

Article

Research on Impact of Digital Economy on Real Economy Based on Perspective of Coupling and Coordination of Manufacturing and Service Industries

Fangli He ^{1,2,3}  and Hongzhen Qin ^{1,*}

¹ School of Mathematics and Computing Science, Guilin University of Electronic Technology, Guilin 541004, China; redheli@guet.edu.cn

² Center for Applied Mathematics of Guangxi (GUET), Guilin 541004, China

³ Guangxi Colleges and Universities Key Laboratory of Data Analysis and Computation, Guilin 541004, China

* Correspondence: qhongzhen@126.com

Abstract: Amid the global wave of digital transformation, advancing the sustainable growth of the real economy has emerged as a key strategic priority. Drawing on panel data from 30 provinces, municipalities, and autonomous regions in China (excluding Tibet, Hong Kong, Macao, and Taiwan) between 2013 and 2021, this study utilizes fixed effects and mediation effect models to investigate both the direct and indirect pathways through which the digital economy drives the sustainable development of the real economy. The results indicate that (1) the digital economy exerts a significant direct positive influence on the real economy, demonstrating its role in spurring growth and innovation while injecting fresh momentum into sustainable development. (2) It also indirectly facilitates the real economy's sustainability by promoting the coupling and coordination of the manufacturing and service sectors, emphasizing the importance of industrial synergy in achieving sustainable economic growth. (3) Regional analysis reveals that the digital economy's positive direct effect on the real economy is particularly evident in North China and the Southeast and Southwest regions. Furthermore, in the Southeast and Southwest, the mediation effect of industrial coupling and coordination further strengthens the sustainability of the real economy. This study offers theoretical insights into the integration of the manufacturing and service industries and provides practical guidance for advancing the United Nations' 2030 Agenda for Sustainable Development. It also highlights policy recommendations for China to build a modern industrial system and achieve high-quality economic growth.

Keywords: digital economy; real economy; industrial coupling and coordination; sustainable development; mediation effect; regional heterogeneity



Academic Editors: Suhaiza Zailani, Abderahman Rejeb and Steve Simske

Received: 4 December 2024

Revised: 4 January 2025

Accepted: 13 January 2025

Published: 17 January 2025

Citation: He, F.; Qin, H. Research on Impact of Digital Economy on Real Economy Based on Perspective of Coupling and Coordination of Manufacturing and Service Industries. *Sustainability* **2025**, *17*, 729. <https://doi.org/10.3390/su17020729>

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

As information technology continues to evolve at a breakneck pace, the digital economy has taken center stage as a vital force propelling global economic change and playing a pivotal role in China's modernization efforts. By 2022, China's digital economy ballooned to an impressive CNY 50.2 trillion, outpacing nominal GDP growth for 11 years in a row and constituting 41.5% of the nation's GDP. Remarkably, the digital economy's impact on the tertiary sector reached 44.7%, while its influence on the secondary sector was recorded at 24.0%. The diminishing disparity in growth rates between these sectors indicates a collaborative development trend fueled by the digitization of both services and industry. The report from the 20th National Congress of the Communist Party of China highlights

a dedication to grounding economic growth in the real economy and promoting new industrialization. Merging modern service industries with cutting-edge manufacturing has been pinpointed as a crucial strategy for nurturing a contemporary industrial framework and achieving high-quality economic progress [1]. These developmental objectives resonate strongly with the fundamental tenets of the United Nations' 2030 Agenda for Sustainable Development, which underscores the importance of economic sustainability, social inclusivity, and environmental stewardship.

The digital economy has emerged as a groundbreaking force, not only revolutionizing traditional economic structures but also fueling the sustainable growth of the real economy with a burst of technological advancements, optimized resource management, and bolstered social efficiency. A myriad of studies have underscored the multifaceted benefits of the digital economy on economic prosperity and societal advancement. For example, in their research, Pang and colleagues [2] showcased how the digital economy dramatically boosts production prowess by enhancing supply chain integrity and operational sharpness, propelling a high-quality economic trajectory. Chenhui and his team [3] contend that the digital economy propels high-quality growth by nurturing innovation and facilitating industrial evolution. Zhang and associates discovered that the digital economy sharpens the efficiency of eco-friendly resource distribution and elevates the green tech innovation bar, thereby enriching the quality of the real economy. Xu and his colleagues [4] emphasized that the digital economy empowers regional development by facilitating industrial reshaping and bolstering R&D innovation in the region. In a study based on Chinese data and utilizing the Difference-in-Differences (DID) approach, Guo and his group [5] examined the digital economy's influence on comprehensive urban economic growth. Their insights revealed that the digital economy fosters high-quality development through two primary channels: bolstering human capital and spurring green tech innovation. However, their work fell short of exploring how the manufacturing and service sectors synergistically enhance the overall efficiency of the real economy, driven by the digital economy's momentum. In their research, Oloyede and colleagues [6] showcased how the digital economy serves as a catalyst for businesses to not only capitalize on economies of scale and scope, as well as enhance efficiency in resource allocation, but also to initiate structural changes, foster industrial evolution, and propel upgrades. This, in turn, boosts total factor productivity, playing a pivotal role in fostering robust economic expansion. Building on this, Guo and associates [5] highlighted that the digital economy is a key facilitator of regional high-quality growth, with advancements in human capital and green tech innovation at the forefront of its transformative effects. Additionally, the digital economy's impact on the real economy varies significantly across regions. Zhao and his team [7] revealed that the digital finance sector's development is not uniform, with more prosperous regions experiencing more pronounced positive effects on the real economy, thereby propelling its growth. In China, the blend of manufacturing and service sectors, along with its effects on the tangible economy, is vastly different from one area to another, thanks to the digital economy's push. For instance, the southeastern powerhouse, Guangdong Province, has been using the "industrial internet plus smart logistics" approach to meld the home appliance manufacturing scene with modern logistics services. This has led to a major boost in supply chain performance and spurred the real economy's evolution. But, in the West, the story is quite different. *The Western Blue Book: China Western Development Report* (2023) notes that the West is falling behind in digital economic strides due to its weaker base, late starts, and slower pace. Hence, it is crucial to address these regional discrepancies when aiming to unify the economy. Tailored policy tweaking is key to maximizing the digital economy's benefits for the real economy and ensuring harmonious growth across various areas.

In the age of the digital economy, propelled by the leaps in information tech, these digital platforms are the unsung heroes, bridging the gap between creators, businesses, and buyers. They cut down on the costs of conducting business [8], make service blending smoother [9], and merge the worlds of making and serving. Plus, with consumers going gaga for variety and personal touches, manufacturers are upping their game to deliver more people-friendly products and services [10]. This shift is speeding up the fusion of the two sectors. Plus, the tech revolution is not just a buzzword; it is fueling a tech upgrade in manufacturing and fine-tuning company structures. The spread of these digital wonders across different fields is like adding fuel to the fire of competition and collaboration, creating a stronger bond between the making and serving industries [11]. This marriage of the two sectors is a win-win, leading to faster innovation in manufacturing [12], higher productivity in services, better use of resources [13], and a boost in overall productivity [14]. Xu and his crew [15] even proved that when making and serving join forces, it is a shot in the arm for local economies. Nonetheless, past research has not delved into how the digital economy is fueling this transformation. To improve this oversight, this paper identifies the digital economy as a key factor that is worth examining to understand its impact on the convergence of manufacturing and service sectors. This study also investigates the potential of this integration to foster the advancement of the tangible economy, presenting avenues for realizing sustainable development objectives.

In the realm of academic discourse, there is a substantial corpus of work that examines how the digital economy affects the traditional economy. Yet, there are still two key areas that need more in-depth study. For starters, industrial coupling, which is a more profound aspect of industrial integration, plays a pivotal role in fostering collaboration and synergy among various sectors. This process ensures that the various components of the integrated system are tightly interconnected [16]. Although current research generally acknowledges that the digital economy fosters a closer relationship between manufacturing and services, the degree to which it enables their coupling and coordination still needs to be examined more thoroughly. Furthermore, the potential of the digital economy to propel the growth of the real economy via the integration and synergy of these two sectors has yet to be fully explored.

In light of these existing research gaps, this paper delves into the effects and underlying dynamics of the digital economy on the traditional economy, focusing on the interplay and synergy between the manufacturing and service sectors. This investigation is not only theoretically profound but also practically crucial for fostering the high-quality, sustainable growth of the real economy. The novel contributions of this research can be outlined as follows: (1) We scrutinize the influence of the digital economy on the interconnection and harmony between manufacturing and services, offering fresh insights into how the digital realm propels sustainable progress through industry amalgamation. (2) We dissect the direct and indirect effects of the digital economy on the real economy's sustainability through the lens of manufacturing–service integration, elucidating the various channels through which the digital realm exerts its influence. (3) We illuminate the diverse impacts of the digital economy on the real economy's sustainability across different regions, taking into account regional disparities. This research, by examining the varying degrees of digital economic development, provides valuable insights for regional economic policy formulation. This research not only lays the groundwork for propelling China's economy towards high-quality growth but also presents actionable advice for attaining the UN's sustainability objectives on a global scale.

2. Theoretical Analysis and Research Hypotheses

2.1. *The Direct Impact of the Digital Economy on the Real Economy*

The digital economy is essentially an economic landscape where digital data and know-how are the cornerstones of production, with cutting-edge info-tech, especially web-based technologies, spearheading changes across economic sectors, business strategies, and social management. On the flip side, the real economy is the heart and soul of the classic economic model, including the likes of farming, manufacturing, building, and the wholesale and retail sectors. It is all about tangible goods and productive actions. The digital economy props up the real economy by developing digital infrastructure, enhancing industrial digital transformation, and integrating digital tech across the board. At the same time, the real economy underpins the digital economy by generating practical needs and market chances for its expansion. The digital economy has a direct effect on the real economy by boosting productivity, broadening the market, spurring innovation, and nurturing the growth of new industries. All these impacts work together to drive the growth, transformation, and advancement of the real economy.

First off, the digital economy is a game-changer for production efficiency. By integrating digital tech, businesses can streamline their production, improve their quality, and significantly increase their efficiency. Thanks to automation and smart systems, companies in the tangible economy can slash time, cut costs, and really elevate the quality and innovation of their goods and services. Plus, the digital economy is fueling the tech transformation of old-school enterprises, boosting the real economy's quality in the process [17]. In their study, Li and colleagues [18] highlighted how the digital economy enhances production prowess and resource distribution through technological advancements and the encouragement of innovative business models, which in turn propels robust economic growth. Moreover, Liu and associates [19] illustrated that the digital economy's expansion greatly accelerates industrial evolution and improvement alongside boosting industrial productivity.

Secondly, the digital realm has significantly widened the marketplace. Huang and his colleagues [20] noted that digital technologies have greatly expanded the scope of e-commerce, allowing for innovative applications. This not only slashes the expenses tied to searching, exchanging, and pairing but also dismantles trade barriers across various industries. These developments foster greater collaboration and interaction among market players, thereby boosting the overall market size. Moreover, the digital economy harnesses the power of big data, enabling businesses to gain a deeper understanding of consumer needs, market trends, and competitive landscapes. By sifting through vast datasets, companies can make more informed decisions, craft tailored marketing plans, and extend their market influence.

Moreover, the digital realm has spurred innovation and birthed fresh sectors of the economy. As per Han and colleagues [21], the digital economy has a profound and favorable effect on the quality of innovation. Qianyu [22] posits that digital tools continuously refine the efficiency of scientific and technological advancements, which in turn spawns novel industries and business paradigms. These developments are pivotal in refining industrial layouts and forming high-quality development frameworks. The digital economy has nurtured the expansion of numerous innovative and emerging sectors, including e-commerce, online finance, and AI. These sectors offer fresh avenues for growth and development for the real economy, propel economic structural evolution and improvement, and empower businesses to reinvigorate their competitive edge.

In summary, this leads to the formulation of hypothesis H1: the digital economy positively promotes the development of the real economy.

2.2. *The Effect of Digital Economy on the Coupling and Coordination of Manufacturing and Service Industries*

The digital economy is a revolutionary shift in the way we think about the economic landscape, relying heavily on digital tech and characterized by digital data and platforms. By harnessing this tech, fueled by both production assets and consumer needs, old-school manufacturers and service providers have been branching out into international markets, merging industry lines, and creating a fresh hybrid model—manufacturing services and service-based manufacturing. This transition underscores the seamless blend of the manufacturing and service sectors.

First off, thanks to digital platforms, it is a breeze to grab and swap info, which lets companies really get a grip on what consumers are after. Not only do they churn out goods that cater to the masses, but they can also roll out customized and varied offerings on the fly. Matching these personalized consumer desires with the desired supply is like a match made in heaven, propelling a seamless fusion between the manufacturing and service sectors [23]. Liu and his colleagues [24] introduced a cutting-edge blockchain-based digital twin platform. It harnesses a service-oriented architecture (SOA) and digital twin technology to seamlessly intertwine the manufacturing and service sectors. The platform enhances resource allocation and service alignment, both of which are crucial for the synergetic growth and harmonious advancement of these two industries.

Secondly, the digital revolution has not only restructured the service sector but has also dramatically altered consumer habits. Thanks to the power of digital gadgets, folks can now tap into information more easily and explore a broader spectrum of options with enhanced efficiency. As a result, service providers are rolling out a variety of digital offerings to foster collaborative value creation with their clientele. This shift underscores the fact that service-based manufacturing has caught on with service-oriented companies. The integration of digital tech is fueling the digital metamorphosis of businesses, propelling the transformation of manufacturing into services and vice versa [25].

Additionally, the shift towards digitalization is a game-changer for manufacturers, dramatically boosting their overall efficiency and maximizing the potential of their workforce. This underscores just how crucial digital technology is in driving the transformation of companies and fostering a seamless blend between the manufacturing and service sectors [13].

In conclusion, hypothesis H2 is as follows: the digital economy enhances the coupled and coordinated development of the manufacturing and service industries.

2.3. *Indirect Impact Effect of Digital Economy on the Real Economy*

As the service sector has grown to play a more substantial role in the total economic output, there has been a notable synergy between the service and manufacturing sectors, giving a fresh boost to the economy's advancement. The digital revolution is not just fueling the real economy's expansion; it is also paving the way for its growth by promoting a seamless blend of the manufacturing and service industries. This subtle yet significant enhancement of the real economy through the fusion of these sectors functions through several pivotal avenues.

First, this approach streamlines the way resources are distributed. The fusion of the manufacturing and service sectors, which is powered by digital advancements, connectivity, and platform-based business models, creates a tighter bond between production and service. This, in turn, leads to a more effective use and distribution of resources. According to Liu and colleagues [26], this convergence is a game-changer in tackling resource mismanagement in China. By harnessing the power of factor flow dynamics, cost-cutting strategies, and innovation-led practices, companies can pivot more nimbly in response to market shifts.

This agility not only boosts production efficiency and service standards but also props up the growth of the actual economy. In the southeastern corner of China, Guangdong Province has been harnessing digital wizardry to ignite a tech revolution. By nurturing the growth of cutting-edge sectors, the region has adeptly upgraded its manufacturing base. Simultaneously, the province has been working on boosting cloud computing and big data solutions, thereby strengthening the interplay between manufacturing and service sectors. According to Wang and his team [27], they have introduced a nifty shared manufacturing service model powered by digital twin tech. This model is a game-changer, as it streamlines resource distribution and skyrockets production prowess.

Second, it amplifies overall factor productivity (TFP). By seamlessly merging manufacturing with service sectors, the digital economy nurtures smart production, streamlines supply chains, and allows for tailored customization—all of which not only enhance productivity and product excellence but also spur TFP expansion by fostering data-centric decision-making systems and innovative hubs. Zhang and his colleagues [28] discovered that the clustering of diverse service sectors drives technological advancements in manufacturing via economies of scale and technological spillovers, thereby elevating the general tech innovation level. This illustrates that intertwining service sectors with manufacturing empowers businesses to nimbly respond to market needs, slash expenses, and refine the efficiency of industrial supply chains, consequently underpinning the growth of the real economy.

Third, it bolsters economic toughness. The digital realm fuels international teamwork and creativity by melding the production and service sectors, giving manufacturers the agility to embrace fresh tech and production techniques. This shift also boosts the service sector's ability to refine its processes and sharpen its smarts, leading to a significant uptick in service efficiency. In their research, Tao and colleagues [29] suggested that digital twin technology is a game-changer for product design and manufacturing, making them smarter and more efficient. Furthermore, it offers instant data insights and service improvements throughout the product's lifespan. By boosting the collaboration of these elements, digital twin tech is a key factor in fostering the expansion and eco-friendly growth of the real-world economy. Jiang and his colleagues [30] argue that merging these two sectors strengthens the local economy's ability to bounce back. It does so by fostering a more cohesive regional market, spurring technological advancements in manufacturing, reshaping the value chain, and altering the way industries operate, their structures, and business strategies. These shifts propel the industry towards modernization and boost its competitive edge, all of which play a crucial role in nurturing the real economy's growth.

In conclusion, hypothesis H3 is as follows: the digital economy drives the development of the real economy through the coupling and coordination of the manufacturing and service industries.

3. Research Design

3.1. Modeling

3.1.1. Benchmark Regression Model

To test the research hypotheses proposed above, a two-way fixed effects model is constructed:

$$\text{Real}_{it} = \alpha_0 + \alpha_1 \text{Digi}_{it} + \sum \alpha_n \text{Controls} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

In Equation (1), Real_{it} represents the level of real economic development in the province (or autonomous region/municipality) i during period t . Digi_{it} denotes the index of digital economic development for province i during period t . Controls include a series

of control variables, such as urbanization, industrial structure, and consumption level. μ_i accounts for individual fixed effects, δ_{it} controls for time fixed effects, and ε_{it} represents the random error term.

In addition to the direct effects captured by Equation (1), this study also seeks to examine the potential mechanisms through which the digital economy influences the development of the real economy. Specifically, based on the analysis in the previous section, the degree of coupling and coordination between the manufacturing and service industries is tested to determine whether it acts as a mediating variable in the relationship between the digital economy and the real economy.

3.1.2. Mediation Effect Model

The digital economy indirectly influences the development of the real economy by enhancing the coupling and coordination between the manufacturing and service industries. From the perspective of theoretical analysis, the coupling coordination degree of the manufacturing and service industries is selected as the mediating variable.

To verify the theoretical assumptions, drawing on the methodology of Shen et al. [31], two additional models are constructed based on Equation (1): Equations (2) and (3).

$$\text{Inte}_{it} = \beta_0 + \beta_1 \text{Digi}_{it} + \sum \beta_n \text{Controls} + \mu_i + \sigma_t + \varepsilon_{it} \quad (2)$$

$$\text{Real}_{it} = \gamma_0 + \gamma_1 \text{Digi}_{it} + \gamma_2 \text{Inte}_{it} + \sum \gamma_n \text{Controls} + \mu_i + \sigma_t + \varepsilon_{it} \quad (3)$$

In this context, Inte_{it} represents the mediating variable, which reflects the degree of coupling and coordination between the manufacturing and service industries.

To determine whether a mediating effect exists, the following steps are performed:

Step 1: If the coefficient α_1 in Equation (1) is statistically significant, it suggests the potential presence of a mediating effect, allowing the analysis to proceed to the next step. If α_1 is not significant, the analysis of the mediating effect is discontinued.

Step 2: If both the coefficient β_1 in Equation (2) and the coefficient γ_2 in Equation (3) are statistically significant, it confirms the existence of a mediating effect. However, if either β_1 or γ_2 is not significant, the bootstrap method can be employed as an alternative approach to further test for the presence of a mediating effect [32].

3.2. Explanation of Variables

3.2.1. Explained Variables

The dependent variable in this study is the level of real economic development. Drawing on the research findings of Guo et al. [33] and incorporating the cultural industry, we construct a provincial-level real economic development indicator system based on seven dimensions: agriculture, industry, construction, transportation and telecommunications, wholesale and retail, cultural industry, and accommodation and catering. The entropy method is employed to calculate the weights of the tertiary indicators, as it effectively mitigates subjectivity. However, this method is highly sensitive to outliers, which may impact the results. To address this issue, we applied standardization and data translation techniques to control for outliers and ensure robustness. After a series of calculations, we obtained the real economic development level, which is denoted as Real_{it} . The specific steps are as follows:

Step 1: Data Standardization: Since all the indicators in this study are positive, the positive efficacy formula is applied. Let x_{itd} represent the value of the d th indicator in the t th year for the i th region, and let $\max(x_d)$ and $\min(x_d)$ denote the maximum and minimum values of the d th indicator, respectively.

$$x_{itd}^* = \frac{x_{itd} - \min(x_d)}{\max(x_d) - \min(x_d)}$$

Step 2: The standardized data are adjusted using a panning process.

$$\tilde{x}_{itd} = x_{itd}^* \times 0.9 + 0.1$$

Step 3: Calculation of the Share: The share of the d th indicator for region i in year t is calculated.

$$p_{itd} = \frac{\tilde{x}_{itd}}{\sum_{i=1}^N \sum_{t=1}^T \tilde{x}_{itd}}, \quad (i = 1, 2, \dots, N, t = 1, 2, \dots, T)$$

Step 4: Information Entropy Calculation: The information entropy value for the d th indicator is determined.

$$E_d = -\frac{1}{\ln(NT)} \sum_{i=1}^N \sum_{t=1}^T p_{itd} \ln(p_{itd})$$

Step 5: Coefficient of Variation: The coefficient of variation for the d th indicator is computed.

$$G_d = 1 - E_d$$

Step 6: Weight Calculation: The coefficient of variation is normalized, and the weight for the d th indicator is derived.

$$W_d = \frac{G_d}{\sum_{d=1}^M G_d} \quad (d = 1, 2, \dots, M)$$

Step 7: Development Level Calculation: The level of real economic development for region i in year t is calculated based on the weighted indicator values.

$$\text{Real}_{it} = \sum_{j=1}^M w_j \tilde{x}_{itj}$$

The indicator system and the corresponding weights for the level of real economic development are presented in Table 1.

3.2.2. Core Explanatory Variables

This study zeroes in on the digital economic development level as the pivotal explanatory factor. Building upon the insights of Wang and colleagues [34], this paper assembles a comprehensive provincial digital economy index system spanning four key areas: digital prowess, infrastructure, industrialization, and digitization of industries. An entropy-based approach is used to ascertain the individual weights of each third-level metric. Mimicking the methodology employed for gauging the real economic development stage, the digital economic development level, symbolized by Digiit , is then calculated. The detailed indicators and their respective weights are outlined in Table 2.

Table 1. System of indicators of the level of development of the real economy.

Tier 1 Indicators	Secondary Indicators	Tertiary Indicators	Unit of Measure	Weights	Direction
Level of development of the real economy	Agriculture	Gross output value of agriculture, forestry, livestock, and fisheries	billions	0.046	+
		Value added of agriculture, forestry, livestock, and fisheries	billions	0.046	+
	Industries	Number of industrial establishments	one	0.063	+
		Total assets of the enterprise	billions	0.041	+
		Value added by industry	billions	0.051	+
	Construction industry	Construction value added	billions	0.051	+
		Total assets of construction enterprises	billions	0.046	+
		Gross construction output	billions	0.049	+
	Transportation, post, and telecommunications	Road mileage	ten thousand kilometers	0.035	+
		Value added of transportation, storage, and postal services	billions	0.044	+
		Postal workers	person	0.035	+
	Wholesale and retail trade	Value added of wholesale and retail trade	billions	0.055	+
		Number of legal person enterprise units in wholesale industry	one	0.054	+
		Total commercial sales in wholesale industry	billions	0.063	+
		Employed persons in urban units of wholesale and retail trade	ten thousand people	0.052	+
	Cultural industry	Number of museums	one	0.036	+
		Number of public library institutions	one	0.039	+
	Accommodation and catering	Value added of accommodation and catering industry	billions	0.049	+
		Number of legal entities in accommodation industry	one	0.037	+
		Turnover of accommodation enterprises	billions	0.055	+
		Employed persons in urban units of the accommodation and catering industry	ten thousand people	0.055	+

Table 2. Digital economy indicator system.

Tier 1 Indicators	Secondary Indicators	Tertiary Indicators	Unit of Measure	Weights	Direction
digital economy	Digital Talent	Number of general colleges and universities	institute	0.068	+
		Number of undergraduate graduates of general institutions of higher education	ten thousand people	0.081	+
	Digital Infrastructure	Number of domain names	ten thousand	0.137	+
		Number of IPv4 addresses	one	0.150	+
	Industrial Digitization	Number of websites per 100 enterprises	one	0.024	+
		Percentage of enterprises with e-commerce trading activities in the total number of enterprises	%	0.056	+
		Percentage of e-commerce sales in GDP	%	0.096	+
	Digital Industrialization	Postal revenue	billions	0.124	+
		Total telecommunications business	billions	0.110	+
		Revenue from software products	billions	0.155	+

3.2.3. Mediating Variables

In this investigation, the key variable we are examining is the extent to which the manufacturing and service sectors are intertwined. Citing the work of Hu and colleagues [1], we assess this integration across three critical areas: the scale of the industries, their economic efficiency, and their potential for growth (refer to Table 3 for details). The scale indicators shed light on how the digital economy propels industry growth, fostering company expansion, job creation, and revenue surges. The efficiency indicators illustrate the digital economy's effect on production prowess, income distribution, and market competitiveness,

emphasizing how technological advancements boost the profitability of businesses and sectors. The potential growth indicators enable us to track how the digital economy shapes the future expansion path of industries, encompassing trends in employment and revenue and capturing the enduring development potential fostered by digital advancements. Initially, we utilized the entropy method to compute the development index for the manufacturing sector ($manu_{it}$) and the service sector ($serv_{it}$) individually. Subsequently, we applied a coupling coordination model to gauge the interplay ($Inte_{it}$) between the manufacturing and service sectors across various regions. Here is our process:

Table 3. Coupled coordination indicator system of the two industries.

Industry Name	Tier 1 Indicators	Secondary Indicators	Interpretation of Indicators	Unit of Measure
service industry	Industry Scale	Number of business units	Number of legal entities in the manufacturing sector	one
		Number of employees	Employed in manufacturing urban units	million
		Business Income	Manufacturing business income	billion
	Economic Benefits	Average labor compensation	Average wage of persons employed in manufacturing urban units	CNY
		Per capita business income	Operating income/number of employees	CNY billions per 10,000 people
	Growth Potential	Rate of growth in the number of employees	(Number of persons employed in the current year/Number of persons employed in the previous year – 1) × 100%	%
Revenue growth rate		(Current year’s operating income/previous year’s operating income – 1) × 100%	%	
services sector	Industry Scale	Number of business units	Total number of business units	one
		Number of employees	Total number of employees	million
		Business income	Total value added	billion
	Economic Benefits	Average labor compensation	Average labor compensation of employed persons	CNY
		Per capita business income	Business Revenue/Number of Employed Persons	CNY billions per 10,000 people
	Growth Potential	Number of employees growth rate	(Current year’s number of employees/previous year’s number of employees – 1) × 100%	%
Growth rate of business income		(Current year’s business income/previous year’s business income – 1) × 100%	%	

Step 1: Calculate the Degree of Coupling: The degree of coupling between the manufacturing and productive services subsystems is determined.

$$C_{it} = 2 \sqrt{\frac{manu_{it} \times serv_{it}}{(manu_{it} + serv_{it})^2}}$$

Step 2: Systematic Comprehensive Evaluation Index: A comprehensive evaluation index for the system is calculated to assess the overall performance of the subsystems.

$$Z_{it} = \alpha manu_{it} + \beta serv_{it}$$

Step 3: Calculate the Degree of Coupling Coordination: The coupling coordination degree is computed to evaluate the level of coordinated development between the manufacturing and productive services subsystems.

$$Inte_{it} = \sqrt{C_{it} * Z_{it}}$$

Typically, the economic contribution of the service sector is greater than that of manufacturing. For example, in 2023, services contributed 60% to China's GDP, while manufac-

turing accounted for over 30%. For the purposes of this study, the weights are set as $\alpha = 0.4$ and $\beta = 0.6$.

3.2.4. Control Variables

To delve into the multifaceted effects of the digital age on the tangible economy, we have crafted a control variable indicator system. This system is grounded in the variables frequently cited in the scholarly discourse. It is structured across three key areas: urbanization trends, industrial composition, and consumer spending patterns, as delineated in Table 4.

Table 4. Indicator system for control variables.

Tier 1 Indicators	Secondary Indicators	Tertiary Indicators
control variable	Urbanization	Ratio of urban population size to total population at the end of the year in each province (c1)
	Industrial structure	Ratio of output value of the tertiary industry to that of the secondary industry (c2)
	Consumption level	Logarithm of per capita consumer spending (c3)

Urbanization tends to go hand in hand with the economic pulse of a region. As the economic ticker ticks upward, the countryside yields to the allure of the city, propelling the real economy forward. We gauge urbanization by the ratio of city dwellers to the total population at year's end, province by province.

The industrial makeup is the backbone of any nation's or area's economic prowess, and shifts in this makeup can sway the real economy in various ways. We assess the industrial landscape by comparing the value output of the service sector to that of the manufacturing sector.

The level of consumer spending is a barometer of the populace's demand for goods and services. A robust consumption level suggests enhanced purchasing power and spending potential, which can, in turn, spur the growth of both the digital and real economies. We measure this level by looking at the log of per capita spending on consumer goods and services.

3.3. Data Sources and Explanations

Since 2013, researchers have tracked the ratio of businesses participating in e-commerce relative to the total number of companies, which serves as a crucial metric for assessing industrial digitization in the digital economy. This analysis focuses on the timeframe from 2013 to 2021, encompassing 30 provinces, municipalities, and autonomous regions in China, while excluding Tibet, Hong Kong, Macao, and Taiwan. This results in a total of 270 balanced observations from provincial panels. The data utilized for this study were collected from various sources, including the *China Statistical Yearbook*, the *Statistical Yearbook of Tertiary Industry*, provincial statistical yearbooks, the *China Industrial Statistical Yearbook*, and the official site of the National Bureau of Statistics. In cases of missing information, interpolation methods were employed to fill in the gaps.

4. Descriptive Analysis

Based on the economic development levels of various regions in China and the commonly adopted method for dividing economic zones, China is categorized into five major economic regions: Southeast, Southwest, Northeast, North China, and Northwest. Table 5 presents the descriptive statistics for the real economy, digital economy, and the coupling coordination degree between the two industries across the full sample and within each economic region.

Table 5. Descriptive analysis.

Sample Type	Variable	Observations	Mean	Standard Deviation	Coefficient of Variation	Minimum Value	Maximum Value
Full Sample	Real economy	270	0.304	0.140	0.463	0.109	0.844
	Digital economy	270	0.268	0.112	0.418	0.116	0.685
	Degree of coordination between the two industries	270	0.357	0.069	0.194	0.266	0.626
North China	Real economy	54	0.342	0.126	0.369	0.174	0.638
	Digital economy	54	0.324	0.136	0.419	0.167	0.685
	Degree of coordination between the two industries	54	0.383	0.056	0.147	0.268	0.526
Southeast Region	Real economy	90	0.387	0.161	0.416	0.136	0.843
	Digital economy	90	0.325	0.110	0.338	0.144	0.685
	Degree of coordination between the two industries	90	0.402	0.080	0.199	0.295	0.626
Southwest Region	Real economy	45	0.280	0.078	0.278	0.182	0.503
	Digital economy	45	0.231	0.053	0.231	0.153	0.391
	Degree of coordination between the two industries	45	0.325	0.029	0.090	0.286	0.409
Northwest Region	Real economy	54	0.187	0.062	0.330	0.109	0.325
	Digital economy	54	0.173	0.040	0.230	0.116	0.284
	Degree of coordination between the two industries	54	0.302	0.025	0.084	0.266	0.361
Northeast Region	Real economy	27	0.221	0.036	0.163	0.175	0.273
	Digital economy	27	0.220	0.041	0.188	0.166	0.301
	Degree of coordination between the two industries	27	0.320	0.023	0.072	0.282	0.372

As shown in Table 5, the mean, minimum, and maximum values of the real economic development index are 0.304, 0.109, and 0.844, respectively, indicating significant disparities in real economic development levels across provinces. Regionally, Southeast China and North China exhibit higher real economy development indexes, Southwest China falls in the middle, and Northeast China and Northwest China have relatively lower values.

Similarly, the mean, minimum, and maximum values of the digital economic development index are 0.268, 0.116, and 0.685, respectively, reflecting considerable variation in digital economic development levels among provinces. Moreover, the ranking of the digital economy development index across the five regions aligns with the ranking of the real economy development index.

Using the commonly adopted classification standards for coupling coordination degrees, this paper divides the coordination levels into seven categories, as shown in Table 6. Combining the statistical information from Tables 5 and 6, the mean, minimum, and maximum values of the coupling coordination degree between China's manufacturing and service industries are 0.357, 0.266, and 0.626, respectively. These values indicate that, overall, the coupling coordination degree of the two industries in China is in a state of mild dysfunction, with substantial differences across provinces. Some provinces have reached the level of primary coordination, while others remain in moderate dysfunction.

Table 6. Classification of coupling coordination.

Interval of Coupling Coordination Degree	Degree of Coupling Coordination	
$0 < D \leq 0.2$	Severe disorder	dissonance
$0.2 < D \leq 0.3$	Moderate disorder	
$0.3 < D \leq 0.4$	Mildly dysfunctional	
$0.4 < D \leq 0.5$	On the verge of becoming dysfunctional	coordination
$0.5 < D \leq 0.6$	Basic coordination	
$0.6 < D \leq 0.8$	Elementary coordination	
$0.8 < D \leq 1$	Quality coordination	

From a regional perspective, the Southeast region demonstrates the highest coupling coordination degree between the two industries, nearing the threshold of dysfunction. The remaining regions are all in a state of mild dysfunction.

The findings from the descriptive analysis show a stark contrast in the southeastern region's development across the three sectors—real economy, digital economy, and the manufacturing–service synergy—when compared to other areas. The Southeast is far ahead, with the northwestern region trailing behind. One likely reason for this gap is that the Southeast's manufacturing sector is cutting-edge and tightly intertwined with the service sector, particularly in high-tech fields like smart manufacturing and e-commerce. Many businesses in this region have consistently upgraded their technology and embraced intelligent transformation, leading to a harmonious blend of manufacturing and services, thereby strengthening their interconnectivity. On the flip side, the northwestern region has a less robust economic base. Its manufacturing is mainly centered on heavy and traditional sectors, and its service sector is heavily reliant on traditional commerce, with little support from modern service sectors like digital and IT services. Consequently, the collaboration between manufacturing and services in the Northwest is notably weaker.

5. Empirical Analysis

5.1. Direct Effect Analysis

This study leverages the fixed effects model, as indicated by the Hausman test, to analyze the full dataset. Table 7 reveals the initial regression outcomes related to the digital economy's influence on the real economy. Columns 1 through 3 in Table 7 suggest that, when employing the individual, time, and two-way fixed effects models, the digital economy demonstrates a substantial positive effect on the real economy, reaching statistical significance at the 1% level. Moreover, Columns 4 to 6 of Table 7 illustrate that, with the inclusion of control variables, the digital economy's positive impact on the real economy remains significant at the 1% level. These insights imply a significant contribution of the digital economy to the advancement of the real economy. Furthermore, as per the latest China Digital Economy Development Index Report from 2024, the digital economy in China expanded to a staggering CNY 53.9 trillion in 2023, making up a substantial 66.45% of the nation's GDP growth. This figure is in line with the findings of our research, thereby lending credence to the validity of our initial hypothesis, H1.

5.2. Indirect Effect Analysis

This research utilizes the synergy between the manufacturing and service sectors as a key intermediary factor and employs a mediation analysis to explore the indirect influence of the digital realm on the tangible economic sector. The detailed findings are detailed in Table 8. From Columns (1), (3), and (5) of Table 8, it is clear that, when using the fixed effects model, the digital economy exerts a notably positive effect on the interplay between the

two industries, showcasing that it fosters harmonious growth. Consequently, hypothesis H2 is confirmed.

Table 7. Benchmark regression results.

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Real	Real	Real	Real	Real	Real
Digi	1.060 *** (0.100)	0.661 *** (0.076)	0.552 *** (0.144)	1.267 *** (0.048)	0.420 *** (0.091)	0.568 *** (0.117)
c1				−0.469 *** (0.056)	−0.208 (0.141)	0.048 (0.170)
c2				−0.084 *** (0.006)	−0.035 *** (0.011)	−0.004 (0.011)
c3				0.140 *** (0.027)	0.133 *** (0.029)	0.121 *** (0.043)
Constant	0.041 * (0.023)	0.126 *** (0.020)	0.152 *** (0.033)	−0.974 *** (0.218)	−0.939 *** (0.210)	−1.017 *** (0.357)
Year fixed	YES	NO	YES	YES	NO	YES
Province fixed	NO	YES	YES	NO	YES	YES
Adjusted R-squared	0.689	0.620	0.776	0.914	0.730	0.799
Sample size	270	270	270	270	270	270
Number of provinces	30	30	30	30	30	30

Note: Robust standard errors in parentheses, *** for $p < 0.01$, * for $p < 0.1$.

Table 8. Mediated effects regression results.

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Inte	Real	Inte	Real	Inte	Real
Inte		1.224 *** (0.104)		0.600 *** (0.155)		0.511 *** (0.156)
Digi	0.457 *** (0.021)	0.708 *** (0.067)	0.184 ** (0.067)	0.309 *** (0.078)	0.233 *** (0.076)	0.449 *** (0.110)
c1	−0.075 ** (0.032)	−0.378 *** (0.049)	−0.232 ** (0.110)	−0.069 (0.128)	−0.147 (0.124)	0.123 (0.147)
c2	−0.023 *** (0.003)	−0.057 *** (0.004)	−0.015 (0.009)	−0.026 *** (0.009)	−0.001 (0.009)	−0.003 (0.010)
c3	0.107 *** (0.015)	0.009 (0.024)	0.128 *** (0.022)	0.057 ** (0.027)	0.003 (0.025)	0.119 *** (0.043)
Constant	−0.710 *** (0.118)	−0.105 (0.194)	−0.782 *** (0.159)	−0.469 ** (0.185)	0.338 (0.213)	−1.190 *** (0.372)
Year fixed	YES	YES	NO	NO	YES	YES
Province fixed	NO	NO	YES	YES	YES	YES
Adjusted R-squared	0.908	0.948	0.714	0.790	0.824	0.825
Sample size	270	270	270	270	270	270
Number of provinces	30	30	30	30	30	30

Note: Robust standard errors in parentheses, *** for $p < 0.01$, ** for $p < 0.05$.

According to the data presented in Columns (1) and (2) of Table 8, the time fixed effects model reveals a notable positive influence of the digital economy on the degree of coupling coordination between the manufacturing and service sectors. Furthermore, both the digital economy and the degree of coupling coordination significantly contribute to the

real economy. This indicates that the mediation effect model highlights how the digital economy affects the real economy indirectly via the coupling coordination between these two industries. Likewise, the results from both the individual fixed effects model and the two-way fixed effects model support this conclusion, confirming that the relationship between the digital economy and the real economy is mediated by the coupling coordination degree of the manufacturing and service sectors.

This suggests that the digital economy plays a pivotal role in fostering genuine economic growth by promoting a synergistic relationship between the manufacturing and service sectors. Additionally, as reported by the Ministry of Industry and Information Technology (MIIT), China maintained its position as the global leader in the production and sales of new energy vehicles for the eighth straight year in 2022. The swift advancement of the new energy vehicle sector has thrived due to the strong interconnection between manufacturing and services, thereby confirming hypothesis H3.

5.3. Robustness Test

To ensure the validity of our research outcomes, this study utilizes two distinct approaches. Initially, we introduce a lagged variable for the digital economy, delaying its inclusion by one time period in our regression analysis. Secondly, we refine our sample scope, focusing on the years 2013 to 2020, to conduct a fresh regression analysis. The core explanatory variables maintain their significance across various models—individual fixed effects, time fixed effects, and two-way fixed effects. Therefore, for the sake of brevity, we only present the estimation and testing results for the regression coefficients of both the core explanatory and mediating variables within the two-way fixed effects model. These findings are detailed in Table 9.

Table 9. Robustness tests.

	One Period Lag Method			Reduced Sample Method		
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Real	Inte	Real	Real	Inte	Real
Inte			0.390 ** (0.156)			0.357 *** (0.104)
L.Digi/Digi	0.610 *** (0.098)	0.203 ** (0.074)	0.531 *** (0.095)	0.532 *** (0.074)	0.207 ** (0.076)	0.458 *** (0.071)

Note: Robust standard errors in parentheses, *** for $p < 0.01$, ** for $p < 0.05$.

The findings presented in Columns (1) and (4) of Table 9 reveal that the digital economy exerts a notably beneficial effect on the real economy. Meanwhile, Columns (2) and (5) highlight that the digital economy plays a crucial role in enhancing the integration and collaboration between the manufacturing and service sectors. Lastly, Columns (3) and (6) illustrate that both the digital economy and the degree of synergy between these two industries positively influence the real economy.

These results confirm that the direct and indirect effects of the digital economy on the real economy are robust.

5.4. Regional Heterogeneity Test

To explore the direct and indirect impact of the digital economy on the real economy within China's five primary economic zones—the Southeast, Southwest, Northeast, North China, and Northwest—we utilize a fixed effects model. Considering the consistency of the explanatory variables' importance across various models, such as the individual fixed effects, time fixed effects, and the two-way fixed effects, we have decided to present only the

estimation and testing outcomes for the regression coefficients of both the key explanatory and mediating variables under the two-way fixed effects model for the sake of conciseness.

5.4.1. Examination of Regional Variability for Direct Effects

Table 10 summarizes the outcomes of the regional variability assessment. The data reveals that in North and Southeast China, the digital economy positively and significantly affects the real economy at a 5% threshold. In Southwest China, this relationship remains positive and significant, albeit at a 10% level. Conversely, in Northwest and Northeast China, the digital economy's effect on the real economy lacks statistical significance. These findings imply that the digital economy's impact is notably weaker in areas where real economic development is comparatively limited.

Table 10. Results of the regional heterogeneity test.

	North China	Southeast China	Southwest China	Northwest China	Northeast China
Variable	Real	Real	Real	Real	Real
Digi	0.218 ** (0.076)	0.481 ** (0.158)	0.592 * (0.248)	0.465 (0.290)	−0.547 (0.206)

Note: Robust standard errors in parentheses, ** for $p < 0.05$, * for $p < 0.1$.

5.4.2. Regional Heterogeneity Test for Indirect Effects

According to the results in Table 10, no mediating effect is observed in the Northwest and Northeast regions. Therefore, further testing is only required to assess whether a mediating effect exists through the coupling coordination degree of the two industries in the Southeast, Southwest, and North China regions regarding the impact of the digital economy on the real economy. The partial results for models (2) and (3) are shown in Table 11. The results reveal that in the Southeast region, the impact of the digital economy on the coupling coordination degree of the two industries is significant at the 10% level, while the impact of the coupling coordination degree on the real economy is significant at the 1% level. This indicates the presence of a mediating effect in the Southeast region.

Table 11. Mediated effects regression results.

	North China		Southeast China		Southwest China	
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Inte	Real	Inte	Real	Inte	Real
Inte		−0.068 (0.156)		0.709 *** (0.198)		1.026 (0.535)
Digi	0.108 (0.117)	0.226 * (0.090)	0.209 * (0.048)	0.334 * (0.073)	0.284 ** (0.065)	0.300 ** (0.086)

Note: Robust standard errors in parentheses, *** for $p < 0.01$, ** for $p < 0.05$, * for $p < 0.1$.

For North China and Southwest China, further testing is conducted using the bootstrap method to determine whether a mediating effect exists. The results, displayed in Table 12, show that a mediating effect is present in Southwest China but not in North China.

Combining these findings with the data in Table 5, it is evident that the impact of the digital economy on the coupling coordination degree of the two industries is not significant in North China. This may be attributed to the large coefficient of variation in the level of digital economic development within the region. In other words, the substantial disparity in digital economy development across North China could weaken the impact of the digital economy on the coupling coordination of the manufacturing and service industries. Consequently, this lack of significant impact may hinder the digital economy's ability to

promote the development of the real economy through the coordinated coupling of these two industries.

Table 12. Results of bootstrap method test in Southwest and North China regions.

Region	Year Fixed	Province Fixed	Number of Samples	Intermediary Effect	95% BootCI		Significance
Southwest China	YES	YES	500	0.292	0.010	0.913	Significant
	YES	NO	500	0.443	0.074	1.141	Significant
	NO	YES	500	0.045	−0.179	0.240	Not significant
North China	YES	YES	500	−0.007	−0.148	0.029	Not significant
	YES	NO	500	−0.008	−0.116	0.032	Not significant
	NO	YES	500	−0.008	−0.116	0.032	Not significant

Note: CI indicates nonparametric percentile bootstrap confidence interval based on bias correction (BC).

6. Conclusions and Implications

This research delves into the interconnectedness of the manufacturing and service sectors, analyzing the tangible and intangible impacts of the digital economy on China's real economy across 30 provinces, excluding Tibet. Spanning from 2013 to 2021, this study employs both a panel data fixed effects model and a mediation effects model to dissect the regional disparities in these effects. The key findings are summarized as follows:

Firstly, the digital economy is a major driver behind the growth of the traditional economy.

Secondly, it spurs the real economy's progress by strengthening the synergy and harmonious growth between the manufacturing and service sectors.

Thirdly, research indicates that the influence of the digital economy on the real economy varies across regions. The specific effects are as follows:

1. In the Southeast and Southwest, the digital economy not only boosts the real economy but also reinforces its growth by improving the interconnected and synchronized expansion of the manufacturing and service sectors.

2. In Northern China, although the digital economy does stimulate the real economy, it does not foster the integrated development of the manufacturing and service industries. Consequently, there is no mediating effect stemming from the alignment of these sectors.

3. In the Northwest and Northeast, the impact of the digital economy on the real economy is statistically insignificant. According to figures from the National Bureau of Statistics, the digital economy's footprint in the northwest corner of China makes up a mere 4% of the country's total digital economic landscape, while the northeast contributes a paltry 5.3%.

Based on these findings, the following policy recommendations are proposed:

1. Foster a Harmonious Growth of Both Digital and Traditional Economies: While it is crucial to fast-track the progress of the digital economy, it is equally important to nurture the traditional economy. The digital sector can only truly thrive when the traditional economy is robust and well developed.

2. Tackle the Uneven Growth of the Digital Economy in Northern China: There exists a significant variation in the development of the digital economy across the North China economic zone, which encompasses Beijing, Tianjin, Hebei, Shanxi, Shandong, and Henan. It is vital to intensify efforts to boost the digital economy in Tianjin, Hebei, and Shanxi. Strategies like broadening online retail sectors can be employed to realize this goal. These efforts will enhance the integration and synergy of manufacturing and service sectors, fostering the advancement of the real economy.

3. Bolster the Digital and Brick-and-Mortar Economies in the Northwest and Northeast Corners of the Nation: It is clear that both sectors are, quite frankly, lagging behind. It is high time for policymakers and pertinent agencies to roll out some strategic measures to

really get these industries up to speed. In the southeastern corner of China, Fujian Province has been a trailblazer in transforming logistics companies with a mix of financial incentives and experimental programs. They have set up cutting-edge logistics platforms that offer robust support to manufacturers, all while slicing down supply chain expenses. By spurring the digital economy's progress in these areas, we can foster a stronger connection and teamwork between the manufacturing and service sectors, which, in turn, is a real shot in the arm for the overall economic growth.

Author Contributions: Conceptualization, F.H. and H.Q.; methodology, H.Q.; software, H.Q.; validation, F.H. and H.Q.; formal analysis, F.H.; investigation, H.Q.; resources, H.Q.; data curation, H.Q.; writing—original draft preparation, H.Q.; writing—review and editing, F.H.; visualization, H.Q.; supervision, F.H.; project administration, F.H.; funding acquisition, F.H. All authors have read and agreed to the published version of the manuscript.

Funding: This work is partially supported by the National Natural Science Foundation of China (NSFC) under grant number 72361009, titled “Construction and Optimization of Nonlinear Prediction Model for Interval Number Sequence”; Guangxi Philosophy and Social Sciences Research Project: “Research on the Internal Mechanism and Strategic Guidance of Digital Transformation Driving the Resilience Enhancement of Outward oriented Enterprises in the Northern Bay Area”, project number: 24JYF004; Guangxi Philosophy and Social Science Research Project: “Mechanisms and Pathways of Digital Transformation Driving Carbon Performance Improvement in Guangxi's Listed Companies”, project number: 23BGL002; Science and Technology Project of Guangxi (Guike AD23023002).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data is contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Hu, C.C. Analyzing dynamic coupling and coordination of modern service and advanced manufacturing industries in Guangdong–Hong Kong–Macao Greater Bay Area. *Heliyon* **2023**, *9*, e16565. [\[CrossRef\]](#)
2. Pang, J.; Jiao, F.; Zhang, Y. An analysis of the impact of the digital economy on high-quality economic development in China—A study based on the effects of supply and demand. *Sustainability* **2022**, *14*, 16991. [\[CrossRef\]](#)
3. Ding, C.; Liu, C.; Zheng, C.; Li, F. Digital Economy, Technological Innovation and High-Quality Economic Development: Based on Spatial Effect and Mediation Effect. *Sustainability* **2021**, *14*, 216. [\[CrossRef\]](#)
4. Xu, R.; Yao, H.; Li, J. Digital Economy's Impact on High-Quality Economic Growth: A Comprehensive Analysis in the Context of China. *J. Knowl. Econ.* **2024**, 1–19. [\[CrossRef\]](#)
5. Guo, B.; Wang, Y.; Zhang, H.; Liang, C.; Feng, Y.; Hu, F. Impact of the digital economy on high-quality urban economic development: Evidence from Chinese cities. *Econ. Model.* **2023**, *120*, 106194. [\[CrossRef\]](#)
6. Oloyede, A.A.; Faruk, N.; Noma, N.; Tebepah, E.; Nwaulune, A.K. Measuring the impact of the digital economy in developing countries: A systematic review and meta-analysis. *Heliyon* **2023**, *9*, e17654. [\[CrossRef\]](#) [\[PubMed\]](#)
7. Zhao, Y.; Feng, Y. Research on the development and influence on the real economy of digital finance: The Case of China. *Sustainability* **2022**, *14*, 8227. [\[CrossRef\]](#)
8. Akbar, Y.H.; Tracogna, A. The digital economy and the growth dynamics of sharing platforms: A transaction cost economics assessment. *J. Digit. Econ.* **2022**, *1*, 209–226. [\[CrossRef\]](#)
9. Li, Y.; Kumarasinghe, P.J. A behavioral model of service-derived manufacturing in e-commerce companies from the innovation chain perspective: A case study from China. *Heliyon* **2023**, *9*, e23080.
10. Ye, X.; Wang, Y.; Shafiee, S. An iterative consumer-centric and technology-driven product innovation strategy based on selective and dynamic consumer attention. *Technol. Forecast. Soc. Change* **2024**, *208*, 123713. [\[CrossRef\]](#)
11. Luo, S.; Liu, J. Enterprise service-oriented transformation and sustainable development driven by digital technology. *Sci. Rep.* **2024**, *14*, 10047. [\[CrossRef\]](#)
12. Zhang, A.; Zhu, H.; Sun, X. Manufacturing intelligentization and technological innovation: Perspectives on intra-industry impacts and inter-industry technology spillovers. *Technol. Forecast. Soc. Change* **2024**, *204*, 123418. [\[CrossRef\]](#)

13. Sui, X.; Hu, H.; Wang, R. The impact of digital transformation on the servitization transformation of manufacturing firms. *Res. Int. Bus. Financ.* **2025**, *73*, 102588. [\[CrossRef\]](#)
14. Lun, X.I.A. Spatial Effect of Industry Convergence on Total Factor Productivity: From the Perspective of the Convergence of Advanced Manufacturing Industry and Modern Service Industry. *J. Beijing Univ. Aeronaut. Astronaut. Soc. Sci. Ed.* **2023**, *36*, 168–179.
15. Xu, Y.; Li, J.; Yan, Y.; Gao, P.; Xie, H. Can coordinated development of manufacturing and information communication service industries boost economic resilience? An empirical study based on China's provinces. *Sustainability* **2022**, *14*, 10758. [\[CrossRef\]](#)
16. Stieglitz, N. Industry dynamics and types of market convergence. In Proceedings of the DRUID Summer Conference on Industrial Dynamics of the New and Old Economy: Who Is Embracing Whom, Copenhagen, Denmark, 6–8 June 2002.
17. Cheng, Y.; Zhou, X.; Li, Y. The effect of digital transformation on real economy enterprises' total factor productivity. *Int. Rev. Econ. Financ.* **2023**, *85*, 488–501. [\[CrossRef\]](#)
18. Li, H.; Zhang, Y.; Li, Y. The impact of the digital economy on the total factor productivity of manufacturing firms: Empirical evidence from China. *Technol. Forecast. Soc. Change* **2024**, *207*, 123604. [\[CrossRef\]](#)
19. Liu, J.; Feng, X.; Liu, J.; Yamaka, W. Digital Economy and Industrial Structure Transformation: Mechanisms for High-Quality Development in China's Agriculture and Rural Areas. *Agriculture* **2024**, *14*, 1769. [\[CrossRef\]](#)
20. Huang, S.; Ye, W.; Han, F. Does the Digital Economy Promote Industrial Collaboration and Agglomeration? Evidence from 286 Cities in China. *Sustainability* **2023**, *15*, 14545. [\[CrossRef\]](#)
21. Han, B.; Li, M.; Diao, Y.; Han, D. Assessing the effect of digital platforms on innovation quality: Mechanism identification and threshold characteristics. *Humanit. Soc. Sci. Commun.* **2024**, *11*, 951. [\[CrossRef\]](#)
22. Li, Q. Strategic Thinking on Digital Economy to Promote the High-Quality Development of China's Independent Innovation Demonstration zones. *Can. Soc. Sci.* **2023**, *19*, 77–83.
23. Wang, Y.; Han, P. Digital transformation, service-oriented manufacturing, and total factor productivity: Evidence from a-share listed companies in China. *Sustainability* **2023**, *15*, 9974. [\[CrossRef\]](#)
24. Liu, X.; Jiang, Y.; Wang, Z.; Zhong, R.Y.; Cheung, H.H.; Huang, G.Q. imseStudio: Blockchain-enabled secure digital twin platform for service manufacturing. *Int. J. Prod. Res.* **2023**, *61*, 3984–4003. [\[CrossRef\]](#)
25. Chin, H.S.; Marasini, D.P.; Lee, D.H. Digital transformation trends in service industries. *Serv. Bus.* **2023**, *17*, 11–36. [\[CrossRef\]](#)
26. Liu, Y.; He, Z. Synergistic Industrial Agglomeration, New Quality Productive Forces and High-quality Development of the Manufacturing Industry. *Int. Rev. Econ. Financ.* **2024**, *94*, 103373. [\[CrossRef\]](#)
27. Wang, G.; Zhang, G.; Guo, X.; Zhang, Y. Digital twin-driven service model and optimal allocation of manufacturing resources in shared manufacturing. *J. Manuf. Syst.* **2021**, *59*, 165–179. [\[CrossRef\]](#)
28. Zhang, M.; Li, W.; Zhang, R.; Yang, X. How do manufacturing and producer service agglomerations affect urban innovation differently? Empirical evidence from China. *PLoS ONE* **2022**, *17*, e0275616. [\[CrossRef\]](#)
29. Tao, F.; Cheng, J.; Qi, Q.; Zhang, M.; Zhang, H.; Sui, F. Digital twin-driven product design, manufacturing and service with big data. *Int. J. Adv. Manuf. Technol.* **2018**, *94*, 3563–3576. [\[CrossRef\]](#)
30. Jiang, N.; Jiang, W. How does regional integration policy affect urban resilience? Evidence from urban agglomeration in China. *Environ. Impact Assess. Rev.* **2024**, *104*, 107298. [\[CrossRef\]](#)
31. Shen, Y.; Wang, G.; Wu, X.; Shen, C. Digital economy, technological progress, and carbon emissions in Chinese provinces. *Sci. Rep.* **2024**, *14*, 23001. [\[CrossRef\]](#) [\[PubMed\]](#)
32. Alfons, A.; Ateş, N.Y.; Groenen, P.J.F. A robust bootstrap test for mediation analysis. *Organ. Res. Methods* **2022**, *25*, 591–617. [\[CrossRef\]](#)
33. Guo, D.; Li, L.; Pang, G. Does the integration of digital and real economies promote urban green total factor productivity? Evidence from China. *J. Environ. Manag.* **2024**, *370*, 122934. [\[CrossRef\]](#)
34. Wang, J.; Tian, Z.; Sun, Y. Digital Economy, Employment Structure and Labor Share. *Sustainability* **2024**, *16*, 9584. [\[CrossRef\]](#)

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.