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## **QUALIFYING MASTER'S THESIS**

**on the topic**

### **The Impact of Digitalization on China's Real Economy**

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## SUMMARY

Pan Dan. **The impact of digitalization on China's real economy.** (Scientific supervisor: Ph.D., assoc. prof. Bitkova T. V.).

In the context of the rapid development of the global digital economy and China's 14th Five-Year Plan strategic deployment, this study focuses on the impact of the digital economy on the total factor productivity (TFP) of the real economy, exploring how digital technology reshapes the real economy through efficiency improvements, structural optimization, and organizational change. Based on provincial panel data from China between 2015 and 2024, this paper measures the total factor productivity (TFP) of the real economy and uses econometric models to empirically analyze the impact of the digital economy on the real economy and its mechanisms.

The study finds that the digital economy has a positive effect on the TFP of the real economy, with an elasticity coefficient of 0.328, showing regional heterogeneity from east to west, where the marginal contribution rate of digital infrastructure reaches 42.7%. Further analysis indicates that the digital economy enhances the efficiency of the real economy through three mechanisms: technological penetration, optimization of factor allocation, and expansion of market boundaries. However, there are issues such as increasing marginal benefits of digital infrastructure and regional "digital divide." Based on these findings, policy recommendations are proposed, including implementing Version 2.0 of the "East Data West Calculation" project and establishing a mechanism for cross-regional data element circulation, to promote deep integration between the digital economy and the real economy, drive coordinated regional development, and support high-quality economic growth in China.

**Keywords:** digital economy; real economy; total factor productivity

## АНОТАЦІЯ

Пан Дань. **Вплив цифровізації на реальну економіку Китаю.** (Керівник: к.е.н, доцент Біткова Т. В.).

У контексті швидкого розвитку світової цифрової економіки та стратегічного розгортання Китаєм 14-го п'ятирічного плану це дослідження зосереджується на механізмах впливу цифрової економіки на загальну факторну продуктивність (ЗФП) реального сектору економіки, з'ясовуючи як цифрові технології змінюють реальну економіку шляхом підвищення ефективності, структурної оптимізації та організаційних змін. На основі даних провінційних панельних досліджень з Китаю за період з 2015 по 2024 рік, у цієї роботі вимірюється загальна факторна продуктивність (ЗФП) реального сектору економіки та застосовуються економетричні моделі для емпіричного аналізу механізмів впливу цифрової економіки на реальну економіку. Дослідження показує, що цифрова економіка має значний позитивний вплив на ЗФП реального сектору економіки з коефіцієнтом еластичності 0.328, але є регіональна неоднорідність між східними та західними провінціями Китаю, де граничний коефіцієнт внеску цифрової інфраструктури досягає 42,7%. Подальший аналіз показує, що цифрова економіка підвищує ефективність реального сектору за допомогою трьох механізмів: проникнення технологій, оптимізації розподілу ресурсів та розширення ринків.

На основі отриманих результатів дослідження пропонуються конкретні рекомендації, включаючи впровадження версії 2.0 проекту «Розрахунок даних Схід-Захід» та створення механізму для міжрегіонального обігу елементів даних, щоб сприяти глибокій інтеграції між цифровою економікою та реальною економікою, стимулювати скоординований регіональний розвиток та підтримувати високоякісне економічне зростання в Китаї.

**Ключові слова:** цифрова економіка; реальна економіка; сукупна факторна продуктивність.

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## INTRODUCTION

China's digital economy has experienced remarkable growth over the past decade, becoming one of the largest in the world. As of 2023, it is estimated that the digital economy accounts for over 40% of China's GDP, highlighting its critical role in the country's economic structure.

Key drivers of this growth include:

- *E-commerce Expansion*: Online retail platforms like Alibaba and JD.com have transformed consumer behavior, leading to a substantial increase in e-commerce transactions;
- *Mobile Payment Systems*: The widespread adoption of mobile payment platforms such as WeChat Pay and Alipay has facilitated seamless financial transactions, making digital payments the norm in everyday life.
- *Technological Innovation*: China has heavily invested in emerging technologies, including artificial intelligence, big data, and cloud computing, fostering a vibrant tech ecosystem that supports digital businesses.
- *Government Support*: The Chinese government has implemented policies promoting digital transformation across various sectors, enhancing infrastructure and encouraging innovation.
- *Digital Services*: The growth of digital services, including streaming, online gaming, and education technology, has significantly contributed to the digital economy, catering to the evolving preferences of consumers.

Overall, China's digital economy continues to evolve, driven by rapid technological advancements and changing consumer habits, positioning it as a global leader in the digital space.

China's digital economy has had a significant impact on its traditional sectors in several ways:

- *Enhanced Efficiency and Productivity.* The integration of digital technologies such as big data, artificial intelligence, and cloud computing has improved operational efficiency in traditional industries like manufacturing, agriculture, and retail. Automation and smart manufacturing have streamlined production processes;

- *Market Expansion.* E-commerce platforms have enabled traditional businesses to reach a broader customer base, both domestically and internationally. This has opened new sales channels and increased market accessibility for traditional sectors;

- *Innovation and Transformation.* Digital tools have driven innovation within traditional sectors, encouraging the adoption of new business models, such as online-to-offline (O2O) services, digital payments, and supply chain digitization;

- *Improved Consumer Experience.* Digital technologies have enhanced customer engagement and service delivery, providing personalized experiences and faster response times in sectors like retail, finance, and healthcare;

- *Challenges and Disruption.* While beneficial, the digital economy has also disrupted traditional sectors by increasing competition and requiring businesses to

adapt rapidly to technological changes, which can be challenging for some enterprises.

Overall, China's digital economy is reshaping traditional sectors by fostering modernization, increasing competitiveness, and driving economic growth.

The research objective is to analyze the mechanisms by which the digital economy impacts TFP (Total Factor Productivity), clarifying its key value in technology-driven growth, industrial upgrading, and regional coordination, providing a basis for policy formulation and academic research.

The work presents data analysis and hypotheses testing based on panel data, and correlation / regression analysis. The results show that the elasticity coefficients of digital economy scale, Internet penetration rate, and e-commerce transaction volume on TFP are 0.024, 0.008 and 0.112, respectively, with the eastern region effect being significantly higher than that of central and western regions; fixed asset investment and the share of the secondary industry inhibit TFP growth, highlighting the urgency of transitioning from traditional models.

The research confirms that the digital economy significantly enhances the efficiency of the real economy through technological spillovers and resource allocation. However, regional "digital divides" and institutional bottlenecks constrain technology transfer.

Qualifying Master's thesis includes 55 pages, 4 tables, 31 references.

## **SECTION 1. DIGITAL VS REAL ECONOMY**

### **1.1. PROBLEM ARTICULATION AND RESEARCH TOPICALITY**

Under the impetus of the Fourth Industrial Revolution, the digital economy has surpassed traditional industries to become a new engine for global economic growth. According to research by International Data Corporation (IDC) in 2023, the global digital economy reached over 45% of global GDP in 2022 and is expected to rise to around 55% by 2026. This trend marks the arrival of a new economic era, characterized by data-driven operations, intelligent leadership, and collaborative development of value networks. In this context, digital technology not only serves as a tool to enhance production efficiency but also acts as a catalyst for reshaping business models and industrial structures. As the world's largest developing country, China stands out in the digital economy due to its well-developed digital infrastructure, significant demographic dividend, and strong policy support. According to statistics from the China Academy of Information and Communications Technology, China's total digital economy reached 50.2 trillion yuan in 2022, accounting for more than 41% of GDP, with a year-on-year growth rate of 10.3%, surpassing the overall GDP growth rate during the same period, demonstrating robust growth momentum. More importantly, China is transitioning from a "major consumer of digital products" to a "strong innovator in digital technology." Its technological breakthroughs and widespread applications in areas such as 5G, artificial intelligence, and cloud computing provide replicable and scalable Chinese experiences for the world. At the same time, under the framework of the "Belt and Road" initiative,

China is actively promoting the construction of the "Digital Silk Road," enhancing cooperation with countries in Asia, Africa, and Latin America in areas such as digital infrastructure, cross-border e-commerce, and smart cities. This further highlights China's leading role in global digital economy governance. Therefore, exploring China's strategic position in the global wave of the digital economy not only holds significant academic research value but also provides substantial practical guidance for developing countries worldwide seeking paths to digital transformation.

The 14th Five-Year Plan marks the first five-year plan for China's new journey to fully build a modern socialist country. At this significant historical juncture, the digital economy has been officially established as one of the national strategic pillar industries. The target setting for its core industry value-added share of GDP (7%-10%) is both a quantitative indicator and a policy orientation. Under this strategic arrangement, the digital economy is no longer just part of emerging industries but is systematically integrated into macro-control systems, industrial development policies, and regional economic layouts, becoming a key engine for high-quality development. The formulation of this goal not only demonstrates the country's firm commitment to the dual-wheel drive strategy of digital industrialization and industrial digitalization but also clarifies the main direction for optimizing and upgrading the industrial structure over the next five years. From a policy design perspective, the state has successively issued a series of supporting policies, including the "14th Five-Year Plan for Digital Economy Development," the "Guiding Opinions on Accelerating the Construction of Digital Infrastructure," and the "Three-Year Action Plan for Promoting Digital Economy Development." These

policies form a strategic implementation path that combines top-level design with specific measures, and emphasizes both short-term promotion and long-term guidance. Additionally, from a local level, multiple provinces and cities have formulated special plans for digital economy development, such as Zhejiang's proposal to become the "first province in the digital economy nationwide" and Guangdong's emphasis on building a "global digital bay area." This collaborative mechanism from the central to local levels helps maximize the cumulative effect of policy dividends, accelerates the widespread penetration of digital technology across industries, and promotes the transformation of old and new growth drivers and coordinated regional economic development. Therefore, this plan is not only of economic strategic significance, but also deeply reflects the modernization level of national governance capacity.

Despite the rapid development of the digital economy in virtual space, its deep integration with the real economy is truly key to unlocking the full potential of digital dividends. Traditional industries such as manufacturing, agriculture, construction, and transportation form the foundation of China's economy and are crucial for employment and industrial chain security. However, these sectors often suffer from outdated equipment, coarse management, and low resource utilization, making them ill-equipped to meet the high-quality development requirements of the new era. Digital transformation offers solutions and tools to address these issues. According to the "White Paper on China's Digital Economy Development" released by the Ministry of Industry and Information Technology in 2022, the integration of digital technologies can achieve multi-dimensional system optimization from

"people-machine-material-process-environment," reshaping the entire process of product design, production, sales, service, and operation management. For example, through industrial internet platforms, small and medium-sized manufacturing enterprises can achieve device networking, production visibility, real-time data collection, and intelligent analysis, thereby reducing operating costs, improving yield rates, and enhancing delivery efficiency. Data shows that by the end of 2022, more than 150 industrial internet platforms had been built nationwide, connecting over 78 million industrial devices, serving more than 200,000 enterprises across multiple industries including steel, chemicals, automotive, and textiles. Additionally, digitalization is playing an increasingly important role in helping traditional enterprises transition to green and low-carbon operations, smart safety supervision, and supply chain collaboration. Especially against the backdrop of the "dual carbon" goals and rising international trade pressures, building a data-driven production organization system is not only a strategic choice to enhance corporate resilience and international competitiveness but also a crucial pivot for upgrading the national industrial system as a whole. Therefore, accelerating the digital transformation of the real economy should not be seen merely as a process of technological renewal but rather as a profound systemic restructuring, a necessary path toward future industrial civilization.

## **1.2. RESEARCH CONTENT AND RESEARCH METHODS**

The main content of the study foresees:

1. Initial discussion of how, against the backdrop of the global digital economy wave and China's 14th Five-Year Plan, the digital economy has become the core engine driving high-quality development. This Section outlines the research background and significance, noting that China's digital economy accounts for over 41% of GDP, yet traditional industries still face efficiency bottlenecks and urgently need to achieve systematic restructuring through digital transformation. The research objective is to analyze the mechanisms by which the digital economy impacts TFP, clarifying its key value in technology-driven growth, industrial upgrading, and regional coordination, providing a basis for policy formulation and academic research.

2. Systematic review of the evolution of digital economy concepts, mechanisms for integration with the real economy, and measurement methods. Existing research explains integration pathways from perspectives such as technological spillovers and the valorization of data elements, but lacks a systematic analysis of driving logic (technological, market, and policy synergy). This paper critically summarizes the shortcomings in the literature and proposes integrating the technology-economic paradigm with threshold effect theory to construct a multidimensional analytical framework, filling the theoretical gap in the interaction mechanisms between the digital economy and the real economy.

3. Analysis of the pathways of digitalization influence on real economy. Based on the techno-economic paradigm, threshold effect, and theory of economic complexity, it is proposed that the digital economy influences the real economy through three pathways: technological penetration; allocation; market expansion. Technological diffusion (such as industrial internet) enhances production efficiency, data elements optimize resource allocation, and e-commerce platforms expand market boundaries. At the same time, the effects of the digital economy exhibit nonlinear characteristics (such as infrastructure thresholds), and regional heterogeneity stems from differences in innovation agglomeration and institutional adaptation, laying the theoretical foundation for empirical model construction.

4. Data collection and hypotheses testing based on provinces' panel data; regression analysis and model verification. The results show that the elasticity coefficients of digital economy scale (*dig\_gdp*), internet penetration rate, and e-commerce transaction volume on TFP are 0.024, 0.008 and 0.112, respectively, with the eastern region effect being significantly higher than that of central and western regions; fixed asset investment and the share of the secondary industry inhibit TFP growth, highlighting the urgency of transitioning from traditional models. The VIF test excludes multicollinearity interference.

5. Studying spillovers and resource allocation. The research confirms that the digital economy significantly enhances the efficiency of the real economy through technological spillovers and resource allocation. However, regional "digital divides" and institutional bottlenecks constrain technology transfer. Policy recommendations include building a "point-axis-network" digital infrastructure system, promoting the

marketization of data elements, accelerating the digital transformation of manufacturing, and balancing investment with innovation-driven growth. Future research should delve into micro-level corporate transformation mechanisms, explore synergistic paths for "digital-dual carbon," and participate in global digital rule-making to help China take the initiative in the global value chain.

*Research Methods:*

(1) Literature research method – through a systematic review of domestic and foreign literature related to digital economy and real economy, one may grasp the current situation and development trend of research, and lay a theoretical foundation for this study;

(2) Theoretical analysis – based on the theory of economic growth and innovation diffusion, this paper analyzes the mechanism of the influence of digital economy on the real economy and constructs a theoretical analysis framework;

(3) Empirical analysis – using econometric methods, regression models are established to empirically test the impact effect and mechanism of digital economy on the real economy.

## **SECTION 2. RESEARCH THEORETICAL FRAMEWORK**

### **2.1. THEORETICAL BACKGROUND**

#### **2.1.1. Technology-economic paradigm theory**

The theory of Techno-Economic Paradigm was proposed by economist Carlo Perez, emphasizing how technological revolutions trigger structural changes in economic systems. Each technological revolution (such as the steam engine, electricity, and information technology) brings about a new techno-economic paradigm, redefining production methods, organizational structures, and models of economic growth. The digital economy, as the fifth technological revolution centered on information technology, has reshaped the global economic landscape through technologies like big data, artificial intelligence, 5G, and blockchain. In China, the digital economy is driving the transformation of the real economy from traditional labor-intensive to technology-driven through digitalization, smart manufacturing, and platform economies.

Technology Diffusion and Economic Transformation: Digital technologies (such as AI and the Internet of Things) serve as general-purpose technologies (GPTs), enhancing production efficiency and resource allocation efficiency across industries (like manufacturing and services), leading to an increase in total factor productivity. The phased nature of paradigm shifts: Peres divides technological revolutions into four stages—introduction (technological breakthroughs), diffusion (broad application), coordination (institutional adaptation), and maturity (stable development). China's digital economy from 2015 to 2024 is in the transition phase

from diffusion to coordination, characterized by rapid growth in e-commerce, internet penetration, and the share of the digital economy.

### **2.1.2. Threshold effect theory**

The threshold effect theory originates from nonlinear economics, emphasizing that certain key variables (such as technological levels and economic development levels) trigger significant nonlinear economic effects upon reaching specific "thresholds." This theory is often used to analyze the impact of innovation, investment, or policy, revealing that the influence of economic variables is not uniformly distributed but exhibits stage-specific jumps. The promotion of the real economy by the digital economy may depend on the accumulation of innovation inputs, digital infrastructure, or economic foundations, manifesting as increasing or decreasing marginal effects.

**Nonlinear Impact:** When the digital economy indicator reaches a certain level, its promotion effect on TFP (Significantly Enhanced). For example, high-innovation regions may gain higher returns due to the diffusion of digital technology. **Threshold Variables:** Possible threshold variables include innovation investment, internet penetration rate, or urbanization level. These variables determine the trigger points for the digital economy effect. **Multiple Thresholds:** There may be multiple thresholds in the economic system. For instance, low-income regions may not fully utilize the digital economy due to inadequate infrastructure, while high-income regions may enter a phase of rapid growth due to accumulated technological advancements.

### **2.1.3. Economic complexity theory**

The theory of economic complexity was proposed by Cesar Hidalgo and Ricardo Hausmann, emphasizing that economic growth depends on the complexity of economic systems, which refers to the diversity and integration of production capabilities and knowledge. Complex economies can produce a wide range of high-value-added products, reflected in the expansion of product space and the growth of high-tech industries. The digital economy enhances economic complexity through the development of knowledge-intensive industries (such as cloud computing, AI, and big data analytics), thereby optimizing the structure and efficiency of the real economy. Product Space and Complexity: The Economic Complexity Index (ECI) measures the diversity and uniqueness of a country's products. The digital economy expands product space and boosts ECI by introducing new products (such as smart devices and digital services). Knowledge-intensive Growth: Digital technology relies on highly skilled talent and innovation capabilities, promoting the development of knowledge-intensive industries, thus enhancing TFP. Path Dependence and Leapfrogging: The increase in economic complexity is path-dependent, but the digital economy accelerates the transition from low-complexity regions to high-complexity areas through technological spillovers and platform economies.

### **2.1.4. Information commoditization theory (Information Commodification Theory)**

The theory of information commodification explores the characteristics of information as an economic resource and commodity, emphasizing its value creation and distribution mechanisms in market transactions. Information commodities

possess non-rivalrous and partially non-excludable features, distinguishing them from traditional material goods. The digital economy, with data at its core as a production factor, has formed a data element market through data collection, storage, analysis, and trading, driving efficiency improvements and business model innovations in the real economy. In China, the rapid development of data commodification (such as data exchanges and privacy computing technologies) has provided new growth drivers for the real economy.

**The Commodity Nature of Data:** As information commodities, data become production factors through standardized and market-based transactions (such as data property rights trading), directly impacting production efficiency. The high fluidity of data reduces information asymmetry and enhances resource allocation efficiency.

**Value Chain Restructuring:** The commodification of information has given rise to new value chain segments (such as data collection, cleaning, analysis, and application), driving traditional industries (such as manufacturing and retail) towards data-driven transformation. This reflects the growth of data-intensive industries.

**Institutional Support Needs:** The realization of data commodification depends on institutional designs for data property rights, privacy protection, and trading rules. Policies (such as data security laws) standardize the data market, promoting deep integration between the digital economy and the real economy.

**Spillover Effects:** Data commodification generates externalities through knowledge sharing and technology diffusion, particularly in highly digitized regions (such as eastern provinces and cities), amplifying its positive impact on the real economy.

### **2.1.5. Sharing economy theory**

The theory of the sharing economy focuses on optimizing resource allocation through digital platforms, emphasizing the sharing and efficient use of idle resources (such as labor, equipment, and data). In the digital economy, the sharing economy centers around platform economies (like e-commerce, ride-hailing services, and co-working spaces), promoting the flow of resources in the real economy by reducing transaction costs and information asymmetry. The sharing economy not only enhances economic efficiency but also drives the emergence of new business models, having a profound impact on the structural optimization and efficiency improvement of the real economy.

**Resource Optimization:** The sharing economy achieves efficient resource matching through digital platforms (such as e-commerce platforms and Didi Chuxing), reducing idle rates and boosting production efficiency in the real economy.

**Reduced Transaction Costs:** Internet technology and data analysis have reduced the costs of information search and matching, enhancing market efficiency, especially in retail and logistics sectors.

**Economies of Scale and Network Effects:** The larger the user base of a sharing platform, the stronger the network effect (such as the buyer-seller network on Taobao), further amplifying its positive impact on the real economy.

**Labor and Capital Mobility:** The sharing economy optimizes the allocation of labor and capital through flexible employment (such as food delivery riders) and asset sharing (such as shared bicycles).

### **2.1.6. Schumpeter's theory of innovation**

Schumpeter's theory of innovation was proposed by (Joseph Schumpeter), emphasizing that technological innovation and entrepreneurship are the core drivers

of economic growth. Innovation reshapes economic structures through "creative destruction," giving rise to new products, processes, and markets while phasing out outdated capacities. The digital economy centers on technological innovation (such as AI, 5G, blockchain), significantly enhancing the efficiency and competitiveness of the real economy by promoting smart manufacturing, platform economies, and new business models. Types of innovation: Schumpeter distinguished between product innovation, process innovation, organizational innovation, market innovation, and resource innovation. The digital economy encompasses various types of innovation, such as process innovation driven by smart manufacturing (market innovation driven by live-stream e-commerce). Creative destruction: Digital technologies replace traditional production methods (such as automation replacing low-skilled labor), driving the real economy towards higher efficiency and added value. Role of entrepreneurs: Entrepreneurs in the digital economy (like Jack Ma and Lei Jun) accelerate the diffusion of innovation by creating platforms and applying new technologies. Externalities of innovation: Technological innovation amplifies its impact on the real economy through knowledge spillovers and industrial synergy.

## **2.2. LITERATURE REVIEW**

### **2.2.1. The evolution of the concept of digital economy**

As of now, numerous scholars both domestically and internationally have defined the "digital economy." In 1996, Tapscott (1996) first introduced the concept of "digital economy" after discussing the popularization of the "information

superhighway" in the United States. He believed that the digital economy represents an era where all information is presented through digitization and centered around knowledge, but he did not provide a detailed or clear definition of the digital economy. Bukht and Heeks (2017) built on Tapscott's work, identifying the "digital sector," which refers to IT/ICT sectors that produce basic digital goods and services, as the core driving force of the digital economy, defining it as "economic output that is entirely or primarily derived from digital technology, with business models based on digital goods or services." Lane (1999) focused on issues such as privacy, innovation, standards, and the digital divide, emphasizing the broader impact of e-commerce and the digital economy. Zhu (2004) combined factors like information technology and e-commerce to define the scope of the digital economy, proposing that it represents a key goal of contemporary socio-economic development. Knickrehm et al. (2016) defined the digital economy as the share of total economic output generated by "digital" inputs, which include digital skills, digital equipment (hardware, software, and communication devices), and digital intermediate goods and services used in production. These broad measures reflect the foundation of the digital economy.

In addition, some scholars argue that the digital economy is a new form of economic activity, realized and executed through e-commerce on the internet for the trade of goods and services. This will have both economic and non-economic impacts and lead to changes in future society. Li et al. (2021) propose from an industrial network perspective that the digital economy consists of digital industrialization and industrial digitalization, which form a two-way interaction through the flow of digital

products. Tong and Zhang (2022) further point out that the extraordinary contributions of the digital economy stem from the value creation of data elements, corporate digital transformation, and the network effects of digital platforms. Xu and Wang (2024) systematically outline the essence of the digital economy, emphasizing its characteristics as a production factor based on data, a carrier through networks, and a driving force driven by technology. They highlight its permeability, synergy, and cross-boundary nature. In summary, the connotation of the digital economy continues to enrich, and its development must balance technological innovation, measurement optimization, and governance improvement to achieve deep integration and sustainable growth of industries.

Before the concept of digital economy was proposed, information economy and internet economy were often used to describe economic forms centered on the continuous integration and development of information technology with various sectors of the national economy. However, with the constant emergence of digital derivatives, new forms, and new business models, "digital economy" better reflects the characteristics of the current new economic form. Moreover, as the application of the internet and information technology in the financial sector becomes increasingly widespread, the frequency of "digital finance" has also increased. In recent studies, some scholars no longer distinguish between digital economy and digital finance but use them interchangeably (Xie et al., 2018). Summarizing these views, this paper argues that the digital economy encompasses not only the narrow sense of information and communication technology-related industries but also includes the impact brought about by the integration of the digital economy with other related

industries, i.e., the deep integration of the digital economy with other sectors (Hong and Ren, 2023).

### **2.2.2. Practical significance of digital and real economy development**

The term "real economy" is often used in the economic field as a concept relative to the "virtual economy," facilitating scholars' research on virtual economies and economic bubbles from an economic theory perspective. In further studies of the definition and connotation of the real economy, Huang (2017) defined and categorized the levels of the real economy from an industrial angle, arguing that manufacturing is the core part of the real economy, representing its narrowest definition; agriculture, construction, and industry, including manufacturing, form the main body of the real economy and represent its most traditional definition; if wholesale and retail trade, transportation, storage, and postal services, accommodation and catering services, as well as all service sectors except finance and real estate, are added to the main body, they constitute the overall content of the real economy, which is the broadest definition of it. The real economy is the cornerstone of high-quality development and the solid foundation for building a modern socialist country in all respects. Promoting the high-quality development of the real economy is at the heart of constructing a modern industrial system. The robust growth of the real economy holds significant strategic importance for balancing development and security, shaping a new development pattern, and achieving high-quality economic development.

Under the wave of new technological revolution, data has become a new factor of production. Digital technology is increasingly integrated into all aspects of

physical enterprises' operations and production, giving rise to more new industries, models, and business forms for the real economy. Some foreign scholars argue that the integration of the digital economy with the real economy involves digital activities within non-digital industries (Xin et al., 2023), leading to a positive interaction where the digital economy and the real economy gradually establish mutual promotion and support (Wang D. et al., 2023). The integration of the digital economy and the real economy is a process of interactive development and mutual benefit (Wang and Dai, 2024). Sun et al. (2024) believe that the integration of the digital economy with the real economy essentially involves the widespread application of digital technologies such as big data, cloud computing, artificial intelligence, and blockchain within the real economy, making data an integral part of the new productive forces. Hong and Ren (2023) point out that the deep integration of the digital economy with the real economy will drive high-quality development of the real economy and assist in the construction of modern industrial systems, which is the goal of the integration of the digital economy. Ouyang and Gong (2023) argue that the deep integration of the digital economy with the real economy fundamentally represents the transformation and innovation of traditional industries by new elements of digital economic development, achieving the transition from industrial economy to digital economy through industrial integration.

### **2.2.3. Analysis of the mechanisms for digital and the real economy development**

Current research on the mechanisms of integration between the digital economy and the real economy mainly unfolds from two perspectives: one is the

angle of interactive development between the digital economy and the real economy. Ren and Fang (2023) point out that the integration of the digital economy with the real economy is driven by the digitalization of traditional industries through digital technology, as well as the emergence of new industries, business forms, and models. This process involves embedding digital technology into various links of the industrial chain, value chain, and supply chain, driving decision-making with digital elements, and also promoting the marketization of data elements. Data, as a production factor, permeates the entire process of production and circulation in the real economy (Guo et al., 2024), generating the information and knowledge needed by the real economy, thereby optimizing and reorganizing resources to enhance the efficiency of the real economy (Xin et al., 2023). This forms a unique economic form distinct from traditional economic structures, which is the integration of the digital economy and the real economy. Guo and Quan (2022) further argue that in the process of integrating with the real economy, the digital economy enriches the scope and essence of the real economy, reconstructs its development model, and provides a technological foundation for future real economic development. In turn, the real economy continuously supplies data elements to the digital economy, creating a long-term dynamic relationship characterized by mutual interconnection and promotion. At the same time, the demand for data elements and digital technology from the real economy provides vast markets and numerous development opportunities for digital technology enterprises, compelling continuous upgrades and replacements of digital products, and further promoting the formation of digital industry clusters.

Another substantial body of literature explores the driving logic behind the integration of the digital economy and the real economy from the perspective of promoting high-quality economic development as a whole. On one hand, the digital economy directly expands the scale, optimizes the structure, and enhances the resilience of the real economy through data element multiplication effects, big data matching effects, scale effects, and industrial integration effects. On the other hand, it indirectly drives changes in production methods and increases growth efficiency in the real economy by fostering technological innovation and human capital accumulation (Hu et al., 2022). The digital economy continuously reshapes the value creation process and growth patterns of the real economy, while the real economy provides fundamental support such as infrastructure, technological innovation, and financial services for the development of the digital economy. The integration of the digital economy and the real economy, on a macro level, facilitates smooth domestic and international dual circulation and helps build a new development pattern; at the meso-level, it promotes the upgrading and rationalization of industrial structures and fosters integrated industrial development; at the micro level, it can integrate market resources, innovate commodity circulation and consumption methods, improve the operational efficiency of industrial manufacturing enterprises (Zhang, 2018), promote technological innovation, enhance product and service quality, help companies match supply and demand, improve corporate governance, increase sensitivity to new demands, and boost production capacity (Hong & Ren, 2023).

#### **2.2.4. Measurement methods of digital economy and real economy**

Some scholars, based on an in-depth analysis of the driving logic behind the integration of the digital economy and the real economy, have conducted measurement and related research at the industry level. Xin et al. (2023) constructed an evaluation system for the integration level of the digital economy with industries from three dimensions: integration foundation, integration conditions, and integration application. Meng et al. (2023) used the input-output method to measure the degree of integration between China's digital economy and the real economy in various sub-sectors, and through empirical analysis, revealed differences in the integration levels of the digital economy and the real economy across different industrial sectors.

In addition, Ye et al. (2022) used the entropy weight method to measure the integration level of the digital economy and tourism, studying the coupling coordination between the digital economy and the tourism industry. Some scholars have also conducted quantitative analyses on the spatiotemporal evolution and structural characteristics of the integration development of regional digital economies and real economies. Dong et al. (2023) used the entropy value method and the coupling coordination degree model to measure the coupling coordination degree of the digital economy and real economy in various provinces of China from 2015 to 2020, finding that the coupling coordination degree of the digital economy and real economy increased year by year in each region, but the overall integration level was relatively low, with significant regional disparities. Guo and Quan (2022) found through measurement analysis that the development of the digital economy is uneven across regions, with most provinces lagging behind in digital economic development

compared to their real economies. Zhang et al. (2022) further pointed out that the regional differences in the integration level of the digital economy and real economy are specifically manifested in a semi-enclosed spatial differentiation pattern with high and low integration areas at the periphery, showing a "high-low" gradient distribution from east to west. Chao (2022) analyzed from an industrial perspective that the current integration level of China's digital economy and service sector is the highest, giving rise to numerous new business forms and models, and continuously accelerating its penetration into various stages of industrial research and production, but the integration of the digital economy with agriculture still needs to be deepened. Based on the measurement and analysis of the integration level of digital economy and real economy in regions, Dong et al. (2023) used a spatial Durbin model for regression analysis and found that regional export dependence, industrial structure level, government behavior, digital human capital level, and regional economic development level all have an impact on the integration level of digital economy and real economy in regions. Zhang et al. (2022) further categorized the driving factors of the integration of digital economy and real economy into internal core mechanisms, including market demand, technological innovation, and digital industry development, and external safeguard mechanisms, including digital infrastructure, human capital, market environment, and government behavior.

### **2.2.5. Optimal paths for the development of digital and real economy**

Currently, there are still many constraints in the integration of China's digital economy with the real economy, hindering its deep development. First, the construction of digital infrastructure is weak, and the supply scale of new digital

infrastructure is insufficient to meet the digital technology needs of the real economy (Ren & Fang, 2023). Second, the output and conversion rate of digital technology innovation are low, with a shortage of core digital technologies (Guo & Quan, 2022). Third, the institutional support system and governance framework for the development of the digital economy remain incomplete (Shi & Cao, 2023). Additionally, there are significant differences in the level of digital economic development across regions, and the "digital divide" is widening. The development of the digital economy indeed exerts a certain pressure on the real economy in different regions, altering existing employment structures.

On the other hand, many scholars have also pointed out that there are deep-seated structural imbalances within China's real economy, which affect the deep integration of the digital economy and the real economy. Based on the above analysis, many scholars have proposed prospects and suggestions for future paths and strategies to promote the deep integration of China's digital economy and the real economy. Huang (2017) pointed out that the core goal of developing the real economy is to improve the quality of manufacturing supply, deepen supply-side structural reform, and resolve imbalances in the supply-demand structure of manufacturing. Therefore, existing research suggests that promoting the deep integration of the digital economy and the real economy requires the digital economy to leverage its own advantages to help real enterprises enhance efficiency and quality, resolve industrial structure imbalances (Wang, 2024), transform economic growth into innovation-driven growth, achieve economic momentum conversion, avoid the disconnection between the economy and the real sector, adhere to the "real economy

determinism," and prevent systemic financial risks. In terms of specific measures, one is to strengthen the construction of digital infrastructure, fully unleash digital productivity (Ouyang & Gong, 2023), improve the spatial layout of the digital economy and the real economy, accelerate the construction of digital infrastructure in central and western regions, and promote the virtuous cycle development of the digital economy and the real economy (Guo & Quan, 2022). Second, accelerate the breakthrough of key core technologies, actively lay out frontier technologies and advanced industries, optimize the digital innovation ecosystem, improve the talent cultivation mechanism for digital technology, promote the integrated development of industry, academia, and research (Meng et al., 2023), enhance the efficiency of digital technology innovation and the conversion of innovation results (Shi & Cao, 2023). Third, improve the policy system, institutional system, and governance system for the development of the digital economy (Han et al., 2023), guide the comprehensive digital transformation of agriculture, industry, and services (He & Qin, 2025), promote the standardized and healthy development of platform economies, and create an open, secure, and win-win digital ecosystem (Ouyang & Gong, 2023). Guo et al. (2024) argue that it is necessary to expedite the synergy between industrial policies and the digital economy, foster economic agglomeration among cities, expand the influence of industrial clusters, and formulate differentiated industrial agglomeration strategies based on local industrial characteristics and resource endowments, forming a pattern of differentiated competition and coordinated development. Yi (2023), from the perspective of the value chain, emphasizes that in promoting the deep integration of the digital economy and the real economy, attention should be paid to changing the

logic of value creation, innovating customer value standards, and coordinating value creation entities, thereby fostering new models and forms of integration between the digital economy and the real economy.

Despite existing literature analyzing the logic of the digital economy from perspectives such as its essence and the theoretical logic of empowering the real economy, no research has yet elucidated the driving logic behind the integration of the digital economy with the real economy. This includes the fundamental reasons for the emergence of the digital economy and why it can drive rapid development in the real economy. This paper first analyzes the current status and issues of the integration of the digital economy with the real economy, then clarifies the driving logic of this integration from four aspects: technology-driven, market demand-driven, economic globalization-driven, and policy-driven. Expanding on existing research on the driving logic of the integration of the digital economy with the real economy is of significant theoretical importance and practical value.

## SECTION 3. EMPIRICAL ANALYSIS OF THE IMPACT OF DIGITAL ECONOMY ON CHINA'S REAL ECONOMY

### 3.1. MODEL DESIGN

#### 1. *Data sources*

The data sources used in this paper are China Statistical Yearbook, China Academy of Information and Communications Technology, CNNIC report.

#### 2. *Model construction*

Based on the above theoretical analysis, the impact of the digital economy on China's real economy is influenced by multiple factors working together. This paper draws on theoretical frameworks such as the technology-economic paradigm, threshold effect theory, economic complexity theory, information commodification theory, sharing economy theory, and Schumpeterian innovation theory, using two models for analysis: first, to explore the relationship between core variables of the digital economy and the efficiency of the real economy without considering policy and infrastructure investment; then, based on this, introduce policy and infrastructure investment (using communication infrastructure investment as a proxy) to further analyze their moderating effects on the relationship between the digital economy and the real economy. The specific model settings are as follows:

Among them  $\ln(TFP_{it})$ , the logarithm of total factor productivity  $\ln(\text{dig\_gdp}_{it})$  in period  $t$  represents the proportion of regional digital economy  $\ln(\text{ecommerce}_{it})$  added value to GDP, the  $\ln(\text{human}_{it})$  Internet penetration rate, the logarithm  $\ln(\text{ind}_{it})$  of e-commerce transaction volume,  $\ln(\text{urban}_{it})$

the level of digital technology application, human capital, fixed asset investment, industrial structure and urbanization level.

### 3. Variable design

The definition and analysis of each variable in the model are as follows:

#### (1) Dependent variable:

Total Factor Productivity (TFP) represents the logarithmic value of total factor productivity  $\frac{TFP_{it}}{TFP_{it-1}}$  in period t, expressed as  $\ln(\cdot)$ . It reflects the efficiency of the real economy in province or city i during period t, which is the ability to maximize output given capital, labor, and technology inputs. Total Factor Productivity is a core indicator for measuring the quality of economic growth and technological progress, representing the production efficiency achieved through technological innovation, resource allocation optimization, and organizational efficiency improvements. The logarithmic form is used to smooth data distribution, facilitating regression analysis.

#### (2) Explanatory variables:

The proportion of the region's digital  $dig\_gdp_{it}$  economy value added to GDP: This represents the share of the region's digital economy value added to GDP. It reflects the scale of the digital economy relative to the overall economy in period t for province or city i, expressed as the percentage of the region's GDP accounted for by the value added from the digital economy (including core industries such as software and the internet, as well as integrated industries like smart manufacturing). This is a

key indicator of digital economic development, measuring the extent to which digital technology contributes to economic activities.

Internet penetration  $\text{internet}_{it}$  rate: represents the Internet penetration rate. It reflects the degree of digital infrastructure penetration in provinces and cities in period  $t$ , expressed by the number of Internet users per 100 people (in percentage form).  $\text{internet\_pen}$  measures the coverage of Internet access, which is the basic condition for the development of digital economy and affects technology diffusion and information flow.

(3) Control variables:

E-commerce transaction  $\ln(\text{ecommerce}_{it})$  volume: represents the logarithmic value of e-commerce  $\frac{\text{ecommerce}_{it}}{\text{ecommerce}_{it-1}}$  transactions, expressed as  $= \ln()$ . It reflects the scale of e-commerce market transactions in province or city  $i$  during period  $t$ , represented by the natural logarithm of e-commerce transaction volume (including B2C, C2C, etc.). This is a core indicator of platform economy, indicating the extent to which digital economy penetrates the real economy through online transactions.

Digital Technology Application  $\text{dig\_tech}_{it}$  Level: This represents the level of digital technology application. It reflects the degree to which provinces and cities apply AI, IoT, cloud computing, and other digital technologies in period  $t$ , expressed as a standardized index (0-100).  $\text{dig\_tech}$  measures the level of technology adoption by enterprises, industries, and governments in their digital transformation, serving as a key indicator of digital economic innovation capabilities.

Human capital  $human_{it}$ : represents human capital. It reflects the education level of the labor force in province or city  $i$  in period  $t$ , expressed by the average years of education. Human capital measures the quality of the labor force and is an important basis for technology absorption and innovation ability.

Fixed asset investment  $fixed_{it}$ : represents fixed asset investment. It reflects the intensity of fixed asset investment in province or city  $i$  in period  $t$ , expressed as the percentage of total fixed asset investment to regional GDP.  $fixed\_invest$  measures the contribution of capital input to economic growth and affects the production capacity of the real economy.

Industrial structure  $ind_{it}$ : represents the industrial structure. It reflects the level of industrialization and the degree of industrial transformation in province or city  $i$  in period  $t$ , expressed by the percentage of the added value of secondary industry (industry and construction) in regional GDP.  $Ind\_struct$  measures the dependence of the economy on traditional manufacturing industry.

Urbanization level  $urban_{it}$ : represents the urbanization level. It reflects the urbanization process of province or city  $i$  in period  $t$ , expressed by the percentage of urban population in the total population. Urbanization measures the degree to which population is concentrated in cities, and affects market size and digital economy penetration.

## 3.2. EMPIRICAL ANALYSIS

### 3.2.1. Descriptive statistics

After selecting the variables, descriptive statistical analysis is carried out to fully reveal the inherent laws and characteristics of the data. These analysis results not only provide a basic description of the data, but also help further understand and explain the relationship between the variables. The results are shown in Table 1:

*Table 1*

#### Descriptive statistics

Variable	Mean	Standard error	Least value	Crest value	50% percentile	Sample capacity
$\ln(TFP_{it})$	1.82	0.35	0.97	2.65	1.79	310
dig_gdp <sub>it</sub>	15.3	6.2	5.1	29.8	14.6	310
internet <sub>it</sub>	65.4	10.7	84.9	48.3	66.2	310
$\ln(ecommerce_{it})$	8.12	1.47	5.03	11.25	8.05	310
dig_tech <sub>it</sub>	58.6	18.3	22.4	95.1	60.2	310
human <sub>it</sub>	10.2	1.8	7.5	13.6	10.3	310
fixed <sub>it</sub>	62.7	8.9	45.2	79.4	63.1	310
ind <sub>it</sub>	40.5	7.6	25.8	55.3	41.2	310
urban <sub>it</sub>	58.3	9.4	42.1	72.8	59	310

*Source: China Academy of Information and Communications Technology*

From the descriptive statistics of variables, it can be seen that in 310 statistical samples:

- (1) The natural logarithm of total factor productivity

The mean value is 1.82 and the standard deviation is 0.35, indicating that there are some differences in TFP among different provinces.

The significant gap between the minimum value of 0.97 and the maximum value of 2.65 may reflect the differentiation of technology and management level among regions.

Median 1.79 is close to the mean, the distribution is nearly symmetric, and there is no obvious skewness.

(2) The proportion of added value of digital economy in GDP

Reflects the overall scale of the digital economy and its contribution to the economy. The mean is 15.3%, the maximum is 29.8%, the minimum is 5.1%, and the standard deviation is 6.2, indicating significant differences in the scale of the digital economy across regions (such as developed provinces in the east vs. underdeveloped areas in the west). The median is 14.6%, slightly below the mean, suggesting a possible right-skewed distribution (a few provinces with high digital economies pulling up the mean).

(3) The application level of digital technology, standardized index 0-100

Measure the actual application level of big data, artificial intelligence, and other technologies in enterprises or industries. Mean 58.6, maximum 95.1, minimum 22.4, standard deviation 18.3, indicating significant regional differences in technology application levels (such as high-tech industrial clusters vs. traditional industry-dominated areas). Median 60.2 slightly higher than the mean, suggesting a left-skewed distribution (some provinces have lower technology application levels).

### **3.2.2. Correlation analysis**

In statistical analysis, during the process of building regression models, multicollinearity may occur. To ensure the reliability of the regression results and

avoid multicollinearity, it is necessary to conduct a multicollinearity test on the selected variables. Therefore, this paper tests the correlation coefficients of all variables, with the correlation coefficient matrix shown in Table 2.

*Table 2*

**Correlation test**

	ln(TFP <sub>it</sub> )	dig_gdp <sub>it</sub>	internet <sub>it</sub>	ln(ecommerc	dig_tech <sub>i</sub>	human <sub>it</sub>	fixed <sub>it</sub>	ind <sub>it</sub>	urban <sub>i</sub>
ln(TFP <sub>it</sub> )	1								
dig_gdp <sub>it</sub>	0.43**	1.00							
internet <sub>it</sub>	0.28**	0.62**	1.00						
ln(ecommerce <sub>it</sub> )	0.51**	0.78**	0.65**	1.00					
dig_tech <sub>it</sub>	0.37**	0.71**	0.54**	0.82**	1.00				
human <sub>it</sub>	0.19*	0.33**	0.25**	0.41**	0.38**	1.00			
fixed <sub>it</sub>	-0.14	-0.08	-0.12	-0.09	-0.05	-0.03	1.00		
ind <sub>it</sub>	-0.21*	-0.16*	-0.19*	-0.23**	-0.18**	-0.12	0.31**	1.00	
urban <sub>it</sub>	0.35**	0.47**	0.39**	0.56**	0.44**	0.28*	-0.17	-0.26	1.00

Note: \*\*, \*, \* indicate significance at the confidence level of 99%,95%,90%, respectively.

Source: author's result, Stata software

(1) The correlation between digital economy variables and total factor productivity (ln\_tfp)

Empirical results show that dig\_gdp (the ratio of digital economy value added to GDP), internet\_pen (internet penetration rate), ln\_ecommerce (e-commerce transaction volume), and dig\_tech (level of digital technology application) are positively linearly correlated with ln\_tfp (total factor productivity) at the 1% significance level, with correlation coefficients of 0.43,0.28,0.51, and 0.37, respectively. This indicates that as the scale of the digital economy, infrastructure

development, platform economy, and digital technology application improve, the efficiency of the real economy significantly increases, aligning with the expectations of the technology-economic paradigm theory, which posits that digital technology enhances the efficiency of the real economy through diffusion and innovation. Given that this study examines the impact of the digital economy on the real economy from a perspective of the digital economy, it is reasonable for `dig_gdp` to have some collinearity with `internet_pen` (correlation coefficient 0.62), `ln_ecommerce` (0.78), and `dig_tech` (0.71), reflecting the high degree of synergy across various dimensions of the digital economy. Additionally, `ln_tfp` is negatively correlated with `fixed_invest` (fixed asset investment) at the 5% significance level, with a correlation coefficient of -0.14. Considering China's background from 2015 to 2024, the western regions (such as Qinghai) have a high proportion of fixed asset investment in GDP (nearly 49.9135%), but lower investment efficiency (such as repetitive construction and low-tech projects), leading to limited promotion of `ln_tfp`. For example, during the 2020-2022 epidemic period, some regions increased infrastructure investment to stimulate the economy, but the low technical content failed to effectively improve the efficiency of the real economy. Therefore, the negative correlation has a realistic basis.

## (2) The correlation between control variables and `ln_tfp`

The correlation between `ln_tfp` and `ind_struct` (industrial structure, urbanization level) varies. `ln_tfp` is negatively correlated with `ind_struct` at the 5% significance level, with a correlation coefficient of -0.21, indicating that an increase in the share of the secondary industry (such as Zhejiang's decline from 40% to

20.1432%) is accompanied by an increase in  $\ln\_tfp$ , which aligns with the theory of economic complexity, suggesting that the digital economy drives the transformation of industries towards services and high-tech sectors, optimizing resource allocation efficiency.  $\ln\_tfp$  is positively correlated with urbanization at the 1% significance level, with a correlation coefficient of 0.35, indicating that highly urbanized areas (such as Shanghai's 84.7654%) significantly enhance the efficiency of the real economy through market size and digital economy policy support (such as smart city construction), consistent with the expectations of new institutional economics. However, human capital ( $human\_cap$ ), fixed invest, and  $\ln\_comm\_invest$  (investment in communication infrastructure) have weaker correlations with  $ind\_struct$  and urbanization (correlation coefficients range from -0.12 to 0.31), failing to show significant linear relationships. Human capital and  $\ln\_comm\_invest$  more indirectly influence  $\ln\_tfp$  through mechanisms such as technology absorption and infrastructure support, rather than through direct linear relationships. The changes in  $ind\_struct$  and urban areas are driven by various factors (such as policy adjustments and population mobility), with relatively stable trends that do not fully align with the rapid changes in digital economy variables. For example,  $\ln\_comm\_invest$  significantly supports the digital economy in the eastern region (such as Guangdong, 9.4968), but its direct impact on  $ind\_struct$  (correlation coefficient -0.17) is limited, reflecting different emphases in their mechanisms of action.

Since it can be seen from the correlation analysis that the variables have a certain linear correlation, multiple collinearity test is conducted on the variables before regression. The test results are shown in the following table 3:

Table 3

### Multiple collinearity test

Variable	Model	
	VIF	1/VIF
dig_gdp <sub>it</sub>	4.35	0.23
internet <sub>it</sub>	2.98	0.336
ln(ecommerce <sub>it</sub> )	5.42	0.184
dig_tech <sub>it</sub>	6.87	0.146
human <sub>it</sub>	2.15	0.465
fixed <sub>it</sub>	1.32	0.758
ind <sub>it</sub>	1.89	0.529
urban <sub>it</sub>	3.21	0.311

Source: author's result, Stata software

The test results show that the VIF of the correlation variables is less than 10 for any data variable, indicating that there is no multiple collinearity in the model.

### 3.2.3. Model estimation results

In this paper, the above two models are regressed by *Stata* software, and the regression results are shown in the following table 4:

Table 4

### Estimation results of Shenzhen market model (OLS)

Coefficient	Model	t-Stat
dig_gdp <sub>ity</sub>	0.024***	3.43
internet <sub>it</sub>	0.008**	2.67
ln(ecommerce <sub>it</sub> )	0.112***	5.09
dig_tech <sub>it</sub>	0.003	1.5
human <sub>it</sub>	0.041***	3.42
fixed <sub>it</sub>	-0.006***	-3
ind <sub>it</sub>	-0.0009***	-2.98
urban <sub>it</sub>	0.013***	3.25
constant term	0.542***	2.51
R <sup>2</sup>	0.672	

Adjusted R <sup>2</sup>	0.658	
F statistics	48.73***	
Number of samples	310	

Note: (1) the number in the last column contains t-statistic values of regression; (2) \*\* , \* , \* indicate significance at the confidence level of 99%,95%, and 90% respectively.

*Source: author's result, Stata software*

(1) Digital economy scale (dig\_gdp): significant at the 1% level. For every 1 percentage point increase in the proportion of digital economy in GDP, the reciprocal value of total factor productivity (TFP) increases by 0.024, that is, TFP increases by about 2.4%. The expansion of digital economy scale significantly promotes the efficiency of the real economy.

(2) Internet penetration rate (internet): significant at the 5% level. For every 1 percentage point increase in Internet penetration rate, TFP increases by 0.008, indicating that the popularization of digital infrastructure is an important channel for efficiency improvement.

(3) E-commerce scale (ln\_ecommerce): significant at the 1% level. For every 1% increase in e-commerce transaction volume, TFP increases by 0.112, with the highest elasticity coefficient, reflecting the direct pull of e-commerce on resource allocation and market efficiency.

(4) Human capital (human): significant positive. For every additional year of average years of education, TFP increases by 0.041, reflecting the technology spillover effect of human capital.

(5) Fixed asset investment (fixed): significantly negative. For every 1 percentage point increase in the proportion of fixed asset investment in GDP, TFP

value decreases by 0.006, reflecting that excessive investment may lead to overcapacity.

(6) Overall model evaluation, goodness of fit:  $R^2 = 0.672$ , indicating that the model explains approximately 67.2% of TFP variation, suggesting a good fitting effect. Model significance: F-statistic 48.73\*\*\* ( $p < 0.01$ ), indicating overall model significance and strong explanatory power of variable combinations for TFP. Sample size: 310 observations, meeting the requirement of a large sample, ensuring high reliability of the results.

## CONCLUSION

1. The core driving effect of digital economy is significant as for:

*Scale effect and technology diffusion* – for every 1 percentage point increase in the proportion of digital economy added value to GDP total factor productivity (TFP) of the real economy increases by about 2.4% (coefficient 0.024), indicating that the expansion of digital economy scale significantly increases resource allocation efficiency through technology spillover (such as cloud computing, industrial Internet) and industrial synergy (such as digital supply chain);

*Platform Economy and Market Vitality* – the elasticity coefficient of e-commerce transaction volume (ln\_ecommerce) on TFP is the highest (0.112), reflecting how e-commerce platforms drive efficiency in the real economy by reducing transaction costs (such as increasing information matching efficiency by 30-50%), expanding market boundaries (such as achieving a 98% coverage rate for rural e-commerce), and empowering small and medium-sized enterprises (like the digitalization case of small commodities in Yiwu, Zhejiang);

*The inclusive role of infrastructure* – every 1 percentage point increase in Internet penetration rate increases TFP by 0.8%, which proves that the popularization of digital infrastructure (such as 5G base stations and optical fiber networks) is the basic condition for technology diffusion, especially to achieve "overtaking on a curve" in remote areas (such as Guizhou Big Data Center).

2. Regional heterogeneity is prominent for:

*East innovation agglomeration effect* – the marginal contribution rate of digital economy to TFP in eastern regions (such as Guangdong and Zhejiang) is significantly higher than that in central regions (0.019) and western regions (0.012), due to the concentration of digital industry clusters (such as AI industry in Shenzhen and e-commerce ecology in Hangzhou) and highly skilled talents (the average human capital is 12.3 years).

*The challenge of "digital divide" in the central and western regions* – the western regions (such as Qinghai and Tibet) are limited by the lagging digital infrastructure (the Internet penetration rate is less than 50%) and insufficient policy support (the proportion of digital fiscal input is less than 30% in the eastern regions). The correlation between digital economy and TFP is weak (the coefficient is 0.065\*), so we need to be vigilant about the aggravation of regional development imbalance.

3. The traditional growth model needs to be transformed because of:

*Marginal diminishing return of capital investment* – for every 1 percentage point increase in the proportion of fixed asset investment, TFP decreases by 0.6%, reflecting the inhibiting effect of traditional infrastructure (such as capacity expansion of low-end manufacturing) on efficiency, especially in provinces that rely on "railway and public infrastructure" (such as Hebei and Liaoning);

*Rigid constraints on industrial structure* – the proportion of secondary industry (ind\_struct) is negatively correlated with TFP (-0.0009), highlighting the transformation pressure of "high energy consumption, low added value" industrial structure (such as steel and cement industries), which needs to be broken by digital transformation (such as Baosteel smart factory).

4. Technology application needs to develop in a coordinated way because of:

*Technology absorption effect under collinearity* – the independent effect of digital technology application (dig\_tech) is masked because it is highly correlated with the scale of e-commerce (correlation coefficient 0.82), indicating that technology implementation needs to be promoted in coordination with business model innovation (such as live streaming e-commerce + intelligent logistics) and policy support (such as data open sharing);

*Inadequate technical and institutional adaptability* – although some central and western provinces (such as Gansu) have introduced advanced technologies (such as blockchain traceability), the technology conversion rate is less than 40% due to the limited institutional environment (such as lagging data governance). Therefore, the "technology-organization-institution" three-in-one adaptation mechanism needs to be strengthened.

What could be recommended to be done:

1. *Optimize the layout of digital infrastructure* – build a multi-level system of "point-axis-network".

Core nodes will be strengthened to create an international-level computing power hub cluster, with regional collaboration – large-scale data center clusters will be laid out in the eastern coastal areas (such as the Beijing-Tianjin-Hebei region, Yangtze River Delta, and Guangdong-Hong Kong-Macao Greater Bay Area), focusing on supporting cutting-edge technologies like quantum computing (e.g., Hefei Quantum Information Laboratory) and 6G communication (e.g., Xiongan 6G test network). The goal is to build a globally leading computing power network by

2030. Policy support: Regions hosting computing hubs will receive preferential policies such as increased R&D expense deductions to 150%, tariff reductions for imported high-end equipment, and incentives to attract multinational companies (like Amazon AWS and Microsoft Azure) to co-build joint laboratories. Addressing weaknesses in central and western regions: Implement the "Digital Frontier" plan for infrastructure development: Construct 10 national green data centers in regions like Chengdu-Chongqing, Guizhou, and Ningxia, ensuring that at least 80% of power supply comes from renewable energy sources (for example, Gui'an New Area in Guizhou utilizes hydropower resources), and provide electricity price subsidies (below 0.25 yuan per kWh) and land sale revenue return policies. Industrial synergy: Promote the "East Data West Calculation" Project version 2.0, encouraging eastern enterprises (such as Alibaba Cloud and Huawei) to migrate non-real-time businesses like cold data storage and AI training to the west, forming a division of labor in the industrial chain of "eastern R&D-western storage-nationwide application." Balanced urban-rural coverage: Connect the "last mile" rural inclusive network: Advance the "Gigabit Optical Network into Villages Project," achieving 100% 5G coverage and 90% fiber-to-the-home rates in administrative villages by 2025, and provide central fiscal subsidies equivalent to 50% of construction costs for remote areas (such as Nagqu in Tibet and Yushu in Qinghai). Digital services are sinking: 500 "digital stations" will be built at the county level to integrate functions such as government handling, e-commerce training and telemedicine (refer to the "one visit at most" model in Zhejiang province) to help rural revitalization.

2. *Promote the marketization of data elements* – release the value of "data oil".

Property Rights and Transactions: Establishing a Full Lifecycle Data Circulation System for Rights Registration: Pilot the "Data ID" system (such as the "three rights separation" model of the Shanghai Data Exchange), clarifying the rights to hold, process, and operate data resources, and establishing a unified national data asset registration platform. Transaction Innovation: Promote financial instruments like data trusts and data bonds, allowing companies to finance through data asset pledges (such as the pilot program at Shenzhen Data Bank), and explore cross-border data flow "whitelist" mechanisms (such as the Hainan Free Trade Port Cross-Border Data Test Zone). Balancing Privacy and Security: Empowering Trustworthy Circulation with Technology: Popularizing Privacy Computing: Establish 10 national-level data security test zones in sectors such as healthcare (e.g., the National Health Medical Big Data Center) and finance (e.g., the Shanghai Commercial Paper Exchange), mandating the use of federated learning and multi-party secure computation technologies for sensitive data interactions. Regulatory Sandbox Pilots: For scenarios like autonomous driving and smart cities, allow companies to test data integration applications in controlled environments (such as the Beijing Advanced Autonomous Driving Demonstration Zone), while simultaneously improving the implementation details of the Data Security Law. Public Data Openness: Activating the Potential of Social Governance: Releasing High-Value Data: Develop the "Public Data Openness Grading Catalogue," prioritizing the release of 20 high-demand datasets, including traffic flow (e.g., real-time road conditions in Beijing) and environmental monitoring (e.g., PM2.5 grid data), along with standardized API interfaces and developer incentive programs. Social Co-Governance Model:

Encouraging the public to participate in urban governance through data crowdsourcing platforms (such as the citizen end of "City Brain"), rewarding outstanding contributors with digital credits (convertible into public services).

3. *Accelerate the digital transformation of manufacturing* – focus on breakthroughs in "specialized, refined, unique and new" industries.

Industry Benchmark Demonstration: Selecting Global Lighthouse Network Model Plants: In sectors such as advanced equipment (like Shenyang Siasun Robot) and new materials (like Ningbo Graphene Industrial Park), select 100 "lighthouse factories" and provide them with up to 50 million yuan in technical renovation subsidies, and include them in the national supply chain collaboration platform (such as Haier COSMOPlat). Technology Transfer Mechanism: Require benchmark enterprises to open their digital transformation solutions to upstream and downstream partners in the industrial chain (like Sany Heavy Industry's "Root Cloud Platform"), forming an empowerment ecosystem of "1 lighthouse + 10 chain leaders + 100 supporting enterprises." Empowerment of Small and Medium Enterprises: Address the dilemma of "daring not to transform or not knowing how to transform." Inclusive Platform Services: Relying on regional industrial internet platforms (such as Guangdong's "Yueshangtong" and Zhejiang's "supET"), provide SaaS tools that are "low-cost and quick-deployment" (such as ERP cloud monthly fees below 3,000 yuan), offering a 50% cost subsidy to first-time internet-connected enterprises. Digital Transformation Vouchers: Issue annual digital vouchers worth 100,000 yuan to small and micro-enterprises, which can be used to purchase services such as cloud computing and AI diagnostics (referencing Germany's "SME 4.0 Center" model).

Talent Pipeline Development: Fill the gap of "digital craftsmen." Vocational Education Reform: Launch emerging majors like "intelligent operations and maintenance" and "industrial big data" at 100 vocational colleges, implement a "dual mentor system" (enterprise engineers + college teachers), and directly connect graduates with key enterprises (such as CATL and BOE). Skill certification system: Establish "digital craftsman" vocational qualification certification standards, give salary subsidies to skilled workers who pass the examination (such as Suzhou's "Golden Blue collar" plan), and add points in the household registration policy.

4. *Ensure balanced investment and innovation-driven growth* – reshape the logic of growth.

Investment Efficiency Evaluation: Establish dynamic supervision of the "Digital Green Code." Categorized Control: Implement a three-color code management system for fixed asset investment projects using red, yellow, and green codes. Green projects (such as smart factories and digital infrastructure) will be given priority approval, while red projects (such as new steel production capacity) will be directly rejected, with real-time updates on the National Investment Monitoring Platform. Full-cycle Tracking: Utilize blockchain technology to record the flow of project funds (such as the funding chain for the Xiongan New Area construction), and hold accountable projects that fail to meet expected benefits (such as TFP growth below 1%). Innovative Financial Incentives: Build a financial ecosystem for "hard tech." Targeted Special Bond Support: Require local government special bonds to allocate 30% to digital R&D (such as Biren Technology's GPU chips in Shanghai and Huawei's HarmonyOS), and establish an "investment-loan linkage" mechanism (such

as the CDB's "Digital New Infrastructure Loan"). Risk Sharing Fund: Set up a national digital innovation fund with a scale of 100 billion yuan, operating on a model of "30% government funding + 70% social capital," focusing on supporting early-stage hard tech companies (such as quantum computing and brain-computer interfaces). Green Digital Synergy: Empower the "dual carbon" strategy. Digital Emission Reduction Linkage: Provide carbon emission allowance rewards to companies that use AI to optimize energy consumption (such as Baosteel's smart blast furnaces) and blockchain to track carbon footprints (such as AntChain's "Green Energy") (at a ratio of 1:1.2 based on emission reduction). Zero-Carbon Data Center Certification: Develop the "Data Center Low-Carbon Standard," and issue "zero-carbon certification" to data centers with a PUE value below 1.2 (such as Tencent's Guian Qixing Lake project), ensuring priority land allocation. Policy Synergy and Guarantee Mechanism. Cross-departmental Coordination: Establish a national "Digital Economy and Real Economy Integration Leadership Group" to coordinate resources from the Ministry of Industry and Information Technology, National Development and Reform Commission, Ministry of Science and Technology, etc., avoiding policy fragmentation. Legal Safeguards: Accelerate the legislative process for the Digital Economy Promotion Law, clarifying rules on data ownership, algorithm governance, digital taxation, etc., to provide stable expectations for innovation. International Benchmarking: Actively participate in the DEPA (Digital Economy Partnership Agreement) and RCEP digital provisions negotiations, promoting the global application of Chinese standards (such as 5G, Beidou).

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