


Article

Impact of Digital Development and Technology Innovation on the Marine Fishery Economy Quality

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Abstract: The digital economy plays an important role in promoting the high quality and sustainable development of the marine fishery economy. Based on the panel data of the digital economy and marine fishery development from 2011 to 2022, we firstly adopted the entropy method to comprehensively evaluate the economy quality level of the digital economy and marine fishing. Secondly, we constructed a two-way fixed effect model to empirically analyze the impact of digital economy development on the marine fishery economy quality and the mediating role of marine green science and technology innovation, and further explored the regional heterogeneity of the digital economy on the marine fishery economy quality. Several findings emerge. The digital economy and the marine fishery economy quality level was relatively low and showed a fluctuating increase. The development of the digital economy can significantly improve the economy quality of marine fishing, and the conclusion was still valid after considering a series of robustness tests. The digital economy can drive the development quality of the marine fishery economy through marine green technology innovation. This paper proposes fostering the advancement of digital technology in the marine fishery sector, to effectively harness the innovation-driven potential of the digital economy, so as to facilitate the harmonious development of both the marine and digital economies.

Keywords: digital economy; marine economy; mediating effect; high-quality development



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Key Contribution: This study makes marginal contributions to the following aspects. Firstly, it explores the impact of the digital economy on the improvement in the marine fishery economy quality; reveals the internal mechanism of enabling the marine fishery economy quality via the digital economy; and enriches the literature in fields related to the marine fishery economy. Secondly, it analyzes the impact path of the digital economy on the marine fishery economy quality from the dimension of scientific and technological innovation of marine fishing, which is a beneficial expansion of the impact mechanism theory of the digital economy and empirical research. Thirdly, it analyzes the difference in the impact of the digital economy on the economic quality of marine fishing from the perspective of heterogeneity in different regions, so as to provide better guidance for governments to implement precise policies.



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1. Introduction

Marine fishing is not only the basic industry of the marine economy system, but also an important growth point of socio-economic economy development, and plays a vital role in eradicating hunger and providing food and nutrition on a global scale.

In 2022, the *FAO Blue Transformation Roadmap* proposed that aquatic product systems are important drivers of employment, economic growth, social development, and environmental restoration, and there is a need to transition to more efficient, inclusive, resilient, and sustainable aquatic product systems in support of *the 2030 Agenda for Sustainable Development*, so as to achieve better production, better nutrition, a better environment,

and better lives [1]. According to *China Fishery Economic Statistics Bulletin*, by the end of 2022, the output value of China's marine fishery had reached CNY 712.775 billion, and the production of marine products was 34.5953 million tons, equivalent to a year-on-year increase of 2.13%, indicating that the marine fishery economy has shown strong resilience [2]. Moreover, many challenges have been faced by the marine fishery economy, such as an unreasonable industrial structure, insufficient development momentum, low total factor productivity, and deterioration of the marine ecological environment. According to the 2022 report data from the State of World Fisheries and Aquaculture released by the *Food and Agriculture Organization of the United Nations (FAO)*, the sustainability of marine fishery resources remains a serious concern, with the proportion of sustainably caught stocks falling to 64.6% in 2019, 1.2% lower than the level in 2017 [3]. Facing increasingly tight resource and environmental constraints and the scarcity of nearshore space resources, optimizing the structure of marine fisheries, stimulating the endogenous driving force of the marine fisheries economy, cultivating new drivers of the marine fisheries economy, and achieving green transformation of the marine fisheries economy have become important tasks for the development of the marine fisheries economy in coastal countries and regions worldwide. Technological innovation is an important cornerstone and core driving force for the transformation and development of marine fisheries. At present, most coastal countries and regions have made technological innovation a strategic investment, promoting the transformation of the marine fishery economy from being resource- and consumption-oriented to intensive, and scale-speed-oriented to quality- and efficiency-oriented, through technological innovation, and enhancing the leading role of technological innovation in the high-quality development of the marine fishery economy.

With the rapid innovation of information technology and its penetration into all sectors of society, the digital economy has become an important engine of global economic change and the driving force for the high-quality development of China's economy. With data elements as the carrier and information technologies, such as the Internet, and artificial intelligence, big data, and cloud computing as development tools, the digital economy constantly reshapes the current mode of production and economic activities by realizing efficiency, power, and quality changes, providing strong technical support and factor supplies for breaking the bottleneck of economic development, and creating opportunities for technological innovation [4]. The development of digital technology promotes the deep integration of information technology and industrial technology, and the digital economy and the real economy, endowing productive forces with the digital and green attributes of the times, and taking full advantage of the role of scientific and technological innovation in driving economic growth [5]. The practice of economic and social operation has proved that the digital economy has a significantly positive role in promoting the transformation and development of real industries such as agriculture, manufacturing, and transportation [6]. In this context, exploring whether the digital economy can exert the reshaping effect to promote the quality development of the marine fishery economy, and whether the digital economy can affect the development quality of the marine fishery economy through technological innovation, has important theoretical significance and practical value for promoting high-quality development and digital enabling the marine fishery economy.

At present, the relevant research of the impact of the digital economy on the quality of the marine fishery economy at home and abroad mainly focuses on the impact of the digital economy on the marine industry structure, the impact of the digital economy on the efficiency of the marine economy, etc., and many methods such as the super efficiency DEA model, intermediary effect, and regulatory effect are used in calculations. **First**, in terms of the impact of the digital economy on the marine industry structure, Jian Lingxiang et al. revealed the impact of the digital economy on the high-quality development of China's marine industry and the development path, and found that the digital economy can promote the high-quality development of the marine industry, but the effect was affected by the regulatory effects of the industrial agglomeration scale effect, consumption level,

sea-related employment opportunities, and innovation ability [7]. From the perspective of industrial upgrading, Fu Kaibao et al. found that the digital economy has a positive promoting effect on the high-quality development of the marine economy, and explored the transmission path from the perspective of industrial upgrading [8]. Chen Qi et al. empirically analyzed the impact of the digital economy on the R&D and innovation capability of the marine industry; tested the internal mechanism of the digital economy's impact on the R&D and innovation capability of the marine industry in terms of the three dimensions of easing financing constraints, optimizing the human capital structure, and reducing the operating cost of enterprises; and further discussed the heterogeneity of enterprises and industries in the digital economy's impact on the R&D and innovation capability of the marine industry [9]. Liu Surong pointed out that the digital economy can significantly promote the high-quality development of the marine economy, especially at the level of innovation and opening up, but there is a nonlinear decreasing trend of marginal effect and regional distribution differences [10]. Cao Li et al. analyzed the impact of the digital economy on marine fishery quality from the perspective of industrial upgrading, and pointed out that the digital economy can positively promote the development of marine fishery economy quality, and industrial structure upgrading can play an intermediary effect in this process [11]. Zhang Yun studied the impact of digital technology on the marine equipment manufacturing industry, and concluded that digital technology had a positive impact on China's MEMI (marine equipment manufacturing industry), and digital trade played a mediating role. In general, the technology management of small and medium-sized enterprises in China lacks high-end professional and technical personnel, and the application of digital technology is unbalanced and insufficient among regions [12].

Second, in terms of the digital economy impact on the efficiency of the marine economy, most scholars initially discussed the relationship between the digital economy and total factor productivity and the high-quality development of the marine economy at the macro level. Sun Caizhi and Song Xianfang incorporated data production factors into the total factor productivity measurement index system to evaluate the impact of digital economy development on the changes in marine economy total factor productivity in 11 coastal provinces and municipalities [13]. Ji Jianyue conducted empirical tests and studied the impact mechanism of environmental regulations and technological innovation on the total factor productivity of the marine economy. Environmental regulations have a significant dual threshold effect on the total factor productivity of the marine economy. The different levels of technological innovation determine that the "off setting effect" and "compensation effect" dominate [14]. Di Qianbin believed that science and technology innovation investment is the key factor that influences the efficiency of the marine economy growth, science and technology innovation, and development of marine economy quality, with a nonlinear relationship [15]. YaozhiXu as empirically calculated that the level of digital industrialization and industrial digitization has played a positive role in improving the complexity of export technology. In the short term, more attention should be paid to the development of industrial digitization to enhance the complexity of export technology. In the process of industrial digitization driven by digital industrialization, the ways to enhance innovation capabilities have a significant impact [16].

Domestic and foreign researchers mainly focus on the micro level of the impact of the digital economy on the marine economy. In the context of the digital economy, specific information technology innovations have an impact on the marine economy and its sustainable development. Duie et al. used a new hybrid machine learning algorithm to improve water quality prediction, which has an impact on the sustainable development of the marine economy [17]. Christian et al. used CIA and MRA methods to provide comparative elements for scientists and policymakers monitoring MCE environmental goals, and provided new digital methods for dynamic assessment of marine and coastal ecosystems [18]. Schoening et al. suggested using Image FAIR Digital Objects (iFDO) to collect image data from marine environments for exploring and monitoring marine habitats [19]. Hanieh Saeedi used data methods to conduct digital research on changes

in deep-sea biodiversity and proposed data sharing for the benefit of the marine economy [20]. Yigit proposed a DT model based on an unmanned aerial vehicle-assisted data collection architecture, providing a comprehensive port management system for smart seaports [21]. Nham N T H et al. found that digitalization plays a crucial role in influencing the sustainability of marine minerals and moving towards a sustainable blue economy. By utilizing knowledge sharing, green economy strategies, and sustainable governance practices, it is possible to achieve a balance between economic growth and environmental protection in the marine sector [22]. Alison Crosby et al. used marine visual AI as a research perspective and conducted a human-centered design study, detailing the community's demand for evaluating marine image data processing systems. Ocean vision AI is based on data with different parameters, effectively promoting scientific analysis, data sharing resources, and visualizing information for policy decision-making [23]. Hans Dietrich Haasis et al. took the digital transformation of maritime transportation, port management, and inland connectivity as their research perspective, and believe that in the present and near future, the digitization and digital transformation of maritime supply chains will be the most powerful and challenging innovative force. In the context of the maritime supply chain, strong discussions on digitalization and digital transformation can not only stimulate investment in infrastructure and technology, but also in knowledge, education, training, communication, and understanding [24]. Ute Brönnner et al. discussed the benefits of digital twins for the ocean, the challenges of developing digital twins, and the latest developments in ocean digital twin technology. It is believed that the digital ocean has changed the interaction between humans and the ocean by accelerating overall understanding, optimizing management, and effective interventions [25]. Diaz Pranita et al. believe that good digital literacy and blue economy management have a significant impact on blockchain technology and smart islands. Their research indicates that for islands that face challenges in accessibility and connectivity, the presence of blockchain and intelligent technology is needed to integrate the various resources of each stakeholder, so that the blue economy on the islands can develop more effectively and efficiently, while ensuring sustainability [26]. Tzachor et al. analyzed the feasibility of digital twins as an emerging and powerful computer technology for ocean spatial planning and sustainable development [27]. Further analysis by Xiaohan Fang et al. confirms that there is a substantive connection between digital technology and the sustainable development of the marine economy, and technological innovation is considered a possible channel. The research findings advocate expanding the application of digital technology through technological innovation as a strategy to promote sustainable development of the marine economy, while ensuring balanced development between regions [28]. Xiaoqiang Pan et al. believe that the powerful data collection and spatial analysis capabilities of the digital ocean provide support and a guarantee for safeguarding national marine rights and the rational development of marine resources [29].

In conclusion, there is a relatively rich literature on the impact of the digital economy on the development of the marine fishery economy. These results also have important reference value for exploring the impact of the digital economy and the high-quality development of the marine fishery economy in this article. However, determining how to develop the high-quality marine fishery economy via the digital economy has not been deeply explored, and previous studies have not yet reached a unified conclusion. Therefore, this study constructs a new framework to measure how the digital economy drives marine fishery economy development quality, in order to provide a new perspective for studying the logical relationship between the digital economy and marine fishery economy quality, and to provide a reference for formulating sustainable development policies for the marine fishery economy. This study has made marginal contributions in terms of the following aspects. **Firstly**, taking the marine fishery economy quality of China's coastal provinces and cities as the research object, we explored the impact of the digital economy on the improvement of marine fishery economy quality, revealed the internal mechanism of enabling marine fishery economy quality by the digital economy, and enriched the literature

in fields related to the marine fishery economy [30]. **Secondly**, the existing research mainly explores the impact mechanism of the digital economy on the total factor productivity of the marine fishery economy from the perspectives of industrial structure upgrading and human capital structure, neglecting the mechanism by which the digital economy affects the quality of the marine fishery economy by promoting technological innovation in the marine fishery industry. Based on the characteristics of marine fishery economy quality development, we analyzed the impact path of the digital economy on marine fishery economy quality from the dimension of the scientific and technological innovation of marine fishing, which is a beneficial expansion of the impact mechanism theory of the digital economy and empirical research [31]. **Thirdly**, we analyzed the difference in the impact of the digital economy on the economic quality of marine fishing from the perspective of heterogeneity in different regions, so as to provide better guidance for governments to implement precise policies.

2. Study Design and Methods

2.1. Study Area

We selected 11 coastal provinces (cities) in China, including Liaoning, Tianjin, Hebei, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi, and Hainan as the research scales, used relevant data to measure the comprehensive level of the marine fishery economy quality and digital economy quality, and focused on exploring the impact relationship between the two. The study period was 2011–2022. The data sources included the *China Fishery Statistical Yearbook (2012–2023)*, *China Statistical Yearbook (2012–2023)*, *China Information Industry Yearbook (2012–2023)*, and *China Marine Economic Statistical Yearbook (2012–2023)*. Missing data were obtained by linear interpolation or calculated by the authors.

2.2. Indicator System Construction

In order to accurately measure the comprehensive level of the digital economy quality and the marine fishery economy, we selected a number of indicators to construct the evaluation index system, and used the entropy value method to measure their comprehensive scores.

The economy quality of marine fishing is mainly divided into three dimensions, including the marine fishery economy quality, the level of marine fishery facilities, and the ecological quality of marine fishing. We selected typical indicators of the three dimensions, forming a total of 16 measurement indicators to form an evaluation system for the level of the marine fishery economy quality. (1) Among them, positive indicators such as the marine fishery output value, marine fishery capture value, total amount of seawater product processing, seawater products output, pelagic fishery products, number of fishery law enforcement agencies, and seawater aquaculture area were selected to measure economic strength. (2) As regards the level of marine fishery infrastructure, which is an important material foundation and spatial carrier on which the development of marine fishery depends, we selected positive indicators for measurement, such as the ownership of marine motorized fishing vessels, the year-end ownership of marine production fishing vessels, the number of mobile marine fishing vessels for marine fishing, the year-end ownership of pelagic fishing vessels, and the ownership of marine auxiliary fishing vessels. (3) The level of ecological quality is crucial to the development of marine fishing, and is an important indicator reflecting the ecological protection and restoration capacity of marine fishing. We selected the indicators of the proportion of near-shore water quality of categories I and II, the area of coastal wetlands, the near-shore and coastal area, the discharge of direct-discharged marine wastewater, etc. for the measurement. The proportion of near-shore Class I and II water quality, the area of coastal wetland, and the near-shore and coastal area are the four positive indicators. The discharge of direct-discharged marine wastewater is the negative indicator.

The digital economy is divided into two levels: industrial digitization and digital industrialization. Among them, five positive indicators for industrial digitization were

selected: fixed assets investment in the information transmission, software, and information technology services industry, number of digital economy enterprises, number of patent applications authorized, online retail sales, and e-commerce sales. For digital industrialization five positive indicators were selected: software and information services industry employees, IT consultancy services revenue, software industry revenue, the number of Internet domain names, and telephone penetration rate. The specific indicators are shown in Table 1:

Table 1. Digital economy and marine fishery economy quality indicator system.

Target Layer	Rule Layer	Weight	Index Layer	Index (Positive/Negative)	Weight	
Marine fishery economy quality	Economic strength of marine fishery	0.506	Marine fishery output value (million yuan)	Positive	0.064	
			Marine fishery capture value(million yuan)	Positive	0.065	
			Total amount of seawater product processing (10,000 tons)	Positive	0.097	
			Seawater products output (10,000 tons)	Positive	0.064	
			Pelagic fishery production (10,000 tons)	Positive	0.078	
			Number of fishery law enforcement agencies (number)	Positive	0.052	
	Level of marine Fishery infrastructure	0.416	Seawater aquaculture area (hectares)	Positive	0.087	
			Ownership of marine motorised fishing vessels (gross tonnes)	Positive	0.075	
			Year-end ownership of marine production fishing vessels (tonnes)	Positive	0.069	
			Number of mobile fishing vessels for marine fishing (ships)	Positive	0.065	
			Year-end ownership of pelagic fishing vessels (kW)	Positive	0.087	
	Ecological quality of marine fisheries	0.08	Ownership of marine auxiliary fishing vessels (gross tonnes)	Positive	0.120	
			Proportion of near-shore of Class I and II water quality (%)	Positive	0.022	
			Coastal wetland area (1000 hectares)	Positive	0.038	
			Near shore and coastal area (square kilometres)	Positive	0.029	
	Digital Economy Level	Industrial digitization	0.521	Direct discharge of marine wastewater (billion tonnes)	Negative	0.008
				Fixed asset investment in information transmission, software and information technology services industry (billion yuan)	Positive	0.064
				Number of digital economy enterprises (number)	Positive	0.067
Number of patent applications authorised (pieces)				Positive	0.131	
Online retail sales (billion yuan)				Positive	0.147	
Digital industrialization		0.479	E-commerce sales (billion yuan)	Positive	0.112	
			Software and information service industry employees (persons)	Positive	0.098	
			IT consultancy service revenue (million yuan)	Positive	0.143	
			Software industry revenue (billion yuan)	Positive	0.111	
			Number of Internet domain names (ten thousand)	Positive	0.109	
Telephone penetration rate (part/one hundred people)	Positive	0.019				

2.3. Research Methods

2.3.1. Entropy Method

The entropy method is a measurement method used to comprehensively evaluate the development level of the object by multiple indicators, and belongs to the objective assignment method. The original information it relies on comes from the objective environment, and the weight of indicators is determined based on the amount of information. This method has been widely applied in various fields such as societal and economic research. Therefore, we selected the entropy method to measure the weights and comprehensive scores of various indicators of the marine environment, marine economy, and digital economy levels. The specific calculations were as follows:

$$e_j = -k \sum_{i=1}^n p_{ij} \ln(p_{ij}) \tag{1}$$

In the equation, $p_{ij} = A_{ij} / \sum_{i=1}^n A_{ij}$, p_{ij} represents the proportion matrix of sample indicator values; A_{ij} represents the standardized data matrix for each indicator; e_j represents the entropy value of the indicator ($0 \leq e_j \leq 1$); n represents the number of marine environmental quality indicators; m is the number of evaluation objects.

Indicator weight calculation:

$$w_j = (1 - e_{ij}) / \sum_{i=1}^n (1 - e_{ij}) \tag{2}$$

In the equation, w_j denotes indicator weights; e_{ij} denotes indicator entropy value; and the criterion layer weights are $w'_j = \sum_{i=1}^m w_j$.

Calculation of comprehensive score:

$$S = \sum_{j=1}^n w_j A_{ij} \tag{3}$$

2.3.2. Model Construction

Bidirectional fixed effects regression is a commonly used regression model used to study the changes in one variable as another variable changes. It is achieved by adding some virtual observations and controlling some variables to more accurately report model performance. In order to verify the direct impact of digital economy development on the quality of the marine fishery economy and the mediating role of marine science and technology innovation, we constructed the following benchmark regression model:

$$\ln Mfc_{i,t} = \alpha_0 + a_1 \ln Dig_{i,t} + a_2 Con_{i,t} + \mu_i + \varphi_t + \varepsilon_{i,t} \tag{4}$$

In the equation, i is individual, and represents different regions; t is time, and represents different years; the explanatory variable $Mfc_{i,t}$ represents the quality of the marine fishery economy; α_0 is a vector of intercept terms; the core explanatory variable $Dig_{i,t}$ represents the level of the digital economy quality; $Con_{i,t}$ represents a set of control variables related to the quality of the marine fishery economy; μ_i is an individual fixed-effects term; φ_t is a time fixed-effects term; and $\varepsilon_{i,t}$ is a random perturbation term.

The mediation effect model is a commonly used model for exploring the internal mechanisms or principles of the relationship between two variables. When considering the influence of the independent variable X on the dependent variable Y, if X affects Y by influencing the variable M, then M is called a mediator or mediating variable. The impact of X on Y through the mediating variable M is called the mediation effect. In order to verify the specific channeling mechanism of digital economy development on the marine fishery economy quality, we constructed the following equations:

$$\ln Mfc_{i,t} = \beta_0 + \beta_1 \ln Dig_{i,t} + \beta_2 \ln Con_{i,t} + \mu_i + \varphi_t + \varepsilon_{i,t} \tag{5}$$

3. Empirical Analysis

3.1. Digital Economy Quality Level Analysis

Based on the entropy method shown in Equations (3)–(5), we calculated the comprehensive level of China’s digital economy quality from 2011 to 2022. The results are shown in Figures 1 and 2.

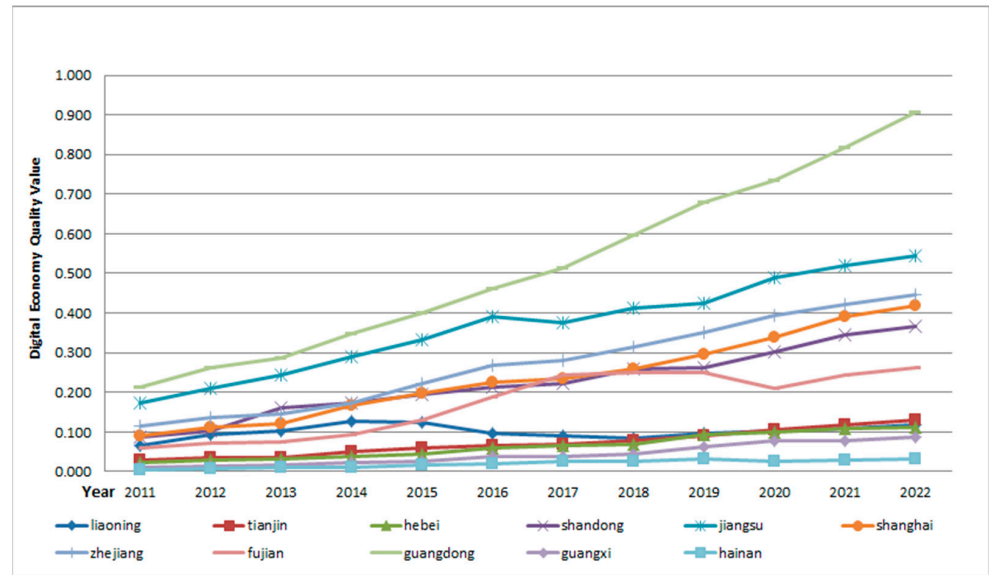


Figure 1. Quality level of digital economy (2011–2022).

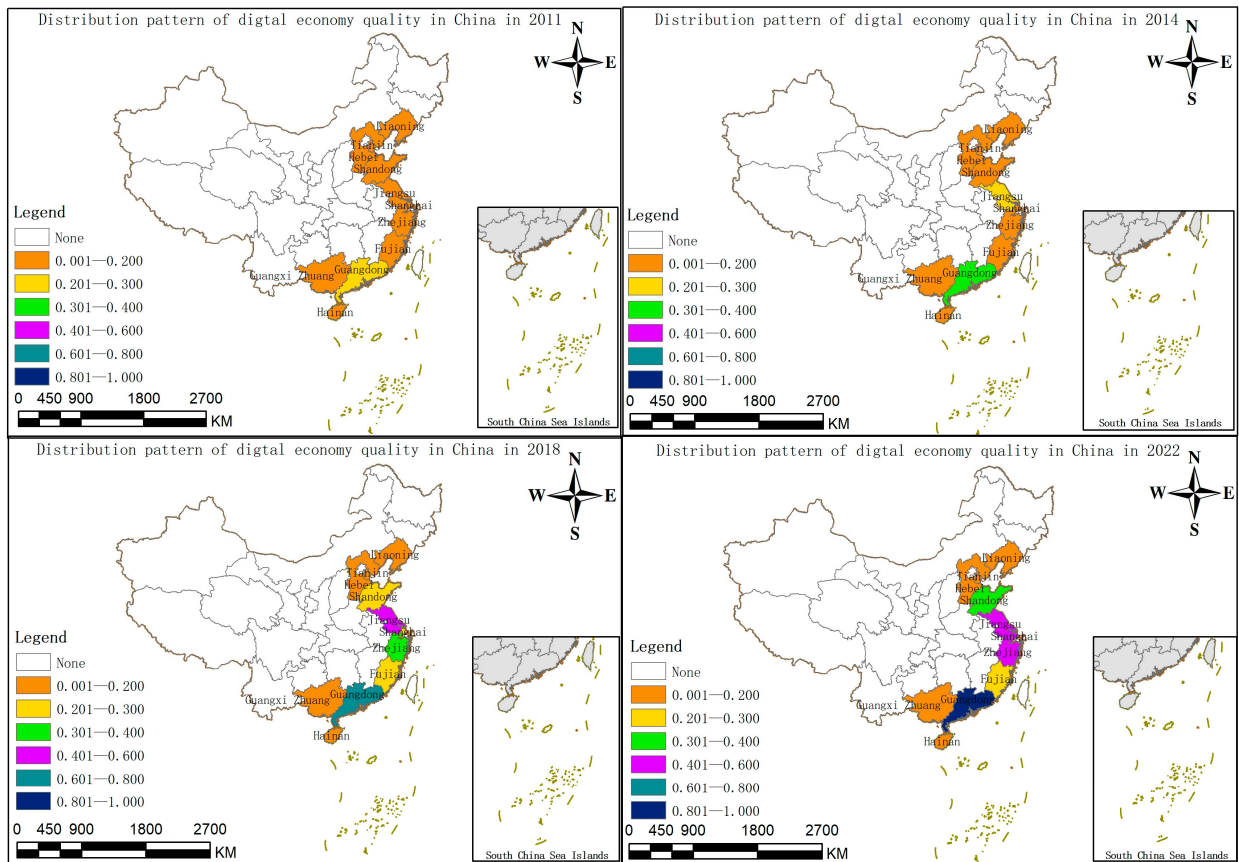


Figure 2. Spatial and temporal evolution of digital economy quality in China (2011–2022).

During the study period, the development of China's digital economy quality showed a wave-like upward trend with an increase of more than three times from 0.08 to 0.31. The growth rate was high, but the overall level was low. From 2011 to 2016, with the exception of Liaoning, the quality of the digital economy in most coastal provinces and cities showed a straight upward trend, especially in Guangxi, Fujian, and Hainan, where the growth rate was more than 40%, while the growth rate of the digital economy in other provinces reached more than 20%. However, Liaoning experienced a brief decline in the quality of its digital economy between 2014 and 2016, but the growth rate still reached more than 9% compared to 2011. From 2016 to 2022, the quality of the digital economy in most provinces and cities increased significantly; except for Liaoning and Jiangsu, which showed a significant decline, the provinces showed a rapid increase, with a growth rate of more than 10%.

As can be seen in Figure 2, the quality of the digital economy presented a spatial distribution pattern of "low in the South and North, and high in the East", with an obvious inter-regional gap and serious inter-provincial polarization. The inter-regional gap was obvious, while the inter-provincial polarization was serious. The average value of the digital economy in the eastern region is about 0.29, the average value of digital economy in the southern region is about 0.18, and the average value of digital economy in the northern region is only 0.11, which indicates that the development difference between regions is obvious. There was a large gap in the quality level of the digital economy between provinces; Guangdong had the highest-quality digital economy, with an average of more than 0.52, while Hainan had the lowest-quality digital economy, of only about 0.02, a difference of nearly 26 times, and the phenomenon of two-level differentiation was very serious. However, in 2022, the quality level of the digital economy in Guangdong was 28 times that of Hainan, and the gap was very obvious.

3.2. Analysis of Marine Fishery Economy Quality Level

Based on the entropy method shown in Equations (1)–(3), the comprehensive level of the marine fishery economy quality was measured in China from 2011 to 2022. Figures 3 and 4 show the results.

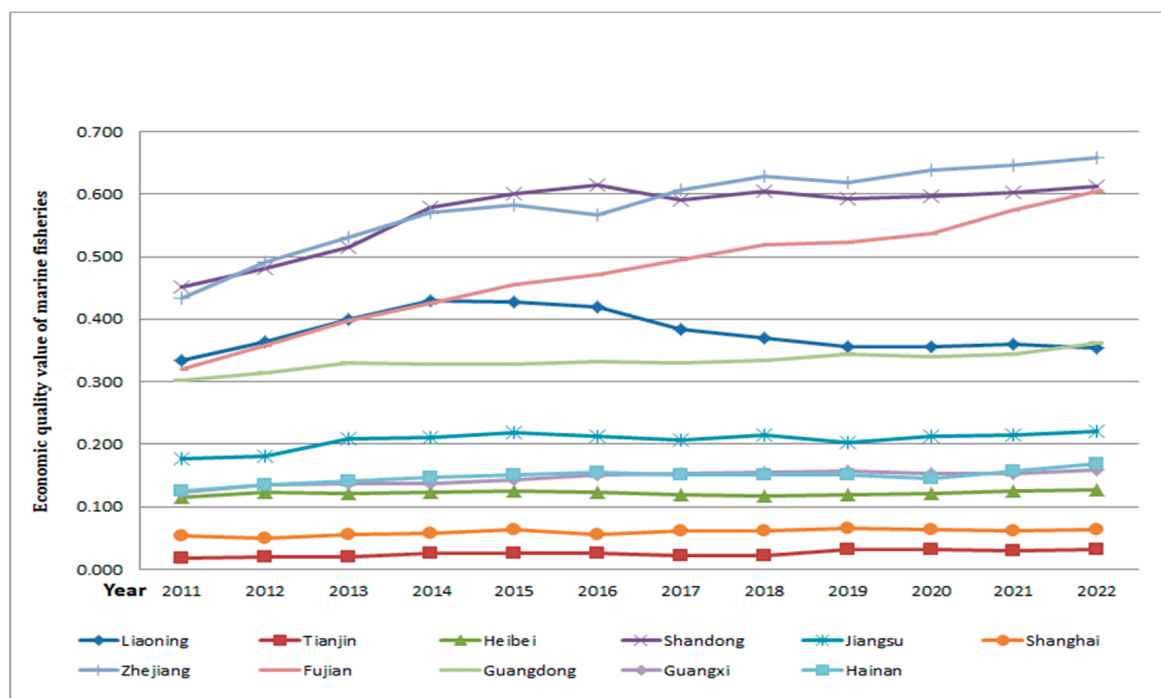


Figure 3. Economy quality level of marine fishery.

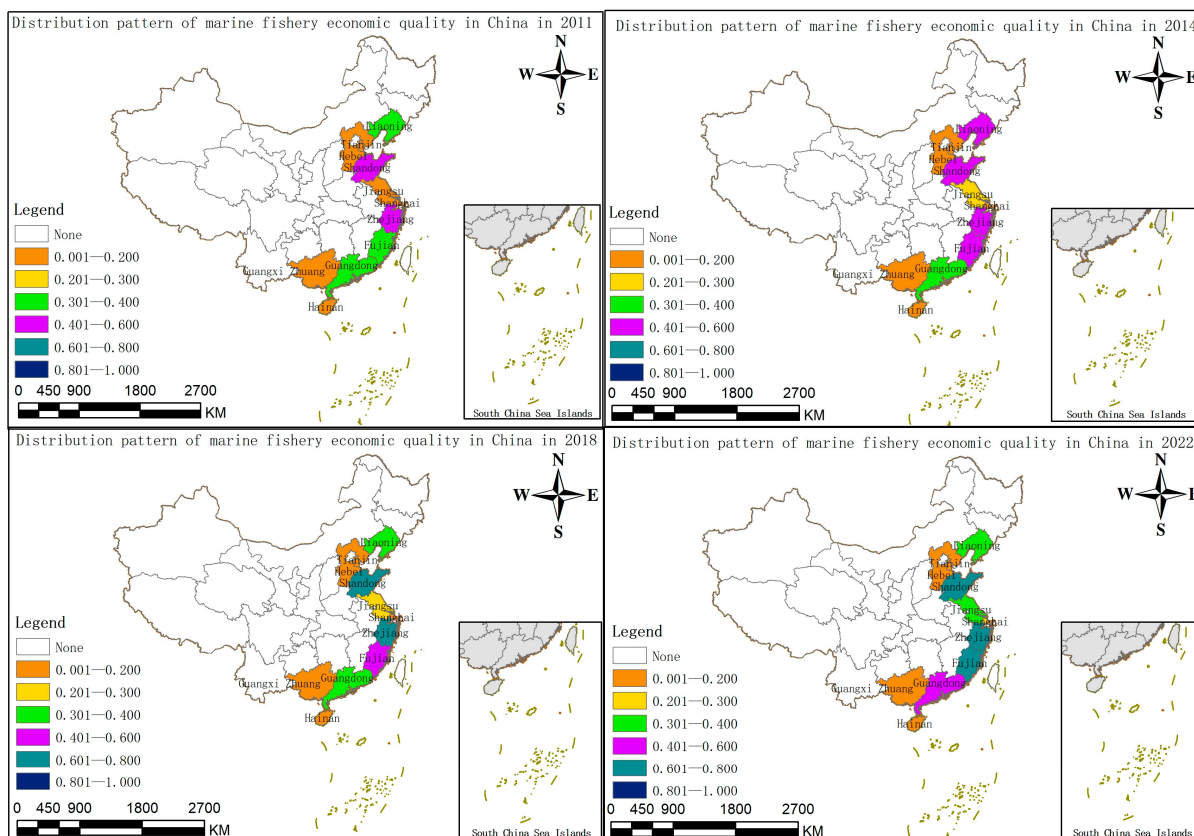


Figure 4. Distribution of the spatial evolution pattern of marine fishery economy quality in China (2011–2022).

The economy quality level of marine fishing in China showed an upward trend, with an average value increase of 4% from 0.2 to 0.3. However, the overall level is low. Between 2011 and 2014, the quality of the marine fishery economy in most provinces and cities showed a steady growth trend, especially Tianjin, Zhejiang, and Fujian, which had the highest growth rates of the marine fishery economy, with average annual growth rates of more than 10%; other regions reached 3%. From 2014 to 2019, the economy quality of marine fishing in most provinces showed a slow upward trend, with average annual growth rates of more than 2%, except for Liaoning and Jiangsu, which had a significant decline. From 2019 to 2022, except for Liaoning and Shanghai, where the economy quality of marine fishing declined slightly, the economy quality of marine fishing in provinces showed a slow growth trend, with average annual growth rates of more than 2%. On the whole, the economic quality of marine fishing in coastal provinces and cities increased slowly, but the average value in most provinces and cities was about 0.3, and only a few provinces and cities reached more than 0.6 in 2022. This indicates that the level of marine fishery economy quality in China is still relatively low. From the perspective of spatial distribution, the economy quality of China’s marine fishery showed a spatial distribution pattern of “low in the South and North, and high in the East”, and the development was more balanced among regions, but there were significant differences between provinces. Among these, the average marine fishery economy quality of the central region was about 0.28, while that of the southern and northern regions was about 0.27, indicating a relatively low inter-regional development difference. During the study period, the economy quality of marine fishery varied greatly among provinces. The highest mean value of marine fishery economy quality in Zhejiang was 0.58, while in Tianjin it was only 0.03, with a difference of nearly 17 times. In 2022, Zhejiang had the highest economy quality of marine fishing, reaching more than 0.65, while Tianjin had the lowest, only about 0.03, with a difference of more than 20 times; hence, the gap was further widened, and the phenomenon of inter-provincial polarization was very serious.

3.3. Analysis of the Impact of the Digital Economy on the Marine Fishery Economy Quality

3.3.1. Benchmark Regression

According to Equation (4) and Table 2, we measured the impact of the digital economy on the economy quality of marine fishing. **Firstly**, the random effects were compared with fixed effect analysis, and the results are shown in Table 3 of models (1) and (2). According to the Hausman test, the fixed effects model is more suitable. **Secondly**, the fixed effects of the digital economy on the economic quality of marine fishing were calculated through fixing industry and time, and the results are shown in model (3) of Table 3. The regression coefficient of the digital economy on the economy quality of marine fishing in China’s coastal provinces and cities was 0.1549. This fully proves that the development of the digital economy has a significant positive role in promoting the economic quality of marine fishing. From the perspective of different regions, as shown in the results of models (4), (5), and (6) of Table 3, showing the regression coefficients of the digital economy in the Northern Marine Economy Circle, the Eastern Marine Economy Circle, and the Southern Marine Economy Circle, the economy quality of marine fishery values were 0.2786, 0.2347, and 0.076, respectively, and the influence coefficients decrease successively. Although it was also significantly positive, the difference was very obvious, which indicates that the impact of the digital economy on the economic quality of marine fishery has significant regional heterogeneity. From the perspective of the digital economy and marine fishery economy quality level, the digital economy and marine fishery economy quality level of the Northern Marine Economy Circle, the Southern Marine Economy Circle, and the Eastern Marine Economy Circle increase in turn, which does not form a positive relationship with the development of the digital economy and the marine fishery economy quality level of the three regions. This shows that the regional digital economy has not fully empowered the development of the marine fishery economy, especially the Eastern Marine Economy Circle and the Southern Marine Economy Circle, where the level of the digital economy is high but the quality of the marine fishery economy is low, indicating that the advanced digital technology in these regions has not been fully applied to the development of the marine fishery economy.

Table 3. Benchmark regression results of the digital economy and marine fishery economy quality.

Model	Random Effect: Model (1)		Fixed Effect: Model (2)		Dual Fixed Effect: Model (3)		Northern Marine Economy Circle: Model (4)		Eastern Marine Economy Circle: Model (5)		Southern Marine Economy Circle: Model (6)	
Variable	Mfc		Mfc		Mfc		Mfc		Mfc		Mfc	
	coef	Std.err	coef	Std.err	coef	Std.err	coef	Std.err	coef	Std.err	coef	Std.err
Dig	0.2053 (***)	0.0375	0.1414 (***)	0.0312	0.1549 (***)	0.0306	0.2786 (***)	0.0764	0.2347 (**)	0.0987	0.076 (**)	0.034
Mrs	0.017 (0.821)	0.0753	0.0286 (0.623)	0.0595	0.1940 (**)	0.0908	−0.291 (***)	0.1138	0.058 (0.67)	0.1349	0.2746 (***)	0.077
Mcy	0.2644 (***)	0.0380	−0.0886 (**)	0.0484	−0.178 (***)	0.0506	−0.148 (**)	0.0691	0.3613 (**)	0.1375	0.2757 (**)	0.1299
Mso	−0.0218 (0.394)	0.0255	0.0129 (0.536)	0.0208	−0.0315 (*)	0.0220	0.011 (0.798)	0.0430	0.02 (0.597)	0.0300	0.012 (0.626)	0.0241
Mis	0.1409 (***)	0.0538	0.0667 (0.121)	0.0426	0.0325 (0.42)	0.0402	0.2051 (*)	0.1127	0.07 (0.23)	0.0635	0.187 (**)	0.0765
-cons	−0.6067 (***)	0.1669	−1.355 (***)	0.1343	−1.293 (***)	0.1657	−1.749 (***)	0.2199	−0.14 (0.77)	0.4675	−0.25 (0.227)	0.2069
Hausman	Chi2(5) = 130.94 (***)											
R ²	0.4415		0.5953		0.6966		0.5936		0.7907		0.7935	
N	132		132		132		48		36		48	

Note: *, ** and *** indicate significance at the level of 10%, 5% and 1%, respectively.

3.3.2. Mediating Effect Calculation

As can be seen from Table 4, we can see that the regression coefficient of the digital economy on the marine fishery economy quality was positive, the regression coefficient of the digital economy on marine scientific and technological innovation capability was also significantly positive, and the regression coefficient of the digital economy and marine scientific and technological innovation on the marine fishery economy quality was significantly positive. This fully indicates that both the digital economy and marine science and technology innovation can significantly improve the economy quality level of marine fishing, and marine science and technology innovation plays an intermediary effect. The digital economy can promote the quality development of marine fishing by promoting the development of the marine science and technology level.

Table 4. Calculation results of the mediating effect of marine science and technology.

Variate	Mfc		Mkn		Mfc	
	(1)		(2)		(3)	
	coef	Std.err	coef	Std.err	coef	Std.err
Dig	0.1549 (***)	0.0360	0.4554 (***)	0.1179	0.1299 (***)	0.0381
Mkn					0.0549 (*)	0.0295
Mrs	0.1940 (**)	0.0908	−0.5563 (*)	0.2970	0.2245 (**)	0.0913
Mcy	−0.178 (***)	0.0506	0.3818 (**)	0.1654	−0.1988 (***)	0.0512
Mso	−0.0315 (0.155)	0.0220	−0.0195 (0.787)	0.0720	−0.0305 (0.165)	0.0217
Mis	0.0325 (0.42)	0.0402	0.2238 (*)	0.1316	0.0203 (0.616)	0.0403
-cons	−1.293 (***)	0.1657	0.9197 (0.212)	0.7317	−1.3439 (***)	0.2229
R ²	0.6966		0.4184		0.7064	
N			132			

Note: The figures in parentheses are standard errors, and *, ** and *** indicate significance at the levels of 10%, 5% and 1%, respectively.

3.3.3. Heterogeneity Test of Mediating Effect

Because of differences in the levels of resources endowment, science, and technology, there are significant differences in the level of the digital economy and the quality of the marine fishery economy among the Northern Marine Economy Circle, the East Marine Economy Circle, and the Southern Marine Economy Circle [32]. Therefore, the mechanism by which the digital economy promotes the development of the marine fishery economy is inevitably different. Table 5 shows the mediating effect results of the three regions. The regression coefficients of the digital economy in the Northern Marine Economy Circle on the marine fishery economy quality and marine scientific and technological innovation are 0.2785 and 0.8268, respectively, which indicates that the digital economy can significantly improve the marine fishery economic quality and the marine scientific and technological innovation level. The regression coefficients of marine scientific and technological innovation and digital economy level on the economy quality of marine fishing are 0.1032 and 0.1932, respectively, which fully indicates that marine science and technology plays a significant mediating effect in the process of the digital economy promoting the improvement in the marine fishery economy quality. The digital economy in the Eastern Marine Economy Circle significantly improved the quality development of marine fishing, but the regression coefficient of the digital economy on scientific and technological innovation of marine fishing was not significant. The regression coefficient of marine fishery scientific and technological innovation on the economy quality of marine fishing in the Southern Marine Economy Circle was also not significant, which indicates that there are great differences and obvious heterogeneity in the process of promoting the economy quality of marine fishing by the digital economy in the three regions. At the same time, it further indicates

that the digital economy in the two major marine economy regions of the east and south has not fully empowered the development of the marine fishery economy, and has not significantly promoted the high-quality development of marine fishery technology.

Table 5. Calculation results of the intermediary effect of marine science and technology in different regions.

Region	Variable	Mfc		Mkn		Mfc	
		(1)		(2)		(3)	
		coef	Std.err	coef	Std.err	coef	Std.err
Northern Marine Economy Circle	Dig	0.2785 (***)	0.0764	0.8268 (***)	0.2720	0.1932 (**)	0.0801
	Mkn					0.1032 (**)	0.0424
	controls	YES		YES		YES	
	-cons	-1.7487 (***)	0.2199	1.4743 (*)	0.7825	-1.9 (***)	0.2164
	R2	0.5936		0.5035		0.6484	
	N	132					
Eastern Marine Economy Circle	Dig	0.2347 (**)	0.0987	-0.008 (0.36)	0.1678	0.2367 (***)	0.1731
	Mkn					0.251 (**)	0.0653
	controls	YES		YES		YES	
	-cons	-1.348 (0.77)	0.4675	-2.432 (***)	0.7945	0.476 (0.348)	0.5916
	R2	0.7907		0.7178		0.8288	
	N	48					
Southern Marine Economy Circle	Dig	0.761 (**)	0.0341	0.1368 (*)	0.0859	0.072 (*)	0.0355
	Mkn					0.032 (0.62)	0.0641
	controls	YES		YES		YES	
	-cons	-0.254 (0.22)	0.2069	-0.981 (*)	0.5214	-0.223 (0.31)	0.2182
	R2	0.7935		0.1619		0.7948	
	N	48					

Note: The figures in parentheses are standard errors, and *, ** and *** indicate significance at the levels of 10%, 5% and 1%, respectively.

3.3.4. Robustness Test

To test the reliability of the impact of digital economy development on the quality of the marine fishery economy, robustness tests were conducted on the regression results, as shown in Table 6. **Firstly**, replacing the intermediary variables, we selected the number of marine fishery technology extension institutions (Mff) to represent the level of marine fishery scientific and technological innovation, and took the logarithm of the number of marine fishery technology extension institutions for regression. The results are shown in Table 6, column (1). The regression coefficients of the digital economy on the quality of the marine fishery economy and marine technological innovation, as well as the regression coefficients of marine technological innovation on the quality of the marine fishery economy, are significantly positive, indicating that the mediating effect of marine technological innovation is still significant. **Secondly**, replacing the explained variables, we removed

the direct discharge of marine wastewater in the marine fishery economy quality index system, recalculated the weight and comprehensive level, and took the measurement results as the explained variables for regression analysis. The regression results are shown in Table 6, column (2). The regression coefficients of the digital economy on the quality of the marine fishery economy and technological innovation in the marine fishery are significantly positive, with values of 0.172 and 0.455, respectively. Moreover, the regression coefficient of technological innovation in marine fishing on the quality of the marine fishery economy is 0.136, which is significantly positive, but there is a significant decrease. This fully demonstrates that the conclusion that technological innovation in marine fishing plays a mediating role in promoting the development of the marine fishery economy quality in the digital economy is robust.

Table 6. Robustness test results.

Variable	Replacement of Intermediary Variable Indicators (1)						Change the Dependent Variable Indicator (2)					
	Mfc		Mff		Mfc		Mfc		Mkn		Mfc	
	Coef	Std. Er	Coef	Std. Er	Coef	Std. Er	Coef	Std. Er	Coef	Std. Er	Coef	Std. Err
Dig	0.155 (***)	0.0361	0.339 (**)	0.1656	0.138 (***)	0.0359	0.172 (***)	0.0434	0.455 (***)	0.1179	0.136 (***)	0.0455
Mff					0.05 (***)	0.0207						
Mkn											0.079 (**)	0.0352
Mrs	0.193 (**)	0.0908	−0.988 (**)	0.4171	0.243 (***)	0.0911	0.210 (**)	0.1093	−0.556 (*)	0.2970	0.254 (**)	0.1090
Mcy	−0.178 (***)	0.0506	1.26 (***)	0.2328	−0.242 (***)	0.0560	−0.294 (***)	0.0609	0.382 (**)	0.1654	−0.324 (***)	0.0612
Mso	−0.03 (0.155)	0.0220	0.09 (0.346)	0.1011	−0.04 (*)	0.0216	−0.05 (*)	0.0265	−0.02 (0.787)	0.0720	−0.046 (*)	0.0260
Mis	0.03 (0.42)	0.0402	0.713 (***)	0.1848	−0.03 (0.935)	0.0420	0.045 (0.35)	0.0484	0.224 (*)	0.1316	0.028 (0.566)	0.0481
-cons	−1.29 (***)	0.2238	0.876 (0.396)	1.0277	−1.338 (***)	0.2195	−1.512 (***)	0.2693	0.919 (0.212)	0.7317	−1.585 (***)	0.2662
R2	0.6966		0.4839		0.712		0.6866		0.4184		0.7011	
N	132		132		132		132		132		132	

Note: The standard error is indicated in parentheses, and *, **, and *** respectively indicate significance at the 10%, 5%, and 1% levels.

4. Discussion

This article empirically analyzes the impact of digital economy development in coastal provinces and cities in China on the quality of marine fishery economy. The results show the following:

First, the digital economy can effectively improve the quality level of the marine fishery economy. As can be seen from the regression model in Table 3, column (3), the influence coefficient was 0.155, and significantly positive. This is mainly limited by the strong synergy and penetration of the digital economy, which makes factor allocation more efficient, helps optimize factor ratios, and improves the quality level of marine fishery economy development. This is similar to the findings of previous studies: the digital economy can significantly promote the high-quality development of the marine economy, especially the promotion effect at the level of innovation and openness [10,11]. Therefore, this study supports and extends early research in terms of multiple aspects.

Second, scientific and technological innovation in marine fishery is an important path for the digital economy to promote high-quality development of marine fishing. According to the results in Table 4, the regression coefficient of the mediating effect was 0.05, and significantly positive. Previous studies mainly focused on the promotion effect of digital technology on marine economic efficiency, the coordination analysis of the digital economy and marine economy, and the impact of marine scientific and technological innovation on the quality of the marine economy [15–17], or the impact of upgrading and development of the marine industrial structure on the marine fishery economy quality [5,6]. There is less analysis of the role and mechanism of technological innovation in marine fishing in promoting the quality development of the marine fisheries economy through the digital economy. We confirmed the mediating effect of scientific and technological innovation in marine fishing, and expanded the research perspective and content of the digital economy and marine fishery economy. This is of great significance for accelerating the development of the digital economy, perfecting the scientific and technological innovation of marine fishing, and improving the economic quality and development of marine fishing.

Third, the digital economy has significant regional heterogeneity in promoting the high-quality development of the marine fishery economy, but it does not match the quality level of the digital economy and marine fishery economy in each region. According to Figures 1 and 3, it can be seen that the average quality of the digital economy in the Eastern and Southern Marine Economy Circles is 0.29 and 0.18, respectively, and the average quality of the marine fishery economy is 0.28 and 0.27, respectively. Both are higher than the average level of the digital economy and marine fishery economy in the Northern Marine Economy Circle. However, the regression coefficient of the digital economy in the Eastern and Southern Marine Economy Circles to the quality level of the marine fishery economy is significantly lower than that in the Northern Marine Economy Circle. The reasons for this are as follows: (1) The digital economy in China is in the early period of the industry life cycle, and the advanced concepts and models of the digital economy in different regions have different application levels in the development of the marine fishery economy. The development of the digital economy in the Eastern Marine Economy Circle and the Southern Marine Economy Circle has not yet carried out all-round and whole-chain transformation of the marine fishery economy, enabling the coordination and cross-field integration of the whole industrial chain, and the transformation and upgrading of the marine fishery, while the digital economy in the Northern Marine Economy Circle is deeply integrated and coordinated with the marine fishery economy. (2) Due to the different regional digital economies, the foundation of the marine fishery economy, resources, and advantages are different, and the emphasis on promoting the development of the digital economy and marine fishery economy is also different. The development of the digital economy in the Eastern and Southern Marine Economy Circles pays more attention to digital technology innovation, digital industry, high-tech industry development, and other aspects, while the leading and supporting role of new technology, new modes, and new applications of the digital economy has not been fully used in the optimization and upgrading of regional marine fishing. In particular, the Eastern Marine Economy Circle has not yet used new Internet technologies to carry out all-round and whole-chain transformation of marine fisheries, improve total factor productivity, take full advantage of the amplification, superposition, and multiplication of digital technology in economic development, and fully release technological dividends and innovation dividends. This leads to a high level of regional digital economies, while the level of influence on the quality of the marine fishery economy is relatively low, and the coordination between the digital economy and marine fishery economy development is low.

We analyzed the driving mechanism of the digital economy on the economic quality of marine fishing from the perspective of marine scientific and technological innovation, which had important theoretical significance and practical value for promoting the development of digitally enabling the marine fishery economy quality [33]. **First**, it not only helps to accurately grasp the development trend of the digital economy, clarifies the important role

of the digital economy in the development of the marine fishery economy, and further enriches the research content of the high-quality development of marine fishing, but also provides a new perspective for promoting the coordinated development of the digital economy and marine fishery economy, and a new research framework for promoting the high-quality development of marine fishing through diversification. **Second**, it provides a realistic path and policy reference for the high-quality development of the marine fishery economy. In particular, the current extensive development of the marine fishery economy lacks the support of green technology. This paper verifies that the development of the digital economy can improve the quality of the marine fishery economy by promoting scientific and technological innovation, and expanded the path of high-quality development of the marine fishery economy. On the one hand, the development of the digital economy provides a guarantee for the scientific and technological innovation of marine fishing; on the other hand, the scientific and technological innovation of marine fishing promotes the improvement in the quality and efficiency of marine fishing, thus making more efficient use of digital resources, fully releasing the potential of digital technology, stimulating the vitality of the marine fishery economy, and ultimately promoting the high-quality development of the marine fishery economy. These studies can provide a decision-making reference for other countries and regions to formulate high-quality marine fishery development policies.

Although we empirically measured the impact and mechanism of China's digital economy development on the quality of the marine fishery economy, it objectively confirmed the positive driving effect of the digital economy on the marine fishery economy and regional differences. However, the unavailability of other index data and marine fishery data will affect the accuracy of the empirical results. Meanwhile, this article has weak analysis of whether the digital economy has a threshold effect on the quality of the marine fishery economy, and whether the digital economy and marine fishery technology have a regulatory effect on the quality of the marine fishery economy [34]. This will also be the focus of future research.

5. Conclusions and Suggestions

5.1. Research Conclusions

Based on the impact and internal mechanism of the digital economy on the marine fishery economy quality in all provinces and cities from 2011 to 2022, the main research conclusions are as follows:

- (1) The development of China's digital economy quality showed a wave-like upward trend, but the overall level was low. The quality of the digital economy presented a spatial distribution pattern of "low in the South and North, and high in the East", with an obvious inter-regional gap and serious inter-provincial polarization. The economic quality level of marine fisheries is showing a gentle upward trend, with an average annual growth rate of over 4%, but the overall level is still relatively low. From the perspective of spatial distribution, the economy quality of China's marine fishing showed a spatial distribution pattern of "low in the South and North, and high in the East", and the development was more balanced among regions, but there were significant differences between provinces, and the phenomenon of inter-provincial polarization was very serious.
- (2) The influence coefficient of the digital economy on the economy quality of marine fishing was significantly positive, showing it can effectively improve the economic quality of marine fishing. The influence of digital economy development on the economic quality of marine fishing had significant regional heterogeneity, and the influence coefficient decreased successively from the Northern Marine Economy Circle, the Southern Marine Economy Circle, and the Eastern Marine Economy Circle, which did not match the level of digital economy quality and marine economy quality of the three marine economy circles.
- (3) Scientific and technological innovation of marine fishing had a positive mediating effect on the digital economy boosting the high-quality development of marine fishing.

The digital economy can improve the quality of the marine fishery economy by improving the scientific and technological innovation ability of marine fishing. The scientific and technological innovation of marine fishing in different regions varied greatly in the promotion of the marine fishery economy quality by the digital economy, and there was significant regional heterogeneity.

5.2. Suggestions

In order to improve the development level of the digital economy in coastal areas of China, promote scientific and technological innovation in marine fishing, and boost the high-quality development of marine fishing, based on the above research conclusions, we put forward the following suggestions:

- (1) Accelerate the development of the digital economy. Continue to promote digital technology innovation; strengthen the combination of digital technology and the economy; innovate in the technological fields of intelligent manufacturing, artificial intelligence, and energy interconnection; comprehensively improve the level of data elements; and take advantage of the penetration and diffusion role of data elements in improving the economy quality of marine fisheries [35]. Shape the production, service, and management innovation pattern of the digital economy, improve digital application scenarios, and constantly cultivate new industries and new forms of business for the development of the digital economy. Perfect digital infrastructure construction; speed up industrial Internet, Internet of things, cloud computing, artificial intelligence, and blockchain equipment such as via large-scale deployment; promote cloud network integration, intelligent agile technology, green low carbon, and the safe control of intelligent integrated digital information infrastructure. Strengthen the integration of digital infrastructure and the intelligent construction of marine fishery infrastructure, and realize intelligent and digital marine fishing.
- (2) Promote the digital development of marine fisheries. Use digital technology to promote the transformation and upgrading of marine fisheries, and build smart fishing ports, smart marine ranches, smart marine manufacturing, and smart ports [36]. Focus on the development of new industries such as green fisheries, ecological fisheries, and recreational fisheries, and build a diversified experience of marine fishery leisure, tourism, and services. Smart equipment for marine farming and fishing has been innovated to achieve online monitoring, precise feeding, and automatic purification of marine fisheries, and improve the production efficiency of marine fisheries. We will support the construction of facilities for deep-water storm-resistant cage breeding, the establishment of marine ranches, the proliferation and release of fish, and healthy aquaculture. Build an intelligent platform for marine fishing. Build a comprehensive research and development intelligent platform that integrates aquatic feed, seedlings, and aquaculture, and build a smart marine big data center and smart marine application platform. Perfect the information platforms of marine fishing trading information, credit supervision platforms, and product traceability platforms, and build the upper and lower linkages, business cooperation, and information sharing system of the modern marine fisheries industry.
- (3) Promote marine fishery science and technology innovation. Strengthen deep-sea farming equipment and varieties, such as technology, to promote the marine fisheries from offshore bay aquaculture to deep-blue breeding, especially to speed up the marine fisheries, using unmanned ships, underwater robots, remote control centers, unmanned surface vessels, ocean surveillance ships, marine carbon sinks, marine farm monitoring devices, and systems such as high-end technology research and development. Use of big data, cloud computing, artificial intelligence, and other technology can assign deep-sea fishery farming equipment with wisdom. Key breakthroughs are water environment perception, intelligent control equipment, production and collection of intelligence information, and data analysis and service system construction, and key techniques for marine fisheries are informationization, intellectualization transforma-

tion, and upgrading. Implement key technology research projects of aquatic genetic breeding, and improve the innovation ability of breeding new aquatic varieties.

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