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Research Investigating the Influence of the Digital Economy on the High-Quality Advancement of New Urbanization in the Yellow River Basin

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Abstract: The rapid development of the digital economy poses both opportunities and challenges for the process of new urbanization. This study utilizes inter-provincial panel data covering the period from 2012 to 2021 in the Yellow River Basin. It employs fixed-effect, mediation effect, and threshold effect models to examine how the digital economy affects the high-quality development of new urbanization in the area. Key findings of the study indicate that the digital economy has a positive impact on the high-quality development of new urbanization in the Yellow River Basin through its facilitation of industrial structure upgrading. The impact exhibits a non-linear "marginal effect," transitioning from slower to faster growth rates. This paper aims to establish a basis for decision-making and policy formulation aimed at enhancing the high-quality development of the digital economy within the context of new urbanization in the Yellow River Basin.

Keywords: digital economy; new urbanization; high-quality development; regional heterogeneity

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1. Introduction

The Yellow River Basin, a region of significant importance in China with a rich historical and cultural heritage, has played a crucial role in economic, social, and ecological development over an extended period. Promoting high-quality new urbanization in the Yellow River Basin is essential to China's national strategy and vital for achieving sustainable development and comprehensively building a modern socialist country. The high-quality development of new urbanization in the Yellow River Basin exemplifies China's modernization efforts, and the emergence of the digital economy further accelerates this process. Leveraging the advantages of the digital economy will invigorate the high-quality development of new urbanization in the Yellow River Basin in this new historical era. This paper focuses on examining the mechanisms and impact of the digital economy on the high-quality development of new urbanization in the Yellow River Basin. Theoretical analysis elucidates the direct, indirect, and non-linear effects of the digital economy on high-quality development in the Yellow River Basin's new urbanization. Empirically, employing inter-provincial panel data spanning from 2012 to 2021, this study utilizes fixed-effect, mediation effect, and threshold effect models to examine how the digital economy influences high-quality development in the Yellow River Basin's new urbanization. Additionally, it provides policy recommendations for harnessing the digital economy to enhance the high-quality development of new urbanization in the Yellow River Basin.

As shown in Figure 1, the basic framework of this thesis is as follows. Fixed effect model, mediation effect model and threshold effect model are used to study the mechanism of digital economy affecting the high-quality development of new urbanization in the Yellow River Basin.

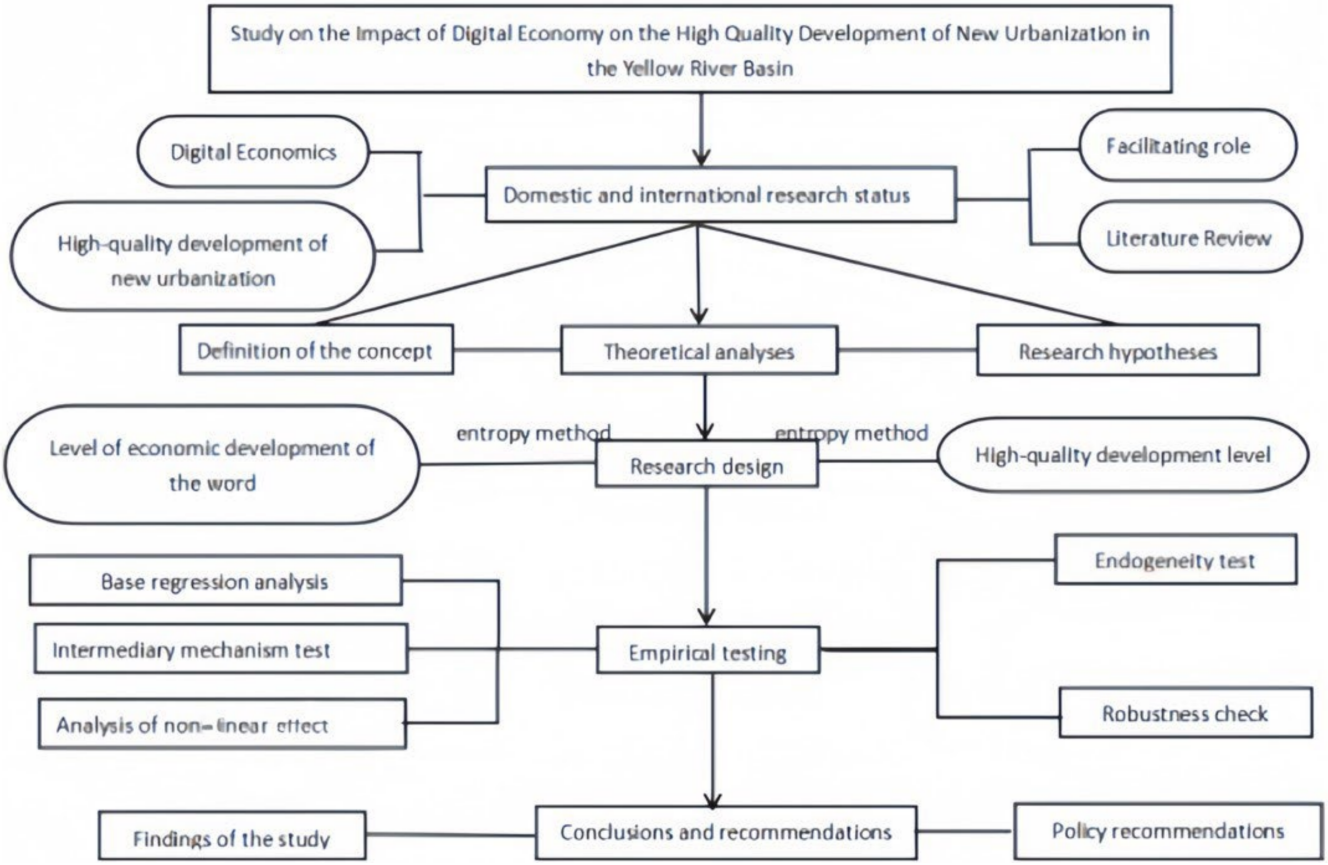


Figure 1. Article framework chart.

2. Literature Review

In September 2016, the G20 Summit provided a definition for the digital economy. It involves economic activities utilizing digitized knowledge and information as primary production factors, modern information networks as crucial carriers, and the efficient application of information and communication technology (ICT) as a significant driver for improving efficiency and optimizing economic structure [1]. According to Wang Changjun (2021), the digital economy, propelled by digital science and technology, fosters synergistic resonance and innovative fusion between data elements and traditional production factors like technology and capital. Its fundamental attributes include innovation, integration, technology, platform, ecology, and empowerment [2]. In 2022, Li Lei developed an evaluation index system for the digital economy. It gauges the level of digital economy development in the Yellow River Basin across four dimensions: digital infrastructure, digital industry development, digital network application, and digital scientific research support. This construction is based on existing pertinent studies [3]. Tu Z. et al. (2024) developed an evaluation index system to assess the level of development of the digital economy, focusing on Internet accessibility and the application of digital convergence [4]. Chen B. et al. (2024) identified four primary indicators (digital industrialization, industrial digitization, digital users, and digital platforms) and seven secondary indicators (digital industry input, digital industry output, digital finance, industry digitization, network penetration, network scale, and digital carriers) to assess the development of China's digital economy [5]. Tomasz (2017) noted that the digital economy can significantly drive the transformation of industrial structure [6]. Wang Yu et al. (2022) concluded that the digital economy can significantly enhance the high-quality development of the Yellow River Basin from the standpoint of industrial structure upgrading [7]. Zhang Lin et al. (2022) concluded that the present digital economy, by examining its core capacity for industrial innovation, has emerged as a new catalyst for industrial economic development, with industrial innovation

serving as the prime mover for digital economy advancement [8]. Yang Xiaoxia et al. (2022) analyze the intrinsic relationship between the digital economy and the industrial chain theoretically, highlighting the potential of the digital economy to stimulate innovation within industrial chains [9]. Stan (2022) argued that through the integration of digital elements, the digital economy can drive the digital transformation of industries [10]. Song Y. et al. (2024) highlighted that the digital economy is emerging as a new driving force to facilitate the transformation of China's industrial structure [11]. Liao S. et al. (2024) noted that the development of the digital economy significantly influences the transformation and upgrading of industrial structure, manifested in its impact on inter-industry structural transformation, intra-industry labor productivity, and the efficiency of industrial resource allocation [12].

Wang Changjun (2021) asserts that the new urbanization strategy represents a comprehensive synthesis of insights gleaned from China's historical urbanization trajectory. It encapsulates China's holistic perspective and forward-looking examination of future urbanization across demographic, environmental, economic, social, and other dimensions. This strategy is distinguished by its focus on people, environmentally friendly and low-carbon approaches, market orientation, multidimensional coordination, and reliance on science and technology [2]. Liao B. (2024) highlighted that new urbanization represents a distinct policy approach for China's urban development. It seeks to address the shortcomings of the "material-based" traditional urbanization, which led to unrefined economic growth and urban–rural disparities. The specific objectives include fostering the citizenship of the agricultural transfer population and promoting coordinated development in urban agglomerations, encompassing large, medium-sized, and small cities, and towns [13]. In 2023, Han Xiuli and colleagues developed an evaluation index system to assess the level of new urbanization. They selected indicators from four dimensions: economic, social, land, and cultural urbanization. The team then evaluated the new urbanization development in nine provinces within the Yellow River Basin spanning from 2009 to 2020 [14]. In 2023, Zhang D. and team proposed a novel approach to urbanization. They suggested evaluating urbanization through five dimensions: population, social development, living services, ecological environment, and living standards. This approach resulted in the construction of an evaluation index system for the development level of new-type urbanization, comprising a total of 18 basic indexes [15]. Hermelin B. (2007) and Michaels G. et al. (2012) demonstrated through empirical research that urbanization enhances technological sophistication and innovation capacity by leveraging the professional division of labor and agglomeration economy. It also fosters industrial structure upgrading. Simultaneously, urbanization elevates technological sophistication and innovation ability, serving as a crucial driver for industrial structure upgrading [16,17]. Song Jinzhao et al. (2022) investigated the coupling and coordination of the new urbanization–industrial structure upgrading–green economy efficiency system in nine provinces and regions within the Yellow River Basin. They discovered significant spatial heterogeneity and pronounced regional imbalance in the degree of coupling and coordination [18]. Pan Xingchen et al. (2023) analyzed the coupling relationship between new urbanization and industrial structure optimization. They indicated that industrial structure upgrading would energize economic development, enhance spatial agglomeration and diffusion effects within urban agglomerations, and drive the construction of new urbanization in the region [19].

The majority of current studies focusing on the digital economy and the high-quality development of new urbanization examine either the entire country or the Yangtze River Economic Belt. Goldfarb et al. (2019) emphasized that digital information can alleviate spatial constraints between urban and rural areas, thereby promoting development in both settings [20]. Yang Peiqing (2020) systematically analyzed the essence and traits of the digital economy. He/she highlighted that digital technology establishes a platform for exchanging resource elements between urban and rural areas, fostering their integrated development [21]. Sun Wenting (2022), through an analysis of the impact of the digital economy in the Yangtze River Economic Belt on farmers' income, highlighted that the

advancement of the digital economy substantially boosted the progress of new urbanization and indirectly contributed to income growth among farmers [22]. Zhao Hua (2023) highlighted that integrating the digital economy into Chinese new urbanization represents a significant milestone, combining the historical urbanization process with China's national context. Furthermore, emphasizing a "people-centered" perspective is crucial for advancing the high-quality development of new urbanization [23]. Xu Zhenhua et al. (2023) suggest that the digital economy has the capacity to enhance the efficiency of urban resource allocation, enlarge urban development space, and fully unlock the potential of new urbanization [24].

In recent years, research into the digital economy and high-quality urban development in the Yellow River Basin has intensified. Zhou Qingxiang et al. (2020) asserted that the digital economy's growth is an inevitable trajectory for economic and social progress in this region. They highlighted the capacity of digital technology to catalyze production, ecology, and life in ways that stimulate high-quality urbanization [25]. Wang Jun et al. (2022) suggested that the digital economy can significantly elevate the standard of high-quality development in the Yellow River Basin, especially benefiting non-resource cities. The impact is most pronounced in upstream and midstream cities compared to downstream ones [26]. Ren Baoping et al. (2023) emphasized that the digital economy embodies the unique innovation, progress, and extensibility inherent in the new economic paradigm. This can optimize the industrial structure of the Yellow River Basin, enhance the efficiency of resource utilization, and drive high-quality development in new urbanization [27]. Zhou Wenhui (2023) and colleagues posit that digital infrastructure, serving as a vital catalyst for the synchronized development of the Yellow River Basin, can facilitate the organic integration of regions along the Yellow River. This fosters increased resilience in economic development and ecological environmental protection through reinforced inter-regional connections, unlocking complementary advantages, fostering win–win cooperation, and establishing a favorable environment of synergistic development, interconnected progress, and shared construction [28].

Existing research primarily focuses on the relationship between the digital economy and industrial structure upgrading, and also between industrial structure upgrading and new forms of urbanization. However, there is limited research on the high-quality development of the digital economy and new urbanization types. Most studies are concentrated nationally and within the Yangtze River Economic Belt, with little attention given to the Yellow River Basin, despite its significant historical importance and role in economic and ecological development [29]. In this study, we focus on the Yellow River Basin, exploring the intricate mechanisms and impactful effects of the digital economy on the high-quality development of new urbanization. Utilizing inter-provincial panel data spanning 2012 to 2021, we assess the progress of the digital economy and the high-quality development of new urbanization in the Yellow River Basin. Additionally, we investigate the influence of the digital economy on the high-quality development of new urbanization and propose policy recommendations to enhance this development in the Yellow River Basin. This paper makes theoretical contributions by providing a comprehensive elaboration of the direct and indirect mechanisms through which the digital economy influences the high-quality development of new urbanization in the Yellow River Basin. This enriches the theoretical research framework of new urbanization. The empirical aspect involves constructing an index system to measure the digital economy's development and an evaluation index system for high-quality new urbanization. After assessing the development levels of the digital economy and high-quality new urbanization in the Yellow River Basin, we analyze the impact of the digital economy on new urbanization quality there. This analysis aids relevant departments in devising policies and measures to foster high-quality new urbanization in the Yellow River Basin, bolstered by the digital economy. This holds practical significance and reference value for relevant departments aiming to introduce policies and measures for advancing high-quality new urbanization in the Yellow River Basin through the digital economy.

3. Theoretical Analysis and Research Hypotheses

The digital economy demonstrates both a superposition and multiplier effect, creating new focal points for economic growth. This underscores the multiplier effect, resulting in the accumulation of fresh advantages and the increase in new kinetic energy for urbanization, facilitated by digital industrialization and industrial digitization.

3.1. Analysis of Direct Action Mechanisms

3.1.1. Advancement of Digital Infrastructure

The digital economy, a prominent force in today's economy and supported by a deep technological legacy, has injected a strong spirit of innovation into the urban development and social governance framework of the Yellow River Basin. This emerging economic model not only provides new theoretical perspectives for urban planning, construction, and management but also rapidly promotes the practical and widespread application of information technology in the region. It enhances the capacity of both urban and rural areas to benefit from digital dividends. A fundamental aspect of the digital economy is achieving precise urban management through intelligent urban infrastructure, Internet of Things (IoT) technology, and big data analysis. In the Yellow River Basin, this approach improves urban operational efficiency and optimizes resource utilization, laying a solid foundation for high-quality new urbanization development. Specifically, the deployment of intelligent transportation systems has improved traffic flow throughout the nine provinces of the Yellow River Basin, reducing congestion, increasing overall transportation efficiency, and providing residents with a more convenient travel experience. Furthermore, the digital economy includes an intelligent energy management system, which effectively reduces energy consumption and promotes the widespread adoption of green energy. This not only provides an innovative response to the demands of new urbanization but also lays a solid foundation for future sustainable development. Driven by the digital economy, these technologies are widely used to enhance urban intelligence and efficiency, providing greater convenience for residents and thus laying a solid foundation for the high-quality development of new urbanization in the Yellow River Basin.

3.1.2. Promoting a Thriving Digital Industry

The rapid expansion of the digital economy has injected new vitality into the Yellow River Basin, fostering novel industries and innovation ecosystems. This has significantly boosted efforts to optimize and upgrade the cities' economic structures. Driven by this digital wave, sectors such as e-commerce, cloud computing, and artificial intelligence have thrived in the Yellow River Basin, emerging as vital catalysts for economic growth. The rapid development of these industries has attracted substantial capital and talent to the cities, transforming the Yellow River Basin into a focal point for global investment and top-tier professionals. The dynamic digital economy stems not only from economic digitization but also generates numerous new jobs and employment opportunities, providing a wide range of choices and development prospects for local residents. Diverse innovative entities, such as high-tech enterprises, business incubators, and research and development (R & D) organizations, have flourished in the Yellow River Basin, establishing an interconnected and mutually beneficial innovation ecosystem. This not only fosters scientific and technological innovation but also drives industrial advancement, imparting a strong impetus for innovation to the local economy. This dynamic innovation environment attracts more entrepreneurial and innovative talent, infusing greater wisdom and vitality into the Yellow River Basin. Furthermore, the evolution of the digital economy has enhanced the competitiveness of cities, making them more attractive. The growing strength in the digital industry and technological innovation has enhanced the global competitiveness of cities in the Yellow River Basin, attracting increased investments and resources. This allure arises not only from unlocking economic development potential but also from improving quality of life and urban governance resulting from digitalization and intelligence.

3.1.3. Promotion of Digital Ecological Sustainability

The rapid emergence of the digital economy has opened new opportunities and propelled efforts towards ecological preservation and sustainable development within the Yellow River Basin. In urban planning and construction, digital technology not only provides intelligent solutions but also plays a crucial supporting role. This technological innovation contributes not only to resource utilization but also to ecological preservation and restoration. Intelligent city management systems, a prominent example of the digital economy, provide essential data support to urban policymakers by continuously monitoring environmental parameters such as air quality, water quality, and waste management. This precise monitoring and data analysis helps cities respond more quickly and accurately to environmental concerns. As a result, there has been a decrease in environmental pollution, improvement in air and water quality, and a significant increase in ecological management efficiency. These initiatives safeguard the ecosystem of the Yellow River Basin and promote its robust development. Digital technology supports environmental governance and plays a pivotal role in fostering the growth of the green industry. The digital economy strongly supports the development of renewable energy, clean technology, and the circular economy, providing a sustainable path for urbanization in the Yellow River Basin. The eco-friendly features of the digital economy foster high-quality and sustainable urbanization in the Yellow River Basin and play a crucial role in protecting and restoring its natural resources and ecosystems. This digital model combines ecological protection and economic development to establish a sustainable foundation for the future of the Yellow River Basin, ensuring a positive interaction between the ecological environment and economic growth.

Hypothesis H1: *The digital economy can directly contribute to the high-quality development of new urbanization in the Yellow River Basin.*

3.2. Analysis of the Indirect Mechanism of Action

The digital economy catalyzes the upgrading of industrial structure and fosters high-quality economic development. Upgrading industrial structure serves as an intrinsic driver and a crucial prerequisite for fostering high-quality development in China's new urbanization.

3.2.1. The Digital Economy Contributes to the Advancement of the Primary Industry

Despite agriculture's enduring significance in the Yellow River Basin region, challenges including low resource utilization efficiency, unstable agricultural product quality, and limited growth in farmers' income have arisen due to constraints imposed by the traditional agricultural production model and changes in market demand. The digital economy introduces innovative concepts and provides technical support for upgrading and transforming the primary industry. The use of digital technology can optimize the agricultural production process, improving both efficiency and quality. Leveraging big data analysis and artificial intelligence technology provides a scientific basis for agricultural decision-making, assisting farmers in making informed management decisions and improving the stability and predictability of agricultural production. Moreover, the digital economy introduces new channels and methods for marketing and distributing agricultural products. Through the utilization of e-commerce platforms, logistics, and distribution systems, agricultural goods can directly connect with consumers, fostering closer relationships between producers and consumers, thus enhancing the traceability and brand recognition of agricultural products. Furthermore, digital technology can facilitate the comprehensive processing and value addition of agricultural products, aiding farmers in converting them into high-value processed food items or agricultural by-products, thereby extending and enhancing the agricultural industry chain.

3.2.2. Digital Economy Boosts the Secondary Sector

The ascent of the digital economy, combined with technological advancements, presents novel opportunities and platforms for driving structural changes in the secondary industry within the Yellow River Basin. This stimulates the development and innovation of emerging industries in return. The integration of digital technology is crucial in driving the intelligent transformation and upgrading of traditional industries. Within the industrial framework of the Yellow River Basin, deploying technologies such as digital production, intelligent manufacturing, and the industrial Internet can boost production efficiency, lower costs, enhance product quality, and bolster overall competitiveness for enterprises. The adoption of the digital economy enables intelligent enhancements in industrial production, driving the restructuring of the industrial landscape and fostering the cultivation and development of new industries. The digital economy provides an innovative development platform for urbanization in the Yellow River Basin. Digital technology and informatization can build the infrastructure and framework for smart cities, facilitating effective urban management and public services. Developing digital infrastructures in areas like transportation, energy, and the environment can enhance urban intelligence, thereby enhancing residents' quality of life and offering convenient public services. Moreover, the digital economy stimulates the development of emerging industries, innovation, and entrepreneurship, injecting new impetus into economic growth during the new urbanization of the Yellow River Basin.

3.2.3. The Digital Economy Fosters the Growth of the Tertiary Industry

The application and innovation of digital technology have brought about significant changes and development prospects for the tertiary industry in the Yellow River Basin through the digital economy. Driven by the digital economy, traditional service industries are encouraged to embark on digital transformation. For example, the catering, retail, and tourism sectors can improve service convenience and efficiency by utilizing digital technologies such as mobile payment, online booking, and e-commerce. This transformation enhances productivity and quality in the service sector, fostering its development and increasing urban consumption. Moreover, digital technologies have broadened the range of business models and opportunities for service providers, including the sharing economy, online education, and telemedicine, fueling the diversification and specialization of the service industry. The rapid growth of the digital economy has propelled e-commerce development, introducing new retail and business models in the Yellow River Basin. The establishment and implementation of e-commerce platforms have significantly transformed business activities in the Yellow River Basin. Residents can seamlessly integrate online and offline consumption by purchasing goods and services through e-commerce platforms. The rise of e-commerce has expanded development opportunities for merchants and entrepreneurs in the Yellow River Basin. Furthermore, the surge in the digital economy offers vast opportunities for innovation and entrepreneurship. In the Yellow River Basin, young individuals and entrepreneurs engage in innovative entrepreneurial activities facilitated by digital technology. This fosters the growth of the tertiary industry and optimizes the city's economic structure. The dynamism in innovation and entrepreneurship injects fresh vitality into urban development in the Yellow River Basin. In summary, the digital economy significantly advances the high-quality development of new urbanization in the Yellow River Basin by driving the structural upgrade of the tertiary industry.

Hypothesis H2: *The digital economy can indirectly promote the high-quality development of new urbanization in the Yellow River Basin by promoting the upgrading of industrial structure.*

3.3. Analysis of Non-Linear Effects

The impact of the digital economy on the high-quality development of new urbanization in the Yellow River Basin varies with different stages of its development and changes in scale. Unlike the traditional economy, the digital economy embodies both informatization and marketization, and its growth adheres to Metcalfe's Law [30]. This law stipulates that

the impact of the digital economy on the high-quality development of new urbanization is non-linear.

During the initial development stage, the digital economy may impede the high-quality progress of new urbanization in the Yellow River Basin. First, the early development of the digital economy could result in the disappearance of or reduction in certain traditional industries and employment opportunities. The adoption of digitalization and automation technologies may substitute for labor-intensive jobs, impeding specific regions and populations in the urbanization process, thereby leading to a relatively modest promotion of new urbanization. Second, the initial stage of digital economy development is characterized by imbalance, resulting in a digital divide—disparities in digital technologies and applications across regions, industries, and individuals. Throughout the new urbanization process, a widening digital divide might hinder certain regions and populations from fully integrating into digital economy development, thus impeding the high-quality progression of new urbanization in the Yellow River Basin. This digital gap may become more evident during the initial development stage, leading to a non-linear marginal effect. Ultimately, the development of the digital economy hinges on adequate infrastructure and human resources. Nevertheless, during the initial developmental phase, the Yellow River Basin may encounter challenges such as insufficient infrastructure construction and human resource allocation, limiting the digital economy's influence on the high-quality advancement of new urbanization. These constraints may gradually exacerbate, resulting in the emergence of non-linear attributes in the digital economy's influence on the high-quality development of new urbanization in the Yellow River Basin. In the later developmental phases, the digital economy may non-linearly foster high-quality advancement in new urbanization within the Yellow River Basin. Initially, subsequent to the widespread integration of digital technology, its innovation and implementation can enhance urban intelligence, streamline planning and management, enhance public services, enrich quality of life, and propel the new urbanization process in the Yellow River Basin. Digital and intelligent technology can transform the production methods and organization of traditional industries, leading to the optimization and upgrading of industrial structure. This facilitates urban economic development and promotes the high-quality development of new urbanization in the Yellow River Basin. Lastly, in the iterative upgrading of the digital economy, the widespread deployment of digital equipment and continual enhancement of digital economic infrastructure have resulted in visible returns on previous investments. This provides enhanced support for new urbanization, promotes the flow of information and resources, and expands connectivity between urban and rural areas, thereby driving the high-quality development of new urbanization in the Yellow River Basin.

Hypothesis H3: *The impact of the digital economy on the high-quality development of new urbanization in the Yellow River Basin has non-linear characteristics.*

4. Research Design

4.1. Measuring the Development Level of the Digital Economy in the Yellow River Basin

4.1.1. Construction of the Measurement Indicator System

Utilizing available data and drawing upon the works of Li Lei [3], Chen Bowen [5], Zhao Tao [31], and other relevant literature, along with insights from the "14th Five-Year Plan for the Development of the Digital Economy", we formulated an indicator system to assess the progress of the digital economy. This system encompasses the groundwork of digital economization, digitized industries, and digitized applications (refer to Table 1).

Table 1. Indicator system for measuring the development of the digital economy.

Objective A	Dimension Indicator B	Characterization Indicator C	Unit of Measure	Indicator Properties	Weight %
Digital Economy	Digital Foundations B1	C1 Number of websites	ten thousand	forward	17.730
		C2 Internet broadband access port	ten thousand	forward	11.571
		C3 Cell phone penetration rate	departments/ 100 persons	forward	2.230
		C4 Length of long-distance fiber optic cable lines	kilometer	forward	6.453
	Digital Industry B2	C5 Total telecommunication services	billions	forward	18.416
		C6 Total postal operations	billions	forward	20.310
		C7 Percentage of people employed in digital industries	%	forward	4.937
	Digital Applications B5	C8 Digital Life Index	-	forward	2.428
		C9 Number of digital TV subscribers	ducal title meaning lord of 10,000 households	forward	12.413
		C10 Digital Inclusive Finance Index	/	forward	3.512

Figure 2 shows the research area of this paper: Yellow River Basin. This paper divides the Yellow River basin into upper Yellow River basin, middle Yellow River basin and lower Yellow River basin.



Figure 2. Map of the Yellow River Basin.

4.1.2. Data Sources and Processing

(1) Data Source: This study focuses on nine provinces and regions within the Yellow River Basin, collecting data from 2012 to 2021 for analysis. The indicator data in this paper are primarily sourced from the China Statistical Yearbook, China Tertiary Industry Statistical Yearbook, China Environmental Statistical Yearbook, China Urban Statistical Yearbook, as well as the statistical yearbooks of individual provinces and regions. The National Bureau of Statistics provided data from 2013 to 2022. Missing data are addressed through interpolation methods.

(2) This paper employs the entropy value method to assess the evaluation index system, an objective assignment approach. The method utilizes the variability of each index to derive their weights, mitigating subjective weight determination and information

overlap among multiple variables. This process establishes an objective foundation for the evaluation [32]. The entropy value indicates the system's level of chaos; higher chaos and data discreteness result in smaller entropy values and larger corresponding weights. Conversely, greater data centralization leads to higher entropy values and smaller corresponding weights.

Indicator setting: There are m evaluation samples, n evaluation indicators, and T years.

$$X = \left\{ X_{ij}^{t} \right\}_{mT \times n} \tag{1}$$

Equation (1) represents the value of the jth indicator in the ith province and city in year t.

Processing data: the data are standardized without dimension. Data translation is also performed in this article to prevent data from being 0 or invalid.

The positive indicator and negative indicator transformation formulae are:

$$Y_{ij}^{t} = \frac{X_{ij}^{t} - X_{jmin}}{X_{jmax} - X_{jmin}} + 0.0001 \quad Y_{ij}^{t} = \frac{X_{jmax} - X_{ij}^{t}}{X_{jmax} - X_{jmin}} + 0.0001 \tag{2}$$

Equation (2): i = 1, 2, $\cdots$ $\cdots$, m (m = 9); j = 1, 2, $\cdots$ $\cdots$, n (n = 30 for the evaluation index of high-quality development of new urbanization in the Yellow River Basin and n = 14 for the measurement index of the level of development of the digital economy in the Yellow River Basin); and t = 1, 2, $\cdots$ $\cdots$, T (T = 10).

Calculation of the entropy value:

$$e_j = -K \sum_{t=1}^{T} \sum_{i=1}^{m} P_{ij}^{t} ln P_{ij}^{t} \tag{3}$$

In Equation (3), e_j is the entropy value of the j indicator, $0 \le e_j \le 1$; $p_{ij}^{t} = y_{ij}^{t} / \sum_{t=1}^{T} \sum_{i=1}^{m} y_{ij}^{t}$, p_{ij}^{t} is the proportion of the value of the ith indicator under the jth indicator in the tth year; and $k = 1/\ln(mT)$, and k is determined by the number of provinces and cities and the number of years.

Determination of weights:

$$W_j = \frac{(1 - e_j)}{\sum_{j=1}^{n} (1 - e_j)} \tag{4}$$

In Equation (4), is the weight of the jth indicator, $0 \le w_j \le 1$; $\sum_{j=1}^{n} w_j = 1$; $(1 - e_j)$ is called the coefficient of variation.

Measurement score:

$$S_i = \sum_{j=1}^{n} w_j \times Y_{ij}^{t} \tag{5}$$

In Equation (5), is the comprehensive evaluation score.

4.1.3. Measurement Results and Analysis

As shown in Table 2, the digital economy of provinces and regions in the Yellow River Basin has continued to grow in the past decade. Shandong and Henan are the top two regions in terms of digital economy development. Shandong consistently ranked first in the comprehensive digital economy development index each year over the decade. The digitalized industry stood out in dimensional indicators, with the total telecom business indicator making the greatest contribution. Shandong Province has proactively aligned with the national digital economy development strategy. Shandong Province has actively responded to the national strategy for the development of the digital economy and accelerated the development of the digital economy through a number of initiatives. It is committed to promoting the integration and development of information technology and traditional industries, and promoting the digitalization, networking and intelligent

upgrading of industries. By promoting the digital transformation of manufacturing and agriculture services and other industries, it improves production efficiency and quality and enhances industrial competitiveness. It actively promotes the construction of digital infrastructure, accelerates the construction of digital infrastructure such as 5G networks, the Internet of Things, and big data centers, and improves network speed and coverage to provide strong support for the development of the digital economy. At the same time, Shandong Province also strengthens talent cultivation and introduction, is building a digital economy talent team, and promotes the cultivation of digital economy talents and innovation and entrepreneurship. Shandong Province is also actively building an ecosystem for the development of the digital economy, and promotes the formation of digital economy industry agglomeration and an atmosphere of innovation and entrepreneurship. Sichuan Province consistently secures the second position in the yearly comprehensive index of digital economy development. Its digital industries are notably prominent, with the total telecommunications business making the most significant contribution among the dimensional indicators. Sichuan's digital economy has consistently and robustly developed, demonstrating strong growth momentum. The development of digital infrastructure, the growth of digital industries, and the extensive adoption of digital technologies have significantly boosted the province's economic growth and fostered innovation. The provinces at the lowest ranks are Qinghai and Ningxia. Qinghai province consistently ranks in the bottom three in the yearly composite index of digital economic development. The digital industry lags in the dimensional indicators, with the total telecommunications business indicator having the most significant impact. In the last decade, Qinghai Province's digital economy development has not kept pace with the national digitization trend, resulting in an inadequate digital infrastructure, a relatively weak digital industry, and insufficient application of digital technologies. This has restrained its potential for economic growth and social progress. Ningxia Province has consistently ranked among the bottom three provinces in the overall index of digital economic development for the past decade. The digital industry is lagging behind in various indicators, with the total telecommunication business indicator having the most significant impact. Located in the lower half of the Yellow River Basin, Ningxia Province faces constraints on the growth of its digital economy due to a lagging digitalization sector, slow development pace, inadequate investment in digital infrastructure construction, and insufficient promotion of digital technology applications.

Table 2. Composite index of digital economy development.

Provinces	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2012–2021 Average Value
Qinghai	0.048	0.060	0.068	0.075	0.082	0.093	0.109	0.114	0.123	0.107	0.088
Sichuan	0.175	0.259	0.307	0.367	0.400	0.479	0.572	0.666	0.751	0.580	0.455
Gansu	0.042	0.065	0.070	0.086	0.090	0.113	0.138	0.169	0.188	0.144	0.111
Ningxia	0.028	0.044	0.057	0.064	0.076	0.085	0.103	0.108	0.116	0.109	0.079
Neimenggu	0.107	0.131	0.138	0.154	0.163	0.178	0.201	0.220	0.236	0.193	0.172
Shaanxi	0.133	0.154	0.169	0.198	0.228	0.263	0.321	0.368	0.409	0.320	0.256
Shanxi	0.090	0.122	0.131	0.159	0.165	0.186	0.214	0.247	0.282	0.222	0.182
Henan	0.114	0.180	0.213	0.295	0.360	0.432	0.532	0.621	0.722	0.518	0.399
Shandong	0.260	0.321	0.376	0.458	0.519	0.595	0.681	0.774	0.868	0.663	0.551

4.2. Evaluation of High-Quality Development of New Urbanization

4.2.1. Evaluation Index System Construction

Based on Han Xiuli [14], Song Jinzhao [18], Yang Peiqing [33], and other related literature, as well as the guiding ideology of the "14th Five-Year Plan" for the development of the digital economy and the "14th Five-Year Plan" for the implementation of new-type townships, and adhering to the principles of science, systematicity, objectivity, precision, and operability, we constructed a system of indicators for evaluating the high-quality development of a new type of townships (Table 3).

Table 3. Evaluation index system for high-quality development of new urbanization.

Objective A	Dimension Indicator B	Characterization Indicator C	Unit of Measure	Indicator Properties	Weight %
New Urbanization	economic urbanization B1	C1 GDP per capita	CNY/person	forward	2.155
		C2 Fixed asset investment per capita	CNY ten thousand	Positive	2.474
		C3 Local fiscal revenue per capita	CNY	Positive	2.108
		C4 E-commerce sales	Billion	Positive	10.140
		C5 Technology market turnover	Billion	Positive	12.339
New Urbanization	urbanization of population B2	C6 Urban registered unemployment rate	%	Negative	0.983
		C7 Share of urban population in resident population	%	Positive	1.356
	social urbanization B3	C8 Public Transportation Vehicles per 10,000 persons	Visualizer	Positive	1.532
		C9 Health technicians per 10,000 people	Person	Positive	1.906
		C10 Public toilets per 10,000 people	Seat	Positive	4.68
		C11 Public libraries per capita	Book/person	Positive	2.834
		C12 Share of expenditure on social security and employment	%	Positive	1.621
		C13 Participation rate of urban basic pension insurance	%	Positive	2.1
		C14 Participation rate of basic medical insurance in cities and towns	%	Positive	4.747
	spatial urbanization B4	C15 Urban construction land area per capita	Square meters/person	Positive	3.244
		C16 Urban built-up area as a share of total area	%	Positive	2.464
		C17 Housing floor space per capita	Square meters	Positive	1.556
		C18 Urban road area per capita	Square meters	Positive	3.208
		C19 Density of road network	Kilometers per square kilometer	Positive	2.23
	ecological urbanization B5	C20 SO_2 emissions	Million tons	Negative	6.185
		C21 Wastewater emission	Million tons	Negative	6.426
		C22 Green space per capita	Square meters/person	Positive	3.087
		C23 Greening coverage rate of built-up areas	%	Positive	1.52
		C24 Comprehensive utilization rate of solid waste	%	Positive	2.351
		C25 Harmless treatment rate of domestic garbage	%	Positive	1.054
	integration of urban and rural areas B6	C26 Per capita disposable income ratio of urban and rural residents	-	Negative	1.866
		C27 Ratio of per capita consumption level in urban and rural areas	-	Negative	1.266
		C28 Engel's coefficient ratio of urban and rural areas	-	Negative	0.768
		C29 Ratio of the number of urban and rural residents covered by the minimum subsistence guarantee	-	Negative	9.33
		C30 Ratio of the number of beds in medical institutions per 10,000 people in urban and rural areas	-	Negative	2.469

4.2.2. Data Sources and Processing

(1) Data sources: China Statistical Yearbook, China Tertiary Industry Statistical Yearbook, China Environmental Statistical Yearbook, China Urban Statistical Yearbook, statistical yearbooks of provinces and regions, and the National Bureau of Statistics from 2013 to 2022. For individual missing data, the interpolation method was used to supplement.
(2) Data processing: Since the entropy method is used to calculate the composite index of digital economy development and the composite index of high-quality development of new urbanization, the data processing is the same as in the previous section.

4.2.3. Evaluation Results and Analysis

As shown in Table 4, the high-quality development of new-type urbanization in the provinces and regions of the Yellow River Basin shows an upward trend. Shandong and Shaanxi are the top two provinces in terms of this development. Shandong Province consistently secures the first position in the annual comprehensive index of high-quality new urbanization development, with a notable emphasis on urban-rural integration among its dimensional indicators. The indicator demonstrating the ratio of urban and rural residents living above the minimum living standard makes the most substantial contribution. Over the past decade, Shandong Province has achieved significant advancements in the high-quality development of new urbanization. By implementing measures like enhancing urban infrastructure, promoting urban–rural integration, and fostering rural development, the province has successfully elevated the living standards of both urban and rural residents. This has led to the coordinated development of urbanization and rural modernization, making a substantial contribution to the economic prosperity and social progress of Shandong Province. For the last decade, Shaanxi Province consistently secured the second position in the comprehensive index of high-quality new urbanization development. Urban–rural integration stands out among the dimensional indicators, and the indicator measuring the ratio of urban and rural residents with minimum subsistence protection makes the most significant contribution. Shaanxi Province has consistently devoted efforts to urban and rural planning as well as the enhancement of quality of life, injecting new vitality into the urbanization process. Following in the ranking are Qinghai and Gansu provinces. Qinghai Province faces challenges in the high-quality development of new urbanization. Its relatively low ranking suggests significant potential for improvement in urban–rural integration, urban planning, and quality of life. Gansu Province ranks among the bottom three in the annual composite index of high-quality new urbanization development. Urban–rural integration lags behind in dimensional indicators, with the ratio of urban and rural residents receiving minimum subsistence allowance having the greatest impact. Gansu Province exhibits unsatisfactory performance and a relatively low ranking in the high-quality development of new urbanization. This may be linked to the complexity of geographic and natural conditions, uneven resource distribution, and delayed infrastructure development. Various policies can be implemented to incentivize the flow of capital and resources towards urbanization, while enhancing the planning of urban–rural integration for achieving a more balanced development.

Table 4. Composite index of high-quality development of new urbanization.

Provinces	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2012–2021 Average Value
Qinghai	0.192	0.206	0.202	0.220	0.223	0.358	0.269	0.275	0.279	0.288	0.251
Sichuan	0.235	0.245	0.261	0.271	0.291	0.359	0.371	0.404	0.415	0.436	0.329
Gansu	0.169	0.177	0.201	0.207	0.205	0.301	0.269	0.288	0.300	0.323	0.244
Ningxia	0.270	0.289	0.309	0.305	0.307	0.347	0.319	0.356	0.356	0.366	0.322
Neimenggu	0.296	0.308	0.337	0.342	0.340	0.412	0.378	0.385	0.389	0.405	0.359
Shaanxi	0.276	0.299	0.326	0.324	0.321	0.364	0.390	0.421	0.435	0.476	0.363
Shanxi	0.232	0.247	0.259	0.257	0.245	0.292	0.277	0.289	0.301	0.323	0.272
Henan	0.257	0.259	0.291	0.293	0.285	0.398	0.356	0.358	0.385	0.401	0.328
Shandong	0.361	0.374	0.403	0.448	0.447	0.496	0.498	0.500	0.548	0.613	0.469

5. Empirical Testing

5.1. Variable Design

5.1.1. Explanatory Variable

The level of high-quality development of new urbanization (Urban) was used as the explanatory variable.

5.1.2. Core Explanatory Variables

The level of the digital economy (Dige) was used as the core explanatory variable.

5.1.3. Intermediary Variable

The mediator variable chosen in this study is industrial structure upgrading (Indus), determined by the proportion of added value from primary, secondary, and tertiary industries to per capita GDP. A higher value indicates a more advanced industrial structure. The digital economy has emerged as a crucial driver for advancing China's industrial restructuring and upgrading in the 14th Five-Year Plan period. This progress is notably expedited through efficient and optimal resource allocation. Considering industrial structure upgrading as a mediating variable facilitates the examination of the indirect influence mechanism of the digital economy on the high-quality development of new urbanization.

5.1.4. Control Variable

Table 5 shows the control variables selected in this paper.

Table 5. Description of control variables.

Control Variables	Variables	Meaning of the Indicator
Level of scientific and technological development	Local finance expenditure on science and technology/local finance general budget expenditure	Reflects the degree of scientific and technological development in a country or region.
Level of human capital	Number of college students enrolled in general colleges and universities/number of resident populations	Reflects the quality of a country's or region's labor force
Level of government intervention	Government Network Transparency Index	Reflects the economic functions of a country's government, especially the central government.
Level of openness	Total import and export of foreign-Invested enterprises	Reflects the total size of a country's foreign trade.
Level of financial development	Added value of financial industry/regional GDP	Reflects the economic strength of a country or region

5.2. Analysis of Baseline Regression Results

In order to study the impact of the digital economy on the high-quality development of new urbanization in the Yellow River Basin, this paper establishes a basic model targeting the direct transmission mechanism:

$$Urban_{i,t} = \alpha_0 + \alpha_1 Dige_{i,t} + \alpha_2 C_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (6)$$

In Equation (6), i stands for area, t stands for time, $C_{i,t}$ is a control variable, μ_i is an individual fixed effect, δ_t indicates a time fixed effect, and $\varepsilon_{i,t}$ is a randomized disturbance term.

Table 6 measures the role of digital economy in promoting the high-quality development of new urbanization in the Yellow River Basin by using the fixed-effect model. The development of the digital economy has provided new opportunities and impetus for urbanization, injecting new energy and dynamism into the urbanization process. In Model (1), where no control variables are included, the estimated coefficient of the primary explanatory variable, the level of digital economy development, is significantly positive,

surpassing the 1% significance level. This outcome illustrates the evident positive impact of the digital economy on fostering high-quality development within the new urbanization context of the Yellow River Basin, thus confirming Hypothesis H1. Models (2) to (5) represent the regression outcomes after considering control variables. In recent years, due to heightened attention and support from the state, the innovation capacity and technological prowess of the Yellow River Basin have shown improvement. A substantial correlation exists between the advancement in science and technology and the degree of high-quality new urbanization development. This correlation implies that augmenting regional financial investments in science and technology within the Yellow River Basin serves not only as essential financial backing but also fosters the quality advancement of new urbanization, bolstering local economic prosperity and societal progress. Investing in education, training, and enhancing human capital is crucial for achieving quality development in new urbanization, particularly in the Yellow River Basin. A higher level of human capital development in this region correlates with greater advancements in new urbanization quality. Governance challenges and contradictions persist in the Yellow River Basin government's administration. These issues, to some extent, hinder the effective implementation of key national strategies in the region. Urban areas that exhibit a high degree of openness to the external world often experience superior development in new urbanization. This is due to their capability to harness external resources and opportunities, leading to a more sustainable and prosperous urbanization process. The high-quality development of new urbanization in the Yellow River Basin can be hindered by financial development, influenced by factors such as excessive financialization, financial risks, widening wealth disparity, and the influence of government policies.

Table 6. Direct effects benchmark regression results.

New Urbanization Quality Development Index (Urban)						
Variant	**Model (1)**	**Model (2)**	**Model (3)**	**Model (4)**	**Model (5)**	**Model (6)**
Dige	0.3695 ***	0.2435 ***	0.3308 ***	0.3676 ***	0.3023 ***	0.3252 ***
	(11.56)	(7.60)	(9.85)	(12.45)	(9.34)	(8.54)
Science		0.0394 ***				
		(6.63)				
Study			2.2499 ***			
			(2.83)			
Government				−0.4275 ***		
				(−3.83)		
InOpen					0.1949 ***	
					(4.49)	
Fiscal						−0.5258 **
						(−2.05)
Constant term	0.2323 ***	−0.1179 ***	0.1983 ***	0.3682 ***	0.2258 ***	0.2776 ***
	(25.98)	(−2.21)	(13.44)	(10.10)	(27.67)	(11.67)
City fixed	YES	YES	YES	YES	YES	YES
Year fixed	YES	YES	YES	YES	YES	YES
Number of periods	10	10	10	10	10	10
Number of cities	9	9	9	9	9	9
R^2	0.5255	0.4822	0.5282	0.5632	0.5525	0.5180

Note: In Table 6, *, ** and *** indicate passing the significance level of 10%, 5% and 1% respectively, and the robust corrected T-statistic is in parentheses, and the *p*-value of the digital economy is all < 0.01, indicating that all pass the significance level test.

5.3. Intermediary Mechanism Test

To investigate the potential indirect impact of the digital economy on the high-quality development of new urbanization, we employ industrial structure upgrading as a mediating variable. This helps assess whether the digital economy enhances the high-quality

development of new urbanization in the Yellow River Basin through improvements in industrial structure.

$$Industrial_{i,t} = \beta_0 + \beta_1 Dige_{i,t} + \beta_3 C_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (7)$$

$$Urban_{i,t} = \varphi_0 + \varphi_1 Dige_{i,t} + \varphi_2 Industrial_{i,t} + \varphi_3 C_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (8)$$

In Model (1), the significance level of the primary explanatory variable, the digital economy, exceeds 1%, reaffirming its substantial role in promoting the high-quality development of new urbanization in the Yellow River Basin. Model (2) examines the association between the digital economy and the mediating factor, industrial structure upgrading. The findings reveal a positive regression coefficient for digital economic development, surpassing the 1% significance level. This suggests a positive influence of the digital economy on industrial structure upgrading. Model (3) examines the impact of industrial structure upgrading on the high-quality development of new urbanization. The positive regression coefficient, surpassing the 1% significance level, suggests that industrial structure upgrading promotes high-quality new urbanization. In Model (4), the association between the digital economy, high-quality new urbanization, and industrial structure upgrading is investigated. The conclusion drawn is that industrial structure upgrading serves as a pivotal factor in the digital economy's promotion of high-quality new urbanization in the Yellow River Basin, validating Hypothesis H2 as a functional mechanism (Table 7).

Table 7. Indirect effects benchmark regression results.

Variant	Urban (1)	InIndus (2)	Urban (3)	Urban (4)
Dige	0.3695 ***	0.0634 ***		0.3501 ***
	(11.56)	(17.29)		(5.00)
InIndus			4.6627 ***	0.3052(0.31)
			(9.08)	
Constant term	0.2323 ***	0.4462 ***	−1.8294 ***	0.0961
	(25.98)	(435.15)	(−7.70)	(0.22)
City fixed	YES	YES	YES	YES
Year fixed	YES	YES	YES	YES
Number of periods	10	10	10	10
Number of cities	9	9	9	9
R^2	0.5255	0.9303	0.3602	0.4211

Note: *, **, and *** denote significance levels through 10%, 5%, and 1%, respectively, and Robust-corrected t-statistics are in parentheses. Both the digital economy and the upgrading of industrial structure can improve the high-quality development level of new urbanization.

5.4. Analysis of Non-linear Effects

Drawing on Hansen's (1999) panel threshold model [34] to examine the possible threshold effect of the digital economy on the high-quality development of new urbanization, the threshold model is set as follows:

$$\begin{aligned} Urban_{i,t} = \theta_0 + \theta_1 Dige_{i,t} I \times (Dige_{i,t} \le \gamma_1) + \theta_2 Dige_{i,t} I \times (\gamma_1 \le Dige_{i,t} \le \gamma_2) + \\ \cdots + \theta_{n+1} Dige_{i,t} I \times (\gamma_n < Dige_{i,t}) + \mu_i + \delta_t + \varepsilon_{i,t} \end{aligned} \quad (9)$$

In Equation (9), $Dige_{i,t}$ is the digital economy threshold variable; γ is the threshold value to be estimated; and I (·) is denoted in Table 8 as the threshold effect test results moderator function, which takes the value of 1 when the condition in parentheses is satisfied, and 0 otherwise.

Initially, Hansen's bootstrap method tests the threshold's existence between two variables to establish the model's specific form and threshold value. This paper delves into a theoretical exploration of the non-linear spillover effect of the digital economy on advancing high-quality new urbanization, employing the digital economy as the threshold variable and considering hypotheses regarding single, double, and triple thresholds. Prior to threshold model estimation, the BS sampling method is employed to ascertain panel

threshold presence and quantity [35]. After 1000 rounds of repeated sampling, this paper successfully passed the single-threshold test. The regression results are presented in Table 8.

Table 8. Threshold effect test results.

Inspect	F-Statistics Value	*p*-Value	Number of BS	Moderator Variable		
				10%	5%	1%
Single Threshold Test	18.19 ***	0.0060	1000	10.9938	13.2522	16.8786
Double Threshold Test	6.66	0.2580	1000	9.6166	11.8741	19.7747
Triple Threshold Test	4.04	0.4800	1000	8.5078	11.9607	18.6790

Note: *, **, and *** denote significance levels through 10%, 5%, and 1%, respectively, and Robust-corrected t-statistics are in parentheses. As shown in Table 8, only a single threshold value passed the 1% significance level, with an F-value of 18.19.

As shown in Table 9, when the threshold value of digital economy is 0.0821, when the threshold value is greater than the threshold value and when the threshold value is less than the threshold value, the promotion effect on the high-quality development of new urbanization is shown. For Dige < threshold 0.0821, the coefficient indicating the impact of the digital economy on the high-quality development of new townships and cities is −0.4289. During the initial stage of digital economy development in the Yellow River Basin, the full realization of the "digital dividend" is hindered by the limited digital scale and user base. Significant investments are required to enhance digital infrastructure, industry scale, and related aspects. Nevertheless, the extended initial investment cycle and limited digital economic development often result in more investment with fewer immediate returns. This dynamic affects the early stages of digital economy development and its influence on novel urbanization. The early phase of digital economic development does not significantly contribute to promoting high-quality development in new urbanization. However, as the digital economy continues to develop and reaches a specific threshold (0.0821 < Dige), the coefficient of influence on the high-quality development of new urbanization is 0.3564. This suggests that the expanding scale of the digital economy, the iterative upgrading process, large-scale input and use of digital equipment, and constant improvement of digital infrastructure lead to realized benefits from prior investments. The transaction cost of interaction between economic subjects and the marginal cost of digital technology research and development are continuously decreasing. The role of the digital economy in promoting high-quality development in new urbanization becomes increasingly evident, signifying a significant increase. The growing digital economy positively contributes to the expansion of social scope and the enhancement of economic quality, particularly in the Yellow River Basin, thus confirming the validity of Hypothesis H3.

Table 9. Regression results of the threshold model.

Variant	Moderator Variable
Dige·I (Th $\leq$ 0.0821)	−0.4289 **
	(−2.76)
Dige·I (Th > 0.0821)	0.3564 ***
	(7.91)
City Fixed	YES
Year Fixed	YES
Number of periods	10

Note: *, **, and *** denote significance levels through 10%, 5%, and 1%, respectively, and Robust-corrected t-statistics are in parentheses. As shown in Table 9, when the threshold value of digital economy is $\leq$0.0821, the significance level of 5% can be passed; When the digital economy threshold value is $\geq$0.0821, the significance level of 1% can be passed.

5.5. Endogeneity Test

In the rapidly evolving era of digitization and intelligence, the digital economy consistently drives the high-quality advancement of new urbanization. This advancement, in turn, acts as a pivotal force propelling the dynamic growth of the digital economy. The robust growth of the digital economy significantly contributes to advancing high-quality development in the Yellow River Basin's new urbanization. Simultaneously, as the level of new urbanization improves, regional infrastructure may see corresponding enhancements. This, in turn, stimulates the amelioration of digital infrastructure and fosters the development of the digital economy. Hence, a mutually reinforcing two-way relationship exists between the digital economy and new urbanization, potentially leading to endogenous issues. Utilizing the findings of Huang Qunhui et al. (2022) [36], we choose the interaction term between the number of fixed-line telephones per 100 people in 1984 and the national Internet penetration rate from the preceding year as the initial instrumental variable. Simultaneously, we employ the lagged term of the Digital Economy Index (dige) with a lag of 1 period as the second instrumental variable for the test. The corresponding estimation results are presented in Table 10.

Table 10. Instrumental variable test results.

Variant	Cities' 1984 Fixed Telephones per 100 Inhabitants × National Internet Investment in the Previous Year		Lag Terms for Lag 1 of the Digital Economy Index (Dige)	
	Model (1)	Model (2)	Model (3)	Model (4)
	Dige	Urban	Dige	
IV-1	0.0232 ***			
	(7.76)			
Dige		0.0132 ***		
		(11.91)		
IV-2			0.7863 ***	
			(16.70)	
Dige				0.3540 ***
				(12.81)
Constant term	−0.1261 **	0.1092 **	0.0759 ***	0.2467 ***
(math.)	(−2.52)	(5.87)	(5.87)	(32.50)
Urban fixed	YES	YES	YES	YES
Year fixed	YES	YES	YES	YES
Number of periods	10	10	10	10
Number of cities	9	9	9	9

Note: *, **, and *** denote significance levels through 10%, 5%, and 1%, respectively, and Robust-corrected t-statistics are in parentheses. As shown in Table 10, the digital economy can still pass the significance level of 1% when the endogeneity test is conducted using the method of replacing explanatory variables and lagging one stage.

Observing the initial phases of models (1) and (3), it is evident that the two instrumental variables exhibit a statistically significant positive correlation with the digital economy at the 1% significance level, meeting the test criteria. Subsequent to addressing the endogeneity issue, the regression outcomes from the second stage of models (2) and (4) reveal a noteworthy positive correlation between the digital economy and new urbanization at the 1% significance level, aligning with the earlier analysis.

5.6. Robustness Check

To assess the scientific validity and feasibility of the empirical findings in the previous paper, this study conducts a robustness test by replacing the core explanatory variables. The composite index of digital economic development for the provinces and regions in the Yellow River Basin, calculated for the period 2012 to 2021, undergoes logarithmic transformation. The resulting logarithmized composite index of digital economic development is then utilized as the new set of core explanatory variables. In Table 11, the model displays estimated coefficients for the new core explanatory variables, all consistently positive

and consistently exceeding the 1% significance level. This suggests that the benchmark regression results remain robust even after substituting the core explanatory variables.

Table 11. Robustness test results.

New Urbanization Quality Development Index (Urban)						
Variant	**Model (1)**	**Model (2)**	**Model (3)**	**Model (4)**	**Model (5)**	**Model (6)**
LnDige	0.0669 *** (7.84)	0.0851 *** (3.52)	0.0673 *** (7.83)	0.0431 *** (3.02)	0.0653 *** (7.92)	0.0669 *** (7.82)
Science		−0.0094 (−0.81)				
Study			−1.1387 (−0.59)			
Government				−0.1286 ** (−2.05)		
InOpen					0.3424 ** (2.62)	
Fiscal						0.4094 (0.79)
Constant term	0.4376 *** (28.57)	0.5592 *** (3.69)	0.4605 *** (11.11)	0.4389 *** (29.21)	0.3935 *** (17.58)	0.4111 *** (11.10)
City fixed	YES	YES	YES	YES	YES	YES
Year fixed	YES	YES	YES	YES	YES	YES
Number of periods	10	10	10	10	10	10
Number of cities	9	9	9	9	9	9
R^2	0.8238	0.7769	0.8179	0.8862	0.8259	0.7995

Note: *, **, and *** denote significance levels through 10%, 5%, and 1%, respectively, and Robust-corrected t-statistics are in parentheses. As shown in Table 11, after the robustness test, both model (1) and model (6) can pass the significance level of 1%, indicating that the digital economy can promote the high-quality development of new urbanization.

6. Conclusions and Recommendations

6.1. Findings

Using inter-provincial panel data from 2012 to 2021, we applied the entropy value method to assess the levels of digital economy development and high-quality development in new urbanization. We simultaneously employed the fixed-effect model, mediating effect model, and threshold effect model to explore the impact of the digital economy on the high-quality development of new urbanization in the Yellow River Basin. The analysis produced the following key findings:

(1) The fundamental regression results indicate a substantial promotive impact of the digital economy on the high-quality development of new urbanization in the Yellow River Basin. With the inclusion of control variables, all regression outcomes successfully pass the significance test at the 1% level, and these findings maintain their robustness even after subjecting them to a robustness test.

(2) The analysis of the transmission mechanism reveals that the digital economy not only directly enhances the high-quality development of new urbanization in the Yellow River Basin but also indirectly contributes to it by fostering industrial structure upgrading. However, the digital economy's role in promoting the high-quality development of new urbanization has diminished compared to its previous impact, suggesting that industrial structure upgrading serves as an indirect mechanism for the digital economy to foster high-quality development of new urbanization in the Yellow River Basin.

(3) From a non-linear perspective, the influence of the digital economy on the high-quality development of new urbanization in the Yellow River Basin exhibits non-linear traits. A threshold value exists for the digital economy's developmental level in the Yellow River Basin. The impact of the digital economy on fostering high-quality new urbanization in the Yellow River Basin is less pronounced when it operates below this threshold. However, when the digital economy surpasses this threshold, its effect on promoting high-quality new urbanization becomes more evident.

This paper investigates the influence of the digital economy on the high-quality development of new urbanization in the Yellow River Basin. It concludes that the digital economy significantly promotes high-quality urban development and can be indirectly facilitated by upgrading the industrial structure. A limitation of this study is its narrow focus on the Yellow River Basin. Future research could broaden its scope to encompass the national level. It should explore how to assess the impact of the digital economy on high-quality urban development across diverse regions, considering regional segmentation and indicator establishment.

6.2. Policy Recommendations

6.2.1. Hastening Infrastructure Development Is Imperative

Formulating a clear digital infrastructure strategy is essential to achieve comprehensive high-speed broadband Internet coverage throughout the Yellow River Basin, particularly in rural areas, thereby enhancing digital infrastructure equity. Developing a smart city management platform that integrates various data types to optimize transportation, energy management, and healthcare services will allow for enhancing public services and meeting residents' diverse needs. Government investment should prioritize achieving broad high-speed broadband Internet coverage, accelerating the deployment of 5G networks, digital power supply, and other critical infrastructures. This initiative is essential for enabling extensive data transmission, smart device connectivity, and establishing a stable, reliable network environment crucial for digital services and information transmission during urbanization.

6.2.2. Promoting Green and Low-Carbon Development

The digital economy has the potential to improve the Yellow River Basin, afflicted by water scarcity and pollution. Establishing a digital water management system facilitates real-time monitoring, analysis, and distribution of water resources. This will reduce water resource wastage, improve water quality, and promote sustainable water use. It will also promote investment in digital technology, smart manufacturing, and renewable energy in the Yellow River Basin. Additionally, supporting the research, development, and application of innovative technologies will improve resource utilization efficiency and reduce carbon emissions. Encouraging enterprises to invest in digital and green technologies, promoting research and the application of low-carbon technologies, establishing a green innovation fund, and providing tax incentives will stimulate greater participation in scientific research and innovation for environmental protection. Advocating for the widespread adoption of digital technology in construction, transportation, and agriculture will promote urban development towards a greener, low-carbon environment. Furthermore, supporting digital platforms for knowledge sharing and education on ecological protection will enhance public awareness and concern for ecosystems.

6.2.3. Optimize Industrial Structure Upgrading

This initiative aims to do the following: improve agricultural science and technology standards, promote research and innovation, and enhance the efficiency and quality of agricultural production; promote agricultural industrialization, integrate agriculture with agricultural product processing, and increase the added value and market competitiveness of agricultural products; advance the modernization of agriculture by promoting mechanization, intelligence, and informationization, thus increasing the automation level of agricultural production and enhancing the sustainable development capacity of agriculture; and encourage the transformation and upgrading of industries in the Yellow River Basin towards high-end manufacturing, high-tech sectors, and green industries to reduce the excessive reliance of traditional industries on resources and alleviate environmental burdens. This initiative aims to promote intelligent manufacturing and facilitate digital transformation. It will encourage industrial enterprises to embrace informatization and intelligent transformation, while promoting the use of industrial Internet and big data technology to

improve production efficiency and product quality; promote the development of modern service industries, stimulate growth in sectors such as finance and scientific-technological services, increase the proportion and value-added of service sectors, thereby creating more high-quality employment opportunities; and promote the development of emerging service industries, driving innovation in the Internet economy, e-commerce, artificial intelligence, cloud computing, and other growing service sectors, while cultivating new growth drivers within the digital economy.

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