Artificial Intelligence, Digital-Real Industry Integration, and Digital Economy Development

Qi Liu[a], Jian Liu[b,*], Fei Lei[c], Yongyue Ma[d]

School of Finance and Economics, Guangdong University of Science and Technology, Dongguan, Guangdong, 523083, China

[a]liuqi@gdust.edu.cn, [b]47628995@qq.com, [c]1005093728@qq.com, [d]3477173675@qq.com

Abstract. This research comprehensively investigates the influence and mechanism of artificial intelligence on the growth of the digital economy, using panel data from 30 provinces in China spanning from 2012 to 2022. The study findings suggest that artificial intelligence has a beneficial impact on the growth of the digital economy. This conclusion is supported by a number of rigorous tests, including model replacements, changes in calculation methodologies, and variations in sample sizes. Artificial intelligence plays a crucial role in advancing the digital economy by facilitating the merger of digital and physical businesses. Therefore, we propose policy recommendations to expedite the development of artificial intelligence products, prioritize the integration of digital and physical industries, and advance the establishment of digital infrastructure. These recommendations aim to offer innovative approaches for accelerating the growth of the digital economy in different regions.

Keywords: Artificial intelligence, Digital-real industry integration, Digital economy development, Mediation effect

1 Introduction

The 20th National Congress of the Communist Party of China's report highlights the need to expedite the development of the digital economy and facilitate its comprehensive fusion with the tangible economy. The digital economy is now playing a crucial role in driving economic growth. It is rapidly and extensively changing the way people live, produce goods, and interact with each other. In the pursuit of constructing a contemporary socialist nation comprehensively, expediting the advancement of the digital economy not only promotes superior economic expansion but also acts as a vital strategy to augment the nation's economic prowess and global competitiveness. Nevertheless, the continuous expansion of the digital economy is hindered by ongoing barriers such as data security concerns, privacy protection problems, and technological and ethical dilemmas[1]. Artificial intelligence is a crucial factor in advancing scientific and technological progress. It can utilize powerful data processing and analysis abilities to drive the digital transformation of traditional industries, contributing to the growth of

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the digital economy. AI's capacity to enhance novel products, forms, scenarios, and modes is especially remarkable. It propels economic growth through its "wisdom," facilitates industrial advancement through its "reality," stimulates new dynamics of productivity, and aids in the integration of digital and physical industries in the modern era. Moreover, the merging of digital and physical businesses promotes the exchange and use of technology, expertise, and resources across various sectors, encouraging the generation of creative ideas and propelling the sustainable growth of the digital economy[2]. An extensive examination of the logical correlation between artificial intelligence (AI), the integration of digital and physical industries, and the growth of the digital economy is strategically important for gaining control over key aspects of economic development and establishing new competitive advantages in the worldwide arena.

Existing research have mostly focused on advancing the digital economy with regards to enhancing productivity[3], boosting commonwealth[4], integrating urban and rural areas[5], and ensuring local financial sustainability[6]. It is necessary to shift research focus towards investigating the elements that influence digital economic growth. Furthermore, further investigation is necessary on the amalgamation of digital and physical sectors and the development of the digital economy. This paper explores the connection between artificial intelligence, the integration of digital and physical industries, and the development of the digital economy. Its goal is to address research gaps and provide empirical evidence to expedite the growth of the digital economy in different regions.

2 Theoretical Analysis and Research Hypotheses

2.1 Artificial Intelligence and Digital Economy Development

AI's impact on digital economy development extends beyond technical advancements to reshaping and promoting the entire economic system. AI enhances production efficiency, enabling machines to complete complex tasks autonomously, reducing manual intervention, and optimizing production processes, thus lowering costs and increasing competitiveness[7]. Additionally, AI facilitates data sharing, breaking information silos and promoting collaborative digital economy development. AI drives innovation, leading to new products, services, and business models, infusing new vitality into the digital economy. Accordingly, hypothesis H1 is proposed:

H1: Artificial intelligence can positively drive the digital economy

2.2 H1: Artificial intelligence Can Positively Drive Digital Economy Development. Artificial Intelligence, Digital-Real Industry Integration, and Digital Economy Development

AI can directly and indirectly promote digital economy development through digital-real industry integration. AI integrates knowledge and skills from different fields, breaking industry barriers and fostering cross-border innovation. For example, in transportation, AI integrates traffic data, urban planning, and environmental policies to enhance the intelligence and greening of transportation systems, promoting deep digital-

real industry integration. This integration supports the transformation and upgrading of traditional industries and the emergence of new industries like digital content, e-commerce, and intelligent manufacturing, boosting digital economy development. Accordingly, hypothesis H2 is proposed:

H2: Artificial Intelligence can promote the integration of digital and actual industries and thus drive digital economy development.

3 Research Design

3.1 Modeling

Based on theoretical analysis, the benchmark model to examine AI's impact on digital economy development is constructed as follows:

$$Dig_{it} = \alpha_0 + \alpha_1 Aip_{it} + \alpha_2 X_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (1)$$

Among them, Dig_{it} and Aip_{it} represent the level of digital economy development and artificial intelligence level respectively; X_{it} characterizes a series of control variables that may affect the development of digital economy; μ_i and ν_t refer to individual and time fixed effects in turn; and ε_{it} is a random interference term.

Further, in order to explore whether the integration of digital and real industries is a pathway for AI to influence the development of the digital economy, the following mediating effect model is constructed by combining the research ideas of Riverboat (2022)[8]:

$$M_{it} = \gamma_0 + \gamma_1 Aip_{it} + \gamma_2 X_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (2)$$

In Eq. (2), M_{it} is the mediating variable in this paper, i.e., the number of real industry fusion; the rest of the variables are defined and interpreted in the same way as in Eq. (1).

3.2 Measurement of Variables

3.2.1 Explained Variable: Digital Economy (Dig).

Based on Li Jian's analysis in 2024[9], the progress of the digital economy is assessed in terms of two aspects: digital finance and Internet development. The Digital Inclusive Finance Index, developed by the Digital Finance Research Center of Peking University, is used to quantify digital finance. Internet development is evaluated based on four indicators: the number of subscribers with Internet broadband access, the number of cell phone subscribers per 100 individuals at the end of the year, the per capita total amount of telecommunication services, and the percentage of employees in the computer software industry. The complete digital economy index for each area is calculated using the entropy-weighted TOPSIS approach, based on this framework.

3.2.2 Core Explanatory Variable: Artificial Intelligence (Aip).

Artificial Intelligence is a technology that simulates, extends, and expands human intelligence, aiming to equip computers or machines with human-like abilities to perceive, think, learn, and make decisions. Based on a deep understanding of the connotation of AI, we refer to the practice of Cui Wei (2024)[10] to reflect the level of AI development by the number of newly installed robots in a region.

3.2.3 Mediating Variable: Digital Real Industry Integration (Dri).

Integrating digital and actual industries refers to the digital economy providing the real economy with data elements, intelligent products, and digital models, thus promoting the real industry to reconstruct its business logic, adjust its organizational structure, and innovate its value model. This phenomenon reveals the coupling and correlation effect between the digital economy and actual economy subsystems, which influence, penetrate, and coordinate each other. Based on this, following the research idea of Wang et al. (2024[11]), a coupling and coordination model is constructed to assess the degree of coordination between the digital economy subsystems and the natural economy subsystems to fully characterize the level of integration of the digital and actual industries in the region. and the specific model is expressed as follows:

$$C_{it} = \sqrt{\frac{Dig_{it} \times Re_{it}}{\left(\frac{Dig_{it} + Re_{it}}{2}\right)^2}} \tag{3}$$

$$T_{it} = \beta_1 Dig_{it} + \beta_2 Re_{it} \tag{4}$$

Among them, Dig_{it} and Re_{it} represent the comprehensive evaluation scores of the digital economy subsystems and the real economy subsystems, respectively; Dri_{it} represents the coupling coordination degree, which is used to measure the level of integration of the digital and real industries; and β_1 and β_2 are the weights of the digital economy system and the real economy system, and the sum of the two is one.

3.2.4 Control Variables.

In order to minimize the impact of external factors on the empirical estimate results, we account for the following variables that might possibly influence the expansion of the digital economy: Human capital (Hum) is quantified by the logarithmic value of the enrollment of students in general higher education institutions. Scientific and technological innovation (Exp)is determined by the ratio of investment in scientific research expenditure to regional GDP. Foreign investment (Fdi)is indicated by the actual amount of foreign investment utilized. Consumption capacity (Com) is measured by the ratio of the retail sales volume of social consumption to regional GDP.

3.3 Samples and Data Sources

The study samples include panel data from 30 provinces in China, specifically omitting Hong Kong, Macao, Taiwan, and Tibet. A grand number of 330 observations were gathered spanning the years 2012 to 2022. The objective of this research is to conduct a scientific analysis of the influence of artificial intelligence on the growth of the digital economy, focusing on the principles of data accessibility and uninterrupted flow. The study mostly use data obtained from several sources, including the China Statistical Yearbook, China Science and Technology Statistical Yearbook, China Information Yearbook, China Industrial Statistical Yearbook, China study Data Service Platform, and statistical yearbooks of different provinces. Linear interpolation is used to handle the little quantity of missing data in the research process.

4 Empirical Results and Analysis

4.1 Baseline Regression Results

The findings of the benchmark regression analyzing the impact of AI on digital economic growth are shown in Table 1. There is evidence to suggest that there is a direct relationship between AI and digital economic progress, even when other factors are taken into account. This confirms the validity of hypothesis H1. Artificial intelligence has the potential to decrease the expenses associated with obtaining and analyzing information, diminish the occurrence of information imbalance, and provide a significant boost to the growth of the digital economy. In fine, artificial intelligence relies on machine learning, deep learning, and other technical means to achieve rapid processing and analysis of massive data, giving rise to new industrial forms and business models such as intelligent manufacturing, intelligent services, intelligent logistics, etc., and providing a source of power for digital economic growth. Regarding control variables, human capital, scientific and technological innovation, foreign investment, and consumption capacity all significantly positively impact the digital economy's development.

Table 1. Impact of artificial intelligence on the development of the digital economy

variant	*Dig*	
	(1)	(2)
Aip	0.375** (2.217)	0.298*** (3.480)
Hum		0.634** (2.303)
Exp		0.572* (1.734)
Fdi		0.215*** (3.047)
Com		0.128*

		(1.809)
constant term (math.)		1.923** (2.413)
Province fixed effects	*yes*	*yes*
time fixed effect	*yes*	*yes*
sample size	330	330
R^2	0.734	0.723

Note: ***, **, and * imply that the estimated coefficients are significant at the 1%, 5%, and 10% confidence levels, respectively, and the data in () are t-values, as follows.

4.2 Robustness Tests

For the purpose of to verify the accuracy of the empirical regression results, additional robustness tests are conducted, specifically focusing on the replacement model. The use of a random effects model is employed to verify the correlation between artificial intelligence (AI) and the advancement of the digital economy. The second option is to substitute the measurement. In the research conducted by Sakhno et al. (2019)[12], principal component analysis is used to recalibrate the digital economy index. This recalibrated index is then reintegrated into the benchmark regression model to verify its accuracy. Furthermore, modify the sample capacity. To guarantee the correctness of the study findings, the regression analysis is re-run after eliminating the samples of the municipalities of Beijing, Shanghai, Tianjin, and Chongqing, since their economic development levels vary from those of other provinces. Furthermore, the variable shrinking therapy.

To mitigate the potential influence of outliers on the empirical study, a 5% shrinkage treatment is implemented on the original sample data. Subsequently, the regression analysis is repeated appropriately. The results of the robustness tests are shown in Table 2. The estimated coefficients of AI on digital economic growth remain consistent with the benchmark regression results, independent of the treatment of the study sample. This consistency confirms the precision of the empirical findings in this work.

Table 2. Robustness test results

variant	Replacement model	Replacement of the measurement methodology	Changing the sample size	Variable indentation
	(1)	(2)	(3)	(4)
Aip	0.273*** (3.283)	0.256*** (4.012)	0.243*** (3.784)	0.201*** (3.113)
constant term (math.)	0.176** (2.043)	0.157*** (3.294)	0.161*** (3.135)	0.184*** (3.181)
control variable	*yes*	*yes*	*yes*	*yes*

Province fixed effects	*yes*	*yes*	*yes*	*yes*
time fixed effect	*yes*	*yes*	*yes*	*yes*
sample size	330	330	286	330
R^2	0.734	0.784	0.802	0.831

4.3 Analysis of Intermediation Effects

Using the formula (2) from before, we conduct an empirical analysis to determine the validity of the route "artificial intelligence → digital-real industry integration → digital economy development". The results of this analysis are shown in Table 3. The regression analysis shows that the coefficient of AI on digital-real industry integration is estimated to be 0.437. This coefficient is statistically significant at the 1% confidence level, suggesting that AI plays a substantial role in promoting the growth of the digital economy via its facilitation of the integration of digital-real sectors. One possible explanation is that AI, leveraging its ability to pioneer innovation, drive transformation, and shape advantages, speeds up the emergence of new industries, models, and energy sources. It also facilitates the integration of big data with the real economy, rural revitalization, social governance, and other areas, as well as the merging of digital and physical industries. This promotes the enhancement and broadening of international collaboration in digital infrastructure, digital transformation, and cybersecurity. It involves working together to establish an inclusive, equitable, impartial, and non-discriminatory environment for development. It also encourages digital companies to expand globally and contributes to the high-quality advancement of the digital economy. To summarize, hypothesis H2 can be confirmed.

Table 3. Intermediation effect regression results

variant	*Dri*
Aip	0.437*** (4.008)
constant term (math.)	1.734** (2.384)
control variable	*yes*
Province fixed effects	*yes*
time fixed effect	*yes*
sample size	330
R^2	0.774

5 Conclusions and Recommendations

A sample of panel data was collected from 30 provinces in China, covering the years 2012 to 2022, to conduct a scientific investigation of the correlation between artificial intelligence and the growth of the digital economy. The study's findings demonstrate

that AI plays a significant role in driving the progress of the digital economy. This key conclusion remains unchanged even after undertaking a number of rigorous tests to ensure the reliability of the results, such as substituting other models, altering measuring methods, and varying the sample size. AI plays a crucial role in driving the development of the digital economy by enabling the convergence of digital and physical businesses, therefore promoting growth in the digital economy.

These results lead to the proposal of the following policy recommendations: First and foremost, the scientific execution of "AI+" projects is of utmost importance. Every region should strengthen the technological infrastructure for implementing "AI+" initiatives, actively enhance domestic computing capabilities, tackle the scarcity of computational resources during extensive model training, foster innovation in distributed computing technology, facilitate the establishment of cloud computing platforms, and advance research in security technology to invigorate and empower the development of the digital economy. Furthermore, it is crucial to prioritize the promotion of the amalgamation of digital and physical sectors. It is necessary for all regions to enhance the incorporation and utilization of new technologies, facilitate the smooth and effective exchange of information, technology, talent, capital, and materials, reduce the time and distance required for the dissemination of technology and knowledge, eliminate limitations and obstacles between different parts of the industrial chain and regions, and overall enhance the level of integration between digital and physical industries to support the internal growth of the digital economy. Furthermore, it is crucial to give priority to the arrangement of digital infrastructure. It is imperative for all regions to expedite the widespread implementation and improvement of 5G networks to guarantee fast, reliable, and secure network connectivity as an essential requirement in daily life. This will provide strong support for remote work, online education, advanced healthcare, and other sectors, while also accelerating the digitalization of various industries and creating a powerful catalyst for the development of the digital economy.

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