linkages across regions, effectively reducing trade costs. Such enhanced connectivity not only expands market boundaries but also creates more opportunities and resources for innovation and entrepreneurship activities, effectively increasing the number of "entrepreneurial nodes." Furthermore, the network effects and economies of scale brought by digitalization reduce information asymmetry. Specifically, digital technologies provide transparent market information, efficient transaction mechanisms, and extensive resource sharing, enabling

entrepreneurs to identify market opportunities more precisely and allocate resources more efficiently. This significantly improves the vitality and success rate of innovation and entrepreneurship. Based on these findings, this study proposes Hypothesis H2:

H2: The impact of the digital economy on the vitality of innovation and entrepreneurship exhibits nonlinear characteristics due to the expansion of international trade.

China's overall economic development is marked by significant regional imbalances and insufficiencies. Grounded in resource-based theory, disparities in resource endowments and locational advantages across regions lead to substantial differences in the development levels of the digital economy among cities. During the early stages of urban development, when digital infrastructure remains underdeveloped, the network effects of the digital economy are incomplete. At this stage, the digital economy's role in boosting innovation and entrepreneurship vitality may be extremely limited. In some cases, government investments in digital infrastructure may even outweigh the value generated by the digital economy itself, potentially inhibiting urban entrepreneurship. Based on these considerations, this study proposes Hypothesis H3:

H3: The impact of the digital economy on innovation and entrepreneurship vitality exhibits regional heterogeneity.

4. Theoretical Model and Research Hypotheses

4.1. Model construction

To verify the overall effect of the digital economy on innovation and entrepreneurship vitality, the following baseline regression model is constructed:

$$\mathrm{Entrep}_{i,t} = \beta_0 + \beta_1 \mathrm{Dige}_{i,t} + \sum \alpha_i \mathrm{Control}_{i,t} + \mu_i + u_{i,t} \quad (1)$$

In Equation (1), $Entrep_{i,t}$represents the Innovation and Entrepreneurship Vitality Index of city i in period t, $Dige_{i,t}$denotes the indicator of the digital economy development level in city i during period t, $Control_{i,t}$ refers to a series of control variables, μ_i indicates the individual fixed effects of city i, and $u_{i,t}$ is the random disturbance term.

Furthermore, to explore the nonlinear association characteristics between the expansion of international trade scale and the quality of digital economy development, this study constructs a threshold effect model as shown in Equation (2):

$$Entrep_{i,t} = \beta_0 + \beta_1 Dige_{i,t} \times D(trade \le \eta_1) + \beta_2 Dige_{i,t} \times D(\eta_1 \le trade \le \eta_2) + \beta_3 Dige_{i,t} \times D(trade \ge \eta_2) \sum \alpha_i Control_{i,t} + \mu_i + u_{i,t} \quad (2)$$

4.2. Variable Selection

(1) Explained Variable: Innovation and Entrepreneurship Vitality (Entrep)

The mainstream methods for measuring innovation and entrepreneurship vitality include labor market approaches and ecological methods. Following Ye Wenping (2018), this study adopts a labor market approach, defined as the ratio of the number of new startups in a region to its labor force population.

(2) Explanatory Variable: Digital Economy Development Level (Dige)

This study draws on Zhao Tao (2020) to calculate the digital economy development level using the entropy weight method. Five secondary indicators are included: (1) the proportion of employees in computer services and software industries, (2) mobile phone users per 100 residents, (3) broadband internet users per 100 residents, (4) per capita telecommunications business volume, and (5) the

digital finance inclusiveness index. These indicators are standardized and dimensionally reduced through the entropy value method, with the final aggregated score designated as the digital economy development index (Dige).

(3) Control Variables

Consistent with urban economic development characteristics and innovation-driven policy requirements, control variables are constructed following Xiong Bin and Wang Zhiwei (2024): Foreign Direct Investment (FDI) is measured by foreign investment inflows (enterprise or individual) into China; Policy Support (Gov) is calculated as the proportion of local general fiscal expenditure to regional GDP; Human Capital (Humal), drawing on Yao Zhanqi (2022), is quantified by the number of college students per 10,000 residents across provinces and over time.

(4) Threshold Variable: Total Import and Export Volume (Trade)

To explore the role of international trade in the relationship between digital economy development and innovation-entrepreneurship vitality, this study uses provincial annual total import and export volume (denominated in USD) as the threshold variable.

4.3. Data Sources

The secondary indicators used to calculate the Digital Economy Development Level (Dige) in this study are sourced from the China Statistical Yearbook. Data for the Innovation and Entrepreneurship Vitality (Entrep) indicator are compiled from the China City Statistical Yearbook and the CSMAR database. The sample covers panel data from 29 provinces (municipalities and autonomous regions) in China (excluding Xinjiang, Tibet, Hong Kong, Macao, and Taiwan) over the period 2012–2022. Descriptive statistics for all variables are presented in Table 1:

Table 1. Descriptive Statistics (N = 319)

VARIABLES	Mean	SD	Min	Max
Entrep	1.456	1.332	0.271	19.380
Gov	0.256	0.110	0.105	0.758
Humal	0.215	0.057	0.085	0.436
Dige	0.244	0.182	0.049	1.000
FDI	2.975	5.751	0.028	56.700

5. Baseline Regression and Mechanism Tests

5.1. Baseline Regression Results

This study employs a fixed effects model for estimation. In the baseline regression analyzing the digital economy's impact on innovation and entrepreneurship vitality, control variables are incrementally added to the regression equation. The results consistently show a significant positive effect of the digital economy on innovation and entrepreneurship vitality. Table 2 reports the baseline regression results of the digital economy's influence on urban green technology innovation. The table indicates that the digital economy development level (Dige) has a highly significant positive impact on corporate innovation and entrepreneurship vitality at the 5% significance level. Specifically, each unit increase in the digital economy index raises innovation and entrepreneurship vitality by 2.735 units, reflecting its robust positive effect and demonstrating the effectiveness of the digital economy as a new economic form in driving innovation and entrepreneurship. This validates Hypothesis H1. Among control variables, both human capital (Humal) and foreign direct investment (FDI) exhibit significant positive effects on innovation and entrepreneurship vitality, with human capital playing a pivotal role. In contrast, policy support (Gov) shows no significant impact on innovation and entrepreneurship vitality.

Table 2. Baseline Regression Results (N = 319)

VARIABLES	(1) Entrep	(2) Entrep	(3) Entrep	(4) Entrep
Dige	7.442**	3.691**	2.711*	2.735**
	(3.413)	(1.393)	(1.349)	(1.330)
Humal			4.528**	4.629**
			(1.930)	(2.026)
FDI		0.198***	0.189***	0.189***
		(0.0354)	(0.0404)	(0.0406)
Gov				0.301
				(0.951)
Constant	-0.363	-0.0356	-0.742*	-0.846*
	(0.834)	(0.339)	(0.367)	(0.459)
R-squared	0.054	0.691	0.703	0.703
Province FE			Yes	

*** denotes statistical significance at the 1%, ** at the 5%, and * at the 10% level; values in parentheses are robust standard errors; the same below.

5.2. Robustness Tests

This study conducts robustness checks through three methods to ensure the reliability of the findings. First, to eliminate potential confounding effects from differences between municipalities and provinces, the data for four municipalities are excluded, and the regression is re-run with the remaining sample. Second, the digital economy index (Dige_new) is recalculated using principal component analysis (Jiang Hao, 2024) to replace the entropy-weighted Dige in the baseline model. Third, to address outliers, a winsorization method is applied to all variables at the 1% and 99% levels to mitigate their impact. Table 3 presents the results, showing that the positive effect of the digital economy on innovation and entrepreneurship vitality remains consistent and significant compared to the baseline regression in Table 2.

Table 3. Robustness Test Results

Variable	Exclude municipality samples	Replace independent variable.	Winsorization	Instrumental Variable	
				Dige	Entrep
Dige	2.349*		2.777**		0.799***
	(1.872)		(2.603)		(3.126)
Humal	9.104***	8.884***	8.917***	-0.200	2.781***
	(6.529)	(6.391)	(6.447)	(-0.690)	(4.778)
FDI	0.062***	0.066***	0.066***	0.000	0.091***
	(4.443)	(4.957)	(4.988)	(0.672)	(7.083)
Gov	1.365	1.750	1.719	-0.101	0.856***
	(1.219)	(1.646)	(1.621)	(-0.644)	(2.996)
Dige_new		2.724**			
		(2.621)			
ldige				0.985***	
				(119.120)	
Constant	-1.509***	-1.829***	-1.824***	0.012	0.170
	(-2.911)	(-3.360)	(-3.355)	(1.400)	(1.005)
F-statistic				1174.9	
R-squared	0.544	0.549	0.548	0.976	0.477

To address potential endogeneity issues caused by reverse causality, this study follows Luo Hongyan (2025) and employs the one-period lagged digital economy (Dige) as an instrumental variable (IV), applying a two-stage least squares (2SLS) approach. In the first stage, the Kleibergen-Paap rk Wald F statistic is 1,174.9, confirming that the lagged Dige is strongly correlated with the original explanatory variable and ruling out weak instrument bias. In the second stage, the core explanatory variable Dige retains its positive directionality and statistical significance (at the 1% level), indicating that even after accounting for endogeneity, the digital economy's positive impact on innovation and entrepreneurship vitality remains robust.

5.3. Threshold Effect Analysis

In the threshold effect model, total import and export volume (Trade) is treated as the threshold variable. The test results are shown in Table 4. The threshold variable (Trade) passes the single-threshold test with an F-statistic of 34.27, significant at the 10% level. However, neither the double-threshold nor triple-threshold effects are statistically significant. The F-statistic of 34.27 in the single-threshold test confirms the presence of a single threshold. Table 5 indicates that the first threshold value of total import and export volume is 2.736. Therefore, single-threshold regression is adopted for subsequent analysis.

Table 4. Threshold Effect Test Results

Threshold Variable	Numbers of Threshold	RSS	MSE	F-Statistic	P-Value
trade	Single-threshold	99.86	0.32	34.27	0.0867
	Double-threshold	93.02	0.30	22.65	0.1667
	Triple-threshold	90.75	0.29	7.72	0.8733

Table 5. Threshold Estimates and Confidence Intervals

Explanatory Variable	Threshold Variable	Numbers of Threshold	coefficient	$D(trade \leq \eta_1)$	$D(trade \geq \eta_2)$	95% confidence interval	
Dige	trade	Single-threshold	2.736	-0.196	4.854***	2.621	2.751
				(1.172)	(1.112)		

As shown in Table 5, when total import and export volume (Trade) is below the threshold value of 2.736 (million USD), its effect on regional innovation and entrepreneurship vitality is insignificant. However, when Trade exceeds 2.736 million USD, its promoting effect on innovation and entrepreneurship vitality becomes substantial, with the coefficient rising to 4.854 and significant at the 1% level. This validates Hypothesis H2.

5.4. Heterogeneity Test

China's vast territory and uneven regional economic development imply varying geographical and locational factors across regions, leading to potential differences in the digital economy's impact on innovation and entrepreneurship vitality. Accordingly, this study classifies China's economic zones into Eastern, Central, and Western regions based on the National Bureau of Statistics' categorization to explore regional heterogeneity. Regression results are presented in Table 6.

Table 6. Results of Heterogeneity Analysis

VARIABLES	Eastern Regions	Enterp Central Regions	Western Regions
Dige	6.352**	-3.573	2.494
	(2.503)	(-1.345)	(1.376)
Humal	-2.419	14.146***	7.181**
	(-0.421)	(5.075)	(2.957)
FDI	0.002***	0.001	-0.000
	(5.216)	(0.651)	(-0.263)
Gov	3.904	-6.905***	-0.086
	(1.186)	(-4.062)	(-0.090)
Constant	-2.027	-0.164	-0.614
	(-1.368)	(-0.432)	(-1.162)
R-squared	0.745	0.820	0.452
N	110	66	110
Province FE		Yes	

Table 6 reveals that in the Eastern Region, the digital economy's development level significantly enhances innovation and entrepreneurship vitality. In contrast, the Central Region shows an inhibitory effect, though it is statistically insignificant. For the Western Region, no significant impact of the digital economy on innovation and entrepreneurship vitality is observed, confirming Hypothesis H3.

6. Conclusions and Policy Recommendations

6.1. Conclusions

Building on prior empirical studies on the digital economy's economic impacts, this research explores its role in promoting innovation and entrepreneurship vitality while examining the nonlinear effects mediated by international trade. Key conclusions are as follows:

First, the digital economy has a significant promoting effect on the activity of innovation and entrepreneurship. Second, when the foreign trade volume reaches the threshold value of 27.36 million US dollars, the promoting effect of the digital economy on the activity of innovation and entrepreneurship will show a notable increase. Third, the digital economy development in the eastern region has significantly enhanced the activity of innovation and entrepreneurship, while the impact of the digital economy in the central and western regions is relatively smaller. This result confirms that there are significant differences in the effect of the digital economy among different regions, which may be related to factors such as the digital infrastructure, economic development level, human resources, and policy support in each region.

6.2. Policy Recommendations

Based on the findings, the following policy implications emerge:

First, governments should actively develop policies to advance digital infrastructure, expand network coverage, improve speed and stability, and lay a solid foundation for digital economic growth. Tax incentives, financial subsidies, and reduced entry barriers for digital enterprises can attract more innovators and entrepreneurs, stimulating market dynamism. Additionally, promoting data-sharing platforms and reducing information asymmetry will encourage digital business model innovation, enhancing competitiveness and further boosting innovation and entrepreneurship vitality.

Second, given the threshold effect of international trade, policymakers should prioritize integrating the digital economy with international trade. Building digital trade platforms, simplifying cross-border e-commerce procedures, and reducing trade costs will create favorable conditions for digital

economy-driven innovation. Encouraging firms to adopt digital technologies for operational and managerial innovation will enhance global competitiveness and seize opportunities in international markets. Strengthening international cooperation and participating in global digital governance will amplify China's influence in digital rule-making, expanding opportunities for digital economy internationalization.

Third, addressing regional heterogeneity requires tailored strategies. For the Eastern Region, consolidating its digital leadership and deepening integration with the real economy will drive industrial upgrading and innovation. For Central and Western Regions, increased policy support, infrastructure investment, and talent cultivation are critical. Cross-regional collaboration between Eastern and Western Regions should be promoted to facilitate resource sharing, narrow developmental gaps, and ensure balanced national progress in digital economy-driven innovation and entrepreneurship.

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