Article
Multi-Dimensional Threshold Effects of the Digital Economy on Green Economic Growth?—New Evidence from China
Yunyan Jiang 1,2 and Feng Deng 1,2,*

1 Center for Innovation Management Research of Xinjiang, Xinjiang University, Urumqi 830046, China
2 School of Economics and Management, Xinjiang University, Urumqi 830046, China
* Correspondence: dengfengxju@126.com

Abstract: China’s economy has shifted from a high-speed growth stage to a high-quality development stage. Achieving green and sustainable growth driven by the digital economy is its most important purpose. Based on provincial panel data from 2013 to 2019, this paper examines the spatial heterogeneity of the digital economy (Dig) and its nonlinear impact on green economic growth (Geg) from multiple dimensions, using threshold models and spatiotemporal geographic weighting models. The study found that: (1) Dig can significantly promote Geg, but it presents a typical nonlinear characteristic: double thresholds with a trend of “weak negative → strong positive → weak positive”; (2) in this process, the three critical nonlinear factors are financial agglomeration (Fina) with a single threshold of “0.186” and the trend of “weak negative → strong positive”, the marketization level (Market) with double thresholds of “4.448 and 9.06” and the trend of “weak negative → strong positive → positive”, and green technology innovation (Grti) with double thresholds of “5.236 and 9.152” and the trend of “strong negative → strong positive → positive”; (3) the multi-dimensional composite threshold effect indicates that when 0.061 < Dig < 0.539, 5.236 < Grti < 9.152, 4.448 < Market < 9.06, and 0.186 < Fina, the digital economy has the greatest effect on the promotion of green economic growth; and (4) the spatial distribution regression results show that there is obvious regional heterogeneity. The paper has reference value in maximizing the promotion effect of the digital economy on green economic growth.

Keywords: digital economy; green economic growth; multi-dimensional thresholds; financial agglomeration; marketization level; green technology innovation

1. Introduction
Since its reform and opening up, China’s economy has achieved rapid growth and created a “Chinese-style development miracle.” However, under the traditional economic development model, the clustering of environmental problems such as high consumption and high pollution is prominent [1,2]. China’s economy has shifted from a stage of high-speed growth to a stage of high-quality development, and the transformation of the growth mode of the economy under the constraints of natural resources is an inevitable choice to solve the problem of low ecological development quality in sustainable development [3]. Green economic growth emphasizes the continuity of natural assets and the need to achieve environmental friendliness and resource efficiency through technological innovation and institutional arrangements, as well as achieving economic growth goals [4]. Green economic growth effectively resolves ecological problems in economic development, becomes an important way to break through the new economic normal, and is the key to the realization of goals such as the construction of China’s ecological civilization and of a beautiful China [5–7].

With the rapid rise of a new generation of information technology, the digital economy has become a new engine for high-quality economic development in China [8,9]. In 2021, the volume of China’s digital economy reached 45.5 trillion yuan, accounting for 39.8% of GDP, and has become an important engine and a key driving force for stable economic
growth. Since the development of China’s digital economy, it has generally shown the remarkable characteristics of high growth rate, large scale, and regionally unbalanced development [10,11]. The huge digital consumer market and the gradually improved internet infrastructure, as well as feasible policies, have become favorable supports for green economic growth [12]. The relationship between the digital economy and green economic growth has attracted the attention of scholars [13–16]. Most scholars believe that the digital economy is accelerating the transformation of old and new, but the question of the circumstances underlying this is an open one. Digital technology empowers the traditional production factor system [13], and green technology innovation solves the problem of resource and environmental constraints [17]. Other scholars believe that the development of the digital economy may not be conducive to green economic growth. The construction of facilities such as digital centers and energy-intensive computers may increase energy emissions [14].

In summary, China’s green growth has achieved some results [18], but in the face of the current acceleration of the green economy transformation and the opportunities offered by digital technology, it is critical to explore the mechanism between the two. In previous research, scholars studied only the linear or nonlinear effects of variables such as green technology innovation or marketization and did not scientifically reveal the current nonlinear relationship between the two. It is necessary to explore ways of maximizing the positive effect of the digital economy on green development. Therefore, this paper explores the following questions: Does the digital economy promote or inhibit the growth of the green economy at this stage? Is there a nonlinear characteristic, and what is its specific trend? Under what circumstances does the digital economy maximize its impact on green economic growth? What is the impact trend of its key influencing factors? Through systematic research on the above issues, we provide a theoretical and practical basis for the further development of China’s digital economy to promote green economic growth.

The possible marginal contributions of this paper are as follows. (1) Compared with existing research, which has mainly taken a single indicator to represent digital economy, this paper constructs an index system with 12 indicators to measure the growth level of the digital economy. Meanwhile, based on the SEEA-2012 framework proposed by the United Nations, green economy growth level is calculated. By integrating the growth of the digital economy and green economy into the same research framework, the linear relationship between them is investigated. (2) In order to maximize the positive impact of the digital economy on green development, the nonlinear relationship between the two, as well as the underlying reasons, is discussed and the specific thresholds of the digital economy are quantified. (3) From the multi-dimensional perspective, we identify the three key factors in this process: financial agglomeration, green technology innovation, and market level, and analyze the potential trend. (4) Using a spatiotemporal geographic weighted model, the spatial and temporal distribution heterogeneity of the impact is investigated, which is conducive to the regional coordinate development. Through impact and spatial analysis, existing research on the effect of the digital economy on green economic growth is enriched and acquires reference significance for formulating precise policies and maximizing the promotion of green economic growth in the future.

The rest of this paper is arranged as follows: the second part introduces the literature review and research assumptions; the third part describes the model construction and the data description; the fourth part contains an empirical analysis of the impact of the digital economy on green economic growth and the multi-dimensional analysis of the nonlinear relationship; the fifth part describes the robustness test; the sixth part assesses regional spatiotemporal heterogeneity using the GTWR model for spatiotemporal analysis; and the final part includes the conclusion and policy recommendations.
2. Literature Review and Research Assumptions

2.1. Linear Research on Digital Economy and Green Economic Growth

The coordinated development of economic growth and the environment is one of the ultimate goals of sustainable development, and it is also the difference between the green growth theory and the traditional neoclassical growth theory [19]. It incorporates resource and environmental issues into the entire growth analysis framework. In the process of development, the purpose of a green economy has evolved from the realization of weak sustainable development [20]. The green economy’s emphasis is on a resource-saving and environment-friendly form of economic development. However, China’s economy has not broken through the constraints of the environmental Kuznets curve in the past few years of rapid development and faces severe resource depletion and environmental pollution problems [21]. At the same time, with the background of global economic fatigue and the repeated outbreaks of the new crown epidemic, it is urgent to find new economic development methods and driving forces. The digital economy is an economic form where digital technology innovation drives economic development as its core content, which solves the problems of China’s ecological development by optimizing the industrial structure and enhancing economic competitiveness [22,23].

The development of the digital economy and green economic growth is a driving force and a path to achieving the coordination of economic growth and environmental development under the current uncertain economic environment [15]. The existing literature on the digital economy and green economic growth is mainly divided into two categories. The first category is the coordinated and integrated development of the digital economy and the green economy, which is conducive to economic recovery [24]. In particular, the synergy effect of the two under the guidance of green policies is conducive to accelerating economic recovery in the post-epidemic era [25]. In addition, the “green recovery” effect can not only promote the development of the industry, but also enhance the flexibility of the labor market, promote social justice transformation, and improve the resilience of the economic system to achieve the goal of sustainable development [26,27].

The second category is the impact of the digital economy on the green economy, and the academic community has not yet formed a consensus view [28]. Scholars support the positive relationship, which coincides with Schumpeter’s view that “innovation is the source and driving force of growth.” The digital economy provides high-quality technical resource support for many fields of life—increasing the sustainability of universities [29], the upgrading of industrial structure [30], empowering the circular economy [31], and commercial digitization [32,33] with household consumption [34–36]. This accelerates the development of emerging industries, improves industrial green production efficiency, and promotes green economic transformation [23]. However, other scholars believe that the digital economy may be detrimental to green economic growth. Some have suggested that digital inclusive finance will widen the gap between the efficiency of non-agricultural economic activities and the efficiency of agricultural production’s [37]. The operation of the digital infrastructure and the storage of massive data require power support [38]. In addition, digital products are widely used in various social activities, and their update and iteration speed are relatively fast. The increase in consumer demand will increase the consumption of raw materials, and it will also require the recycling of waste, which is not conducive to the growth of the green economy [39].

In addition, scholars have discussed the relationship between the two from a spatial perspective. Their distribution has significant regional differences, displaying an unbalanced and scattered polycentric structure [40], and its effect may change with increased development. Based on the above analysis, with the improvement of the level of the digital economy, the process of its impact on the dependent variable may have periodic characteristics, showing a nonlinear impact relationship [41,42]. On this basis, the theoretical hypothesis of this paper is proposed.

**Hypothesis 1a.** The digital economy has a positive impact on green economic growth.
Hypothesis 1b. The impact of the digital economy on green economic growth has a threshold effect.

2.2. Nonlinear Research on Digital Economy and Green Economic Growth

2.2.1. Digital Economy, Green Technology Innovation and Green Economic Growth

The process of the digital economy’s promotion of green economic growth may be affected by green technology innovation. Firstly, digital technologies such as big data and cloud computing offer high information processing efficiency, increased sensitivity of enterprises to green consumption preferences and green products, help for enterprises to identify green development opportunities, and a change in the driver of enterprises from experience to data [43]. Second, green technology innovation is uncertain, and the cost of research and development is high; digital finance relieves the financing difficulties that may be encountered by green technology innovation in energy-related industries [17]. Finally, the horizontal development of the digital economy promotes the growth of the green economy by improving the level of regional green technology. The improvement of related environmental technologies has expanded the use of renewable energy, thereby promoting green economic growth [44]. Based on the above analysis, the second theoretical hypothesis of this paper is put forward.

Hypothesis 2. Green technology innovation has a threshold role in the process of the digital economy’s promotion of green economic growth.

2.2.2. Digital Economy, Marketization Level and Green Economic Growth

The promotion of green economic growth by the digital economy may be affected by the level of marketization. The classic growth theory states that the main reason for the difference in per capita income is the difference in TFP among countries or regions [45] and that improving the efficiency and the progress of production technology is a powerful way to improve TFP. On the one hand, improving the level of marketization can improve the efficiency of resource utilization and reduce the total energy consumption through the rational allocation of production resources [46]. In regions with a relatively high level of marketization, the phenomenon of homogeneous competition is prominent, thereby expanding or maintaining the existing market share. In addition, a digital platform based on internet technology avoids the inconvenience caused by geographical gaps, not only providing an information exchange platform, but also effectively expanding the market size and improving the success rate of transactions [47]. Therefore, the third hypothesis is proposed:

Hypothesis 3. Marketization level has a threshold effect on the digital economy’s promotion of green economic growth.

2.2.3. Digital Economy, Financial Agglomeration, and Green Economic Growth

Financial development is closely related to economic growth [48], and the promotion of green economic growth by the digital economy may be affected by financial agglomeration. First, the development of the financial market can reduce carbon emissions and promote green economic growth by promoting technological innovation and supporting energy conservation and environmental protection entities [17]. Capital allocation and capital stock caused by agglomeration of the financial industry may lead to regional heterogeneity in the promotion of green economic growth by the digital economy [49]. Under the constraints of the level of financial agglomeration, the improvement of green development efficiency by financial agglomeration presents a “gradient” enhancement trend [50]. Improving the local financial level may promote the “polarization” of the financial center, which will form a certain siphon effect on the financial resources of the surrounding cities and positively affect the local digital economy to promote the growth of the green economy, resulting in a certain regional imbalance. Based on the above analysis, the fourth hypothesis of this paper is put forward:
Hypothesis 4. Financial agglomeration acts as a threshold in the promotion of green economic growth by the digital economy.

In order to clarify the mechanism by which the digital economy can maximize the promotion of green economic growth, this paper selected factors related to green technology innovation, financial agglomeration, marketization, and related research topics as threshold variables based on previous scholarly research and explored their impact on the two possible threshold effects. The specific logical framework of this paper is shown in Figure 1 below.

Figure 1. Mechanism diagram.

3. Research Design
3.1. Model Construction

3.1.1. Benchmark Regression

According to Wei and H (2022) [51], the following benchmark regression model assesses the direct impact of the digital economy on green economic growth:

\[ \ln G_{\text{eg}i,t} = \alpha_0 + \alpha_1 D_{\text{ig}i,t} + \lambda Z_{i,t} + \mu_i + \epsilon_{i,t} \]  

(1)

In Formula (1), \( \ln G_{\text{eg}i,t} \) represents the logarithm of green economic growth in year \( t \) in province \( i \); \( D_{\text{ig}i,t} \) represents the development level of the digital economy in year \( t \) in province \( i \); \( Z_{i,t} \) represents a collection of control variables affecting the green economic growth; \( \mu_i \) represents an unobservable individual fixed effect; \( \epsilon_{i,t} \) stands for a random error term. In order to test whether there is a nonlinear relationship between the digital economy and green economic growth, the square term of the explanatory variable is introduced on the basis of Model (1), and Model (2) is obtained:

\[ \ln G_{\text{eg}i,t} = \alpha_0 + \alpha_1 D_{\text{ig}i,t} + \alpha_2 D_{\text{ig}i,t}^2 + \lambda Z_{i,t} + \mu_i + \epsilon_{i,t} \]  

(2)

3.1.2. Threshold Regression Model

According to the theory of externalities, the impact of the digital economy on green economic growth is restricted by many factors. Through the analysis of its key influencing factors, the relationship between the two can be better understood. In order to further clarify the nonlinear relationship between the digital economy and the green growth of China’s economy, we used the threshold regression model proposed by Hansen (1999) [52] to conduct in-depth research, choosing green technology innovation, marketization level and financial agglomeration, and digital economy as the threshold variables. The panel threshold model is set as follows:

In Formula (2), \( \ln G_{\text{eg}i,t} \) represents the logarithm of green economic growth in year \( t \) in province \( i \); \( D_{\text{ig}i,t} \) represents the development level of the digital economy in year \( t \) in province \( i \); \( Z_{i,t} \) represents a collection of control variables affecting the green economic growth; \( \mu_i \) represents an unobservable individual fixed effect; \( \epsilon_{i,t} \) stands for a random error term. In order to test whether there is a nonlinear relationship between the digital economy and green economic growth, the square term of the explanatory variable is introduced on the basis of Model (1), and Model (2) is obtained:

\[ \ln G_{\text{eg}i,t} = \alpha_0 + \alpha_1 D_{\text{ig}i,t} + \alpha_2 D_{\text{ig}i,t}^2 + \lambda Z_{i,t} + \mu_i + \epsilon_{i,t} \]  

(2)
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Compared with the traditional GDP that focuses on the growth rate caused by the economy, green economic growth considers the carrying capacity of the ecological environment and economic development. The accounting included environmental pollution indicators and resource consumption indicators, which can better evaluate the quality of China’s economic growth [54]. There are many existing green GDP measurement methods, and the SEEA system method is the more authoritative accounting method for ecological natural resource assets so far [55]. Based on the research objectives and data availability, this paper constructed the green GDP indicators of each province in China from 2013 to 2019 based on the SEEA-2012 framework proposed by the United Nations. The calculation process is \( GEG = TGDP - CRD - CEDL \), where \( TGDP \) is the gross national product of each region, and other indicators are as follows (Table 1).

\[
\text{InGeg}_{i,t} = \theta_0 + \theta_1 \text{Dig}_{i,t} \cdot I (\text{Dig}_{i,t} \leq \omega_1) + \theta_2 \text{Dig}_{i,t} \cdot I (\omega_1 < \text{Dig}_{i,t} \leq \omega_2) + \theta_3 \text{Dig}_{i,t} \cdot I (\text{Dig}_{i,t} > \omega_2) + \theta Z + \mu_i + \varepsilon_{i,t},
\]

(3)

\[
\text{InGeg}_{i,t} = \theta_0 + \theta_1 \text{Grti}_{i,t} \cdot I (\text{Grti}_{i,t} \leq \omega_1) + \theta_2 \text{Grti}_{i,t} \cdot I (\omega_1 < \text{Grti}_{i,t} \leq \omega_2) + \theta_3 \text{Grti}_{i,t} \cdot I (\text{Grti}_{i,t} > \omega_2) + \theta Z + \mu_i + \varepsilon_{i,t},
\]

(4)

\[
\text{InGeg}_{i,t} = \theta_0 + \theta_1 \text{Market}_{i,t} \cdot I (\text{Market}_{i,t} \leq \omega_1) + \theta_2 \text{Market}_{i,t} \cdot I (\omega_1 < \text{Market}_{i,t} \leq \omega_2) + \theta_3 \text{Market}_{i,t} \cdot I (\text{Market}_{i,t} > \omega_2) + \theta Z + \mu_i + \varepsilon_{i,t},
\]

(5)

\[
\text{InGeg}_{i,t} = \theta_0 + \theta_1 \text{Fina}_{i,t} \cdot I (\text{Fina}_{i,t} \leq \omega_1) + \theta_2 \text{Fina}_{i,t} \cdot I (\omega_1 < \text{Fina}_{i,t} \leq \omega_2) + \theta_3 \text{Fina}_{i,t} \cdot I (\text{Fina}_{i,t} > \omega_2) + \theta Z + \mu_i + \varepsilon_{i,t},
\]

(6)

Among these, \( \text{InGeg}_{i,t} \) is the explained variable green economic growth; \( \text{Dig}_{i,t}, \text{Grti}_{i,t}, \text{Market}_{i,t}, \text{Fina}_{i,t} \) are the threshold variables, representing the digital economy, green technology innovation, marketization level and financial agglomeration, respectively; \( \omega_n \) is the threshold value; \( I (\cdot) \) is the indicative function, the value in parentheses is established when 1, otherwise, 0; \( Z \) is the set of control variables; \( \mu_i \) is the individual fixed effect; and \( \varepsilon_{i,t} \) is the random disturbance term.

3.1.3. Spatiotemporal Geographically Weighted Model (GTWR)

The impact of the digital economy on green economic growth shows not only spatial differences, but also significant temporal differences. The geographically weighted regression (GWR) model only considers the space, ignoring the non-stationarity of time and space, and is limited by the sample size. Huang et al. (2010) [53] introduced the time dimension to the GWR model, forming the spatiotemporal geographically weighted regression model (GTWR). This paper draws on its research results, and the model is constructed as follows:

\[
\text{InGeg}_i = \rho_0 (u_i, v_i, t_i) + \rho_1 (u_i, v_i, t_i) \text{Dig}_{i,1} + \varepsilon_i; i = 1, 2, \ldots, n.
\]

(7)

In this formula \( \text{InGeg}_i \) is the dependent variable matrix of green economic growth in the province; \( \text{Dig}_{i,1} \) is the explanatory variable digital economy matrix of a province \( i \); \( \rho_1 (u_i, v_i, t_i) \) is the rate of change of the green economic growth of a province \( i \) with the development of the digital economy; \( (u_i, v_i, t_i) \) is the spatiotemporal coordinates of \( i \) provinces; \( \rho_0 (u_i, v_i, t_i) \) represents the spatiotemporal intercept term of a province \( i \); and \( \varepsilon_i \) is the error term.
Table 1. The indicator system for CRD and CEDL.

| Comprehensive Index | Sub-Indexes | Illustration |
|---------------------|-------------|--------------|
| Cost of resource depletion (CRD) | Cost of arable land resource depletion (r1) | Reduced area of cultivated land × agricultural output value per unit of cultivated land = reduction of arable land area × (total agricultural output value/agricultural arable land area) |
| CRD = r1 + r2 + r3 | Cost of energy resource consumption (r2) | Energy resource consumption × average energy price |
| | Cost of water resources (r3) | Water resources consumption × average water price |
| Cost of environmental degradation loss (CEDL) | Environmental disaster cost (r4) | Direct loss of earthquake disaster (r4.1) Discounts on forest fire losses (r4.2) Direct loss of natural disasters (r4.3) Direct loss of geological hazards (r4.4) |
| CEDL = r4 + r5 | Total expenditure on environmental pollution control (r5) |

Explanatory Variables

Digital Economy (Dig). Scholars have constructed measurement indicators from different perspectives such as internet maturity [56], a single proxy indicator as a representation, and a comprehensive indicator system evaluation from multiple dimensions such as infrastructure, industry, and governance. So far, no unified measurement index system has been developed. In the government work report of the two sessions in 2022, accelerating digital information infrastructure, promoting industrial digital transformation, and enhancing key software and hardware technology innovation and supply capabilities are important directions for the next development of China’s digital economy [57]. Referring to the existing research [58, 59] and considering the data availability and completeness, this paper constructed first-level indicators from three aspects of the digital economy: digital economy development carrier, digital economy industrial foundation, and digital economy innovation power. The specific index system is shown in Table 2.

Table 2. Digital economy index evaluation system.

| Comprehensive Index | First-Level Indicator | Secondary Indicators | Indicator Nature |
|---------------------|-----------------------|----------------------|------------------|
| Digital Economy     | Digital economy       | Number of broadband ports per capita | + |
|                     | development carrier   | Number of electronic reading rooms | + |
|                     |                       | Fiber-optic cable length (km) | + |
|                     |                       | Number of mobile Internet users | + |
|                     | Digital industry      | Total revenue of telecom industry business (billion yuan) | + |
|                     | development foundation| Broadband entry rate (%) | + |
|                     |                       | Added value of the tertiary industry (billion yuan) | + |
|                     |                       | Number of employees in the IT industry (10,000 people) | + |
|                     |                       | Digital TV user rate (%) | + |
|                     | Digital economy       | R&D employees (10,000 people) | + |
|                     | innovation power      | R&D projects | + |
|                     |                       | R&D intensity (%) | + |

Trend Description

The average trend chart of the digital economy development (Dig) and green economic growth (InGeg) is shown in Figure 2.

Specifically, InGeg development presented three echelons: high, medium, and low. When InGeg > 11, mainly in Beijing and Shanghai, it showed a high level of green economic growth. When 10.5 < InGeg < 11, a total of nine regions including Shandong and Inner Mongolia were in the moderate growth level. When InGeg was <10.5, a total of 14 regions including Henan and Jiangxi were at a low growth level. On the whole, green economy
growth in most parts of China was at a medium-low level, showing a trend of “high in the east and low in the west,” which must be further driven.

![Figure 2. Digital economy development level and green economic growth in 30 provinces.](image)

Regarding Dig, there was a large regional heterogeneity. The development levels of the digital economy in Beijing, Jiangsu, and other cities were much higher than the levels in their respective regions; in particular, Guangdong province achieved a leading level by relying on its local resource advantages. The development levels of the digital economy in Henan and Chongqing were small and in their construction periods. However, the Dig in western regions such as Yunnan and Gansu was lower than 0.1, remaining in the early stage of construction. The overall development lagged behind other regions. It will be necessary to accelerate the development and construction of the digital economy in the region.

3.2.2. Threshold Variables

Green Technology Innovation (Grti). Scientific and technological innovation achievements that meet standards such as “scientific nature, green and environmental protection” are recognized and awarded green patent licenses [60], so the number of green patents granted is a reliable measure and best represents the quality of regional technological innovation. According to the international green patent classification code published by the World Intellectual Property Office (WIPO), the patent applications provided by the State Intellectual Property Office were used, referring to Du et al. (2021) [61].

Marketization level (Market). The degree of marketization, on the one hand, can characterize the vitality of an economy’s market, and on the other hand, it can characterize whether the rational allocation of regional resources is reasonable [62]. Drawing on the measurement method of [63], the marketization level was measured by the marketization comprehensive index.

Financial agglomeration (Fina). Financial agglomeration is an important indicator that reflects the polarization of financial development differences between regions [64]; financial resources are continuously adjusted in the flow, forming financial centers in specific regions, from the scale effect and polarization effect. Referring to Ma et al. (2021) [65], the ratio of the added value of the financial industry to the population size was finally used to measure the level of financial agglomeration.

3.2.3. Control Variables

In order to reduce the influence of exogenous factors on the accurate measurement of the digital economy’s effect on the growth of the green economy, the level of infrastructure (Infra), environmental regulation (Er), the degree of government intervention (Gov), and
the opening degree (Open) to the outside world were selected as control variables. These are shown in Table 3.

Table 3. Control variables.

| Control Variable                   | Measure                                                                 | References                      | Source                                      |
|-----------------------------------|-------------------------------------------------------------------------|---------------------------------|---------------------------------------------|
| Infrastructure level (Infra)      | Infrastructure construction is the basis of digital economy development and its integration with the real economy. It is measured by the ratio of the length of the road to the square miles of one region. | Geng and Zhao (2018) [66]       | National Bureau of Statistics; MCA          |
| Environmental regulation (Er)     | Environmental regulation is an effective way for the government to encourage enterprises to turn to green production using administrative means to restrict the production behavior and force enterprises to innovate. This paper uses the ratio of completed investment to GDP in industrial pollution control to reflect it | Tao and Hu (2019) [67]         | National Bureau of Statistics              |
| Government intervention (Gov)     | The government influences the level of regional green economic development through the budgeting of public finances. This paper uses the ratio of local fiscal general budget expenditure to GDP to represent the level of government intervention. | Xiao et al. (2020) [68]        | National Bureau of Statistics              |
| Open to the outside world (Open)  | The level of competitiveness in international trade determines the position of the country in the global value chain and the type of goods imported and exported. This paper uses the ratio of total import and export goods to GDP to reflect it. | Liu et al. (2018) [69]         | National Bureau of Statistics; The People’s Bank of China |

3.2.4. Data Sources and Descriptive Statistics

This paper considered the panel data of 30 provinces, municipalities, and autonomous regions in China from 2013 to 2019 (excluding Tibet, Hong Kong, Macao, and Taiwan regions) for analysis. After consulting the literature and other materials, some missing data were processed by the interpolation method. The data sources were the China Industrial Economic Research Database, the EPS Database, and other databases, as well as the China Environmental Statistical Yearbook, China Urban Statistical Yearbook, China Regional Economic Statistical Yearbook, China Energy Statistical Yearbook, and the National Bureau of Statistics. The descriptive statistics of each variable are shown in Table 4.

Table 4. Descriptive Statistics.

| Variables | N  | SD  | Mean | Min  | Max  |
|-----------|----|-----|------|------|------|
| InGeg     | 210| 0.455 | 10.680  | 9.687 | 11.618 |
| Dig       | 210| 0.148 | 0.187  | 0.032 | 0.838 |
| Gov       | 210| 0.113 | 0.267  | 0.12  | 0.753 |
| Open      | 210| 0.269 | 0.263  | 0.013 | 1.257 |
| Infra     | 210| 0.23  | 0.428  | 0.036 | 0.964 |
| Er        | 210| 0.137 | 0.132  | 0.002 | 1.103 |
| Fina      | 210| 0.476 | 0.471  | 0.091 | 3.038 |
| Griti     | 210| 1.273 | 7.772  | 3.689 | 10.436 |
| Market    | 210| 1.812 | 8.062  | 3.58  | 11.494 |

4. Empirical Analysis

In this section, the estimation results of the basic model, the quantile regression model, the Hansen threshold model and the corresponding analysis will be provided in turn.
4.1. Benchmark Regression Analysis

To explore the relationship between the digital economy and green economic growth, this paper used a fixed-effects model for benchmark verification. The regression results are shown in Table 5.

Table 5. Benchmark regression results.

| Variables | (1)     | (2)     | (3)     | (4)     | (5)     | (6)     |
|-----------|---------|---------|---------|---------|---------|---------|
|           | lnGeg   | lnGeg   | lnGeg   | lnGeg   | lnGeg   | lnGeg   |
| Dig       | 1.916 *** | 1.918 *** | 1.797 *** | 1.319 *** | 1.193 *** | 2.48 *** |
|           | (0.229)  | (0.23)  | (0.179)  | (0.199)  | (0.191)  | (0.25)  |
| Gov       | -0.112   | -0.242   | -0.188   | -0.071   | -0.141   | -0.141   |
|           | (0.777)  | (0.771)  | (0.783)  | (0.644)  | (0.523)  |         |
| Open      | -0.248   | -0.21    | -0.21    | -0.506 *** | -0.506 *** | -0.506 *** |
|           | (0.237)  | (0.172)  | (0.146)  |         | (0.171)  |         |
| Infra     | 2.056 *** | 1.914 *** | 1.222 *** |         |         |         |
|           | (0.452)  | (0.369)  | (0.341)  |         |         |         |
| Er        | -0.351 *** | -0.258 *** |         |         |         |         |
|           | (0.08)   | (0.057)  |         |         |         |         |
| Dig²      |          |          |          | -1.867 *** |         | -1.867 *** |
|           |          |          |          | (0.288)  |         | (0.288)  |
| _cons     | 10.322 *** | 10.352 *** | 10.474 *** | 9.659 *** | 9.759 *** | 10.005 *** |
|           | (0.043)  | (0.205)  | (0.231)  | (0.294)  | (0.235)  | (0.213)  |
| fixed effect | control | control | control | control | control | control |
| Observations | 210     | 210     | 210     | 210     | 210     | 210     |
| R-squared  | 0.615    | 0.616    | 0.622    | 0.732    | 0.771    | 0.829    |

Standard errors are in parentheses; *** p < 0.01.

In Table 5, according to Model 1, column (1) only displays the core variables, and column (5) is the estimation result after adding control variables. It can be seen in column (1), that the overall model fit was good, and the regression coefficient of the Dig was significantly positive at the 1% level, indicating that the digital economy can positively promote green economic growth; in column (5), α_1 was significantly positive, indicating that under the constraints, there was still a promoting relationship between the two. This was in line with Hypothesis 1a for the following reasons. Firstly, the digital empowerment infrastructure, based on the support of modern information equipment, can accurately identify and supervise the overall production process and reduce resource consumption [70]. Secondly, the rapid development of digital platforms provides a place for market entities to communicate and trade effectively, reduces the problem of information asymmetry between market entities, and improves the efficiency of regional green development [71]. Thirdly, the integration of digital technology and physical industries is conducive to the optimization and upgrading of traditional industries and promotes the green development of local industries [72].

In column (6), Model 2 was used for further estimation; after adding the quadratic term regression, the coefficient of dig was significantly positive, but the coefficient of Dig² was significantly negative, indicating that there was a nonlinear relationship between the digital economy and the green economy, which verified Hypothesis 1b for the following reasons. On the one hand, differences in the development levels of regional digital economy facilities will have different impacts on the development of the green economy. In areas with a high infrastructure level, both the information transmission capacity and the computing power of the data center are higher than in other areas, and the promotion effect is relatively strong. On the other hand, different regions are based on different resource endowments and development foundations. In the different development stages of the digital economy, its impact on green economic growth fluctuates. In addition, the digital economy may be affected by other external factors in the process of promoting green economic growth, showing a nonlinear characteristic. The circumstances under which the digital economy can maximize the positive effect on green economic growth must be explored.
Regarding the control variables, infrastructure positively promoted the green economy at different levels of growth, indicating that in the early development stage of the digital economy, digital empowerment infrastructure had the highest contribution level [73]. The coefficient of environmental regulation was significantly negative, indicating that in the low development stage of the green economy, the increase in pollution control costs may trigger additional production costs. The coefficient of government intervention indicated that the government played an insignificant role in the current period. The coefficient of openness was significantly negative because, although China’s position in the global value chain has improved, its reliance on the export of low value-added products in the early stage of development has not completely changed [74]. A trade export model that is characterized by competitive advantages, a reduction in resource and energy consumption and environmental pollution, and the achievement of green growth needs to be further explored.

4.2. Quantile Regression Analysis

Benchmark regression actually reflects the average marginal effect, but the mean regression results cannot fully explain the impact of the independent variables on the entire conditional distribution of dependent variables. Referring to the practice of Koenker and Bassett (1978) [75] and Ma et al. (2022) [76], this paper selected three quantiles of 0.25, 0.50, and 0.75, and used the quantile regression model to explore whether the impact has different characteristics at different quantiles. The regression results are shown in Table 6.

Table 6. Quantile regression results.

| Variables | Low Level   | Medium Level | High Level  |
|-----------|-------------|--------------|-------------|
| Dig       | 2.7822 ***  | 3.0341 ***   | 3.7142 ***  |
|           | (0.1133)    | (0.4088)     | (0.1024)    |
| Dig^2     | −2.1218 *** | −2.3833 ***  | −4.6254 *** |
|           | (0.2627)    | (0.8189)     | (0.2485)    |
| Gov       | 0.3900 **   | −0.0514      | 0.2809 *    |
|           | (0.1612)    | (0.1276)     | (0.1681)    |
| Open      | −0.4595 *** | −0.4216      | −0.4929 *** |
|           | (0.1045)    | (0.3617)     | (0.0822)    |
| Infra     | 0.3668 ***  | 0.4148 **    | 0.9901 ***  |
|           | (0.0809)    | (0.2056)     | (0.0658)    |
| Er        | −0.3556 *** | −0.2280 ***  | −0.1805 **  |
|           | (0.1248)    | (0.0540)     | (0.0838)    |

Standard errors in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01.

In Table 6, according to the overall results of quantile regression, the relationship between dependent variables and independent variables was consistent with the benchmark regression model. Comparing the coefficients of the 25% and 75% quantiles, their effects show a marginal growth trend, indicating that the higher the level of green development is, the more obvious the promotion effect on economic growth and pollution reduction is. The reason may be that, in areas with a high level of green economic development and owing to the scale effect, productive service industries gather and a livable environment increases population and attracts talents [77]. The construction of digital infrastructure is relatively complete, and the application of digital technology in energy conservation, emission reduction, and smart city management has become increasingly mature [78]. Meanwhile, less developed areas of the green economy are mostly resource-dependent provinces, where the level of digital technology innovation and digital talent capital accumulation is low and there is a large potential space to develop the green value of the economy [79].

Comparing the coefficients of Dig^2 illustrated that the nonlinear characteristics at different quantile levels existed. As the quantile level rose, the nonlinear characteristics of
the digital economy and their effects on the growth of the green economy were gradually
enhanced, which further verified Hypothesis 1b. The digital economy can improve the
backward production processes of traditional industries and the level of intelligent man-
agement, so that, in the end, the improvement of production efficiency, accompanied by the
energy saving and emission reduction efficiency, will further promote green growth [80,81].
However, the development of the digital economy is inseparable from the support of data
centers. Its reliance on power resources in the process of construction and operation is
likely to cause energy consumption pressure and environmental pollution [82], which may
result in phase characteristics.

4.3. Threshold Effect Analysis

Based on the previous research results, this paper selected green technology innovation,
marketization level, financial agglomeration, and the digital economy development itself
as threshold variables to explore the nonlinear relationship between the two and used
Stata 17.

4.3.1. Existence Test of Threshold Effect

The existence of the threshold effect was tested after 300 repeated samplings. The
results are shown in Table 7.

| Threshold Variables | Test Model       | F Value | p Value | Threshold Value | 95% Confidence Interval |
|---------------------|------------------|---------|---------|-----------------|-------------------------|
| Digital             | Single threshold | 52.060  | 0.000   | 0.061           | [0.060, 0.063]          |
|                     | Double threshold | 22.690  | 0.003   | 0.539           | [0.495, 0.585]          |
| Grti                | Single threshold | 21.490  | 0.013   | 9.152           | [9.093, 9.162]          |
|                     | Double threshold | 21.740  | 0.000   | 4.448           | [3.908, 4.747]          |
| Market              | Single threshold | 31.360  | 0.057   | 9.060           | [8.938, 9.156]          |
| Fina                | Double threshold | 16.140  | 0.007   | 0.186           | [0.184, 0.194]          |

According to Table 7, the threshold variables all passed the existence test, the financial
agglomeration was at the 1% significance level with a single threshold, the green technol-
gy innovation and marketization levels were at the 10% significance level with double
thresholds, and the digital economy was at the 1% significance level with double thresholds.

4.3.2. Analysis of Threshold Regression Estimation Results

The regression test results of threshold Models (3)–(6) are shown in Table 8 below.

| Variables          | $Id = \text{Dig}$ | $Id = \text{Grti}$ | $Id = \text{Market}$ | $Id = \text{Fina}$ |
|-------------------|-------------------|-------------------|-----------------------|-------------------|
| $Gov$             | 0.184             | 0.186             | 0.060                 | −0.533            |
|                   | (0.346)           | (0.400)           | (0.353)               | (0.592)           |
| $Open$            | −0.355 **         | −0.303 **         | −0.336 **             | −0.310 **         |
|                   | (0.146)           | (0.119)           | (0.130)               | (0.145)           |
| $Infra$           | 1.614 ***         | 1.483 ***         | 1.958 ***             | 1.670 ***         |
|                   | (0.288)           | (0.264)           | (0.305)               | (0.317)           |
| $Er$              | −0.278 ***        | −0.269 ***        | −0.278 ***            | −0.299 ***        |
|                   | (0.052)           | (0.080)           | (0.067)               | (0.066)           |
| $Dig \cdot (Id \leq \omega_1)$ | −1.290 **        | −1.208 ***        | −0.710                | −0.336            |
|                   | (0.587)           | (0.364)           | (1.397)               | (0.504)           |
| $Dig \cdot (Id > \omega_1)$ | 1.054 ***         | 1.054 ***         | 1.054 ***             | 1.054 ***         |
Table 8. Cont.

| Variables | $Id = Dig$ | $Id = Grti$ | $Id = Market$ | $Id = Fina$ |
|-----------|------------|-------------|---------------|-------------|
|           | (3)        | (4)         | (5)           | (6)         |
| $Dig \cdot (\omega_1 < Id \leq \omega_2)$ | 1.270 *** (0.141) | 1.509 *** (0.171) | 1.581 *** (0.145) |
| $Dig \cdot (Id > \omega_2)$ | 1.031 *** (0.126) | 1.127 *** (0.180) | 0.871 *** (0.187) |
| _cons     | 9.851 *** (0.168) | 9.862 *** (0.147) | 9.734 *** (0.158) | 10.045 *** (0.244) |
| $N$       | 210        | 210         | 210           | 210         |
| $R^2$     | 0.8318     | 0.8092      | 0.8163        | 0.8039      |

Standard errors in parentheses; ** $p < 0.05$, *** $p < 0.01$.

(1) Development of the digital economy. According to the regression results of Model 3, the threshold values were 0.061 and 0.539, the regression coefficient was significant at the 1% level, and the overall trend moved from negative inhibition to positive promotion. The specific trends were as follows:

When the threshold variable $Dig < 0.061$, the digital economy inhibited the growth of the green economy. During this period, the development level of the digital economy was in the initial stage, and the contribution level of digital empowerment infrastructure was the highest under the subdivision [65]. In order to narrow the digital infrastructure gap, the construction of a large-scale digital infrastructure was carried out in an orderly manner across the country, a large number of resources were consumed, and the relationship between $Dig$ and $\ln G\text{eg}$ was competitive.

When $0.061 < Dig < 0.539$, its effect moved from negative to positive. This indicated that the development of the regional digital economy experienced a period of rapid growth, the supporting measures were gradually completed and put into operation, and sustainable development issues such as environmental resources were gradually being considered. The improvement of the digital technology optimizes the existing production process, reduces the waste of resources caused by the mismatch of factors, and promotes cleaner production. At the same time, the construction of ecological civilization has become the key content of local government assessment and also provides a good foundation for the development of the digital economy. At this moment, the explanatory power of the independent variables reached a peak.

When $Dig > 0.539$, the regression coefficient of the explanatory variable dropped slightly to 1.127, which was significant at the 1% level. The digital economy had developed to a certain stage, and it was difficult to expand its influence. Based on the different resource endowments in different regions, the effect of the digital economy has a “pulling characteristic” and a “radiating characteristic” with the first-tier cities (for example, Beijing, Shanghai and Guangzhou) as the axis, and the regional differences have deepened [83]. To achieve sustainable development goals, further research is needed to formulate appropriate development strategies. Hypothesis 1b was verified.

(2) Green technology innovation. From the regression results in Table 8, it can be seen that there were two thresholds for green technology innovation. The effect of the digital economy on green economic growth was divided into three ranges. At the 1% significance level, it showed a trend from negative to positive promotion. The trends were as follows:

When the threshold variable $Grti < 5.236$, there was an inhibitory relationship between the two. The impact of new products produced through technological innovation had a time lag. In the research and development stage, many resources have needed to be invested in experiments. These have not only failed to directly promote economic growth for the time being but have also caused pollution which may have inhibited green economic growth.
When the threshold variable was between $5.236 < Grti < 9.152$, the digital economy significantly promoted the growth of the green economy. During this period, it provided a good environment for the realization of green technology innovation and accelerated the process. Digital technology can integrate and fully grasp consumers' green consumption tendency, offer a preference for green environmental protection policies and other green resources, and allow enterprises to identify and grasp green development opportunities and accurately implement green technology innovations.

When the threshold variable $Grti > 9.152$, the influence of the independent variable on the dependent variable was weakened under the constraint of the level of green technology innovation. Analyzing the reasons, we can see that it needed to undergo a cycle based on the iterative replacement of technology and partially positive promotion. The growth rate of digital economy development is too high, which may also bring some pollution and offset the positive promotion effects to some extent, which further verified Hypothesis 2.

(3) The level of marketization. According to the regression results of Model 5, the two thresholds were 4.448 and 9.06. At the 1% significance level, they showed a trend from weak negative to positive promotion. The specific trends were as follows:

When the threshold variable $Market < 4.448$, the regression coefficient was significantly negative at the 1% level, indicating that in the early development stage of the digital economy, the mobility of production factors was low, the development of the overall market-oriented system and supporting measures was weak, and the market regulation function had not fully played out. The main body of resource allocation was dominated by the government, and the development of the digital economy mainly depended on the guidance of national policies [84].

When the threshold variable was between $4.448 < Market < 9.06$, it accelerated the positive effect of the digital economy on green economic growth. With the improvement of marketization, the relevant supervision, transaction, and other systems gradually improved, providing a stable foundation. At the same time, the improvement of the marketization level is conducive to the optimal allocation of data resources, enhancing the knowledge spillover effect of the digital economy on the green economic growth.

When the threshold variable $Market > 9.06$, the positive promotion effect was weakened at the 1% significance level. In the stage of in-depth market-oriented reform, the corresponding supporting system still needed to be improved; for example, the property rights system involving restraining technology and data element should be gradually improved. In addition, the differences in regional factor endowments and the development needs of specialty industries require local governments to formulate appropriate policies, which further confirms Hypothesis 3.

(4) Financial agglomeration. From the regression results in Table 8, it can be seen that financial agglomeration had a single threshold value of 0.186, and the overall trend changed from negative inhibition to a 1% level of significant positive promotion. The specific trends were as follows:

When the threshold variable $Fina < 0.186$, the estimated coefficient of the digital economy was -0.336, which failed the significance test. The traditional financial industry is dominated by banking, which supports the development of local enterprises through credit services. When the financial agglomeration rate is low, limited financial resources tend to support traditional manufacturing industries. Along with economic growth and scale expansion, the local pollution situation worsens, which is not conducive to green economic growth [42].

When the threshold variable $Fina > 0.186$, the regression coefficient was 1.054, which was significant at the 1% level, and the impact of the digital economy on green economic growth was enhanced. Diversified digital financial services provided financial support for companies engaged in clean technology R&D and application and actively encouraged companies to create green technologies and green value. Many financial institutions participated, which promoted the enrichment of local financial resources and the improvement
of services. Capital flowed into clean and efficient green industries, reshaping resource allocation and thereby promoting the local green economy [85]. This further verified Hypothesis 4.

The multi-dimensional composite threshold effect indicated that when 0.061 < Dig < 0.539, 5.236 < Grti < 9.152, 4.448 < Market < 9.06, 0.186 < Fina, the digital economy had the greatest effect on promoting green economic growth, and the effect of marketization and green technology innovation was more significant. This shows that vigorously promoting the digital economy, creating a good market environment, and at the same time giving certain financial support to green technology innovation are conducive to the green growth of China’s economy.

5. Robustness Analysis

In order to verify the robustness of the empirical results, this paper used a variety of methods for testing, and the specific regression results are reported in Table 9 below.

Table 9. Results of the robustness test.

| Variables          | Model 1          | Model 2          | Model 3          | Model 4          |
|--------------------|------------------|------------------|------------------|------------------|
|                    | Lag. 1           | Lag. 2           | Replace          | SYS-GMM          |
| Dig                | 0.9277 ***       | 0.8982 ***       | −0.7871 ***      | 0.3313 *         |
|                    | (0.2872)         | (0.2984)         | (0.1477)         | (0.1849)         |
| controlled variable| Yes              | Yes              | Yes              | Yes              |
| AR (1)             |                 |                  |                  |                  |
| AR (2)             |                 |                  |                  |                  |
| Hansen P cons      | 10.0162 ***      | 10.3524 ***      | 0.8466 ***       | 3.1441 ***       |
|                    | (0.2061)         | (0.2168)         | (0.2797)         | (0.8134)         |
| fixed effect       | YES              | YES              | YES              | YES              |
| N                  | 180              | 150              | 210              | 180              |
| R²                 | 0.7855           | 0.7313           | 0.5249           |                  |

Standard errors in parentheses; * p < 0.1, *** p < 0.01.

5.1. Lag Effect Test

This paper adopted the robustness test of digital economic variables with one lag period and two lag periods. The results in Models 1 and 2 (Table 9) were consistent with the benchmark regression results, suggesting they were robust.

5.2. Replacing the Dependent Variable

The high coupling between China’s economic growth and fossil energy consumption has played an important role in the development of the past few decades. Therefore, this paper used energy consumption intensity to replace green economic growth, referring to Xie et al. (2021) [86], and used unit GDP energy consumption to characterize energy consumption intensity. As seen in Model 3 (Table 9), there was a negative correlation between the digital economy and energy consumption intensity, indicating the results were robust.

5.3. System GMM

The robustness test was conducted using the systematic GMM model. Drawing on the practice of Zhang and Wang (2022) [87], the terrain relief was selected as an instrumental variable. The final regression result is shown in Model 4, verifying that the results were robust.
6. Further Analysis

6.1. Fitting Effect of the Model and Related Tests

In order to investigate the spatiotemporal evolution of the influence of the digital economy driving green economic growth, this paper used ArcGIS 10.8 software and the GTWR model to perform regression analysis on dependent variables and independent variables. The correlation coefficients of the regression results are shown in the Table 10.

Table 10. Related parameters of the GTWR model.

| Number | Model Parameter     | Value       |
|--------|---------------------|-------------|
| 1      | Bandwidth           | 0.142369    |
| 2      | Residual Squares    | 3.53915     |
| 3      | Sigma               | 0.12982     |
| 4      | AICC                | -120.074    |
| 5      | R²                  | 0.918721    |
| 6      | Adjusted R²         | 0.916729    |
| 7      | Spatiotemporal Distance Ratio | 0.541833 |

6.2. Spatial and Temporal Variation Characteristics of Digital Economic Factors

The following temporal and spatial heterogeneity characteristics were found.

6.2.1. Trend Analysis of Effect

According to the characteristics of the sample panel data, the regression coefficients of digital economy factors in 2013, 2016 and 2019 were selected for analysis. According to the differences, the coefficients of digital economy factors in each region were further summarized and sorted and then divided into rising and falling trends (see Table 11).

Table 11. Coefficient trend diagram.

| Downtrend | Uptrend |
|-----------|---------|
| Beijing, Tianjin, Hebei, Shanxi, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Shandong, Henan, Shaanxi, Gansu, Qinghai, Ningxia | Inner Mongolia, Fujian, Jiangxi, Hubei, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Xinjiang |

The research results indicated that there were two main trends: “continuous decline” and “first rise and then fall”. In exploring the reasons, we found that China’s digital economy has developed gradually since the implementation of the “Broadband China” strategy in 2013. Most regions have also incorporated the development of the digital economy into their regional development plans. The growth rate has been particularly significant. Since the Thirteenth Five-Year Plan, as of 2018, the average annual growth rate reached 8.87%, and the development level of China’s digital economy has significantly improved [88], but the regional digital infrastructure gap became prominent. In order to solve the problem of the uneven development of regional digital infrastructure, the construction of China’s digital infrastructure was promoted in an orderly manner [74]. Gradually, the contribution of infrastructure to green economic growth and development has weakened.

6.2.2. Spatial Distribution Trend Analysis

The spatial distribution maps illustrate the differences in the spatial distribution of the regression coefficients of the digital economy. The results are shown in Figure 3. Overall, from 2013 to 2019, the impact of the digital economy on green economic growth had significant spatial and temporal differences, spatial distribution, and the degree of influence showed a change trend from east to middle and west, and from north to south.
was greater than 1, and the effect was more obvious. The weakening of the global economy
became apparent in the central region. The coefficient of Sichuan, Zhejiang, and other places
was more obvious in the central region. The coefficient of Sichuan, Zhejiang, and other places
was greater than 1, and the effect was more obvious. The weakening of the global economy
required new drivers for economic growth. The development of the digital economy
was conducive to promoting the transformation of new and old kinetic energy and bringing

Figure 3. Spatial distribution of the GTWR model’s regression coefficient for (a) 2013, (b) 2016, and
(c) 2019.

As shown in Figure 3a, in 2013 the impact of the digital economy on green economic
growth did not form a large-scale spatial agglomeration. Compared with the central and
western regions, the impact was higher in the eastern regions. In the early stage, the
overall economic development level of the eastern region was relatively high, and the
corresponding digital economy construction was carried out first, which played a role in
promoting the growth of the local green economy.

According to Figure 3b, in 2016, with the improvement in the digital economy, the
difference in the spatial distribution of coefficients weakened. The promotion effect was
more obvious in the central region. The coefficient of Sichuan, Zhejiang, and other places
was greater than 1, and the effect was more obvious. The weakening of the global economy
required new drivers for economic growth. The development of the digital economy was
conducive to promoting the transformation of new and old kinetic energy and bringing
new driving forces for economic growth. The Yangtze River Delta region and the Chengdu-Chongqing region included in the central region received more support from policies.

According to Figure 3c, major changes took place in 2019. The effect on the eastern and central regions was significantly weakened, and some regions experienced negative effects, while the western region as a whole still showed a positive impact, especially in Xinjiang. After completion of the period of phased construction in the eastern and central regions, the non-green value attributes became apparent. The extent of the resource consumption associated with data center maintenance and electronic waste pollution gradually emerged. It is now necessary to formulate appropriate development plans for the next stage based on regional advantages and resources.

7. Conclusions and Implications

This research discussed the factors under which the digital economy can maximize the promotion of green economic growth. Achieving green and sustainable growth driven by the digital economy was its most important purpose. Based on provincial panel data from 2013 to 2019, this paper examined the spatial heterogeneity of the digital economy and its nonlinear impact on green economic growth from multiple dimensions, using threshold models and spatiotemporal geographic weighting models. Through the above empirical tests, the following conclusions were drawn: (1) The digital economy can significantly promote green economic growth, but it presents a typical nonlinear characteristic: double thresholds with a trend of “weak negative → strong positive → weak positive”; (2) in this process, the three nonlinear critical factors are financial agglomeration (Fina) with a single threshold of “0.186” and the trend of “weak negative → strong positive”, marketization level (Market) with double thresholds of “4.448 and 9.06” and the trend of “weak negative → strong positive → positive”, and green technology innovation (Grti) with double thresholds of “5.236 and 9.152” and the trend of “strong negative → strong positive → positive”; (3) the multi-dimensional composite threshold effect indicates that when 0.061 < Digit < 0.539, 5.236 < Grti < 9.152, 4.448 < Market < 9.06, 0.186 < Fina, the digital economy has the greatest effect on promoting green economic growth, and the effect of marketization and green technology innovation is more significant; (4) regional heterogeneity demonstrates two decreasing trends of “increase first, then decrease” and “decline” (except for Xinjiang). Accordingly, the following policy implications are put forward.

(1) According to the staged characteristics of the role of the digital economy, a combination of “visible” and “invisible” hands should promote the development of a regional green economy. When the development of the regional green economy is at a low level, it relies on government policies to advance and at the same time accelerate the construction of regional digital infrastructure. When it is at a medium level of development, we must vigorously promote the process of digital construction and strengthen the role of the digital economy. When at a high level of development, we must use the “invisible hand” to allocate resources and optimize cross-regional allocation, especially to improve property rights supervision, and establish a digital platform with government support to improve the effectiveness and reliability of transactions.

(2) The transformation and implementation of green technology innovation achievements must be accelerated. Technological innovation has a certain time lag, and government support should be strengthened in the early stage to ease the cost pressure of enterprises. In the medium term, the independent innovation ability and achievement transformation ability of market entities will be improved, and the vitality and potential of low-carbon technological innovation in the digital economy will be realized. In the later stage, we should focus on optimizing environmental technology, accurately quantifying investment, reducing unnecessary waste of raw materials, avoiding errors caused by a vague production experience, improving process efficiency, and promoting the development of a green economy.
(3) We must promote improvement of the level of marketization and use regional financial resources to promote the development of the local green economy. In the early stage of green economy development, marketization has a weak negative effect, and the effect of financial resource agglomeration is not obvious. We recommend improving the marketization system and promoting the construction of a business environment. In the middle stage of development, the positive effect of marketization is prominent. It is suggested to increase market openness, promote the rational allocation of resources, and improve the efficiency of use. At the same time, improving the level of marketization will increase the activity of the local market, attract more capital investment, and have a significant financial agglomeration effect. Financial institutions must be encouraged to stimulate enterprises to initiate green innovation through financial support and other means and to promote the development of the regional green economy.

(4) According to the current situation of unbalanced regional development, we should formulate a reasonable plan. This includes accelerating the construction of digital economic infrastructure in areas with low levels of green economic development, providing a foundation for the digital economy, and promoting the development of traditional industries or integration with entities. For example, in the early stage of digitalization construction in Xinjiang, regional construction was accelerated through policy support. In areas with a high level of digital economy, we can consider the prevention of energy rebound and the achievement of coordinated economic and ecological development.

In the post-pandemic era, faced with increasing and uncertain risks at home and abroad, the development of the digital economy has bucked the trend and achieved rapid growth, which is not only an important measure to ensure the realization of China’s new dual-cycle development pattern, but also crucial to China’s comprehensive green transformation. The research conclusions of this paper can support China in further maximizing the role of the digital economy in promoting green economic growth. However, based on the availability of data and space constraints, there are the following limitations to our work. First, the selection of indicators for the construction of the index system may have been insufficient based on availability. Second, other influencing factors such as human capital and urbanization level were not considered. These can be incorporated into the analysis framework for further research. Third, the announcement of the “Broadband China” national strategy implementation plan in 2013 laid the foundation for the rapid development of China’s digital economy. Therefore, based on the availability of data, the research in this paper mainly focuses on the provincial data from 2013 to 2019. If the data is further expanded to the prefecture-level city data and the study period is lengthened, the research results may be more robust. Fourth, we only measured the overall level of the digital economy and explored its relationship with green economic growth. This could be subdivided into digital industries and industrial digitalization in further explorations.

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