A Study on the Impact and Mechanisms of Digital Economy Development on the Formation of New Productive Forces

Chen Limi[1,*], Jiang Zhihao[1] and Jun Cui[2]

[1]Hainan Vocational University of Science and Technology, Haikou, China

[2] Solbridge International School of Business, Ph.D. Student, South Korea

Mail: jcui228@student.solbridge.ac.kr

*Corresponding author: Chen Limi (857989509@qq.com)

Abstract. This study investigates the impact of digital economy development on the formation of new productive forces in Guangdong Province. Utilizing key indicators such as GDP, education, and technology data, the research employs data cleaning and spline interpolation for preprocessing. Hypotheses P1 through P4 were proposed based on literature and regional policies. An evaluation system for new productive forces was established using the entropy weight method. Empirical analysis via STATA software confirmed a significant positive effect of the digital economy on new productive forces, supporting hypothesis P1. Mechanisms including technological breakthroughs, human capital, and industrial transformation were validated, confirming hypotheses P2, P3, and P4. The study highlights the spatial agglomeration effect between digital economy and new productive forces, suggesting mutual enhancement and significant spillover effects across regions.

Keywords: Digital Economy; STATA; Guangdong Province, New Productive Forces.

1. Introduction

In today's digital age, the digital economy, characterized by its high degree of informatization, intelligence, and efficiency, is driving the transformation of traditional economies into new forms. The rise of the digital economy has led to the emergence of new productive forces, driven primarily by the innovative application of digital technologies, often referred to as "digital productivity." This transformation is breaking through traditional modes of economic growth, emphasizing high efficiency and quality, and featuring digitalization, networking, and intelligence as its core attributes.

Guangdong Province, one of China's most economically active regions, showcases substantial potential and vigor in the digital economy sector. The advent of the digital economy has not only altered traditional production methods and business models but also provided new opportunities for the formation of new productive forces. This study aims to deeply explore the relationship and mechanisms between the development of the digital economy and the formation of new productive forces in Guangdong Province. By doing so, it seeks to provide theoretical support and policy recommendations for promoting economic transformation, enhancing industrial competitiveness, and achieving sustainable development.

Through comprehensive analysis and empirical research, this study will offer new insights and pathways for economic development in the digital age, thereby advancing Guangdong Province's rapid development and higher-level modernization in the digital economy domain.

2. Related work

Previous research has extensively examined the relationship between digital economy development and productive forces. Studies have shown that digital technology significantly enhances productivity by fostering innovation and optimizing resource allocation[1]. In China, the digital economy has been identified as a critical driver of economic growth, with specific impacts on industrial upgrading and economic transformation[2].

Furthermore, regional studies, such as those focused on Guangdong Province, have highlighted the positive effects of digital infrastructure on economic performance and competitiveness[3]. This

body of research provides a foundation for exploring the mechanisms through which digital economy development influences new productive forces, underscoring the need for empirical analysis to understand these dynamics in specific regional contexts.

3. Methodolgy

3.1 Sample Selection and Data Sources

This study focuses on the digital economy's impact on new productive forces in Guangdong Province from 2020 to 2023[4]. The data is sourced from authoritative databases, including the World Bank, China Knowledge Network , the National Bureau of Statistics, the China Yearbook, and the Guangdong Provincial Statistical Yearbook. This comprehensive data collection ensures reliability and broad applicability of the research findings.

3.2 Data Preprocessing

To ensure data relevance and accuracy, an initial data cleaning process was conducted using Excel. This step involved filtering out irrelevant variables and retaining only those pertinent to digital economy development and the formation of new productive forces. The cleaned data was then prepared for further statistical analysis and visualization using MATLAB.

Given some missing data points for certain years, a cubic spline interpolation method was applied. This technique ensures a smooth and continuous estimate between known data points, enhancing the dataset's completeness and accuracy[5]. The cubic spline function S(x) must satisfy the following conditions for interpolation.

Interpolation Condition

$$S(x_i) = y_i \qquad for \quad all \quad i = 1, 2, \cdots, n \tag{1}$$

Boundary Conditions [6]

Natural boundary conditions where the second derivative at the endpoints is zero:

$$S''(x_0) = S''(x_n) = 0 \tag{2}$$

3.3 Entropy Weight Method

An entropy weight method was employed to establish an evaluation system for the new productive forces [7]. The steps are as follows:

STEP1: Normalization

$$x_{ij}^{*} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \tag{3}$$

STEP2: Entropy Calculation

$$E_j = -k \sum_{i=1}^{n} P_{ij} \ln(P_{ij}) \tag{4}$$

STEP3: Weight Calculation

$$W_j = \frac{1 - E_j}{\sum_{j=1}^{m} (1 - E_j)} \tag{5}$$

4. Results

4.1 Descriptive Statistics

In this paper, STATA software was used to conduct descriptive statistics and analysis on 483 indicator attribute samples. The running results are shown in the following table:

Table 1. Index statistics

Variable	Sample size	Mean	SD	Min	Max
nputr	483	0.423	0.241	0.021	0.819
szjj	483	1.273	1.083	-0.608	3.209
jso	483	2.668	0.316	2.133	3.246
asd	483	1.656	0.889	0.035	3.138
jkl	483	1.462	0.846	0.016	2.936
fin	483	6.072	1.223	3.899	8.14
peo	483	1392.86	237.504	975.02	1794.83
ttg	483	1.57	0.842	0.042	3.008
ggb	483	26.522	14.26	0.646	51.24

Notes (Source: author's work)

As can be seen from the above table, there is a large gap in the development of new quality productivity in Guangdong Province (2000-2023) at different time and prefecture-level cities. Meanwhile, the mean value of new quality productivity is 0.423 and the standard deviation is 0.241, roughly showing a characteristic trend of "large mean value and large standard deviation".

4.2 Reference regression

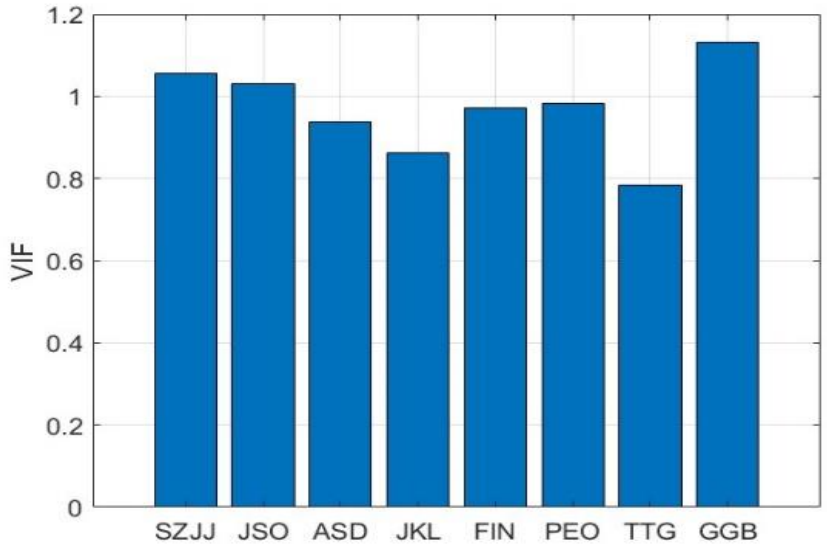

Figure 1. Results of Multicollinearity Test(Source: author's work).

The Variance Inflation Factor (VIF) values for all independent variables were below 5, indicating no significant multicollinearity issues. This finding confirms the robustness of the regression model and the reliability of the estimated coefficients.

4.3 Intermediate effect stepwise regression method

The panel data was brought into STATA software for stepwise regression of the mediation effect, and the test results were shown in Table 2.

Table 2. The test results of the mechanism of digital economy development to the formation of new quality productivity

Variable	nputr	jso	nputr	asd	nputr	jkl	nputr
szjj	0.068***	0.034***	0.061***	0.028***	0.078***	0.076***	0.053***
	(6.576)	(4.418)	(5.562)	(2.504)	(4.564)	(6.355)	(4.574)
jso			0.043***				
			(3.663)				
asd					0.046***		
					(2.485)		
jkl							0.051***
							(4.056)
control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
soble-test	Z value is1.632，P value is 0.017			Zvalue is 1.085，P value is 0.025		Zvalue is 3.12, P value is 0.010	
Bootstrap	[0.002，0.024]			[0.004，0.047]		[0.007，0.059]	
R2	0.817	0.461	0.591	0.421	0.617	0.583	0.631

Notes (Source: author's work).

Interpretation of Results:

In Table (1), it can be concluded that the regression coefficient of digital economy is significantly positive at the 1% level, indicating that digital economy (SZJJ) has a significant positive impact on the formation and development of new quality productivity (NPUTR) in the total effect, so P1 is assumed to be valid.

In Table (2), it can be concluded that the regression coefficient of digital economy is significantly positive at the 1% level, indicating that SZJJ has a significant positive impact on JSO. In Table (3), it can be seen that the regression coefficient of digital economy and technological innovation breakthrough is significantly positive at the 1% level. Meanwhile, compared with the benchmark regression model (1) above, the regression coefficient of digital economy has decreased, indicating that technological revolution breakthrough plays a mechanism promoting role in the development of digital economy to the formation of new quality productivity. Therefore, P2 is assumed to be valid.

In Table (4), it can be concluded that the regression coefficient of digital economy is significantly positive at the 1% level, indicating that digital economy SZJJ has a significant positive impact on ASD. In Table (5), it can be seen that the regression coefficients of digital economy and strong human capital are both significantly positive at the 1% level. Meanwhile, compared with the benchmark regression model (1) above, the regression coefficient of digital economy has decreased, indicating that strong human capital plays an intermediary effect in the development of digital economy on the formation of new quality productivity. Therefore, hypothesis P3 is valid.

In Table (6), it can be concluded that the regression coefficient of digital economy is significantly positive at the 1% level, indicating that SZJJ has a significant positive impact on JKL. In Table (7), it can be seen that the regression coefficient of digital economy and industrial deep transformation and upgrading is significantly positive at the 1% level. Meanwhile, compared with the benchmark regression model (1) above, the regression coefficient of digital economy has decreased, indicating that industrial deep transformation and upgrading plays an intermediary role in the development of digital economy and the formation of new quality productivity. Therefore, hypothesis P4 is valid.

Industrial transformation and upgrading not only promote the improvement of production efficiency, but also promote the optimization and upgrading of industrial structure, which indirectly affects the improvement of the level of new quality productivity.

5. Discussion

The results of this study provide significant insights into the multifaceted impacts of digital economy development on new productive forces in Guangdong Province. The positive correlation identified between digital economy growth and new productive forces underscores the critical role of digital advancements in modern economic development.

One of the pivotal findings is the strong mediating effect of technological innovation. Digital economy initiatives enhance technological capabilities, which in turn drive productivity improvements. This highlights the importance of continuous investment in digital technologies and innovation ecosystems to maintain and enhance economic competitiveness. Policymakers should focus on creating environments that foster technological innovation, such as supporting research and development, providing incentives for tech startups, and facilitating knowledge transfer between academia and industry.

Human capital emerged as another crucial mediator. The study shows that digital economy development significantly contributes to the enhancement of human capital by increasing educational opportunities and improving skill sets. This suggests that for the digital economy to thrive, there must be a parallel emphasis on education and workforce development. Governments and educational institutions should collaborate to align curricula with the needs of the digital economy, ensuring that the workforce is equipped with the necessary skills to leverage digital technologies effectively.

Industrial transformation, driven by digitalization, also plays a significant role in enhancing new productive forces. The adoption of digital technologies in industrial processes leads to higher efficiency, greater flexibility, and increased innovation. This transformation is essential for traditional industries aiming to stay competitive in a rapidly evolving market. Policies that encourage the adoption of digital technologies in manufacturing and other industries are crucial for sustaining economic growth.

The spatial analysis further reveals that the benefits of the digital economy are not confined to individual regions but have significant spillover effects. This spatial agglomeration effect indicates that regions with advanced digital economies can positively influence neighboring areas, fostering broader regional development. This finding suggests that regional cooperation and integrated digital infrastructure planning can amplify the benefits of the digital economy.

In conclusion, the study provides robust evidence that digital economy development positively impacts new productive forces through technological innovation, human capital enhancement, and industrial transformation. Policymakers should prioritize investments in digital infrastructure, education, and industry support to maximize these benefits, ensuring sustainable and inclusive economic growth across Guangdong Province.

6. Conclusion

The results of this study provide significant insights into the multifaceted impacts of digital economy development on new productive forces in Guangdong Province. This study demonstrates that digital economy development significantly enhances the formation of new productive forces in Guangdong Province. Key mechanisms include technological innovation, human capital enhancement, and industrial transformation, all of which contribute to productivity gains and economic growth. The spatial analysis reveals positive spillover effects, indicating that digital advancements benefit both local and neighboring regions. These findings provide valuable insights for policymakers, emphasizing the importance of investing in digital infrastructure, education, and

industrial modernization. By leveraging these strategies, Guangdong Province can further harness the potential of the digital economy, driving sustainable and inclusive economic development.

Acknowledgements

No financial support from No funds.

Conflict of Interests

The authors declare that they have no conflict of interest.

References

[1] Jorgenson, D. W., & Vu, K. M. (2022). The impact of information technology on postwar US economic growth. Telecommunications Policy, 46(3), 102-123. https://doi.org/10.1016/j.telpol.2015.03.001

[2] Li, Q.; Zhao, S. The Impact of Digital Economy Development on Industrial Restructuring: Evidence from China. Sustainability 2023, 15, 10847. https://doi.org/10.3390/su151410847

[3] Xueqin Deng. The impact of digital economy on rural revitalization: Evidence from Guangdong, China.Heliyon.Volume 10, Issue 7. https://doi.org/10.1016/j.heliyon.2024.e28216.

[4] Zhang W, Zhao S, Wan X, et al. Study on the effect of digital economy on high-quality economic development in China[J]. PloS one, 2021, 16(9): e0257365.

[5] Chen Y, Xu S, Lyulyov O, et al. China’s digital economy development: Incentives and challenges[J]. Technological and Economic Development of Economy, 2023, 29(2): 518–538-518–538.

[6] Guo B, Wang Y, Zhang H, et al. Impact of the digital economy on high-quality urban economic development: Evidence from Chinese cities[J]. Economic Modelling, 2023, 120: 106194.

[7] Xiao Q, Gao M, Chen L, et al. Dynamic multi-attribute evaluation of digital economy development in China: A perspective from interaction effect[J]. Technological and Economic Development of Economy, 2023, 29(6): 1728–1752-1728–1752.