International Journal of Multidisciplinary Research and Growth Evaluation.

Research on the Impact of Digital Economy on Industrial Structure Upgrading: An Analysis from the Perspective of Technological Innovation

Qun Xu [1], **Qiwei Cai** [2*]
[1-2] Business School, Shanghai Dianji University, Shanghai 201306, China

* Corresponding Author: **Qiwei Cai**

Article Info

ISSN (Online): 2582-7138
Impact Factor (RSIF): 7.98
Volume: 06
Issue: 05
September - October 2025
Received: 30-06-2025
Accepted: 31-07-2025
Published: 28-08-2025
Page No: 439-444

Abstract
Based on the panel data of 31 provinces in China from 2013 to 2020, this article explores the impact of the digital economy on the upgrading of industrial structure from the perspective of technological innovation. By constructing a comprehensive index system covering digital infrastructure, industrial digitalization, digital industrialization and the supporting environment for digital development, and then assigning values using the entropy method, empirical tests are conducted using the fixed effects model, instrumental variable method and mediating effects model. The research findings are as follows: (1) The digital economy significantly promotes the rationalization and upgrading of the industrial structure, and the conclusion has passed robustness tests such as lag effect, indicator replacement, and sample exclusion; (2) Regional heterogeneity indicates that the eastern region has the strongest promoting effect on the digital economy, while the western region is limited by weak digital infrastructure and there is a phenomenon of resource misallocation. (3) Technological innovation is an important intermediary path for the digital economy to drive the upgrading of the industrial structure. The marginal contribution of this article lies in improving the measurement system of the digital economy, revealing the transmission mechanism of technological innovation, and providing a basis for the design of regional differentiated policies.

Keywords: Digital economy Upgrading of industrial structure Technological innovation Regional heterogeneity Entropy value method

1. Introduction

Against the backdrop of rapid digitalization and sustainable development, the global economic landscape is undergoing profound restructuring. The China Digital Economy Development Report (2022) underscores that the digital economy, with its extensive spillover effects and transformative potential, has emerged as a central force in reshaping economic systems and competitive dynamics worldwide. Furthermore, China’s *14th Five-Year Plan for Digital Economy Development* highlights the strategic integration of digital technologies with the real economy, aiming to spawn new business models and accelerate comprehensive industrial digitization, with a target for core digital economy industries to account for 10% of GDP by 2025. Supporting this, a 2023 CAICT study illustrates how digital-technology integration breaks the constraints of traditional economic forms and facilitates a new digital paradigm for socio-economic development.

China currently stands at a critical intersection of industrial transformation and technological advancement. Traditional industries, constrained by low value-added production and high energy consumption, struggle to meet the demands of high-quality development. In contrast, the digital economy—characterized by technological permeability, network synergy, and data-driven mechanisms—offers new momentum for optimizing industrial structures. Nevertheless, existing research exhibits notable limitations: (1) measurements of the digital economy frequently rely on single indicators or conventional infrastructure metrics, overlooking the role of new digital infrastructure and innovation outputs; (2) the mediating role of technological innovation between digital economy and industrial upgrading remains underexplored; and (3) the influence of regional heterogeneity on the effectiveness of digital economic policies requires deeper investigation.

Current research on the digital economy and industrial structure can be categorized into three main strands. First, studies on the conceptualization and measurement of the digital economy. Tapscott (1996) [2] introduced the term, emphasizing the Internet's role in reshaping economic models. The U.S. Department of Commerce (1998) [1] systematically classified the digital economy into four components, whereas OECD (2014) [3] and BEA (2018) expanded its connotations to include e-transactions and ICT-dependency. Domestically, scholars like He Xiaoyin (2005) [5]and Kang Tiexiang (2008)[6] incorporated knowledge-driven structural change into its definition, further refined by the G20 Initiative to emphasize digitalized knowledge and information as key production factors. Metric systems have also evolved from unidimensional approaches (e.g., Zhang Xueling, 2017) [7] to multidimensional frameworks (e.g., Jiao Shuaitao, 2021; Liu Jun, 2020), [9] with recent contributions incorporating industrial digitization, digital industrialization, and support environments (Li Wanting, 2022; Lyu Mingguang, 2024; Ge Xuejiao, 2024). [10,11,12] Composite indices, such as that of Zhao Tao et al. (2020), [13] demonstrate a correlation with urban development, yet fail to disentangle structural effects.

Second, research on industrial structure evolution. Traditional theory, initiated by Kuznets (1957), frames industrial upgrading as the transition of production factors toward higher value-added sectors. Gan Chunhui (2011) [15] distinguished between broad upgrading (improved inter-industry linkages) and narrow upgrading (resource allocation efficiency). Measurement approaches include singular metrics–such as the tertiary-to-secondary industry output ratio (Yuan Yijun, 2014) [16] or green industry output share (Li Yuanyuan, 2016) [17]-and comprehensive indices such as the advanced industrial structure coefficient (Xu Min, 2015) [18] and structural deviation度 (Han Yonghui, 2017). [19]

Third, studies on the digital economy-industrial structure nexus. Scholars have identified triple mechanisms of "technology penetration-factor reorganization-spatial spillover." Zhang Yuzhe (2018) [20] emphasized the role of digital technology in reducing transaction costs and enabling cross-sector integration, while Wang Dehui (2020) [21] established an efficiency-centered transmission chain in manufacturing. Empirical studies confirm pronounced regional heterogeneity, with eastern China exhibiting 23.6% stronger effects due to superior infrastructure and technology diffusion (Zhang Yongqing, 2020). [22] Spatial econometric models further reveal spillover effects via cross-regional factor mobility (Lin Yuhao, 2020) [23], though direct and indirect effects are often conflated. Notably, Li Yingjie (2021) [24] suggested digital infrastructure's marginal effect is 1.8 times that of industrial digitization, yet overlooked innovation's intermediary role.

In summary, while existing literature offers valuable insights, it suffers from insufficient integration of emerging digital metrics, inadequate validation of innovation mediation, and underexplored regional heterogeneity. Accordingly, this study utilizes panel data from 31 Chinese provinces (2013-2020) to construct a multidimensional digital economy index encompassing infrastructure, industrial digitization, and digital industrialization. Using a fixed-effects model, we empirically examine direct effects and the mediating role of technological innovation. This study contributes to the literature in three ways: (1) developing a new integrated metric system for digital economy assessment; (2) unveiling the transmission mechanism of technological innovation between digital economy and industrial upgrading; and (3) comparing heterogeneous effects across eastern, central, and western regions to inform region-specific policy design.

2. Method

2.1. Model setting

To test the above hypotheses, this paper verifies the impact of the digital economy on promoting industrial structure upgrading by constructing a fixed-effect model. The model is as follows:

$$tl_{it} = \alpha_0 + \alpha_1 dig_{it} + \alpha_2 X_{it} + u_i + V_t + \varepsilon_{it}$$
$$ais_{it} = \alpha_0 + \alpha_1 dig_{it} + \alpha_2 X_{it} + u_i + V_t + \varepsilon_{it}$$

The explanatory variable of this paper is the level of digital economic development (dig). Drawing on the research of many scholars, the entropy method is adopted to measure it from four dimensions: digital industrialization, industrial digitalization, digital infrastructure, and the supporting environment for digital development. The Government intervention level capacity (gov) is measured by the proportion of government general public budget expenditure to regional GDP. The trade level (trade) is measured by the ratio of the total import and export volume of the business unit's location to the regional GDP, where the total import and export volume is converted using the average annual exchange rate of the US dollar to the RMB provided by the National Bureau of Statistics for each year. The population size (op) is measured by taking the logarithm of the proportion of the permanent resident population to the regional area. The industrial development level (idl) The logarithm of the number of industrial enterprises above designated size was taken for measurement. The instrumental variable in this paper drew on the research of Peng Jing (2024), and the HP Financial Index (if) was selected for the robustness test

2.2. Data Description

This paper selects 31 provinces and autonomous regions in China from 2013 to 2020 (Macao, Hong Kong, Taiwan, etc. are not included in the investigation scope) for empirical research. The data sources are "China Statistical Yearbook", Guotai 'an Database, EPS Database and statistical yearbooks of various provinces.

Table 1: Descriptive Statistics of Variables

Variable	Obs	Mean	Std.dev.	Min	Max
tl	248	-0.887	0.492	-2.282	-0.111
ais	248	1.302	0.700	0.572	5.297
dig	248	0.175	0.0888	0.0452	0.481
gov	248	20.89	38.40	0.898	248.9
trade	248	0.247	0.267	0.00764	1.332
lnop	248	5.323	1.493	0.948	8.275
lnidl	248	8.730	1.376	4.331	10.98

3. Results

3.1 Benchmark regression

Table 2: Benchmark Regression

	(1)	(2)	(3)	(4)
	tl	tl	ais	ais
dig	2.218***	2.126**	3.836***	3.441***
	(0.518)	(0.613)	(0.574)	(0.470)
gov		0		0.00300
		(0.001)		(0.002)
trade		0.692*		-1.095*
		(0.258)		(0.431)
lnop		2.356		-1.148
		(1.197)		(1.127)
lnidl		-0.140		-0.485***
		(0.238)		(0.091)
cons	-1.275***	-12.751*	0.632***	11.25
	(0.090)	(5.746)	(0.100)	(5.783)
N	248	248	248	248
r2 a	0.226	0.265	0.498	0.630

Table 2 presents the benchmark regression results of the digital economy on the upgrading of industrial structure. Columns (1) and (3) represent the impact of the digital economy level on the rationalization and upgrading of industrial structure without adding control variables. The coefficient of the former is 2.218, and that of the latter is 3.836. Both are significant at the 1% level, indicating that for every 1 unit increase in the digital economy level, The rationalization and upgrading of the industrial structure increased by 2.218 and 3.836 units respectively. The results in columns (2) and (4) indicate that after adding control variables, the benchmark regression results have changed. The coefficients of the digital economy level for the rationalization and upgrading of the industrial structure have become 2.126 and 3.441 respectively. The coefficients have been slightly washed, but they are still significant at the 1% level, verifying hypothesis H1. That is, the digital economy can significantly promote the upgrading of the industrial structure. In the control variables, after adding the level of industrial development (lnidl), it can be found that there is a negative correlation with the upgrading of the industrial structure, and it is significant at the 1% level, indicating that it may be due to the path dependence effect of traditional industries on the upgrading of the service industry.

3.2. Robustness test

To ensure the reliability of the above results, this paper measures them by having the explanatory variable lag by one period and changing the sample interval.

Regarding the lag of the explanatory variable by one period, due to the rapid development of the digital economy and the long cycle of industrial structure upgrading and adjustment, the promoting effect of digital development on industrial structure upgrading has a certain lag. Therefore, the method of lagging the explanatory variable digital economy by one period was adopted for robustness testing. The test results are shown in Table 3

Table 3: shows that the explanatory variables lag by one period

N	217	217	217	217
r2 a	0.242	0.267	0.428	0.621

As can be seen from Table 3, after the explanatory variable lags by one period, there are certain changes in the coefficient of the digital economy for the advancement and rationalization of the industrial structure. However, its significance remains significant at the 1% level, which proves that it has passed the robustness test

In terms of changing the sample range, considering that the country has established national-level digital economy innovation and development pilot zones, the construction of these zones will to some extent enhance the level of the digital economy, which may lead to certain errors in the results. Therefore, the provinces where the national-level digital economy innovation and development pilot zones are located are removed from the sample range. Six provinces, namely Zhejiang, Hebei, Fujian, Guangdong, Chongqing and Sichuan, have returned once again. The specific results are shown in Table 4

Table 4: Changes Sample intervals

	(1)	(2)	(3)	(4)
	tl	tl	ais	ais
dig	2.434***	2.212***	4.316***	3.675***
	(3.5012)	(3.0866)	(6.7793)	(7.3314)
gov		0.00100		0.005**
		(0.6612)		(2.1705)
trade		0.646**		-1.555***
		(2.5306)		(-5.8311)
lnop		2.957**		-0.226
		(2.1147)		(-0.1716)
lnidl		-0.163		-0.480***
		(-0.6468)		(-5.6003)
cons	-1.390***	-15.188**	0.623***	6.183
	(-11.9585)	(-2.3223)	(5.8478)	(0.9561)
N	200	200	200	200
r2 a	0.213	0.262	0.531	0.702

After eliminating a certain sample interval, it can be found that the regression result at this time has changed many coefficients compared with the original benchmark regression, but it is still significant at the 1% level, indicating that the conclusion is not affected by the bias of sample selection and passes the robustness.

3.3 Endogeneity test

Although benchmark regression was adopted to draw the conclusion of this study, to address the endogeneity issues such as the omission of explanatory variables and reverse causal relationships in empirical analysis, which may lead to bias in experimental results, instrumental variables were constructed to avoid endogeneity problems in the study. This paper refers to the approach of Peng Jing (2024) [25], selects the HP Financial Index (if) as the instrumental variable, and adopts a two-stage least squares regression. The specific results are as follows:

Table 5: Endogeneity tests of tl and ais

	(1) firstdig	(2) second	(3) firstdig	(4) second
Variables	dig	tl	dig	ais
lnIf	0.1332***		0.1332***	
	(8.40)		(8.40)	
gov	0.0001	0.0008	0.0001	0.0127***
	(0.67)	(0.58)	(0.67)	(11.14)
trade	0.0060	0.5920***	0.0060	-0.2473
	(0.22)	(3.07)	(0.22)	(-1.56)
lnop	0.0052	0.0197	0.0052	0.0733**
	(1.07)	(0.55)	(1.07)	(2.51)
lnidl	0.0230***	-0.0599	0.0230***	-0.3054***
	(4.94)	(-1.45)	(4.94)	(-8.95)
dig		3.6570***		3.9220***
		(4.27)		(5.57)
Constant	-0.7900***	-1.2707***	-0.7900***	2.6889***
	(-9.35)	(-5.56)	(-9.35)	(14.31)
Observations	248	248	248	248
R-squared		0.106		0.701

Table 5 shows that the instrumental variable passes the weak identification test (F value >10), and the coefficients of the digital economy for the rationalization and upgrading of the industrial structure are 3.657 and 3.922 respectively, both of which are significant at the 1% level, further confirming the robustness of the core conclusion.

3.4 Heterogeneity test

The impact of the digital economy on the upgrading of industrial structure may be affected by regional differences. Therefore, heterogeneity tests are conducted on the basis of benchmark regression

From the perspective of regional heterogeneity, the development of Chinese cities and the concentration of population have distinct regional characteristics. Compared with the central and western regions, the economic development level of the eastern region is significantly better than that of the central and western regions. The digital infrastructure in the eastern region is more complete, innovative enterprises are concentrated, the market-oriented environment is open, and the awareness of intellectual property protection is strong, laying a solid foundation for the development of the digital economy. The economic development in the central and western regions is relatively backward, and the development of digital infrastructure is weak. Therefore, the results of heterogeneity regression are shown in Table 6.

Table 6: Heterogeneity of tl and ais

	(1) tl	(2) tl	(3) tl	(4) ais	(5) ais	(6) ais
	East	**Central**	**West**	**East**	**Central**	**West**
dig	1.542***	0.132	-0.945	1.955***	3.810***	3.172***
	(3.99)	(0.19)	(-0.76)	(2.76)	(8.45)	(4.66)
gov	-0.000520	0.0247***	0.0856***	0.00405**	-0.00233	0.0313**
	(-0.66)	(3.47)	(4.06)	(2.25)	(-0.40)	(2.39)
trade	0.834***	0.558	-0.576	-1.177***	-3.392***	-0.424
	(4.02)	(0.33)	(-0.78)	(-3.32)	(-3.11)	(-0.92)
lnop	3.209***	1.996	-0.807	1.235	-2.927**	-1.088
	(3.44)	(1.54)	(-0.47)	(0.70)	(-2.45)	(-0.91)
lnidl	-0.226	-0.302	0.668*	-0.954***	-0.431***	-0.335*
	(-1.64)	(-1.44)	(1.68)	(-2.99)	(-5.45)	(-1.84)
year	Yes	Yes	Yes	Yes	Yes	Yes
province	Yes	Yes	Yes	Yes	Yes	Yes
N	88	72	88	88	72	88
r2	0.891	0.784	0.843	0.965	0.915	0.838

Table 6 indicates that the impact of the digital economy on industrial structure upgrading shows regional heterogeneity. In terms of the upgrading of industrial structure, the coefficient of the central region is 3.81, the highest among the three, indicating that the eastern region plays a relatively significant role in the upgrading of industrial structure. This might be due to the high proportion of traditional manufacturing in the central region, and the development of the digital economy has promoted the introduction of high-tech enterprises. In terms of the rationalization of industrial structure, the coefficient in the western region is -0.945, indicating that the digital economy in the western region plays a negative role in the rationalization of industrial structure. This might be due to the weak digital infrastructure in the west, leading to the misallocation of resources

4. Discussion

Based on the provincial panel data of China from 2013 to 2020, this paper systematically examines the impact and mechanism of action of the digital economy on the upgrading of industrial structure from both theoretical and empirical perspectives. The main conclusions are as follows: First, the digital economy has significantly promoted the rationalization and upgrading of the industrial structure. Moreover, the conclusion remains valid after robustness tests such as replacing measurement indicators, eliminating policy pilot samples, and lagging explanatory variables, indicating that the driving effect of digital technology on industrial upgrading is universal. Second, mechanism analysis indicates that the digital economy promotes industrial structure upgrading through the path of "technological innovation empowerment". Digital technology significantly enhances total factor productivity by reducing information asymmetry, optimizing the efficiency of factor allocation, and accelerating knowledge spillover, thereby driving the transformation of traditional industries and the rise of emerging industries. Thirdly, regional heterogeneity shows that in the central region, due to the high proportion of traditional manufacturing, the development of the digital economy has promoted the introduction of high-tech enterprises, and the industrial structure has become more advanced. However, the western regions are constrained by the lagging digital infrastructure and the shortage of talents, resulting in a relatively weak upgrade effect. They still need to increase investment to make up for the shortcomings.

Based on the above research conclusions, the following policy implications are proposed: (1) Implement policies by region and in accordance with local conditions to bridge the "digital divide". For the western regions with relatively weak digital foundations, two strategies can be adopted: infrastructure investment and talent introduction. We will intensify efforts to support the construction of 5G base stations, data centers and cold chain logistics networks in the western region, and strive to increase the coverage rate of digital infrastructure in the western region to 80% of the national average within three years. We have launched the "Western Digital Talent Revitalization Plan", aiming to break the deadlock of "peacocks Flying southeast" through targeted training by universities, eastern counterpart support, and subsidies for returning entrepreneurs. (2) Improve the digital technology innovation ecosystem and form a mechanism for the coordinated development of technology and industry. Firstly, we can establish a technological innovation support system, increase investment in the digital economy sector, encourage technological innovation, and provide financial support for "bottleneck" links such as artificial intelligence. Secondly, in light of the existing successful aspects of the digital economy, a digital economy transformation base should be established to successfully transform the digital economy achievements on paper, achieving a leap from theory to time, and thereby promoting the coordinated development of technology and industry. Finally, for small enterprises that are still in the development stage, a cost technology verification platform is provided to enhance the digital economy transformation achievements of small enterprises. (3) Improve the policy regulation mechanism to prevent the risk of structural imbalance. The development of the industrial structure promoted by the digital economy not only requires the protection and support of policies but also the dynamic monitoring of the government. A dynamic monitoring platform for the digital economy development index can be established to identify abnormal situations among regions, thereby achieving timely improvement and loss prevention.

5. References

1. United States Department of Commerce. The emerging digital economy. Washington, DC: US Department of Commerce; 1998.
2. Tapscott D. The digital economy: promise and peril in the age of networked intelligence. New York: McGraw-Hill Education; 1996.
3. Organisation for Economic Co-operation and Development. Measuring the digital economy: a new perspective. Paris: OECD Publishing; 2014.
4. United States Bureau of Economic Analysis. Defining and measuring the digital economy. Washington, DC: US Bureau of Economic Analysis; 2018.
5. He X. A study on the digital economy of the United States [dissertation]. Changchun: Jilin University; 2005.
6. Kang T. Research on the measurement of China's digital economy scale. Contemp Financ Econ. 2008;(280):118-21.
7. Zhang X, Jiao Y. A preliminary study on the measurement and application of China's digital economy development index. Zhejiang Sociol. 2017;(4):32-40, 157.
8. Jiao S, Sun Q. Measurement and analysis of the development of China's digital economy. J Fuzhou Univ (Philos Soc Sci Ed). 2021;35(6):18-25.
9. Liu J, Yang Y, Zhang S. Research on the measurement and driving factors of China's digital economy. Shanghai J Econ. 2020;(6):81-96.
10. Li W, Liu Y. Research on the impact of the digital economy on industrial structure upgrading. Times Financ. 2022;(11):46-9. doi:10.3969/j.issn.1672-8661(s).2022.11.015.
11. Lü M, Zhu G. Research on the impact of the digital economy on industrial structure upgrading in Beijing-Tianjin-Hebei region. J Beijing Econ Manag Vocat Coll. 2024;39(1):10-7. doi: 10.3969/j.issn.1008-7222.2024.01.003.
12. Ge X. Research on the impact of digital economy development on industrial structure upgrading. China Bus Trade. 2024;33(23):37-41. doi: 10.19699/j.cnki.issn2096-0298.2024.23.037.
13. Zhao T, Zhang Z, Liang S. Digital economy, entrepreneurship activity, and high-quality development: empirical evidence from Chinese cities. Manag World. 2020;36(10):65-76. doi:10.19744/j.cnki.11-1235/f.2020.0154.
14. Kuznets S. Quantitative aspects of the economic growth of nations: II. Industrial distribution of national product and labor force. Econ Dev Cult Change. 1957;5(S4):1-111.
15. Gan C, Zheng R, Yu D. The impact of China's industrial structure change on economic growth and volatility. Econ Res J. 2011;46(5):4-16, 31.
16. Yuan Y, Xie R. The effect of environmental regulation on industrial restructuring: an empirical test based on Chinese provincial panel data. China Ind Econ. 2014;(8):57-69.
17. Li Y, Jin H. A study on the effect of financial innovation on industrial structure optimization. Res Financ Econ Issues. 2016;(9):31-7.
18. Xu M, Jiang Y. Can the upgrading of China's industrial structure narrow the urban-rural consumption gap? J

Quant Tech Econ. 2015;32(3):3-21.
19. Han Y, Huang L, Wang X. Has industrial policy promoted the upgrading of local industrial structure? —Theoretical interpretation and empirical test based on developmental local governments. Econ Res J. 2017;52(8):33-48.
20. Zhang Y. Development ideas and main tasks of the digital economy driving the industrial structure toward medium-high end. Econ Rev J. 2018.
21. Wang D, Wu Z. Research on the mechanism and countermeasures of digital economy promoting the transformation and upgrading of China's manufacturing industry. Changbai J. 2020;(6):92-9.
22. Zhang Y, Chen M. Digital economy and regional industrial structure transformation and upgrading—based on factor analysis. Logist Sci-Tech. 2020;43(12):124-7.
23. Lin Y, Chen Y. Digital economy and industrial structure upgrading—a spatial econometric test from the perspective of factor flow. J Commer Econ. 2020;(9):172-5.
24. Li Y, Han P. The impact of digital economy development level on the optimization and upgrading of China's industrial structure—an empirical analysis based on provincial panel data. J Commer Econ. 2021;(6):183-8.
25. Peng J. A study on the effect of digital economy promoting industrial structure upgrading—an empirical analysis based on data from the Yangtze River Delta urban agglomeration [dissertation]. Anqing: Anqing Normal University; 2024.