Article

Research on the Spatial-Temporal Evolution and Driving Mechanism of Coupling Coordination among Digital-Tourism-Environment in the Yellow River Basin

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Abstract: The digital economy, the tourism industry, and ecological protection are closely related, which holds paramount significance for regional sustainable development. Based on panel data from 2011 to 2021 in the Yellow River Basin, the study scrutinizes the spatial and temporal variances and driving factors of the three-system coupling coordination degree. The results indicate that: (1) The development level of the three systems is significantly different. The coupling coordination degree shifts from imminent imbalance to marginal coordination, but there is a noticeable expansion in spatial disparities. (2) The coupling coordination degree of non-resource cities significantly surpasses that of resource cities, and regenerative cities outperform growing, mature, and declining cities. The overall pattern of the provincial capital cities “center-periphery”, decreased the coordination characteristics. The spatial correlation of coupling coordination degree presents two aggregation patterns of “high-high” and “low-low”, and the overall correlation gradually weakens. (3) The driving factors reveal that the economic driving force is the largest, followed by the internal driving force, and the government regulatory force and scientific and technological driving force are relatively weak. Consequently, this paper proposes to strengthen the integration and penetration function of the digital economy and have it play the linkage role between regions. This lays down a solid foundation for crafting scientifically informed policies aimed at achieving regional sustainable development.

Keywords: digital economy; tourism industry; ecological environment; coupling coordination model; driving factors

1. Introduction

Sustainable development is a significant challenge facing human society. The United Nations calls for action by all countries to promote economic prosperity while protecting the planet [1]. Sustainable development is generally defined as “development that meets the needs of the present without compromising the ability of future generations to meet their needs” [2]. Its core emphasizes the comprehensive sustainability of the economy, social culture, and the environment. As the world’s second-largest economy and the largest developing country, China’s economic transformation and upgrading are crucial for global sustainable development. The Yellow River Basin, spanning the three major topographical terraces of China, has rich natural and cultural resources. It serves as a significant ecological barrier, economic zone, energy basin, and cultural tourism gathering area in China [3]. However, the economic foundation of the region is relatively weak, and traditional industry dominated by the heavy energy and chemical sectors has exacerbated the ecological burden [4], triggering a variety of ecological problems [5]. To balance ecological protection and economic development, provinces and cities in the Yellow River
Basin have been continually shifting their development concepts and optimizing industrial structures, yet some challenges remain [6]. In 2019, the major national strategy of “Ecological Protection and High-Quality Development of the Yellow River Basin” was officially launched. The central government mandates that provinces of the Basin unwaveringly pursue a path of ecological priority and green development, viewing this strategy as a vital long-term plan related to the great rejuvenation of the Chinese nation. Therefore, the ecological protection and high-quality development of the Yellow River Basin are of great significance to China’s economic transformation and global sustainable development, which is an important reason to consider it as a study area.

The tourism industry and the digital economy, owing to their inherent advantages and development potentials, have become significant driving forces for ecological protection and high-quality development in the Yellow River Basin. Specifically, the tourism industry is an environment-friendly industry with prominent cultural characteristics and a strong comprehensive driving force [7], which plays a positive role in both economic growth and ecological protection [8]. Meanwhile, the digital economy, as a new production factor, contributes to enhance industrial performance, structure, and innovation [9]. However, transportation and its related services inevitably generate energy consumption and indirectly lead to environmental problems such as increased carbon emissions and resource waste [10]. Therefore, how to promote the coupled coordinated development of the digital economy, the tourism industry, and the ecological environment in the basin has become a pressing issue to focus on for researchers. Existing studies indicate that there is a synergistic relationship of mutual influence and common development between the three systems. Firstly, there is a benign development path between the ecological environment and the tourism industry, and scholars have used the coupled coordination model to conduct in-depth research [5,11,12]. The extent of environmental pollution affects both tourist volume and tourism revenue [13,14]. An inverted U-shaped connection has been confirmed between the tourism industry and the ecological environment, which is called the environmental Kuznets curve [15–17]. Secondly, the digital economy has multiple impacts on the tourism industry and the ecological environment. By constructing a fixed-effects model and a spatial Durbin model, researchers point out that the digital economy can foster the growth of the local tourism industry [18] and has a positive spatial spillover effect [19]. At the same time, the digital economy is also conducive to reducing the total amount and intensity of carbon emissions [20] and there is a nonlinear effect of first increasing and then inhibiting carbon emissions [21]. This insight has been verified in diverse sectors, including agriculture [22], manufacturing [23], and tourism [24,25].

In conclusion, the digital economy and the tourism industry are closely related to the ecological environment, which is of great practical significance for regional sustainable development. Although researchers have made valuable explorations, there remains a need for further investigation. First, there is a lack of empirical studies at the city level in the basin [26]. The relevant studies mainly focus on the provincial [27,28], city cluster [29,30], industry [31], enterprise [32], and other levels. Secondly, existing studies on the coupling of the Yellow River Basin mostly focus on the quantitative analysis of two variables, and mainly concentrate on the ecological environment and economic development [33,34], high-quality development [35], urbanization development [36], and so on. There is a lack of empirical research on the ternary coupling coordination of the digital economy, the tourism industry, and ecological protection.

Considering the current research and the significance of this issue, we have chosen to utilize panel data from 78 prefecture-level cities in the Yellow River Basin spanning from 2011 to 2021 and investigate the coupling coordination of the digital economy, the tourism industry, and ecological protection within the basin. The research questions include: (1) What is the current level of the three-system coupling coordination in the Yellow River Basin? (2) What is the evolutionary trend of the three-system coupling coordination in the Yellow River Basin, that is, what characteristics are present in different times and places? (3) What are the factors that drive the three-system coupling coordination in the
Yellow River Basin? The research framework is outlined as follows: The Section 1 includes the research background, relevant literature reviews, and research contributions. The Section 2 delves into the mechanism of DTE system coupling coordination. The Section 3 constructs the compositive evaluation index system for assessing the digital economy, the tourism industry, and the ecological environment. The Section 4 utilizes the coupling coordination degree model, kernel density calculation, and spatial autocorrelation analysis to examine the spatial and temporal evolution of ternary system coupling coordination degree. In the Section 5, we identify the influencing factors of ternary coupling coordination by using a panel Tobit model and then analyze the driving mechanisms. Ultimately, the paper summarizes the development characteristics of the three-dimensional coupling coordination in the Yellow River Basin, with a view to providing beneficial support for regional coordinated development and sustainable development.

2. Coordination Mechanism

The digital economy, the tourism industry, and the ecological environment constitute an intricate system with mutual influence, interaction, and interconnection. The synergy theory was proposed by Harken, which emphasizes the interaction and matching, coordination, and cooperation among the subsystems within the composite system, and jointly promotes the system as a whole to transform from the old structure to a new structure and from disorder to order [37]. This study primarily relies on the synergetic theory to interpret the coupling coordination of the digital economy, tourism, and ecology, aiming to achieve comprehensive and balanced upgrading of the three systems (Figure 1).

![Figure 1. The coupling mechanism of the digital economy, the tourism industry, and the ecological environment.](image)

2.1. The Ecological Environment and the Digital Economy

A favorable ecological environment can create a habitable living environment, and bolster the region’s attractiveness to investment and talent [37], which provides the material basis for the advancement of the digital economy. In order to conserve the ecosystem effectively, government authorities implement environmental regulations. Reasonable environmental regulation can engender the “learning effect” and “innovation compensation...
effect”. This promotes enterprises to accumulate knowledge and engage in technological innovations to meet environmental policies, offsetting or surpassing the cost of environmental regulation [38]. Ultimately, these synergistic effects can achieve a win-win situation for both environmental protection and economic upgrading.

The digital economy can improve environmental quality. The digital economy relies on digital technologies, data elements, and infrastructure to transcend the constraints of time and space [21]. It accelerates the transition from material to information resources and lowers the energy and physical consumption of the real economy, thus reducing the intensity of carbon emission [10,39]. First, the digital economy directly provides technical support for environmental governance. Technologies, such as big data, cloud computing, and remote sensing, enable monitoring of air quality and environmental carrying capacity. Second, the digital economy is able to advance energy efficiency, technological progress, and industrial structure. The integration of the digital economy and traditional industries can accelerate the improvement of intelligent and low-carbon industries with high energy consumption and high emissions, which optimizes the efficiency of resource allocation and enhances total factor productivity [20,21]. Simultaneously, the expansion of the digital economy has accelerated the digital transformation of conventional industries and facilitating industrial restructuring and promoting the development of technology-intensive sectors [40].

2.2. The Ecological Environment and the Tourism Industry

The ecological environment is the prerequisite for the tourism industry to survive and thrive [12,41]. Natural resources and ecosystems are indispensable components of tourism resources. The main factors that attract tourists to destinations include wildlife, natural beauty, and eco-cultural elements [15]. To a certain extent, a high-quality ecosystem helps to mitigate the negative effect of tourism development on environmental carrying capacity, thereby facilitating the sustainability of the ecological environment. Stringent environmental standards can also reduce the adverse impact of tourism activities on carbon emissions [16,17] and propel the prosperous development of the tourism industry by escalating the industrial structure, cultivating technological innovation, and improving the city image [41].

Tourism, as an environmentally friendly industry, is fully capable of becoming an effective tool for environmental protection when reasonably utilized [8], but if it is overdeveloped, it will also affect the ecological balance and environmental quality [27]. Tourism has a positive impact on environmental quality by supplying critical services, encouraging technological advancement, and promoting efficient energy use [10]. Specifically, tourism destinations provide tourists with environmentally friendly products and services, which can motivate locals and tourists to embrace pro-environment behaviors [42], ultimately promoting the sustainable utilization of ecological resources. As the tourism industry has a high dependence on and high standards for the ecological environment, it also prompts local governments to inhibit the expansion of high-pollution and high-energy-consumption industries and to seek institutional innovation and technological progress [43]. Through the introduction of renewable energy, green technology, and digital management, the tourism industry can not only improve the efficiency of energy use and tourism labor efficiency, but also effectively monitor and manage tourism activities, which in turn reduces environmental pollution [44], and even counteracts the negative impact of tourism on the environment.

2.3. The Digital Economy and the Tourism Industry

The essence of the digital economy is a new economic format based on Internet technology [24], which provides technical support for propelling the tourism industry and environmental protection. The digital economy affords the tourism industry a more expansive space for innovation and consumption, which is conducive to modifying the industry structure and innovating the business system. As digital technology gradually
penetrates the tourism industry, it has transformed the industry structure from a labor-intensive to a technology-intensive and environmentally friendly structure [45,46]. It can also generate diverse tourism forms to stimulate tourism consumption and augment tourism revenue [19,47]. The digital economy has completely subverted the commercial system and marketing strategies within the tourism sector, emerging as a pivotal force in enhancing the competitiveness of tourism destinations. The tourism industry establishes a global business network through cyber-physical systems [48], which helps tourists to search, identify, purchase, and evaluate the tourism services they need, such as transport, accommodation, and attraction tickets [45]. This diminishes the transaction costs for tourists and scenic spots and then fosters the development of the global trade in tourism services [25]. In tourism transactions, massive tourist data and digital footprints are generated to detect tourists’ consumption behavior and expectations, realizing refined and personalized marketing [48,49]. Therefore, digital technologies offer optimized pathways for the industrial structure, production process, and supply-demand matching in the tourism market [24], which is conducive to enhancing resource utilization and emission reduction [50].

Tourism is an industry that is easy to digitize and information-intensive [48], which offers a wide range of application scenarios for digital technologies. Due to the highly interactive nature of the tourism industry, the tourism market has emerged with higher requirements for the usability, accessibility, and flexibility of digital technology [45], thus promoting a deeper integration of technology and tourism.

3. Index Measurement, Data Sources, and Research Methods

3.1. Study Area

The Yellow River Basin encompasses the area traversed by the main and tributary streams of the Yellow River, primarily covering nine provinces and regions: Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shanxi, Shaanxi, Henan, and Shandong, with a total basin area of 795,000 km². The vast basin crosses four major geomorphological units such as the Qinghai-Tibet Plateau, Inner Mongolia Plateau, Loess Plateau, North China Plain, as well as the three major terraces of China’s topography. It includes natural ecological corridors and several important ecological function areas such as the Sanjiangyuan, Qilian Mountains, Qinling Mountains, and so on. While the natural environment of the Basin has been continuously improving [51], ecological fragility remains its greatest challenge [5]. The Yellow River Basin has a rich cultural foundation, with distinctive regional cultures such as Hehuang culture, Guanzhong culture, Heluo culture, and Qilu culture, as well as several historic ancient capitals including Xi’an, Luoyang, Zhengzhou, Kaifeng, and Anyang. This provides diverse carriers and numerous possibilities for tourism development [52]. The digital economy is a significant driving force for high-quality development in the basin and can unleash high-quality development dividends by optimizing industrial structures [53]. Currently, the number of digital economy enterprises in the Yellow River Basin has increased significantly, showing a pattern of “strong in the east and weak in the west” and a trend of “contraction” [32]. Overall, the digital economy, the tourism industry, and the ecological environment in the Yellow River Basin have a positive development trend, with immense potential and space for growth. Since the Outline of the Development Plan for the Yangtze River Economic Belt and other documents include Sichuan Province in the Yangtze River region, this study excludes Sichuan Province. Considering the research scale, basin characteristics, and regional connections, this study focuses on the cities and regions traversed by the main and tributary streams of the Yellow River and the entire provinces of Henan and Shandong, selecting a total of 78 prefecture-level cities from eight provinces and regions as the research objects.

There are significant differences in the development modes between resource-based and non-resource-based cities of the basin. Resource-based cities are mainly dominated by the mining and processing of natural resources such as minerals and forests and
generally face the dual pressures of ecological destruction and high carbon emissions in the region [54]. Therefore, based on the National Sustainable Development Plan (NSDP) for Resource-Based Cities issued by the State Council in 2013 [55], this paper further divides the research objects into resource and non-resource, with a total of 40 resource-based cities and 38 non-resource-based cities. In addition, following the principles of classified guidance and distinctive development, the NSDP divides resource-based cities into four types, growing, mature, declining, and regenerative, based on the capacity for resource security and sustainable development. This classification is also reflected in our study (Figure 2).

![Figure 2. Classification of resource-based and non-resource-based cities in the Yellow River Basin.](image-url)

3.2. Index Selection and Data Sources

The study is grounded in the theoretical framework of the coupling coordination degree among the DTE systems. Based on summarizing previous studies, we strive to build a comprehensive, scientific, and feasible evaluation index system for the digital economy, the tourism industry, and the ecological environment.

1) Referring to existing research [21,24], the digital economy indicators are divided into digital infrastructure, digital industry upgrading, and digital technology applications.

2) Following the structure outlined in the Report on China’s Sustainable Development Strategy by the Chinese Academy of Sciences [56], the ecological environment indicators are categorized into three elements: ecological environment elements, ecological environment pressures, and ecological environment protection.
(3) Drawing on the study of Ma et al. [57], the tourism economic indicators are divided into tourism development elements, tourism market scale, and tourism economic level. Table 1 contains the specific indicators of all variables.

The original data came from various sources in this paper, including the China Urban Statistical Yearbook, the China Tourism Statistical Yearbook, the China Environmental Statistical Yearbook, the Statistical Yearbook of the study region, the Statistical Bulletin of National Economic and Social Development of each region, water resources bulletins, or data from prefecture-level city statistics bureaus. The missing data are matched by provincial data or filled in by linear interpolation. In this study, the method of extreme value standardization is employed to pre-process the original data. The entropy method is adopted to gauge the comprehensive development level of the digital economy, the ecological environment, and the tourism industry.

### Table 1. The evaluation index system of the digital-tourism-environment system.

<table>
<thead>
<tr>
<th>Target Layer</th>
<th>Element Layer</th>
<th>Index Layer</th>
<th>Nature</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tourism industry system</td>
<td>Development elements</td>
<td>Number of employees in the tourism industry</td>
<td>+</td>
<td>0.059</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of star-rated hotels</td>
<td>+</td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of travel agencies</td>
<td>+</td>
<td>0.062</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Density of tourist attractions</td>
<td>+</td>
<td>0.067</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of enterprises in accommodation and catering industries</td>
<td>+</td>
<td>0.083</td>
</tr>
<tr>
<td></td>
<td>market scale</td>
<td>Number of domestic tourists</td>
<td>+</td>
<td>0.047</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inbound tourist arrivals</td>
<td>+</td>
<td>0.295</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total number of tourists</td>
<td>+</td>
<td>0.047</td>
</tr>
<tr>
<td></td>
<td>economic level</td>
<td>Domestic tourism revenue</td>
<td>+</td>
<td>0.060</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tourism foreign exchange earnings</td>
<td>+</td>
<td>0.190</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross tourism income</td>
<td>+</td>
<td>0.057</td>
</tr>
<tr>
<td>Environmental element</td>
<td></td>
<td>Per capita green park area</td>
<td>+</td>
<td>0.058</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Green coverage rate</td>
<td>+</td>
<td>0.260</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water resources content</td>
<td>+</td>
<td>0.484</td>
</tr>
<tr>
<td>Ecological protection system</td>
<td>Environmental pressure</td>
<td>Industrial wastewater discharge</td>
<td>-</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carbon emissions</td>
<td>-</td>
<td>0.105</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Energy consumption</td>
<td>-</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>Environmental governance</td>
<td>Comprehensive utilization rate of industrial waste</td>
<td>+</td>
<td>0.058</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Centralized treatment rate of sewage treatment plant</td>
<td>+</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Domestic waste disposal rate</td>
<td>+</td>
<td>0.012</td>
</tr>
<tr>
<td>Digital infrastructure</td>
<td></td>
<td>Internet broadband access ports</td>
<td>+</td>
<td>0.122</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of Domains</td>
<td>+</td>
<td>0.197</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optical cable line length</td>
<td>+</td>
<td>0.115</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E-commerce sales</td>
<td>+</td>
<td>0.185</td>
</tr>
<tr>
<td>Digital economic system</td>
<td>Digital industry development</td>
<td>Employment in information transmission, software, and information technology services</td>
<td>+</td>
<td>0.190</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total volume of telecommunication service</td>
<td>+</td>
<td>0.103</td>
</tr>
<tr>
<td></td>
<td>Digital technology application</td>
<td>Mobile phone penetration</td>
<td>+</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internet broadband penetration rate</td>
<td>+</td>
<td>0.050</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Digital Financial Inclusion Index</td>
<td>+</td>
<td>0.018</td>
</tr>
</tbody>
</table>

### 3.3. Research Propositions

The research content of this paper is the coupling coordination level of the digital economy, the tourism industry, and the ecological environment in the Yellow River Basin,
and the spatio-temporal evolution and driving mechanism of the ternary coupling coordination degree. Therefore, the following propositions are proposed:

**Proposition 1.** The coupled coordination level of the digital economy, the tourism industry, and the ecological environment in the Yellow River basin can present obvious temporal heterogeneity.

**Proposition 2.** The spatial distribution and evolution trend of the digital economy, the tourism industry, and the ecological environment in the Yellow River basin can show obvious spatial heterogeneity.

**Proposition 3.** The driving factors of the coupling and coordination degree of the digital economy, the tourism industry, and the ecological environment in the Yellow River Basin are diversified and complex, including many factors such as the economy, the market, technology, and government.

### 3.4. Research Methods

#### 3.4.1. The Coupling Coordination Degree Model

The coupling coordination degree model is a method to evaluate the degree of interaction and coordinated development among various elements in a system. The degree of coupling reflects the degree of interdependence and mutual restriction between multiple systems, while the degree of coordination measures the degree of benign coupling between multiple systems and reflects the quality of coordination [58]. Based on the coupling coordination model, this paper constructs a coupled model of the digital economy, the ecological environment, and the tourism industry based on existing research. The formula is as follows:

\[ C = \frac{U_1U_2U_3}{(U_1+U_2+U_3)^3} \]  

\[ T = \alpha U_1 + \beta U_2 + \gamma U_3 \]  

\[ D = \sqrt{C \times T} \]  

where \( U_1, U_2, \text{ and } U_3 \) symbolize the comprehensive level indexes of the digital economy, the tourism industry, and the ecological environment, respectively. \( C \) signifies the three-system coupling degree, and the level range is from 0 to 1. According to existing research and the status quo of social and economic upgrading, the weight coefficients (\( \alpha, \beta, \text{ and } \gamma \)) assigned to the three systems are set at 1/3 each. According to the research of Zhao et al., coupling coordination degree is divided into ten stages on account of the uniform distribution of the variation amplitude of \( D \) [12]. These values are delineated as follows: \( [0.0, 0.1), [0.1, 0.2), [0.2, 0.3), [0.3, 0.4), [0.4, 0.5), [0.5, 0.6), [0.6, 0.7), [0.7, 0.80, [0.8, 0.9], \text{ and } [0.9, 1] \). The coordination levels range from extreme imbalance, severe imbalance, moderate imbalance, mild imbalance, imminent imbalance, marginal coordination, primary coordination, intermediate coordination, and good coordination to high-quality coordination.

#### 3.4.2. Calculation of Nuclear Density

The observed data points are fitted through the smooth peak function, and then the actual probability distribution curve is simulated to show the distribution of random variables. The calculation formula is as follows:

\[ f(x) = \frac{1}{nh} \sum_{i=1}^{n} K\left(\frac{x-x_i}{h}\right) \]
Here, $f(x)$ represents the probability density function estimation of the three-system coupling coordination degree, $n$ represents observed sample size, and $h$ represents the bandwidth.

3.4.3. Analysis of Spatial Autocorrelation

Spatial autocorrelation mirrors the correlation degree between a particular phenomenon in a specific area and the same phenomenon in adjacent area units. It is applied to discover potential interdependencies between phenomena [59]. This paper adopts the global Moran’s $I$ index and Lisa index to determine the spatial autocorrelation and spatial clustering characteristics for the coupling coordination within the ternary system. The range of the Moran’s $I$ index is $-1$ to $1$. When the value is less than zero, it indicates a negative correlation and spatial discreteness; when the value is more than zero, it depicts a positive correlation and spatial aggregation. The Lisa index is generally classified into four types: low-low aggregation, high-high aggregation, low-high aggregation, and high-low aggregation.

The formula of global autocorrelation is as follows:

$$\text{Moran}’I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} \omega_{ij} (P_i - P_{\text{mean}}) \times (P_j - P_{\text{mean}})}{(\sum_{i=1}^{n} \sum_{j=1}^{n} \omega_{ij}) \times \sum_{i=1}^{n} (P_i - P_{\text{mean}})^2}$$

(5)

Here, $n$ signifies the observed sample size. $P_i$ and $P_j$ denote the values of the relevant indicator for individual $i$ and individual $j$ in the region, respectively. $P_{\text{mean}}$ signifies the mean value of these indicators and $\omega_{ij}$ denotes the spatial weight matrix.

3.4.4. Tobit Model

Since the coupling coordination degree is generally distributed between 0 and 1, it is a restricted dependent variable. In order to avoid the bias caused by OLS estimation, a Tobit model is usually used for estimation. In this study, a panel Tobit random-effects model is chosen to examine the influencing factors of DTE system coupling coordination to avoid conflict between the fixed-effects and the panel Tobit models.

$$Y_{it} = \alpha + \beta X_{it} + \epsilon_{it}$$

(6)

$Y_{it}$ is an explanatory variable, representing the level of ternary coupling coordination of city $i$ in $t$ period. $X_{it}$ is a matrix of explanatory variables, representing the driving factors of coupling coordination level of city $i$ in $t$ period. The $\alpha$ and $\epsilon_{it}$ present the intercept term and the random perturbation term.

4. Spatial-Temporal Features of DTE System Coupling Coordination Degree

4.1. Analysis of the Comprehensive Development Levels of the Three Systems

As can be seen from Figure 3, there are apparent variances in the comprehensive development levels of the three systems during the observation period. From the index of the comprehensive development level, the ecological environment > the digital economy > the tourism industry. From the speed of change, the digital economy exhibited the fastest growth, followed by the tourism industry, while the ecological environment experienced the slowest growth.
From 2011 to 2021, the comprehensive development level of the digital economy in the Yellow River Basin showed a rapid upward trend. The index climbed from 0.170 in 2011 to 0.422 in 2019, with an average annual growth rate of 18.5%. In 2021, the growth rate increased to 19.3% from 0.422 in 2019. The digital economy is a new driving force for the high-quality development of the Yellow River Basin [53], and digital infrastructure is an important support for the development of the digital economy. According to the data on the website of the provincial industry and information department, it can be seen that the total number of 3G base stations in the Yellow River Basin reached 186,000 in 2011; in 2019, 38,700 5G base stations were opened; and 299,300 5G base stations were opened in 2021. In addition, the digital economy continued to grow rapidly during the pandemic, which is consistent with related research [25,48].

From 2011 to 2021, the comprehensive development level of the ecological environment in the Yellow River Basin showed a steady upward trend. The index increased from 0.503 in 2011 to 0.630 in 2019, with an average annual growth rate of 3.16%. Subsequently, the index rose from 0.630 in 2019 to 0.674 in 2021, with an average annual growth rate of 3.74%. Specifically, the ecological environment in the middle and upper reaches is relatively fragile, but there are many ecological spaces under protection. The problem of illegal development has been gradually curbed, and the ecological index has been improved [60]. Although the ecological environment in the middle and lower reaches is better than that in the upper reaches, the dense population and industry and active economic activities have increased environmental pressure [61]. As local governments continue to attach importance to the construction of an ecological civilization [35], the ecological environment level of the Yellow River Basin is generally good during the study period, but the growth rate needs to be improved. As for the small peak in the increase in 2020, it mainly stems from the lockdown measures during the COVID-19 pandemic, which can also be confirmed by existing research [62].

The level of tourism industry development in the Yellow River Basin showed a continuous growth trend from 2011 to 2019 until a sudden drop in 2019. The value soared from 0.110 in 2011 to 0.232 in 2019, with an average annual growth rate of 13.89%. Nevertheless, there is a noticeable decline from 2019(0.232) to 2021(0.175), a decrease rate of 24.66%. The sustained development of the tourism industry in the basin is mainly due to rich tourism resources [52] and the rising demand for tourism [63]. Meanwhile, in response to the central government’s concept of ecological civilization development, an eco-friendly tourism industry has naturally become a vital choice for local governments. However, as the Yellow River Basin covers the eastern, central, and western parts of China, there are large differences in the development level, industrial structure, and resource endowment between various regions. Some regions have weak economic foundations and poor regional cooperation and coordination awareness. This not only causes little change in the tourism index of some regions during the observation period, but also becomes a
bottleneck for improving the overall development level of the tourism industry. The sharp decrease in the tourism index in 2020 is closely related to the COVID-19 pandemic. In contrast to the digital economy, the tourism industry has obvious vulnerability and volatility [57]. While lockdown measures have positively impacted the ecological environment, they have harmed the thriving development of the tourism industry.

4.2. Temporal Evolution of DTE System Coupling Coordination

From the analysis of the mean value (Table 2), the DTE system coupling coordination degree of the Yellow River Basin entered the stage of marginal coordination. The three-system exhibited a consistent upward trend from 2011 to 2019, signifying that the coupling coordination level of the DTE systems was continuously deepened during the observation period. In 2020 and 2021, the coupling coordination was sharply decreased. From the analysis of city types, the coupling coordination degree of non-resource-based cities was higher than that of resource-based cities. The reason may be that non-resource-based cities have diversified industrial structures, while resource-based cities have a single industry that can cause environmental degradation [59].

Table 2. The DTE system coupling coordination degree of the Yellow River Basin.

<table>
<thead>
<tr>
<th>Year</th>
<th>Whole Basin Coordination Grade</th>
<th>Resource Cities</th>
<th>Non-Resource Cities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Growth Maturity Decline Regeneration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>0.429 imminent imbalance recession 0.418 0.372 0.429 0.385 0.480 0.442</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>0.456 imminent imbalance recession 0.442 0.393 0.453 0.410 0.512 0.471</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>0.483 imminent imbalance recession 0.469 0.424 0.478 0.430 0.548 0.498</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>0.498 imminent imbalance recession 0.479 0.443 0.488 0.432 0.556 0.519</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>0.517 marginal coordination development 0.497 0.464 0.503 0.452 0.573 0.539</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>0.540 marginal coordination development 0.518 0.474 0.528 0.471 0.601 0.566</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>0.565 marginal coordination development 0.542 0.494 0.552 0.488 0.639 0.590</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>0.593 marginal coordination development 0.571 0.521 0.583 0.506 0.672 0.618</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>0.608 primary coordination development 0.584 0.538 0.598 0.520 0.675 0.635</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>0.583 marginal coordination development 0.557 0.516 0.566 0.500 0.648 0.613</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>0.599 marginal coordination development 0.572 0.538 0.580 0.512 0.661 0.632</td>
<td></td>
<td></td>
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</tbody>
</table>

After the 18th National Congress of the Communist Party of China in 2012, the Central Committee of the CPC put forward higher quality requirements for the development of the Yellow River Basin, focusing on the overall situation of ecological civilization construction. In order to practice the new development philosophy and strengthen the construction of an ecological civilization, governments at all levels have been eliminating backward production capacity, optimizing the industrial structure, and upgrading the level of regional economic development [6]. However, due to the delayed effects of policies and the time and process needed to change traditional development concepts and adjust industrial structures, it was not until 2015 that the ternary system reached a
marginally coordinated level, and finally entered the primary coordinated level in 2019. The major national strategy of “Ecological Protection and High-Quality Development of the Yellow River Basin” was officially implemented in 2019, which should have facilitated the three-system coordinated development. However, in 2020, the tourism sector was severely shocked by the COVID-19 pandemic, causing the coupling coordination degree to drop to a marginally coordinated level. By 2021, there was an increase in coupling coordination surpassing that of 2018 and it approached the primary coordination level. On one hand, as epidemic prevention and control became normalized, the tourism and hotel industries have started to adjust their business strategies, shifting from complete stagnation to intermittent recovery. On the other hand, 2021 marked the first year of China’s 14th Five-Year Plan, with development strategies such as dual-carbon targets, digital prowess, and the amalgamation of culture and tourism. In the same year, the central government issued the Outline of the Yellow River Basin Ecological Protection and High-Quality Development Plan and mandated earnest compliance by local governments. Consequently, despite 2021 being in the stage of epidemic prevention and control, many favorable policies and development planning functioned synergistically, providing important guidance for local governments to carry out their work in a reasonable and orderly manner, and the coupling coordination degree of the ternary system is also gradually picking up.

In order to explore the temporal variation of DTE system coupled coordination, we adopt the kernel density estimation curve (Figure 4). From the curve’s position, the kernel density function was shifted to the right as a whole with a specific right trailing phenomenon, which indicates that the coupling coordination has an upward trend during the observation period. There are some cities with high coupling coordination. The curve shape demonstrated fluctuations in the central peak and a slightly larger curve width, which means that the absolute difference may expand dynamically in the basin. Finally, the polarization phenomenon manifested such that the main peak gradually transitions to a bimodal state, and the side peaks were significantly lower, indicating that the basin has an obvious gradient effect and is significantly differentiated. Although ternary coupling coordination has significantly improved in the Yellow River, there is evident heterogeneity in the economic foundation, industrial condition, government capacity, technological innovation, and policy support among various regions. These disparities make it difficult to achieve rapid catch-up for cities with low coordination levels in the short term, and the gap is likely to continue to widen for a while.
Figure 4. The kernel density curve of DTE system coupled coordination in the Yellow River Basin.

4.3. Spatial Evolution of DTE System Coupling Coordination

Due to space limitations, we choose the spatial distribution maps of four nodes in 2011, 2016, 2019, and 2021 (Figure 5a–d). From Figure 5a–c below, it was found that three-system coupling coordination degree represented a progressive pattern in space. The quantitative distribution exhibited a “pyramid” structure characterized by a scarcity of high coordination and much low coordination. Specifically, ternary coupling coordination in 2011 was generally at a low stage, of which 43 cities were at the imbalance level. In 2016, the spatial distribution of coupling coordination manifested an increasing trend from edge to center. Meanwhile, the number of cities at the disorder level decreased to 32, and the number of cities at the primary coordination stage increased to 11. The cities of Xian, Zhengzhou, Yantai, Jinan, and Qingdao upgraded the intermediate coordination stage. In 2019, the spatial distribution displayed a “center-periphery” pattern led by provincial capital cities. All 26 cities with mild coordination entered the marginally coordinated stage, and five cities with intermediate coordination upgraded to the good coordination grade. After 2016, it could be found that the “Matthew effect” feature was more apparent. The ternary coupling coordination level was dominated by marginally coordinated grades and primary coordinated grades in the basin. It is challenging to achieve the phenomenon of grade jumping.

Figure 5. The spatial evolution of DTE system coupling coordination in the Yellow River Basin. (a) Coupling coordination level in 2011; (b) Coupling coordination level in 2016; (c) Coupling coordination level in 2019; (d) Coupling coordination level in 2021.

Regarding city types, non-resource cities exhibited a higher coupling coordination degree, forming a high-level development zone represented by Qingdao, Jinan, Zhengzhou, and Yantai. These cities whose three-system coupling coordination level was greater than the average value of the basin account for 20.5%, among which Qingdao (0.973), Jinan (0.917), Zhengzhou (0.951), and Xian (0.930) had stepped into the high-quality coordination grade. Due to the advantages of being provincial capitals, Jinan, Zhengzhou, and Xi’an leverage their robust conditions to attract substantial investments, information influx, and tourist traffic. With well-established digital infrastructures, a mature tourism
industry, and environmental governance experience, these advantages are pivotal in fostering their three-system coupled coordination upgrading. With the geographical advantage of being near the sea, Qingdao has created good conditions for the adequate circulation of technology, talents, and social factors. In addition, there are 32.05% (25) of the cities whose coupling coordination level was below the average value in the whole basin. Some cities in Gansu, Ningxia, and Inner Mongolia were in the marginal coordination stage. Although there is sufficient ecological space in the upper reaches, the underdeveloped social economy, delayed initiation of the tourism industry, and the lagging progress of digital technology has greatly constrained the three-system coupling coordination degree. Notably, seven of China’s excellent tourism cities in Henan are also low-value areas below the average level. This is due to the marginalization of urban development along the east of Henan. These cities still rely on traditional industries and lack essential elements to activate their abundant tourism resources. Consequently, it is difficult to enhance the three-system coupling coordination degree.

From the standpoint of resource cities, the distribution pattern adheres to the sequence “regeneration > maturity > growth > decline”. During the study period, there are varying degrees of growth among the four types of resource cities. The regenerative cities had the best performance in ternary coupling coordination, while the mature cities closely approached the average level of the basin. Among the regenerative cities, Luoyang (0.724), Zibo (0.721), Linyi (0.716), and Nanyang (0.672) witnessed a substantial enhancement of coordination levels in 2019, becoming the highland for the three-system coupling coordination upgrading among resource cities. The ternary coupling coordination degree of declining cities was relatively lagging behind. Only Jiaozuo (0.60) city achieved the primary coordination stage, the cities of Baiyin (0.504), Shizuishan (0.501), and Tongchuan (0.500) initially entered the marginal coordination stage, while the cities of Puyang (0.470) and Wuhai (0.471) remained at the imminent imbalance stage. The coordinated upgrading of Jiaozuo benefits from government support, which cultivates tourism as a leading industry, heightens efforts in ecological restoration, and accelerates the coordinated development of urban industries.

Generally speaking, regenerative cities eliminate resource dependence by actively developing green industries. They have made good progress in the high-tech industries, tourism, and the ecological environment. However, growing and mature cities rely on economic dividends derived from resource-based industries, which leads to truncated industrial chains, monotonous structures, and environmental challenges. It is difficult to form collaborative development of industries. Declining cities are undergoing economic transformation. Due to long-term accumulated environmental pollution and outdated facilities, the development of tourism, the digital economy, and the environment is poor and hinders effective utilization of the three forces. The exception is the “Jiaozuo phenomenon,” a notable example of a declining coal city transforming into a tourist destination.

In general, prefecture-level cities in Shandong have evolved into high-level agglomerations, while some cities in Ningxia and Gansu have developed into low-level agglomerations. It is noteworthy that Shandong actively promotes the conversion of old and new driving forces and is committed to shifting the cultural tourism industry from quantitative expansion to technological progress and green development, further strengthening the three-system coupling coordination. What is more, there are obvious regional disparities in the coupling coordination in the basin. Most cities have yet to attain a high coordination stage. There is more space and potential for subsequent upward movement.

The Moran’s I index can scientifically explore the spatial correlation of the ternary system. As shown in Table 3, the global Moran’s I index was significantly positive, indicating that the three-system coupling coordination level presents a spatial aggregation effect in the basin. The index generally demonstrated a fluctuating downward trend from 0.098 to 0.035, indicating that the spatial correlation effect gradually weakened. Despite the Yellow River Basin linking numerous cities, its limited navigational value fails to foster
stable regional cooperation and economic ties, making the ternary system show some volatility and weak correlation.

**Table 3.** Moran’s I index and *p* value in the Yellow River Basin.

<table>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>index</td>
<td>0.098</td>
<td>0.085</td>
<td>0.099</td>
<td>0.060</td>
<td>0.066</td>
<td>0.069</td>
<td>0.064</td>
<td>0.048</td>
<td>0.031</td>
<td>0.034</td>
<td>0.035</td>
</tr>
<tr>
<td><em>p</em></td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.002</td>
<td>0.026</td>
<td>0.017</td>
<td>0.014</td>
<td></td>
</tr>
</tbody>
</table>

Further, using Lisa cluster diagrams (Figure 6a–d), we found that the spatial characteristics of the “high-high” agglomeration region remained relatively stable and distributed in Shandong Province. After 2016, the “low-low” agglomeration region, distributed in the cities of Wuzhong, Qingyang, Dingxi, and other upstream cities, exhibited a slow convergence trend. The Shandong Peninsula attained a high coordination level and had a strong spatial correlation within the basin. In contrast, the northwest areas of Gansu and Ningxia had lower coupling coordination and less spatial correlation. The “high-low” agglomeration of Lanzhou and Yinchuan with the adjacent domains showed that the “siphon” effect of capital cities was significant in the western region. From Figure 6a–c, the disappearance of “low-high” agglomeration with Binzhou, Dezhou, and their surrounding areas can be ascribed to the implementation of “integrated development of Jinan metropolitan area,” which promotes the two cities to break away from the lower level of ternary coupling coordination. By 2019, Sanmenxia and Ankang city displayed a “low-high” spatial distribution with their surrounding areas, suggesting that the rapid improvement of the coupling coordination within these vicinities had a restraining influence on the two cities. This phenomenon may be due to the substitution of industrial, resource, and service aspects between the two cities and their proximate area.

**Figure 6.** The spatial clustering of DTE system coupling coordination in the Yellow River Basin. (a) Spatial clustering level in 2011; (b) Spatial clustering level in 2016; (c) Spatial clustering level in 2019; (d) Spatial clustering level in 2021.
Generally speaking, the spatial correlation of three-system coupling coordination levels presented two aggregation patterns of “high-high” and “low-low”. The overall spatial correlation was weak, and the radiation ability gradually decreased with the geographical distance. Therefore, the degree of coordinated upgrading among the digital economy, tourism, and ecology needs to be improved. This coincides with the conclusion of the analysis of spatial pattern evolution above.

5. Driving Factors of DTE System Coupling Coordination Degree

By analyzing the temporal and spatial evolution characteristics of ternary system coupling coordination degree, it can be found that there are obvious differences between resource-based cities and non-resource-based cities. Therefore, this study mainly discusses the driving factors of ternary coupling coordination degree from the two dimensions of the basin as a whole and city type. Combined with previous studies [12,64,65], we select digital facilities, market demand, environmental regulation, economic strength, industrial structure, consumption capacity, technological innovation, government intervention, and traffic carrying capacity. These factors are expressed in terms of the level of digital facilities, the scale of the tourism market, the intensity of environmental regulations, per capita GDP, the ratio between secondary and tertiary industries, the number of patent applications, local fiscal expenditure as a percentage of GDP, per capita disposable income, and the volume of tourist turnover.

From a basin-wide perspective in Table 4, all the variables listed have a significant positive driving effect on the three-system coupling coordination degree. The regression coefficients for economic strength (gdp), consumption capacity (inc), market demand (mar), and environmental regulation (envir) are 0.132, 0.110, 0.0763, and 0.0709, respectively, and all pass the 0.001 level of significance test. The regression coefficient for traffic carrying capacity is 0.013, and it passes the 0.01 level of significance test. The data indicate that economic strength, consumption capacity, market demand, and environmental regulation have a significant driving effect on the coupling coordination during the study period. Although the value of traffic carrying capacity is the lowest during the study period, it does not mean that it always contributes the least to the three-system coupling coordination. Existing research has proved that traffic carrying capacity has a significant impact on the sustainable development of the digital economy, the tourism industry, and the ecological environment [66–68]. Through decades of transport infrastructure construction, China’s current transport structure has gradually improved. One possible explanation is that when the traffic carrying capacity basically matches the social demand, its driving effect will show a diminishing effect, which partially can be confirmed by existing research [69].

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1) Whole Basin</th>
<th>(2) Resource City</th>
<th>(3) Non-Resource City</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per capita GDP (gdp)</td>
<td>0.132 ***</td>
<td>0.0966 ***</td>
<td>0.150 ***</td>
</tr>
<tr>
<td></td>
<td>(0.0117)</td>
<td>(0.0157)</td>
<td>(0.0177)</td>
</tr>
<tr>
<td>Industrial structure (indus)</td>
<td>0.0382 ***</td>
<td>0.0432 ***</td>
<td>0.0286 *</td>
</tr>
<tr>
<td></td>
<td>(0.00806)</td>
<td>(0.0100)</td>
<td>(0.0127)</td>
</tr>
<tr>
<td>Market demand (mar)</td>
<td>0.0763 ***</td>
<td>0.0665 ***</td>
<td>0.0854 ***</td>
</tr>
<tr>
<td></td>
<td>(0.00357)</td>
<td>(0.00491)</td>
<td>(0.00521)</td>
</tr>
<tr>
<td>Consumer capacity (inc)</td>
<td>0.110 ***</td>
<td>0.161 ***</td>
<td>0.0728 **</td>
</tr>
<tr>
<td></td>
<td>(0.0181)</td>
<td>(0.0248)</td>
<td>(0.0255)</td>
</tr>
<tr>
<td>Digital facility (fac)</td>
<td>0.0536 ***</td>
<td>0.0447 ***</td>
<td>0.0661 ***</td>
</tr>
<tr>
<td></td>
<td>(0.00306)</td>
<td>(0.00366)</td>
<td>(0.00487)</td>
</tr>
<tr>
<td>Technological innovation (tech)</td>
<td>0.0141 ***</td>
<td>0.00971 *</td>
<td>0.0191 ***</td>
</tr>
<tr>
<td></td>
<td>(0.00335)</td>
<td>(0.00417)</td>
<td>(0.00509)</td>
</tr>
</tbody>
</table>
Government intervention (gover) 0.0467 *** 0.0317 0.0586 ***
(0.0124) (0.0165) (0.0177)
Environmental regulation (envir) 0.0709 *** 0.0586 ** 0.0951 ***
(0.0163) (0.0186) (0.0274)
Traffic carrying capacity (traff) 0.0134 * 0.0210 * 0.000846
(0.00657) (0.00892) (0.00963)
_cons −2.607 *** −2.887 *** −2.259 ***
(0.156) (0.212) (0.229)
N 847 440 407

Note: * p < 0.05, ** p < 0.01, *** p < 0.001.

From the perspective of city types, all the variables except government intervention and traffic carrying capacity are significant drivers for resource-based and non-resource-based cities. The positive driving forces of consumption capacity (inc), economic strength (gdp), market demand (mar), and environmental regulation (envir) on resource-based cities have weakened successively. The positive driving forces of economic strength (gdp), environmental regulation (envir), market demand (mar), and consumption capacity (inc) in non-resource-based cities have weakened successively. During the study period, government intervention has an insignificant effect on the ternary coupling coordination of resource-based cities. Resource-based cities typically form a consensus on developing resource-based industries and the industrial structure has obvious path dependence. Government intervention needs to carefully consider local resource endowments and the degree of resource dependence [70]. The data indicate that traffic carrying capacity has a stronger driving effect on resource-based cities compared to non-resource-based cities. On one hand, this suggests that the development demand and level of traffic carrying capacity are more aligned in non-resource-based cities. On the other hand, traffic carrying capacity has a fundamental impact on the transformation [71] and upgrading of resource-based cities, thereby naturally leading to relatively higher demand and dependence on traffic carrying capacity.

In conclusion, the determining factors affecting three-system coupling coordination degree in the Yellow River Basin can be outlined as follows: foremost is the economic pulling force (economic strength, industrial structure, and consumption capacity), followed by the internal driving force (market demand, digital facilities, and environmental regulations). Government regulatory authority (government intervention) and the technological impetus force (technological innovation) are relatively weak.

5.1. The Economic Pulling Force

The results of the Tobit model analysis indicate that the regression coefficients for economic strength, industrial structure, and consumption capacity are all significantly positive. The economic pulling force can work synergistically from both the supply and demand sides to promote the three-system coupling coordination. The continuous improvement of the economic development level and per capita disposable income can strengthen the attention and support of both the government and the public towards ecological and environmental issues [8,15,16]. In order to promote high-quality development in the Yellow River Basin, local governments are no longer only focused on high GDP growth rates but also consider the optimization and upgrading of industrial structures as important tasks [72]. The proportion of the service industry and high-tech industry in the local industrial structure is continuously increasing, which can promote the sustainable development of the tourism industry and the digital economy, and drive the improvement of the ecological environment through stricter environmental regulations [41]. Consumption capacity can drive the development of the digital economy and the tourism industry from the demand side [57] and positively promote the ecological environment by releasing the ecological dividends of the tourism and digital sectors.
5.2. The Internal Driving Force

As the coefficients of market demand, environmental regulation, and digital infrastructure increase one unit, the ternary coupling coordination level rises by 0.076, 0.071, and 0.054, respectively. The internal driving force can promote the coupled coordinated development of the ternary system, and the positive effect of market demand is the most significant. The continuous improvement of residents’ material life and the continuous enrichment of spiritual needs have led to a trend of diversified and large-scale market demand, becoming an important force in advancing the coupling and coordination of the ternary system. A specialized tourism report from the China Tourism Academy points out that tourists favor nature-friendly tourism activities and digital tourism products and services [73]. The tourism industry, while driving local economic growth and meeting tourists’ expectations, also helps local governments enhance their environmental protection awareness and implement relevant environmental protection policies [15]. Environmental regulation not only increases public investment in environmental protection [41] but continuously stimulates the energy-saving and emission-reduction potential of the tourism industry [16], thereby improving the quality of the ecological environment. Digital infrastructure can provide strong support for both environmental protection and tourism development. On the one hand, digital facilities can reduce unnecessary ecological damage by promoting the digitization of smart cities, transportation systems, industrial processes, etc. [39]. Through communication media and emerging products, digital facilities help to improve the public’s environmental awareness and environmental protection ability and guide the public to form a green lifestyle [21]. On the other hand, digital facilities can enhance the informatization level of tourism development and management. Research by the China Tourism Academy shows that new business forms such as big data platforms, smart tourism public services, cloud tourism platforms, digital experiences, and immersive tourism scenes have accelerated development [73]. The innovative tourism formats, models, and services spawned by the digital infrastructure can meet the demand of the tourism market and achieve tourism prosperity [56].

5.3. Government Regulatory Authority

Government intervention primarily promotes the three-system coupled coordinated development through resource support and policy guidance. The financial support of the government can provide stable backing for infrastructure construction, technological research and development, tourism development, and environmental regulation [74], thereby enhancing the resilience of the digital economy, the tourism industry, and the ecological environment. Active fiscal policies by the government help resolve deep-seated contradictions in economic development, advance sustainable development across various social sectors, and promote mutual and coordinated development. Taking the “14th Five-Year Tourism Plan” as an example, it explicitly adheres to innovation-driven principles, accelerating the advancement of smart tourism characterized by digitalization, networking, and intelligence. It also upholds ecological priority, firmly maintaining ecological boundaries, reasonably utilizing natural resources, and expediting the promotion of green and low-carbon development. Overall, government intervention can not only play a role in the economic domain but also facilitate the coordinated development of society and ecological civilization [75]. Through proactive fiscal support and policy guidance, government regulation can effectively promote the benign development of the digital economy and the tourism industry, ensure the smooth implementation of ecological protection, and then have a positive driving effect on the three-system coupled coordinated.

5.4. The Technological Impetus Force

The digital economy and tourism sectors are primarily driven by technological innovation. The tourism and digital industries can attract more innovative talent by expanding human capital and funding for technological innovation. The digitalization of the tourism
industry hinges on online booking systems, virtual reality technology, and intelligent navigation, which significantly amplifies the efficiency of the tourism economy. Tourists can relish a more convenient and personalized travel experience, thus contributing to the sustainable growth of tourism [49]. Technological innovation helps to create an efficient networked platform, and through the use of intelligent monitoring systems, big data analysis, and other technological means, it helps to improve the ecological environment management capacity [20] and effectively reduce the carbon emission rate of the tourism industry [24]. It is certain that technological innovation does have a positive driving effect on the ternary coupling coordination, but there is room for further improvement.

6. Discussion

This study incorporates the digital economy, the tourism industry, and the ecological environment into a unified analysis framework, and explains in detail the mechanism of the three-system coupling coordination. This breaks through the previous research paradigm of bivariate relationships and provides a theoretical reference for future research on ternary coupling coordination. By collecting a large amount of data and constructing an evaluation model, the research clearly shows the development level, spatial and temporal evolution characteristics, and driving factors of the triple coupling coordination in the Yellow River Basin, and puts forward suggestions for improving the existing problems, which is of practical significance for promoting sustainable development in the Yellow River Basin.

The empirical results of the coupled coordination model are stable and reliable and can be mutually verified with existing studies. The research proposals are confirmed as follows.

First of all, the coupled coordination level of the digital economy, the tourism industry, and the ecological environment in the Yellow River Basin can present obvious temporal heterogeneity. The three-system coupling coordination degree exhibits a growing and then falling tendency in the Yellow River Basin, maintaining a low coordination grade [34]. The data before the COVID-19 epidemic further confirmed the coupling and coordination among the digital economy, the tourism industry, and the ecological environment. The spatial difference of coupling coordination degree shows an expanding trend within the basin [11], which may be caused by the heterogeneity of factors such as economic level, industrial structure, government capacity, scientific and technological innovation, and policy support among different regions [12,33,76]. Compared with the high-level development of the digital economy and environmental protection, the development of the tourism industry lags, which results in its poor coupling coordination [5]. The lockdown measures during the COVID-19 epidemic expedited the digital economy [25] and improved the ecological environment [62], but severely damaged the tourism industry [57], thereby hindering the enhancement of three-system coupling coordination. It is worth stating that the short-term decrease in the coordination degree does not represent the long-term trend of coordinated development [62].

Second, the spatial distribution and evolution trend of the digital economy, the tourism industry, and the ecological environment in the Yellow River Basin can show obvious spatial heterogeneity. The spatial correlation of cities in the basin is gradually diminishing, and there is a significant core-periphery structure. Compared to other basins [77], the limited navigational value of the Yellow River brings about a looser interconnection between the cities. Concerning city types, there are significant spatial differences between resource-based and non-resource-based cities [59]. Non-resource cities with a high coupling coordination degree cluster in provincial capitals and coastal cities, and provincial capitals reveal a noticeable siphon effect [33]. The resource-based cities that have transformed to develop the tourism industry have a higher coupling coordination degree. This corroborates the findings of Hou et al. that tourism development and environmental management are essential approaches to propel the sustainable development of resource-based cities [54]. The distribution pattern of resource-based cities is “regeneration >
maturity > growth > decline”, which also reflects the changes and stage characteristics of resource utilization, industrial development, and economic growth in the process of urban development.

Finally, the driving factors of the coupling and coordination degree of the digital economy, the tourism industry, and the ecological environment in the Yellow River Basin are diversified and complex, mainly including many factors such as the economy, the market, technology, and government. Concerning driving factors, it is evident that environmental regulation, economic strength, industrial structure, technological innovation, and government intervention can effectively amplify three-system coordinated upgrading. This has been supported by existing studies [64,76,78]. In addition, this study further points out that upgrading the three-system coupling coordination is affected by a combination of the economic pulling force, the internal driving force, government regulation authority, and the technological impetus force in the Yellow River Basin, which guides further research.

7. Conclusions
7.1. Findings
This paper analyzes the spatial-temporal features and driving factors of the three-system coupling coordination in the Yellow River Basin from 2011 to 2021. The main findings are as follows:

First, the comprehensive index levels of ternary systems showed a significant difference. The digital economy was on an upward trend, with the fastest growth rate. The tourism industry exhibited an inverted U-shape pattern, with an initial rise and subsequent decline. Meanwhile, the ecological environment demonstrated relative stability, marked by the slowest growth rate.

Second, the three-system coupling coordination degree upgraded from imminent imbalance to marginal coordination and displayed a relatively stable growth trend at first and then a fluctuating decline. Regarding city types, resource cities remained at the marginal coordination level, while non-resource cities reached the primary coordination stage. The kernel density curve shifted to the right, and the right tail was long. The main wave crest fluctuated, and the single peak emerged multi-peak, indicating that the spatial discrepancy was dynamically expanding in the entire basin.

Third, there were significant regional variances of DTE system coupling coordination, forming a high-level area represented by the provincial capital city, with an overall “center-periphery” decline feature. There was a significant positive spatial correlation of coupling coordination, mainly constituting the “high-high” agglomeration area represented by Shandong and the “low-low” agglomeration area represented by Gansu and Ningxia. From the perspective of city types, the high-value distribution of non-resource cities was concentrated in Shandong province, while the low-value distribution was concentrated in some cities of Gansu and Ningxia. The coordination value of resource cities appeared to be “regeneration > maturity > growth > decline”. The phenomenon is highly relevant to the resource status, industrial conditions, ecological issues, and development philosophy of these cities.

Fourth, the three-system coupling coordination degree is affected by multiple driving factors such as economic strength, consumption capacity, market demand, environmental regulation, industrial structure, government capacity, digital technology, and technological innovation, and their influence is successively weakened.

7.2. Practical Inspiration
The results show that the three-system coupling coordination in the Yellow River Basin is marginally coordinated, whereby the development speed of the digital economy far exceeds the speed of the tourism industry and the ecological environment, and the comprehensive development level of the tourism industry lags behind the digital and
environmental level. In order to promote the coordinated development of the three, and to promote the ecological protection and high-quality development of the Yellow River Basin, it is necessary to strengthen the integration and penetration role of the digital economy and for it to play a linkage role between the regions.

(1) Consolidate the pivotal role of digital technology in harmonizing the tourism industry and the ecological environment. The Yellow River Basin needs to pay more attention to the green attributes of the digital economy, promote the intelligent, informative, and efficient operation of cities, and enhance the overall level of integration between the digital economy and industrial development [26].

This necessitates a concerted focus on leveraging cutting-edge technologies, including big data, artificial intelligence, and the Internet of Things (IoT). The region should fully utilize advanced technologies to reinforce the application of intelligent management systems, energy efficiency optimization technologies, and digital environmental monitoring in the tourism industry. Increase the role of digital technologies in energy conservation and emission reduction for tourism operations, accommodation, transportation, and waste management. The digital economy of the Yellow River Basin generally presents a pattern of “strong in the east and weak in the west” and shows a trend of “contraction” [32]. Facilitating information sharing through digital technology enables different regions to enhance the information exchange on environmental monitoring and passenger flows across the upper, middle, and lower reaches. This collaborative approach aims to foster regional ecological protection and industrial harmony.

(2) Narrow the regional gap in the three-system coupling coordination degree. Ecological protection and high-quality development of the Yellow River Basin is a major national strategy, but local governments have a relatively obvious tendency to self-selection when executing multi-task-oriented central decisions [79]. Therefore, the regions in the Yellow River Basin should formulate diversified policy combinations based on actual conditions such as city types and industrial structures, fully promoting the coupled and coordinated development of the ternary system.

Firstly, non-resource cities actively absorb advanced technology and management experience from coastal cities in Shandong. Resource cities should not only concentrate on learning from the successful experience of regenerative cities but also improve government intervention mechanisms, upgrade transport carrying levels, and promote the digital and green transformation of industries in an orderly manner. Secondly, the region should exert spillover and radiation effects in provincial capital cities. Notably, efforts should be dedicated to bolstering marginal cities through policy inclination and industrial transfer. Reinforcing the efficient flow and optimal allocation of capital, technology, and talents is essential within the basin, which improves regional cooperation capacity and the sustainable development level.

7.3. Limitations and Future Research

This study has thoroughly investigated the time-space evolution and the driving factors of the three-system coupling coordination level. Nevertheless, there are still some limitations, and it provides a direction for future research. Owing to the limitations in data acquisition, some intricacies in the form of detailed indicators were omitted from the research objectives. In future studies, multidimensional indicators, like the tourism economy, can be utilized to evaluate the comprehensive development level of the ternary system. It is necessary to persist in verifying the coordination level after the epidemic. This study confines itself to prefecture-level cities in the Yellow River Basin and neglects considering other basins. Future research can endeavor to compare research in different basins, offering valuable insights to guide sustainable development more effectively.

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