sustainability

MDPI

Article

Impact of Digital Finance on Industrial Green Transformation: Evidence from the Yangtze River Economic Belt

Liuhua Fang [1], Bin Zhao [1], Wenyu Li [1], Lixia Tao [1], Luyao He [2], Jianyu Zhang [1] and Chuanhao Wen [3,*]

[1] Research Center for Economic of Upper Reaches of Yangtze River, Chongqing Technology and Business University, Chongqing 400067, China; fangliuhua@ctbu.edu.cn (L.F.); 2021301029@email.ctbu.edu.cn (B.Z.); liwenyu11799@163.com (W.L.); taolixia@ctbu.edu.cn (L.T.); 2021351026@email.ctbu.edu.cn (J.Z.)
[2] Zhongxian County Judicial Bureau, Chongqing 404300, China; heluyao163@163.com
[3] College of Economics, Yunnan University, Kunming 650000, China
* Correspondence: chhwen1972@ynu.edu.cn; Tel.: +86-185-0234-0601

Abstract: Profound changes in information technology have resulted in the rapid development of the digital economy, digitalizing the financial sector and deepening green reforms. Consequently, digital finance has become an important driving force of green development. Using the entropy value method and the global super-efficiency slacks-based measure model, this paper measures the extent of digital finance and industrial green transformation in 108 prefecture-and-higher-level cities in the Yangtze River Economic Belt from 2011 to 2020. It empirically examines the effects and impact mechanisms of digital finance development on industrial green transformation based on the two-way fixed effects, mediated effects, and spatial econometric models. Digital finance can significantly drive industrial green transformation, and this finding remains robust to the exclusion of macro-systematic effects and robustness tests like the introduction of instrumental variables. Digital finance has a positive spatial spillover effect on industrial green transformation. Industrial structure upgrading and green technology innovation are the key ways in which digital finance impacts industrial green transformation; their respective mediating effect contribution rates are 18.70% and 20.93%. In the context of the impact of digital finance on industrial green transformation, significant heterogeneity was observed across regions, the administrative rank of cities, and the degree of developed traditional finance. Based on these conclusions, this paper presents policy recommendations like giving full play to digital finance's green driving effect, optimizing digital finance's green empowerment mechanism, implementing regional industrial green differentiated development based on local policies, and encouraging support for green innovation pilots.

Keywords: digital finance; industrial green transformation; Yangtze River Economic Belt

check for updates

Citation: Fang, L.; Zhao, B.; Li, W.; Tao, L.; He, L.; Zhang, J.; Wen, C. Impact of Digital Finance on Industrial Green Transformation: Evidence from the Yangtze River Economic Belt. *Sustainability* **2023**, *15*, 12799. https://doi.org/10.3390/su151712799

Academic Editor: Cristina Raluca Gh. Popescu

Received: 28 July 2023
Revised: 20 August 2023
Accepted: 22 August 2023
Published: 24 August 2023

Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

For a long time, global economic development relied on the consumption of traditional factors of production, such as energy and land. These fueled rapid economic development while causing a series of problems affecting sustainable human development, like global warming and ecological environment deterioration. Such use of resources and the environment is no longer the endogenous driving force of economic development but has become a constraint on economic and social development [1] For China, since the reform and opening up in 1978, economic development has witnessed historic milestones that attracted worldwide attention, with the gross regional product (GDP) growth perennially ranking among the world's top, a miraculous illustration of world economic development. However, with changes in the population structure and market supply and demand, the past's rough development model, which relied mainly on resource factor inputs, revealed huge contradictions with population, resources, and the environment; additionally, the conflict between economic development, resource, and environmental constraints has intensified [2,3]. In September 2020, President Xi Jinping announced at the 75th session

of the United Nations General Assembly that China intended to peak its carbon dioxide emissions by 2030 and work toward achieving its carbon neutrality target by 2060. In 2021, China's total carbon emissions were as high as 11.47 billion tons, about twice that of the US (5 billion tons) and 4-times that of the EU (2.79 billion tons), which is more than the combined total of the EU and the US. Thus, the development approach needs an urgent change. We still have a long way to go before we attain green transformation.

In March 2021, China adopted the Outline of the 14th Five-Year Plan for National Economic and Social Development and Vision 2035. It proposed to adhere to ecological priorities and green development, accelerate the transformation of green development methods, and synergistically promote high-quality economic development and high-level ecological and environmental protection. As China's golden economic belt, the Yangtze River Economic Belt (YREB) spans 11 provinces and municipalities in 3 major regions, namely the East, Middle East, and West. It contributes more than 40% of the total economy, with 21% of the country's land area. It is a pioneering demonstration belt for high-quality economic development and ecological civilization and is a carrier belt where many industrial enterprises are concentrated. As the primary pollution-generating sector in the country, in the YREB, industrial pollution has accumulated over a long period, hugely affecting the ecological environment of the YREB. The traditional industrial development model of high energy consumption, high emissions, and high pollution has undergone continuous changes, and industrial green transformation (IGT) in the YREB is both a reality and a future need. IGT requires green guidelines, and the concept of green development is integrated into the entire process of industrial restructuring and layout to promote the green transformation and upgrading industry as well as to push industrial development toward green practices, low-carbon emission, resource conservation, pollution reduction, and productivity improvement [4]. IGT reflects the extent of local industrial development and embodies the extent of resource use and ecological and environmental protection in the region, which are important criteria for measuring the green development of regional industry, becoming important propellers of industrial green development [5,6].

Real economic development cannot be achieved without the support and services of finance. As the basis for building a market-oriented technological innovation system and a core element of modern economic operation [7,8], finance is an important tool for the government to promote economic development and environmental governance. It plays an active role in promoting high-quality economic development. However, traditional financial services are also inadequately developed, characterized by inadequate transmission mechanisms, and entail low resource allocation efficiency; consequently, many enterprises face high financing costs or are unable to obtain financing [9,10]. This seriously inhibits many enterprises from engaging in green technological innovation (GTI) and improving production efficiency. With the development of the internet, digital technology and traditional financial services industry integration generated new types of financial services that rely on artificial intelligence, big data, cloud computing, blockchain, biometrics, and other digital technologies. This enables digital finance (DF) and financial services to be more inclusive, efficient, low-cost, and accurate. The powerful resource allocation function of DF can greatly alleviate the mismatch of financial resources [11]. By providing new development ideas and support services for industrial enterprises to conduct green innovation activities, DF has become an important factor that promotes ecological priority and green development; it also ensures the upgrading of IGT. In view of this, this paper takes 108 prefecture-level cities in the Yangtze River Economic Belt from 2011 to 2020 as research samples. By constructing the global super-efficiency SBM model, the panel two-way fixed effect model, the mediating effect model, and the spatial econometric model, this paper discusses and analyzes the impact of DF on IGT, transmission path, and spatial spillover effect and expands the analysis of heterogeneity problems such as spatial and temporal heterogeneity. This study reveals the importance of DF driving IGT and provides empirical evidence for further expanding the existing research.

The possible innovations and contributions of this paper are as follows: First, the impact of DF on IGT is studied with a focus on the industrial sector. Second, through theoretical analysis, this paper explores the intermediary channels of energy efficiency, industrial structure upgrading, and green technology innovation, deepening the existing theoretical research on DF-enabled green transformation development. Third, the differences in various sub-dimensions of DF on IGT are explored, and the differences in the influence of geographical location, urban administrative hierarchy, and the degree of traditional financial development on IGT are explored. Fourth, a spatial econometric model incorporating a geographic threshold weight matrix is applied based on the spatial linkage characteristics of factors to avoid bias in results caused by neglecting spatial layout and spatial dependence. This paper provides theoretical and policy insights to promote the practice of "ecological priority and green development" in the YREB and the green and high-quality development of the whole basin economy while enriching the research related to the green development of DF-influenced regions.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature on DF and IGT. Section 3 analyzes the relationship between DF and IGT and the underlying mechanism. It presents the corresponding research hypotheses. Section 4 constructs an econometric model and introduces the relevant variables and data sources. Section 5 conducts an empirical analysis of the relationship between DF and IGT, focusing on the transmission mechanism, spatial spillover, and other aspects for verification. Section 6 presents the main conclusions in conjunction with the empirical analysis and uses them to present the corresponding policy recommendations. Figure 1 shows the study's logical flow chart.

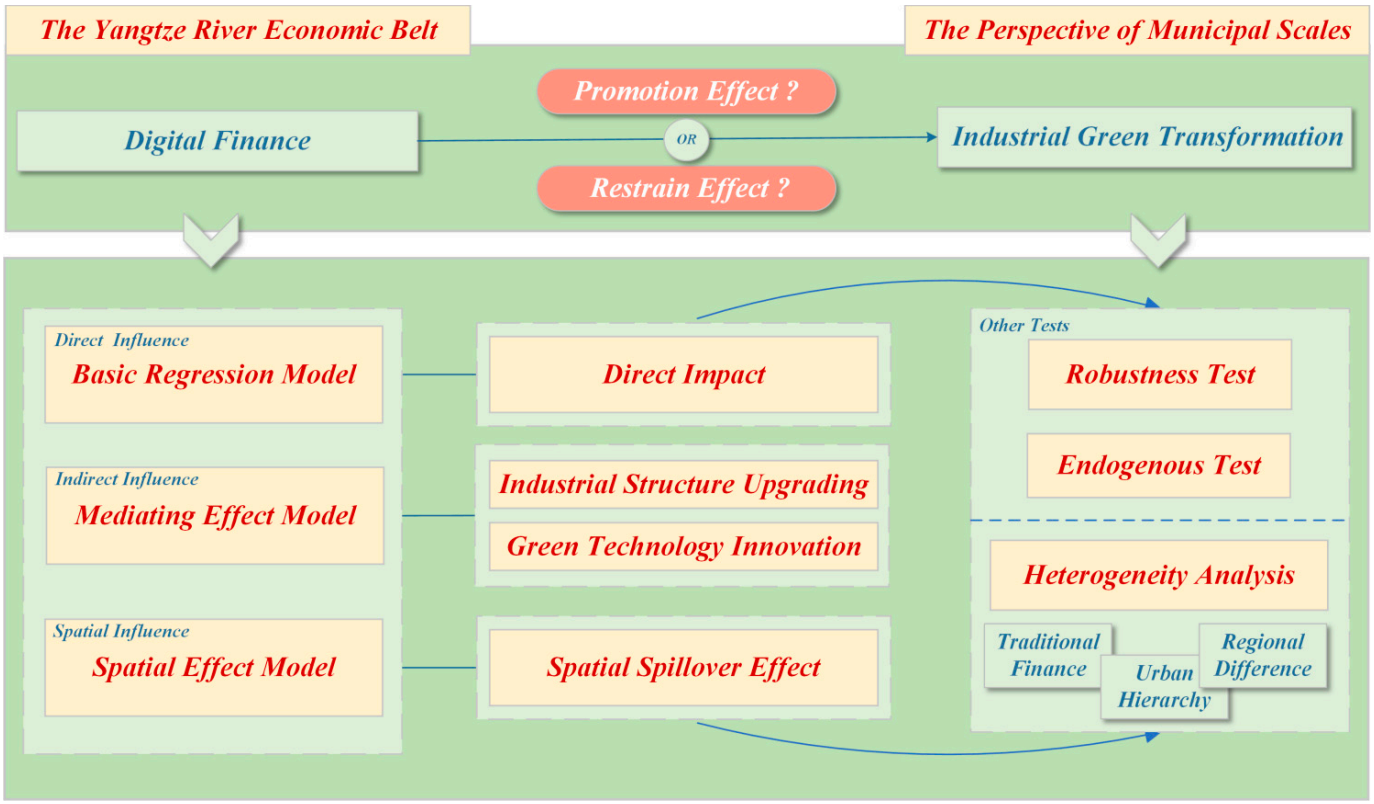


Figure 1. The logical flow chart.

2. Literature Review

The existing studies on IGT are related to three aspects: connotation, measurement, and influencing factors. (1) The concept of IGT. Graedel and Allenby proposed that the importance of IGT is to maximize the use of resources from the entire production chain

and reduce the generation of industrial waste [12]. Alba and Todorov argued that IGT is mainly about achieving economic growth, protecting the environment, using resources efficiently, and reconciling the contradictions between industry and environmental protection [13]. Wang et al. pointed out that IGT is beneficial to achieving resource consumption saving and environmental pollution emission constraints in industrial development, promoting efficient and ecological development of industry, and facilitating the dynamic evolutionary process of industry shifting from unsustainable development to sustainable development [14]. Qi et al. argued that IGT is oriented toward the intensive use of resources and environmental friendliness, with green innovation as the core, to achieve green and sustainable development of the whole process of industrial production and obtain a win–win situation in terms of economic and environmental benefits [15]. (2) The measurement of IGT. The existing studies mainly focus on the measurement of IGT efficiency and the construction of a multi-dimensional evaluation index system. First, IGT efficiency measures are mainly divided into parametric and non-parametric methods. Parametric analysis methods mainly include the Solow residual method, CD production function, and stochastic frontier analysis (SFA). However, such methods usually only consider the expected inputs and outputs, such as capital and labor, ignoring the impact of factors such as environment and resources on industrial green development. Therefore, some scholars adopted non-parametric methods that consider environmental pollutants and energy consumption as input–output factors to measure the efficiency of industrial green development. Non-parametric methods are represented by data envelopment analysis (DEA) and its modified forms, such as the use of DEA-DDF models [16] and Malmquist–Luenberger productivity indices [17], SBM models [18], and the global super-efficiency SBM model [19] with Luenberger productivity [20]. Second, a multi-dimensional evaluation index system is constructed based on the connotation of IGT, and a comprehensive evaluation method is applied to measure the degree of IGT. Li et al. and Li et al. constructed an industrial green development index system based on economic operation, resource reduction, pollution management, and low-carbon production [21,22]. Shang et al. established a system of IGT evaluation indicators based on three dimensions, namely economic, environmental, and social [23]. (3) Studies on the driving forces of IGT. Scholars focused on the impact of environmental regulation [24,25], technological innovation [26,27], energy consumption [28], and urbanization [29] on IGT. Zhai and An found that environmental regulation, as a moderating variable, positively influences the green transformation of manufacturing by acting on technological progress and government behavior [30]. However, it decreased the positive impact of financing capacity on the green transformation of manufacturing. Chen et al. used panel data from 30 Chinese provinces to find that environmental regulation has a catalytic effect on industrial green development [31]. Shao et al. concluded that the improvement in energy efficiency can effectively enhance the efficiency of green technologies and, thus, positively impact the transition to green industrial development [32]. Chen et al. discovered that increased urbanization is inconducive to the greening of China's industry [20]. Zhu et al. proposed that technological progress has been the most important factor affecting green total factor productivity, while declining scale efficiency and management efficiency are the two inhibiting factors [33]. Miao et al. indicated that technological innovation has a significant positive driving effect on the green transformation of strategic emerging industries through the stochastic frontier analysis method and exhibits a development trend [34]. Chen et al. suggested that the role of technological innovation is irreplaceable and is important in maintaining the region's green development [35].

The existing literature on the impact of DF on IGT is relatively scarce and mainly focuses on relevant research, providing a useful reference for this paper. Finance, as the core of the modern economy, plays an important role in economic growth [36,37] and is significant in promoting green development. Levine argued that finance alleviates the external financing constraints faced by firms and promotes economic growth and green development through the capital support effect and capital allocation effect [38]. Yuan et al. found, based on a panel data analysis of 285 prefecture-level cities in China from

2003 to 2015, that the impact of financial development may also have a spatial effect [39]. Additionally, financial agglomeration not only directly promotes green development but also positively influences the green development of neighboring areas. With the booming development of artificial intelligence and big data technologies, the organic integration of traditional finance and emerging technologies led to the emergence of DF, which has gradually become a research hotspot in the field of finance [40,41]. Wang et al., who based their study on the panel data of prefecture-level cities in China, concluded that DF contributes to haze pollution control and achieves its pollution reduction efficacy by enhancing regional innovation capacity [42]. Further, there is a non-linear relationship between DF and haze pollution reduction. Zhuang et al. discovered through an empirical study that DF is an important driving force behind reducing energy consumption per unit of GDP and improving green development [43]. He et al. used provincial panel data to find that DF can significantly improve green development efficiency, and industrial structure upgrading is its transmission path [44]. There was no significant impact in the Western region. Lei et al., using panel data from 256 cities in China from 2011 to 2018, found that DF significantly suppresses the intensity of urban carbon emissions and promotes urban green development [45]. Razzaq and Yang, using city-level data in China from 2008 to 2019, found that DF promotes urban green development by supporting the digital transformation of enterprises and addressing energy poverty to encourage green growth and promote green development [46].

The literature review shows that there are in-depth studies on DF and green development, but some areas are worthy of deepening and expansion. First, the research perspective is focused on the industrial sector, and there are few studies on the impact of DF on IGT. Taking the YREB as a research area, it is rare to examine how DF affects the IGT of cities in the YREB. Second, the focus on the intrinsic relationship between DF and IGT is inadequate, especially in terms of using reasonable data and methods to explore the mechanism of DF influencing IGT. Third, the existing studies neglect the issue of heterogeneity that may arise from differences in the impact of DF on IGT due to the geographical location and administrative levels of cities. Fourth, previous studies mostly ignored the spatial spillover effect of DF on the existence of green development.

3. Theoretical Analysis and Research Hypothesis

3.1. The Direct Impact of DF on IGT

DF is a new form of finance formed by the overlay and integration of traditional finance and digital technology [47]. The internet-based, intelligent, and networked business model of DF enables its coverage to break the temporal and spatial limitations of traditional financial development [48,49]) and accelerates the efficient integration and free flow of capital, information, data, and other factors. Additionally, the efficient flow of production factors accelerates the effective matching and precise articulation of supply and demand, guides the resource rational layout, improves resource allocation efficiency [11], reduces the intensity of resource and energy consumption, promotes energy conservation and emission reduction, and promotes IGT. By improving information screening capabilities through modern information technology tools [50,51], DF reduces information asymmetry in the financial services process, improves information transparency, reduces moral hazard and poor information in the investment and financing process of industrial enterprises [52], and optimizes industrial enterprises' ability to prevent and control financial risks. Further, the increased risk resistance allows industrial enterprises to use financial resources more efficiently to conduct innovative activities and improve productivity, promoting IGT. The inclusive nature of DF enables the expansion of the coverage of DF services and enriches the sources of finance needed for enterprise development [53]. Based on digital technologies like big data and blockchain, DF can tap into the idiosyncratic information of industrial enterprises and improve capital market information efficiency by increasing the attention of the capital market, prompting banks to pay more attention to the environmental benefits of enterprises. In turn, the banks are prompted to increase lending rates to absorb the

environmental risks of enterprises, forcing industrial enterprises with negative environmental externalities to reduce pollution and industrial gas emissions and improve their environmental performance. Ultimately, this will create a closed loop of environmental governance in which financial resources will "reward the good and punish the bad" in the disposal of the ecological environment and promote IGT.

H_1: *DF can contribute to urban IGT.*

3.2. The Indirect Impact of DF on IGT

(1) Industrial structure upgrading (ISU). The development of DF remedies the problem of financial discrimination that exists in traditional finance, expanding the coverage and penetration of financial services and enabling clean and environment-friendly industries to access the same financial resources as key and popular industries with high energy consumption and pollution. This effectively alleviates capital distortions and financial mismatches, thereby reducing overcapacity and facilitating the transformation and upgrading of industrial structures to green and clean [54], driving green transformational development. Second, the widespread use of DF has, on the one hand, deepened the integration of digital technologies and industrial chains, accelerated the process of networking, intelligentization, and servitization of traditional industries, and given new momentum to the green transformation of traditional industries. On the other hand, it has given rise to new digital and intelligent industries that require higher levels of technology and labor quality, driving the flow of highly qualified talent and cutting-edge technologies to the emerging digital and intelligent industries. This will help raise the proportion of knowledge-intensive industries [55], push the industrial structure toward the middle and high end, and promote the industrial structure toward advancement. The digital and network attributes of DF can reduce information asymmetry and lower transaction costs, helping to de-intermediate transactions and optimize resource allocation [56], as well as promoting the upgrading of the industrial structure. As a converter of production factors and economic growth, the upgrading process of industrial structures not only enhances the efficiency of resource use and improves environmental quality but also strengthens the synergy of factors, optimizes resource allocation, leads to efficiency and kinetic change by releasing structural dividends, and ultimately promotes ISU [57], boosting IGT development. Accordingly, this paper proposes the following hypothesis:

H_2: *DF enhances IGT by driving ISU.*

Green technological innovation (GTI). With limited financial resources, the traditional financial sector tends to have a "backward-looking" preference. In other words, financial resources are tilted toward some highly polluting sectors by selecting credit clients based solely on the assets and profitability of enterprises, resulting in the financial exclusion of enterprises with green development potential and those in the growth stage [58]. DF development has given new impetus to the development of GTI by enterprises that face financing constraints, such as "difficult and expensive financing. First, the universality and high penetration of DF extend the reach of traditional finance, enabling long-tail groups like small and medium enterprises, which are excluded and discriminated against by traditional finance, to enjoy the same financial services [59], improving the efficiency of financial resource allocation. This unleashes more financial support for MSMEs, which drive innovation, to engage in GTI. Second, with the support of digital technologies like big data, artificial intelligence, and blockchain [60], DF can process massive amounts of data at a low cost, reducing transaction costs and the cost of accessing information for market players. This could help enterprises overcome the dilemma of financing constraints in conducting innovation activities [61,62], providing multi-level financing channels and service methods for enterprises, solving the financial problems in GTI, and promoting the deepening of technological change. Moreover, DF enriches access to data and information, reduces the degree of information asymmetry, and makes the information of enterprises more

transparent. This then helps strengthen the government's efforts to regulate pollution in industrial enterprises, reduce the cost of public participation in environmental monitoring, and effectively curb environmental corruption in industrial enterprises. This further pushes enterprises to increase their R&D in green technologies to cope with the digital external environment [63]. The GTI activities by enterprises drive them toward technological breakthroughs with low resource consumption, low environmental pollution, and high input and output. This, in turn, effectively promotes IGT development. Accordingly, this paper proposes the following hypothesis:

H_3: *DF improves IGT by promoting GTI.*

3.3. The Spatial Effect of DF on IGT

The use of digital technologies, such as big data, cloud computing, and artificial intelligence in DF enabled the efficient transfer of information and compressed the limitations of the spatiotemporal pattern in traditional financial services. This strengthens the spatiotemporal compression and dynamic interaction of regional economic cyberspace, increasing the breadth of association and depth of exchange in linking economic activities between regions and greatly promoting the cross-regional flow of DF innovation results. The digital attributes of DF itself will generate technology spillover and learning effects, making it possible to promote its own IGT level by learning from the advanced green technologies and policies of neighboring regions. Moreover, the local promotion of IGT development will bring a demonstration effect to neighboring regions, exerting pressure on them to improve the environment and focus on eco-efficiency, triggering a "green tournament". Inter-regional economic activities have a significant spatial correlation. Wang et al. verified the spatial spillover effects of internet development using panel data from 285 prefecture-level cities in China [64]. Furthermore, Du et al. verified that DF has a significant positive spatial spillover effect on environmental pollution in the surrounding areas [65]. Additionally, Shen et al. found that DF inclusion has a significant positive impact on economic growth and spatial spillover effects on neighboring countries [66].

H_4: *DF can enhance IGT levels in neighboring regions through spillover effects.*

4. Research Methods and Data Sources

4.1. Research Methods

4.1.1. Super-Efficiency SBM Model

The scientific and reasonable treatment of non-desired outputs in the industrial environment is key to accurately measuring the level of IGT. Although a single directional distance function can distinguish between desired and undesired outputs, it can only measure the radial proportional changes of industrial inputs and outputs in the invalid decision unit. It fails to consider the non-zero slack term, which tends to overestimate the level of IGT. Therefore, Tone [67] proposed a directional SBM-DDF model based on a combination of directional distance function and slack measure model to overcome factor slack variation. The super-efficiency SBM model is specified as follows. In this paper, the idea of constructing a global production technology set based on the SBM model has been referred to [68], and a global super-efficiency SBM model was used to measure the level of IGT. This enabled both inter-period comparative analysis and the identification of the relative effectiveness of effective decision units. The super-efficiency SBM model is specified as follows:

$$\min\varphi = \frac{1/M\sum_{t=1}^{T}\sum_{m=1}^{M}(\bar{x}/x_{qm})}{1/(N+1)(\sum_{t=1}^{T}\sum_{n=1}^{N}\bar{y}/y_{qm}+\sum_{t=1}^{T}\sum_{i=1}^{I}\bar{b}/b_{qi})}$$

$$s.t.\begin{cases} \bar{x} \geq \sum_{t=1,\neq p}^{T}\sum_{r=1,\neq q}^{Q}\lambda_r^t x_{rm}^t, \bar{x} \geq x_{qm}, m = 1,\ldots,M \\ \bar{y} \leq \sum_{t=1,\neq p}^{T}\sum_{r=1,\neq q}^{Q}\lambda_r^t y_{rm}^t, \bar{y} \geq y_{qn}, n = 1,\ldots,N \\ \bar{b} \geq \sum_{t=1,\neq p}^{T}\sum_{r=1,\neq q}^{Q}\lambda_r^t b_{ri}^t, \bar{b} \geq b_{qi}, i = 1,\ldots,I \\ \sum_{r=1}^{Q}\lambda_r^t = 1, \lambda_r^t \geq 0, r = 1,\ldots,Q \end{cases} \quad (1)$$

In Formula (1), φ is the green development efficiency of the decision unit q in period p conditional on global production technology and variable scale payoffs. λ_r^t denotes the weight of the input and output values of the r-th decision unit in period t. x denotes the input element of the decision unit. $x = (x_1, x_2, \ldots, x_M) \in R_+^M$, y denotes the desired output type of the decision unit, $y = (y_1, y_2, \ldots, y_N) \in R_+^N$, b indicates the type of non-desired output of the decision unit, $b = (b_1, b_1, \ldots, b_I) \in R_+^I$.

4.1.2. Baseline Regression Model

A two-way fixed effects model was constructed to explore the direct effect of DF on IGT.

$$IGT_{it} = \alpha_0 + \alpha_1 DF_{it} + \alpha_2 Control_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (2)$$

In Equation (2), IGT_{it} denotes the level of IGT in year t in area i, DF_{it} denotes the level of DF development in year t in area i, $Control_{it}$ indicates a set of control variables, α_0 indicates intercept term, α_1 and α_2 denote coefficients to be estimated for DF and control variables, μ_i indicates area fixed effects, δ_t indicates time fixed effect, and ε_{it} indicates the random perturbation term.

4.1.3. Intermediary Effect Model

The direct transmission effect of DF on IGT is expressed in Equation (2). Based on the abovementioned analysis, DF has the potential to indirectly impact IGT through ISU and GTI. To test this inference, the following mediating effects model was constructed, drawing on Baron and Kenny [69]:

$$Med_{it} = \beta_0 + \beta_1 DF_{it} + \beta_c Control_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (3)$$

$$IGT_{it} = \gamma_0 + \gamma_1 DF_{it} + \gamma_2 Med_{it} + \gamma_c Control_{it} + \mu_i + v_t + \varepsilon_{it} \quad (4)$$

In Equations (3) and (4), Med_{it} denotes the mediating variables, which in this paper are ISU and GTI, respectively. β_0 and γ_0 denote intercept terms, β_1 denotes the coefficient of the effect of DF on the mediating variable, γ_1 denotes the direct impact factor of DF on IGT, γ_2 is the coefficient of the effect of the mediating variable on IGT; the meanings of the other variable symbols are the same as in Equation (2).

4.1.4. Spatial Econometric Model

(1) Spatial correlation test

The premise of the spatial econometric model analysis is the existence of spatial interactions among regions. Hence, verifying first whether the research objects are spatially correlated is necessary. In this paper, the Global Moran's I was used to measure the spatial

agglomeration characteristics of the IGT and DF of the 108 cities in the YREB. Global Moran's I is calculated as follows:

$$Moran's\ I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(x_i - \overline{x})(x_j - \overline{x})}{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}\sum_{i=1}^{n}(x_i - \overline{x})^2} \quad (5)$$

In Equation (5): n is the number of study areas, x_i and x_j are observations in areas i and j, respectively. This article mainly represents the relevant values of IGT and DF; W_{ij} is the spatial panel weight matrix, the Global *Moran's I* index takes values in the range $[-1, 1]$. Global *Moran's I* index greater than 0 indicates a positive spatial correlation between regions and a spatially clustered distribution; Global *Moran's I* index less than 0 indicates a negative spatial correlation between regions and a spatially discrete distribution, while 0 indicates no spatial correlation.

(2) Spatial panel model

Barriers between regions are gradually decreasing, and factors and products are moving more freely between neighboring regions. This has led to a gradual reduction in the scale of action of spatial spillover effects between regions. Thus, this paper developed an econometric model of the impact of DF development on IGT from a spatial perspective:

$$\begin{aligned} IGT_{it} &= \alpha_0 + \rho\sum_{j=1}^{n} W_{ij}IGT_{it} + \theta_1 W_{ij}DF_{it} + \theta_2\sum_{j=1}^{n} W_{ij}Control_{it} + \phi_1 DF_{it} + \phi_2 Control_{it} + \mu_i + \nu_t + \varepsilon_{it} \\ \varepsilon_{it} &= \lambda\sum_{j=1}^{n} W_{ij}\varepsilon_{it} + \nu_{it}, \nu_{it} \sim N(0, \delta_{it}^2 I_n) \end{aligned} \quad (6)$$

In Equation (6), W_{ij} is the spatial panel weight matrix, and this paper used the economic–geographic nesting matrix, ρ and λ are the spatial autoregressive and spatial autocorrelation coefficients, respectively; θ_1 and θ_2 are the elasticity coefficients of the spatial interaction terms of the core explanatory and control variables, respectively; ε_{it} is the spatial error autocorrelation term, and v_{it} is the random disturbance term. Generally, the common spatial measurement models are SAR, SEM, and SDM. When ρ is not equal to 0 and θ and λ are equal to 0 in Equation (5), the model is SAR, when ρ and θ are equal to 0 and λ is not equal to 0, the model is SEM, when ρ and θ are not 0 but λ is 0, the model is SDM. The meanings of the other variable symbols are the same as in Equation (2).

4.2. Variable Specification

4.2.1. The Dependent Variable

IGT. Based on previous literature, this paper used industrial green development efficiency to characterize the extent of IGT from the perspective of a win–win situation of both industrial economic performance and environmental performance. According to the neoclassical growth theory, the basic variables of production function include four indicators, namely capital, labor, technology, and output. This paper primarily considered the rigid constraints of resources and environment on the scale and speed of industrial economic development and incorporated the impact of economic activities on resources and environment into the analytical framework of industrial economic growth; it also selected labor, capital, and resources as input indicators and gross industrial output value above scale and pollutant emissions as output indicators. Referring to the research methodology of Ran et al. [70], the global super-efficient SBM model was used to measure the level of IGT.

Input indicators. Due to the availability of data on the industrial sector at the city level, this paper used the input of the industrial component of labor to measure the amount of industrial labor input. This is expressed as the sum of the number of employees in extractive industries, manufacturing industries, and electricity, gas, and water production and supply

industries, following the methodology of Xiao and Lu [71]. Capital input is expressed as the total fixed assets of industrial enterprises above the scale. Energy resource inputs are expressed as industrial electricity consumption and industrial water consumption.

Output indicators. Desired output is expressed as the total output value of industrial enterprises above the regional scale. Non-desired output is measured by industrial wastewater emissions, industrial sulfur dioxide emissions, and industrial smoke and dust emissions in terms of air pollution, water pollution, and other environmental problems brought about by industrial development. Table 1 shows the indicator system for IGT.

Table 1. IGT measurement indicator system.

Target Level	Code Level	Indicator Level
IGT	Input indicators	Sum of the number of employees in extractive industries, manufacturing, electricity, heat, gas, and water production and supply (persons)
		Total fixed assets of industrial enterprises above scale (million) Industrial power consumption (million kilowatts)
		Industrial water consumption (million tons)
	Output indicators	Total industrial output value above scale (million)
		Industrial wastewater discharge (million tons)
		Industrial sulfur dioxide emissions (tons)
		Industrial fume and dust emissions (tons)

4.2.2. Key Independent Variable

The Digital Inclusive Finance Index published by the DF Research Centre of Peking University was used as a proxy variable to measure the level of DF development Guo et al. [72]. This index presents an overall digital inclusive finance index and three segmented indices, namely the breadth of DF coverage, the depth of DF usage, and the degree of digitalization. The level of DF reflects the multi-level and diversification of DF services. It also accurately measures the level of DF development in each city.

4.2.3. Intermediate Variables

The following mediating variables were selected based on the previous theoretical analysis indicating that DF can influence urban IGT through ISU and GTI. (1) Industrial structure upgrading (ISU). The ISU is characterized by changes in the ratio of various industries, especially the shift from the highly polluting, energy-intensive secondary industry to the tertiary industry. Therefore, the proportion of the value added by the tertiary industry to the value added by the secondary industry is used to characterize the ISU. The larger the index, the more advanced the industrial structure of the region. (2) GTI. The number of patents is the direct output of regional innovation activities and is the most visible expression of regional innovation initiatives and new technology generation. Using patent numbers to measure innovation has two advantages. One, patent data can reflect the innovation capacity and level of innovation agents more intuitively and objectively. Two, patent data can be broken down and focused on GTI. In this paper, the number of green patents granted per 10,000 people was used to indicate the level of GTI in a city. The larger the index, the higher the level of GTI in the region.

4.2.4. Control Variables

Considering that IGT will also be influenced by other factors, the following control variables were selected. (1) Level of economic development (PGDP). Economic development can provide a solid material basis for the green transformation of industrial enterprises, making the residents more aware of environmental protection and restraining the emission behavior of enterprises. Drawing on Zhao and He [73], the per capita gross regional product

of cities was used to express this, and it was naturally logarithmicized to reduce the volatility and heteroskedasticity of the data. (2) Opening up to the world (OPEN). While increased openness to the outside world is beneficial for the introduction of advanced production technology and management knowledge from abroad, it may also lead to the introduction of highly polluting and high-emission industrial enterprises from abroad into the country, creating "pollution sanctuaries". Referring to the practice of Copeland and Taylor [74], the ratio of the actual utilization of foreign capital to the GDP of the region is used to measure. (3) Government intervention (GOV). The heavier the government's intervention in the market, the less favorable it is for industrial enterprises to achieve IGT. Drawing on Liu et al. [75], general government public budget expenditure as a percentage of the regional GDP is used to express this. (4) Environmental regulation (REG). In the short term, the increase in environmental regulations may increase the production costs of industrial enterprises and reduce their productivity, causing a "cost constraint effect". However, when enterprises adapt to environmental regulations, they proactively adjust their production and management decisions, forcing industrial enterprises to engage in GTI. This brings the "green guidance effect" into play and improves the level of urban IGT. Referring to the measurement method of Chen and Mei [76], the comprehensive utilization rate of general industrial solid waste is used as a proxy variable. (5) Infrastructure development (INF). Convenient urban infrastructure leads to lower transport costs for enterprises, enabling them to improve production efficiency and develop green technological innovation. This contributes to urban IGT. Borrowing from Jiang et al. [77], the urban road area per capita representation is used and natural logarithmized.

4.3. Data Description

According to the availability and completeness of the data of the variables selected in this paper, 108 prefecture-level cities of the YREB were chosen as the research objects. The data, except the Digital Inclusive Finance Index, were obtained from the China City Statistical Yearbook, the China Environment Statistical Yearbook, the China Regional Economic Statistical Yearbook, and the YREB provincial and municipal statistical yearbooks and statistical bulletins. Some of the missing data were filled in by interpolation. Descriptive statistics for all key variables used in this study are shown in Table 2.

Table 2. Descriptive statistics for key variables.

Variable	Obs	Mean	Std. Dev	Min	Max
IGT	1080	0.1853	0.1371	0.0135	1.2644
DF	1080	0.4900	0.1999	0.0403	0.9110
PGDP	1080	10.7239	0.5913	9.0912	12.2011
OPEN	1080	0.1801	0.2646	0.0003	2.5139
GOV	1080	0.1979	0.0846	0.0760	0.6750
REG	1080	0.8356	0.1958	0.0593	1.0000
INF	1080	2.8362	0.4403	0.8109	3.8373
ISU	1080	0.9377	0.4244	0.2723	4.9322
GTI	1080	0.9379	1.3251	0.0040	11.5161
FIN	1080	2.4012	0.9477	0.7642	6.5594

5. Results and Discussion

5.1. Baseline Regression Results and Discussion

On the basis of Formula (2), this paper uses the Hausman test to test whether the model is a random effect model or a fixed effect model. The *p*-value of the Hausman test is significantly positive at the level of 1%, so the fixed effect model is selected for regression. Table 3 presents the results of the baseline regression of DF on the urban IGT. Column (1) is the regression result without consideration of control variables; columns (2–6) are the regression results with the sequential inclusion of control variables. As observed in column (1), the estimated coefficient of the core explanatory variable DF development level was 0.494, and it passed the test at the 1% significance level. Meanwhile, as

seen in columns (2–6) with the inclusion of control variables, in turn, the regression coefficients of DF development level on IGT were all around 0.5 and passed the test at the 1% significance level. This indicates that the DF development level has a significant positive contribution to IGT over the period examined, and all models control for time and individual fixed effects. This result validates H_1. As seen in column (6) with all control variables included, the estimated coefficient of DF on IGT was 0.507 and passed the test at the 1% significance level, indicating that DF can significantly drive IGT. The reason is that, on the one hand, DF effectively expands the coverage of financial services, reduces the cost of the threshold for industrial enterprises to access financial services, enhances the efficiency of financial services, and alleviates the asymmetry in access to information. It provides diversified financing channels for industrial enterprises to engage in GTI and green production methods, and it provides financial security for green investment projects. These promote industrial enterprises to achieve green production technology upgrades and green transformation of production methods, driving them toward achieving green transformation development while also empowering cities to achieve IGT. On the other hand, DF applies information digital technology to the financial sector and provides diversified and personalized financial products for the green transformation of industrial enterprises, which enhances the degree of matching between the financial supply side and industrial enterprises as the financial demand side. The increase in rich and flexible financial methods provides financial security for industrial enterprises to engage in green production methods and enhances the ability of financial services for economic development, thus promoting the development of the industry to achieve green transformation. Analyzing the control variables in column (6), the estimated coefficient of IGT was significantly negative for the level of openness to the outside world, as the increase in the level of openness to the outside world will lead foreign enterprises to bring backward and highly polluting enterprises into the country, creating a "pollution refuge" phenomenon and aggravating regional environmental degradation [78]. This is inconducive to the realization of IGT in cities. The estimated coefficient of government intervention on IGT is significantly negative, which means that excessive government intervention in the market is inconducive to the improvement of IGT in cities. The regression coefficient of environmental regulation on IGT is significantly negative, indicating that the stronger the environmental regulation, the more expensive it is for enterprises to combat environmental pollution, crowding out their funds for green production and green innovation. This is inconducive to cities achieving IGT.

Table 3. Estimation results of baseline regression.

Variable	(1) IGT	(2) IGT	(3) IGT	(4) IGT	(5) IGT	(6) IGT
DF	0.494 ***	0.504 ***	0.453 ***	0.462 ***	0.480 ***	0.507 ***
	(2.968)	(3.000)	(2.708)	(2.746)	(2.862)	(3.105)
PGDP		0.047	0.050	0.029	0.026	0.024
		(1.221)	(1.293)	(0.816)	(0.717)	(0.659)
OPEN			−0.673 **	−0.615 *	−0.640 **	−0.659 **
			(−2.005)	(−1.886)	(−2.026)	(−2.107)
GOV				−0.245 ***	−0.221 **	−0.219 **
				(−2.613)	(−2.361)	(−2.317)
REG					−0.097 ***	−0.096 ***
					(−3.277)	(−3.263)
INF						0.015
						(1.142)
Cons	−0.057	−0.564	−0.559	−0.290	−0.186	−0.222
	(−0.702)	(−1.276)	(−1.266)	(−0.724)	(−0.460)	(−0.557)

Table 3. *Cont.*

Variable	(1) IGT	(2) IGT	(3) IGT	(4) IGT	(5) IGT	(6) IGT
City	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
R^2	0.547	0.548	0.550	0.552	0.557	0.557
N	1080	1080	1080	1080	1080	1080
Hausman test						21.44 (0.000)

Note: *, **, *** denote significance levels of 10%, 5%, and 1%, respectively, and the numbers in parentheses below the coefficient estimates are the t-statistics of the coefficient estimates.

5.2. Endogeneity Treatment and Robustness Tests

5.2.1. Endogeneity Treatment

The instrumental variables approach was used to alleviate the endogeneity problems caused by reciprocal causality and omitted variables as much as possible. Firstly, referring to Xie et al. for the selection method of instrumental variables [79], the two-stage least squares (2SLS) regression method was employed, with internet penetration as the first instrumental variable for DF. On the one hand, internet penetration, as the infrastructure of DF, is closely linked to changes in DF; on the other hand, after controlling for variables related to IGT, there is no direct path of influence between internet penetration and IGT, which makes internet penetration a potentially effective instrumental variable. The results of the regression with internet penetration as an instrumental variable are shown in column (1) of Table 4. The Kleibergen–Paap rk LM test was significant at the 1% level, rejecting the original hypothesis that instrumental variables are under-identified. The Kleibergen–Paap Wald rk F-statistic was greater than the critical value at the 10% level of the Stock–Yogo test, rejecting the original hypothesis of weak instrumental variables and confirming the correlation between instrumental and potentially endogenous variables. After considering the endogeneity issue, the estimated coefficient of DF on IGT is still significantly positive at the 10% level, indicating that DF can promote IGT, confirming the robustness of the previous regression results. Secondly, the lagged period of DF is chosen as the second instrumental variable in this paper, and 2SLS regression is conducted. The results of column (2) in Table 4 show that the original hypothesis of "insufficient identification of instrumental variables" and the original hypothesis of weak instrumental variables are rejected once again, which indicates the validity of the instrumental variables, and the estimation result is basically the same as that in the baseline regression, which verifies the robustness of the previous estimation result once again.

Table 4. Endogeneity analysis and robustness tests.

	(1)	(2)	(3)		(4)
Variable	**NET**	**L.DF**	**Excluding Macro Factors**		**Replace the Explanatory Variable**
	IGT	IGT	IGT	IGT	SO_2
DF	0.922 *	0.386 ***	0.507 ***	1.314 *	−0.174 ***
	(1.766)	(7.723)	(2.996)	(1.660)	(−3.808)
Cons	−0.496	−0.771	−0.222	−0.132	−0.140
	(−0.754)	(−0.959)	(−0.609)	(−0.094)	(−1.423)
Control	YES	YES	YES	YES	YES
Province effect	NO	NO	YES	YES	NO
Province∗year effect	NO	NO	NO	YES	NO
City	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES

Table 4. *Cont.*

	(1)	(2)	(3)		(4)
Variable	**NET**	**L.DF**	**Excluding Macro Factors**		**Replace the Explanatory Variable**
KP rk LM statistics	85.290	45.765			
	(0.000)	(0.000)			
KP rk Wald F statistics	58.936	59.656			
	(16.38)	(16.38)			
R^2	0.553	0.555	0.557	0.734	0.743
N	1080	1080	1080	1080	1080

Note: *, *** denote significance levels of 10%, and 1%, respectively, and the numbers in parentheses below the coefficient estimates are the t-statistics of the coefficient estimates.

5.2.2. Excluding Macro-Systemic Influences

The robust standard errors of the baseline regressions were clustered only at the city level, and this paper controlled for macro-systematic environmental effects by setting province–fixed and province–year interaction effects, such as cities with better economies having a "first mover advantage" in DF development. The parameters of the effect of DF development on IGT were significantly positive, controlling for macro factors (column (3) of Table 4), and the estimation results were generally robust.

5.2.3. Substitution of Explanatory Variables

The estimated results of replacing the explanatory variables are presented in column (4) of Table 4. The regression results show that the estimated parameter of DF development on industrial SO2 emissions was significantly negative, indicating that DF development can promote industrial emission reduction and boost IGT. This confirmed, to some extent, the robustness of the baseline estimation results.

5.3. Analysis of Mechanism Test Results

Based on previous analysis, DF may influence IGT through the pathways of ISU and GTI. To test whether these three transmission pathways exist, the pathways through which DF influences IGT were explored based on Equations (2)–(4); Table 5 presents the regression results.

Table 5. Estimated results of intermediation effects.

Variable	**(1) IGT**	**(2) ISU**	**(3) IGT**	**(4) GTI**	**(5) IGT**
DF	0.507 ***	1.756 ***	0.413 ***	0.314 ***	0.401 **
	(3.105)	(6.132)	(2.695)	(5.824)	(2.478)
ISU			0.054 **		
			(2.130)		
GTI					0.338 ***
					(2.763)
Cons	−0.222	−3.647 ***	−0.026	0.255 **	−0.136
	(−0.558)	(−6.282)	(−0.065)	(2.170)	(−0.335)
Control	YES	YES	YES	YES	YES
City	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
R^2	0.557	0.908	0.560	0.936	0.562
N	1080	1080	1080	1080	1080

Note: **, *** denote significance levels of 5%, and 1%, respectively, and the numbers in parentheses below the coefficient estimates are the t-statistics of the coefficient estimates.

As indicated in column (2) of Table 5, the effect of DF on ISU was significantly positive at the 1% level, which indicates that DF can promote ISU. Column (3) shows a positive effect of DF and ISU on IGT, passing the significance level test. The estimated coefficient of DF

on ISU was smaller than the estimated coefficient of the total effect of DF on IGT, indicating that ISU plays a mediating effect between DF and IGT, confirming H2. The development of DF has been accompanied by the rapid development of digital technology, and the continuous penetration of digital technology into the financial sector will comprehensively promote ISU through channels such as digital industrialization and digitization of industry. ISU enables the transfer of factors of production from inefficient to efficient sectors and the rational allocation of production efficiency, changing the degree of path dependence of the economy on traditional factors of production, such as resources and capital and the efficiency of their use, thus having a positive impact on IGT. Column (4) shows that DF had a positive effect on green technology innovation and passed the 1% significance level test. Additionally, column (5) shows that the coefficients of the effects of DF and green technology innovation on IGT were both positive, and both passed the significance test. The marginal effect of DF on IGT decreased compared to the total effect of DF on IGT. H_3 was confirmed, implying that DF can reduce the financing cost of industrial enterprises, provide diversified financing channels, and improve the mismatch of credit resources so that industrial enterprises can make use of capital allocation to invest more in green technology research and development. Furthermore, GTI can lead to the clean transformation and green development of industries and help cities achieve IGT.

The gradual regression method confirmed ISU and GTI as the mediating variables of DF affecting IGT. The mediating effect contribution was further calculated using the mediating effect formula, $\beta_1 \times \gamma_2 / \alpha_1$. Table 6 shows the specific settlement results. The contribution rates of DF to promote IGT through ISU and GTI were 18.70% and 20.93%, respectively. This indicates that improvement and promotion of GTI are the main strategies by which DF can improve IGT, mainly reflecting the "innovation effect". The "structural" effect of ISU was not negligible.

Table 6. Contribution of intermediary effects.

Intermediary Variables	β_1	γ_2	γ_1	Intermediary Effect Contribution Rate
ISU	1.756	0.054	0.413	18.70%
GTI	0.314	0.338	0.401	20.93%

5.4. Analysis of Spatial Spillover Effects

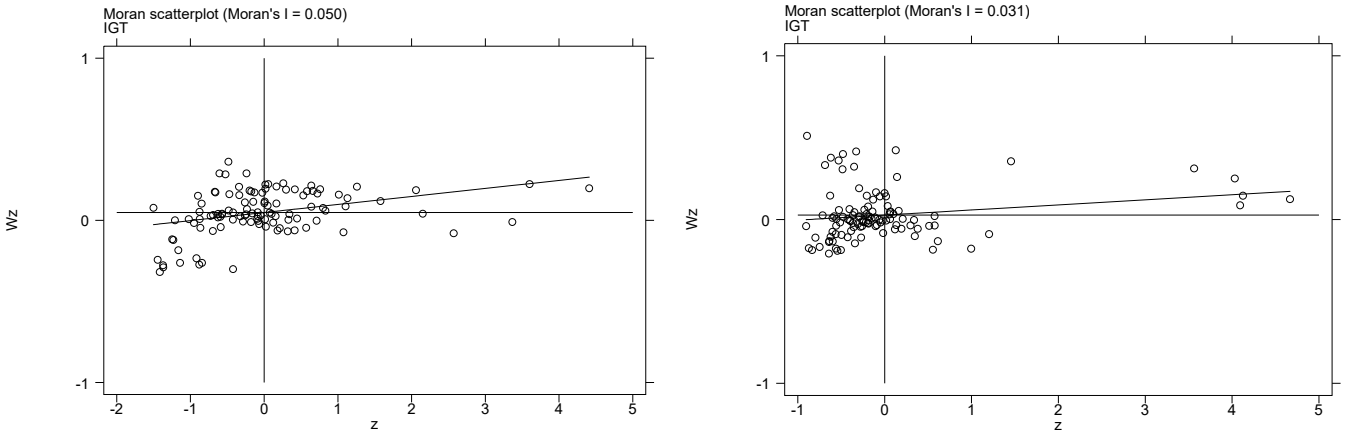
Before estimating the spatial effects, a spatial autocorrelation test between IGT levels and DF development levels had to be performed. Moran's I method was used to calculate the spatial correlation under the nested weight matrix of economic geography (Table 7). The values of Moran's I for both the DF development level and IGT level from 2011 to 2020 were positive, and both passed the significance test, i.e., there was a positive spatial autocorrelation, indicating a certain degree of spatial clustering between the DF development level and IGT level in space.

In order to further understand the spatial characteristics and local correlation of IGT and DF, the local Moran's indices of 108 prefecture-level cities in the YREB were calculated, and the local Moran's scatter plots of IGT and DF in 2011 and 2020 were drawn, respectively. From Figures 2 and 3, it can be seen that the Moran's I indexes of IGT and DF are both positive, and most of the cities are concentrated in the first and third quadrants, showing a high level of agglomeration and low level of agglomeration, which indicates that there is a positive spatial correlation between IGT and DF in the YREB.

Table 7. Moran's index of DF and IGT from 2011 to 2020.

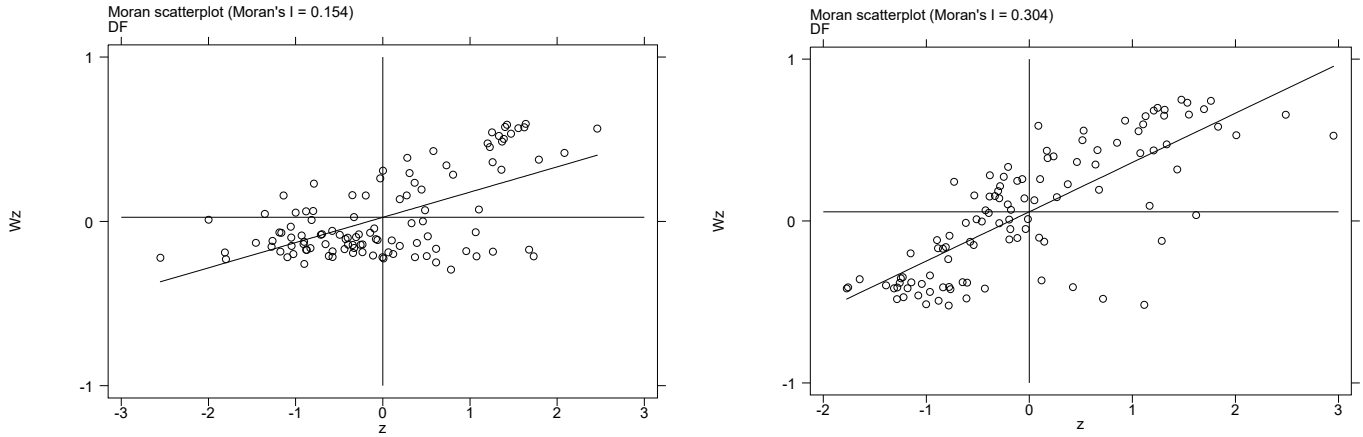
Year	IGT		DF	
	Moran's I	**Z-Value**	**Moran's I**	**Z-Value**
2011	0.050 ***	4.902	0.154 ***	13.225
2012	0.029 ***	3.292	0.187 ***	15.923
2013	0.015 **	2.187	0.209 ***	17.742
2014	0.043 ***	4.843	0.231 ***	19.481
2015	0.015 ***	2.316	0.222 ***	18.764
2016	0.009 **	1.721	0.180 ***	15.474
2017	0.017 ***	2.425	0.230 ***	19.495
2018	0.007 *	1.570	0.281 ***	23.602
2019	0.034 ***	3.605	0.289 ***	24.220
2020	0.031 ***	3.468	0.304 ***	25.475

Note: *, **, *** denote significance levels of 10%, 5%, and 1%, respectively, and the numbers in parentheses below the coefficient estimates are the t-statistics of the coefficient estimates.



(**a**) (**b**)

Figure 2. Moran scatter plot of IGT in 2011 (**a**) and 2020 (**b**) under the economic geography nested weights matrix.



(**a**) (**b**)

Figure 3. Moran scatter plot of DF in 2011 (**a**) and 2020 (**b**) under the economic geography nested weights matrix.

Different spatial regression models reflect different spatial dependencies. First, the LM test was used to determine whether a spatial Durbin model was introduced. According to the test results presented in Table 8, both the LM-Lag and Robust LM-Lag tests rejected

the original hypothesis of no spatial lag at the 1% level. Moreover, the LM-Error and the Robust LM-Error tests rejected the original hypothesis of no spatial error at the 1% and 5% levels, respectively. Therefore, a spatial SDM model containing endogenous spatial interaction effects and error term spatial interaction effects was introduced as the baseline model with reference to a study by a related scholar [80]. Second, after considering both time and individual effects, the Hausman test rejected the original hypothesis of random effects at the 1% level, so the individual time double fixed SDM model was chosen. Finally, under the spatial Durbin model selection, the Wald and LR tests were conducted, and both significantly rejected the original hypothesis, indicating that the spatial Durbin model would not degenerate into a spatial lag model or a spatial error model. Therefore, the individual time bi-fixed SDM model was the optimal model for analyzing the impact of DF development on IGT.

Table 8. Spatial econometric model selection test.

Inspection Type	Test Statistics Results	*p*-Value
LM-Error test	9.664	0.001
LM-Lag test	12.785	0.000
R-LM-Error test	4.180	0.041
R-LM-Lag test	7.300	0.007
Wald-sar test	24.71	0.000
Wald-sem test	25.54	0.000
LR-SDM-SAR test	24.68	0.000
LR-SDM-SEM test	25.79	0.000
Hausman test	69.53	0.000

Table 9 presents the results of the spatial estimation of DF affecting IGT in the YREB cities under the economic–geographic nested matrix. The model estimation results were decomposed with reference to the approach of LeSage and Pace to examine the spatial spillover effect of DF development on IGT [81]. As evident in the estimation results presented in column (1) of Table 9, the spatial autoregressive coefficient of IGT was significantly positive at the 10% level, which indicates that the homogeneity spillover effect of IGT was more significant. It is probably because the digital platform is used as an important carrier in DF, and the online synergy effect of the digital platform compresses the distance in time and space, which enhances the breadth of inter-regional economic activities and the depth of communication as well as greatly promotes the cross-regional flow of DF innovation technology and innovation results. Therefore, it had a positive spillover effect on IGT in neighboring regions.

Table 9. Regression results for the impact of DF on the IGT spatial model.

	(1)	(2)	(3)	(4)
	Elasticity Coefficient	**Direct Effect**	**Indirect Effect**	**Total Effect**
DF	0.013 **	0.014 **	0.281 ***	0.295 ***
	(2.426)	(2.205)	(2.630)	(2.686)
W×DF	0.281 **			
	(2.529)			
Control	YES	YES	YES	YES
rho	0.021 *			
	(1.917)			
R^2	0.027			
City	YES	YES	YES	YES
Year	YES	YES	YES	YES
Log-likelihood	1060.994			

Note: *, **, *** denote significance levels of 10%, 5%, and 1%, respectively, and the numbers in parentheses below the coefficient estimates are the t-statistics of the coefficient estimates.

5.5. Analysis of Heterogeneous Results

5.5.1. Regional Heterogeneity

Given the variation in locational conditions, resource endowments, and degree of economic development, examining the spatial heterogeneity of the impact of DF on IGT is an important part of clarifying the relationship between the two. In this paper, the YREB was divided into two sub-samples according to the Central–Eastern region and the Western region to explore the regional heterogeneity of DF development for IGT. The results in columns (1,2) of Table 10 reveal that DF development in the Middle East region had a positive contribution toward IGT and passed the significance test at the 10% level, while the coefficient of the impact of DF on IGT development in the Western region was positive but insignificant. The possible explanation is that the Central and Eastern regions of the YREB have relatively better digital infrastructure development, a more complete financial system, and a richer range of relevant financial systems and product services. These not only facilitate credit financing for enterprises of different sizes to develop green technologies and conduct green production needs but also create a good financial market environment for the green development of urban industries. These are, therefore, more conducive to the positive effect of DF on IGT impact. On the one hand, the industrial development model in the Western region is mainly resource-intensive. Industrial development tends to rely on the traditional factor inputs in a crude development model, with a more serious path dependence and lock-in effect, and the backwardness and lack of talents and technology make the production technology of enterprises lack green innovation, making it difficult to achieve green transformation. On the other hand, the insufficient supply of digital infrastructure and the underdevelopment of digital technology in the Western region made it difficult to highlight the impact of DF on IGT.

Table 10. Analysis of heterogeneity.

Variable	Regional Difference		Urban Hierarchy		Traditional Financial	
	(1)	(2)	(3)	(4)	(5)	(6)
	Mid-Eastern Region	Western Region	Center	Peripheral	Developed	Underdeveloped
DF	0.475 *	0.324	0.034	0.620 ***	0.222	0.973 **
	(1.962)	(1.164)	(0.278)	(3.207)	(1.643)	(2.584)
Cons	0.361	−1.137 **	−0.152	−0.205	−0.777	0.855
	(0.736)	(−2.268)	(−0.463)	(−0.468)	(−1.115)	(1.455)
Control	YES	YES	YES	YES	YES	YES
City	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
R^2	0.483	0.745	0.889	0.551	0.618	0.574
N	770	310	120	960	540	540

Note: *, **, *** denote significance levels of 10%, 5%, and 1%, respectively, and the numbers in parentheses below the coefficient estimates are the t-statistics of the coefficient estimates.

5.5.2. Urban Hierarchy Heterogeneity

Due to the special economic and political status of central cities, the central cities have more economic and financial resources but also face more stringent environmental regulatory policies. Therefore, the impact of DF on IGT may be heterogeneous at the city level. This paper further discusses it by classifying municipalities directly under the central government, provincial capitals, and sub-provincial cities as central cities and other prefecture-level cities as peripheral cities. As can be seen in columns (3,4) of Table 10, the estimated coefficients of DF on IGT for peripheral cities pass the significance test at the 1% level and have a positive direction. In contrast, the estimated coefficient on IGT for central cities is positive but does not pass the significance test, indicating that DF can drive IGT in peripheral cities. This may be because the center cities, as developed regions, already have a more developed financial services system, which has a crowding-out effect on DF. The relatively economically backward peripheral cities, however, have a relatively high degree

of financial disincentives, which gives DF room to exert its inclusive effect and can better promote IGT in peripheral cities.

5.5.3. Traditional Finance Heterogeneity

The development of DF has significantly weakened the financial exclusion of traditional financial institutions from disadvantaged areas and regions. Then, does the inclusive effect of DF development exist, and is it more beneficial to IGTs in areas that are relatively backward in terms of traditional financial development? This paper used the deposit and loan balances of financial institutions in each city as a proportion of regional GDP to express the regional traditional financial development (FIN). The median of this variable was used as the criterion to divide the total sample into regions with less-developed traditional finance and regions with developed traditional finance, and the differences in the effects of DF on IGT were examined in groups. Columns (5,6) of Table 10 show the regression results. The results show that the regression coefficient of DF on traditionally less financially developed regions was 0.973, which passed the 5% significance level test, and the coefficient on traditionally financially developed regions was 0.222 but was not significant. The possible explanation is that due to the inclusive nature of DF, the more backward the traditional financial development and the less accessible the financial services are, the more the regions can enjoy the "dividends" brought by the development of digital inclusive finance and can more fully exploit the positive impact of DF on the IGT of the region.

6. Conclusions and Policy Implications

6.1. Conclusions

Based on the panel data of 108 prefecture-and-higher-level cities in the YREB from 2011 to 2020, the entropy method and the super-efficient SBM model were applied to measure the level of DF development and the level of IGT. Various econometric models were further applied to empirically test the impact characteristics of DF development on IGT, and the following conclusions were drawn:

(1) DF can drive IGT, and this conclusion holds after robustness tests using the instrumental variables approach, replacing the explanatory variables, and excluding the effects of macro-systematic factors.

(2) In terms of the mediating mechanism, DF plays a catalytic role in urban IGT by promoting industrial structure upgrading and stimulating green technological innovation, and the contribution rates of each of the two transmission paths are 18.70% and 20.93%.

(3) There is a significant spatial spillover effect of DF development on IGT in neighboring regions, i.e., the development of DF not only boosts IGT in the region but also promotes IGT in near neighboring regions, contributing to the formation of a pattern of coordinated regional development.

(4) In terms of heterogeneity, DF shows a positive contribution to the level of IGT in cities in the Central and Eastern regions, peripheral cities, and cities with less developed traditional finance, while the impact on urban IGT in Western regions, central cities, and cities with developed traditional finance is not yet significant.

6.2. Policy Implications

Based on the above findings, the following policy insights were obtained:

(1) The green driving effect of DF must be considered. An integrated layout of the YREB's "digital infrastructure" should be built, and the construction of DF-related infrastructure should be continuously improved. The breadth and depth of DF services should be enhanced, and the deep integration of high-end technologies, such as big data, cloud computing, artificial intelligence, and blockchain, with the financial and green industries should be promoted to further unleash the green momentum of DF. The deepening of the YREB's IGT should also be promoted.

(2) DF's green empowerment mechanism for energy efficiency improvement should be optimized. There should be industrial structure upgrading and green innovation incentives.

The endogenous drive should be strengthened, DF and green policies in the same frequency should be promoted, and the structural adaptation and systemic innovation of digital technology and financial services should be strengthened. DF should be promoted to serve the industrial economy to leap up in energy level, and the BIGT efficiency of the YREB should be enhanced.

(3) The top-level design and "tailored" "city-specific policies" should be optimized. The best DF entry point, according to the state of regional industrial development, the current state of economic development, and the level of environmental resources, should be identified. The full flow and efficient allocation of capital, data, technology, talent, and other factors should be promoted, and the benefits of green innovation should be enhanced. To further improve the quality of DF services in the Central and Eastern regions of the YREB, the supporting digital infrastructure in the relatively backward Western regions should be accelerated. Additionally, improving the environment for the application of DF in industrial industries should be the focus to fully release the spatial contribution capacity of DF to the YREB's IGT.

(4) There should be encouragement and support for the innovative piloting of the YREB's DF to IGT, and the inclusive benefits of DF should continue to deepen. The regional green industrial system should be improved. The sustainable and healthy development of the regional economy should be promoted, and the YREB's ecological leadership and economic support role should be given full play.

6.3. Future Perspectives and Limitations

The profound changes in the field of information technology have promoted the rapid development of DF, effectively facilitating the transformation of the economic development mode. Taking 108 prefecture-level cities in China's YREB as the research object, this paper demonstrates the role of DF in empowering IGT and provides a new perspective for promoting the development path of economic and social green transformation. However, there are still some shortcomings in this study. Firstly, due to the limitation of the sample size, the summary analysis of the driving mode of DF influencing IGT is only based on the data of the cities in the YREB, and the intrinsic relationship between the two is not explored at the national city level. Secondly, due to the lack of academic consensus on the measurement scale and methodology of IGT, as well as the limitations of the available data, the empirical study conducted in this paper may be biased, and in-depth research on the measurement methodology and the way of measurement is needed in the future in order to accurately reflect the degree of IGT in the region. Thirdly, a comprehensive and systematic study of the impact of DF on IGT is a systematic project that requires long-term stable data accumulation and continuous methodological innovation. Fourthly, the impact of DF on IGT and the channel of action is complex, and this paper analyses it from both direct and indirect perspectives. However, in the indirect effect, this paper only explores the transmission channels of two intermediary variables, ISU and GTI, and other intermediary variables that exist have not been studied, which can be expanded on in depth in the future.

Author Contributions: The co-authors together contributed to the completion of this article. Specifically, individual contributions: Conceptualization, L.F. and B.Z.; methodology, L.F. and W.L.; software, L.F.; validation, L.F. and L.T.; formal analysis, B.Z.; investigation, L.F. and L.H.; resources, L.F.; data curation, B.Z. and W.L.; writing—original draft preparation, L.F.; writing—review and editing, L.H., L.T. and W.L.; visualization, J.Z. and L.H.; supervision, L.F., J.Z. and C.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Key Program of the National Social Science Foundation of China (No. 20&ZD095; Supported by Chuanhao Wen), the Program of Chongqing Postgraduate Research Innovation Social Science Planning Project of Chongqing (No. CYB23264; Supported by Qiuyue Yu), Innovative Research Program for Postgraduate of Chongqing Technology and Business University (No. yjscxx2023-211-10; Supported by Wenyu Li), Innovative Research Program for Postgraduate of Chongqing Technology and Business University (No. yjscxx2023-211-11; Supported by Lixia Tao), Key research grant of Construction of Chengdu-Chongqing Twin-city Economic Circle (No. SC22ZDCY01; Supported by Jirui Yang).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the author.

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

References

1. Sharif, A.; Saha, S.; Loganathan, N. Does tourism sustain economic growth? Wavelet-based evidence from the United States. *Tour. Anal.* **2017**, *22*, 467–482. [CrossRef]
2. Khan, M.K.; Khan, M.I.; Rehan, M. The relationship between energy consumption, economic growth and carbon dioxide emissions in Pakistan. *Financ. Innov.* **2020**, *6*, 1–22. [CrossRef]
3. Xin, L.; Sun, H.; Xia, X.C. Spatial-temporal differentiation and dynamic spatial convergence of inclusive low-carbon development: Evidence from China. *Environ. Sci. Pollut. Res.* **2022**, *30*, 5197–5215. [CrossRef]
4. Kemp, R.; Never, B. Green transition, industrial policy, and economic development. *Oxf. Rev. Econ. Policy* **2017**, *33*, 66–84. [CrossRef]
5. Liu, C.Y.; Xin, L.; Li, J.Y.; Sun, H.P. The impact of renewable energy technology innovation on industrial green transformation and upgrading: Beggar thy neighbor or benefiting thy neighbor. *Sustainability* **2022**, *14*, 11198. [CrossRef]
6. Zheng, C.J.; Deng, F.; Zhuo, C.F.; Sun, W.H. Green credit policy, institution supply and enterprise green innovation. *J. Econ. Anal.* **2022**, *1*, 20–34. [CrossRef]
7. Tadesse, S. Financial architecture and economic performance: International evidence. *J. Financ. Intermediation* **2002**, *11*, 429–454. [CrossRef]
8. Tripathy, N. Does measure of financial development matter for economic growth in India? *Quant. Financ. Econ.* **2019**, *3*, 508–525. [CrossRef]
9. Sassi, S.; Goaied, M. Financial development, ICT difusion and economic growth: Lessons from MENA region. *Telecommun. Policy* **2013**, *37*, 252–261. [CrossRef]
10. Kapoor, A. Financial inclusion and the future of the Indian economy. *Futures.* **2014**, *56*, 35–42. [CrossRef]
11. Robb, A.M.; Robinson, D.T. The capital structure decisions of new frms. *Rev. Financ. Stud.* **2014**, *27*, 153–179. [CrossRef]
12. Graedel, T.E.; Allenby, B.R.; Comrie, P.R. Matrix approaches to abridged life cycle assessment. *Environ. Sci. Technol.* **1995**, *29*, 134–139. [CrossRef]
13. Alba, J.M.D.; Todorov, V. How green is manufacturing? Status and prospects of national green industrialisation. The case of Morocco. *Int. J. Innov. Sustain. Dev.* **2018**, *12*, 308–326. [CrossRef]
14. Wang, Y.; Hu, H.; Dai, W.J.; Burns, K. Evaluation of industrial green development and industrial green competitiveness: Evidence from Chinese urban agglomerations. *Ecol. Indic.* **2021**, *124*, 107371. [CrossRef]
15. Qi, Y.W.; Zou, X.Y.; Xu, M. Impact of Chinese fiscal decentralization on industrial green transformation: From the perspective of environmental fiscal policy. *Front. Environ. Sci.* **2022**, *10*, 1006274. [CrossRef]
16. Chen, S.Y.; Golley, J. Environmental efficiency growth in China's industrial economy. *Energy Econ.* **2014**, *44*, 89–98. [CrossRef]
17. Guo, X.; Wang, J. Outward foreign direct investment, green financial development, and green total factor productivity: Evidence from china. *Environ. Sci. Pollut. Res. Int.* **2023**, *30*, 47485–47500. [CrossRef]
18. Fukuyama, H.; Weber, W.L. A Directional Slacks-Based Measure of Technical Inefficiency. *Socio Econ. Plan. Sci.* **2009**, *43*, 274–287. [CrossRef]
19. Liu, K.; Qiao, Y.R.; Zhou, Q. Analysis of China's Industrial Green Development Efficiency and Driving Factors: Research Based on MGWR. *Int. J. Environ. Res. Public Health* **2021**, *18*, 3960. [CrossRef]
20. Chen, H.X.; Shi, Y.; Xu, M.; Xu, Z.H.; Zou, W.J. China's industrial green development and its influencing factors under the background of carbon neutrality. *Environ. Sci. Pollut. Res. Int.* **2022**, *30*, 81929–81949. [CrossRef]
21. Li, W.; Wang, J.; Chen, R.X.; Xi, Y.Q.; Liu, S.Q.; Wu, F.M.; Masoud, M.; Wu, X.P. Innovation-driven industrial green development: The moderating role of regional factors. *J. Clean. Prod.* **2019**, *222*, 344–354. [CrossRef]
22. Li, W.; Xi, Y.Q.; Liu, S.Q.; Li, M.J.; Chen, L.; Wu, X.P.; Zhu, S.P.; Masoud, M. An improved evaluation framework for industrial green development: Considering the underlying conditions. *Ecol. Indic.* **2020**, *112*, 106044. [CrossRef]
23. Shang, D.; Lu, H.Y.; Liu, C.; Wang, D.; Diao, G. Evaluating the green development level of global paper industry from 2000–2030 based on a market-extended LCA model. *J. Clean. Prod.* **2022**, *380*, 135108. [CrossRef]
24. Hou, J.; Teo, T.S.H.; Zhou, F.L.; Lim, M.K.; Chen, H. Does industrial green transformation successfully facilitate a decrease in carbon intensity in China? An environmental regulation perspective. *J. Clean. Prod.* **2018**, *184*, 1060–1071. [CrossRef]
25. Allan, B.; Lewis, J.I.; Oatley, T. Green industrial policy and the global transformation of climate politics. *Glob. Environ. Politics* **2021**, *21*, 1–19. [CrossRef]
26. Khan, T.; Khan, A.; Wei, L.; Khan, T.; Ayub, S. Industrial innovation on the green transformation of manufacturing commerce. *J. Mark. Strateg.* **2022**, *4*, 283–304. [CrossRef]

27. Du, K.; Cheng, Y.Y.; Yao, X. Environmental regulation, green technology innovation, and industrial structure upgrading: The road to the green transformation of Chinese cities. *Energy Econ.* **2021**, *98*, 105247. [CrossRef]
28. Han, D.R.; Li, T.C.; Feng, S.S.; Shi, Z.Y. Does renewable energy consumption successfully promote the green transformation of China's industry? *Energies* **2020**, *13*, 229. [CrossRef]
29. Yue, J.P.; Zhang, F.Q. Evaluation of industrial green transformation in the process of urbanization: Regional difference analysis in China. *Sustainability* **2022**, *14*, 4280. [CrossRef]
30. Zhai, X.Q.; An, Y.F. Analyzing influencing factors of green transformation in China's manufacturing industry under environmental regulation: A structural equation model. *J. Clean. Prod.* **2020**, *251*, 119760. [CrossRef]
31. Chen, H.X.; Yang, Y.P.; Yang, M.T.; Huang, H. The impact of environmental regulation on China's industrial green development and its heterogeneity. *Front. Ecol. Evol.* **2022**, *10*, 967550. [CrossRef]
32. Shao, S.; Luan, R.R.; Yang, Z.B.; Li, C.Y. Does directed technological change get greener: Empirical evidence from Shanghai's industrial green development transformation. *Ecol. Indic.* **2016**, *69*, 758–770. [CrossRef]
33. Zhu, X.H.; Chen, Y.; Feng, C. Green total factor productivity of China's mining and quarrying industry: A global data envelopment analysis. *Resour. Policy* **2018**, *57*, 1–9. [CrossRef]
34. Miao, C.L.; Fang, D.B.; Sun, L.Y.; Luo, Q.L.; Yu, Q. Driving effect of technology innovation on energy utilization efficiency in strategic emerging industries. *J. Clean. Prod.* **2018**, *170*, 1177–1184. [CrossRef]
35. Chen, L.L.; Zhang, X.D.; He, F.; Yuan, R.S. Regional green development level and its spatial relationship under the constraints of haze in China. *J. Clean. Prod.* **2019**, *210*, 376–387. [CrossRef]
36. Rajan, R.; Zingales, L. Financial dependence and growth. *Am. Econ. Rev.* **1998**, *88*, 559–586.
37. Jabeen, G.; Ahmad, M.; Zhang, Q.Y. Combined role of economic openness, fnancial deepening, biological capacity, and human capital in achieving ecological sustainability. *Ecol. Inform.* **2023**, *73*, 101932. [CrossRef]
38. Levine, R. Finance and Growth: Theory and Evidence. In *Handbook of Economic Growth*; Elsevier: Amsterdam, The Netherlands, 2005; Volume 1, pp. 865–934.
39. Yuan, H.X.; Zhang, T.S.; Feng, Y.D.; Liu, Y.B.; Ye, X.Y. Does financial agglomeration promote the green development in China? A spatial spillover perspective. *J. Clean. Prod.* **2019**, *237*, 117808. [CrossRef]
40. Liu, S.; Koster, S.; Chen, X.Y. Digital divide or dividend? The impact of digital finance on the migrants' entrepreneurship in less developed regions of China. *Cities* **2022**, *131*, 103896. [CrossRef]
41. Jagtiani, J.; Lemieux, C. Do fintech lenders penetrate areas that are underserved by traditional banks? *J. Econ. Bus.* **2018**, *100*, 43–54. [CrossRef]
42. Wang, K.L.; Zhu, R.R.; Cheng, Y.Y. Does the development of digital finance contribute to haze pollution control? Evidence from China. *Energies* **2022**, *15*, 2660. [CrossRef]
43. Zhuang, R.L.; Mi, K.N.; Zhi, M.L.; Zhang, C.Y. Digital Finance and Green Development: Characteristics, Mechanisms, and Empirical Evidences. *Int. J. Environ. Res. Public Health* **2022**, *19*, 16940. [CrossRef]
44. He, Z.M.; Chen, H.C.; Hu, J.W.; Zhang, Y.T. The impact of digital inclusive finance on provincial green development efficiency: Empirical evidence from China. *Environ. Sci. Pollut Res.* **2022**, *29*, 90404–90418. [CrossRef]
45. Lei, T.Y.; Luo, X.; Jiang, J.J.; Zou, K. Emission reduction effect of digital finance: Evidence from China. *Environ. Sci. Pollut. Res.* **2023**, *30*, 62032–62050. [CrossRef] [PubMed]
46. Razzaq, A.; Yang, X.D. Digital finance and green growth in China: Appraising inclusive digital finance using web crawler technology and big data. *Technol. Forecast. Soc. Chang.* **2023**, *188*, 122262. [CrossRef]
47. Ozili, P.K. Impact of digital finance on financial inclusion and stability. *Borsa Istanb. Rev.* **2018**, *18*, 329–340. [CrossRef]
48. Lu, L.R. Promoting SME Finance in the Context of the Fintech Revolution: A Case Study of the UK's Practice and Regulation. *Bank. Financ. Law Rev.* **2018**, *33*, 317–343.
49. Pierrakis, Y.; Collins, L. Crowdfunding: A new innovative model of providing funding to projects and businesses. *SSRN Electron. J.* **2013**, 2395226. [CrossRef]
50. Kong, T.; Sun, R.J.; Sun, G.L.; Song, Y.T. Effects of Digital Finance on Green Innovation considering Information Asymmetry: An Empirical Study Based on Chinese Listed Firms. *Emerg. Mark. Financ. Trade* **2022**, *58*, 4399–4411. [CrossRef]
51. Lin, M.; Prabhala, N.R.; Viswanathan, S. Judging borrowers by the company they keep: Friendship networks and information asymmetry in online peer-to-peer lending. *Manag. Sci.* **2013**, *59*, 17–35. [CrossRef]
52. Demertzis, M.; Merler, S.; Wolf, G.B. Capital Markets Union and the Fintech Opportunity. *J. Financ. Regul.* **2018**, *4*, 157–165. [CrossRef]
53. Itay, G.; Wei, J.; Karolyi, G.A. To FinTech and Beyond. *Rev. Financ. Stud.* **2019**, *32*, 1647–1661.
54. Wang, X.Y.; Wang, Q. Research on the impact of green finance on the upgrading of China's regional industrial structure from the perspective of sustainable development. *Resour. Policy* **2021**, *74*, 102436. [CrossRef]
55. Nambisan, S.; Wright, M.; Feldman, M. The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. *Res. Policy* **2019**, *48*, 103773. [CrossRef]
56. Li, J.; Wu, Y.; Xiao, J.J. The impact of digital finance on household consumption: Evidence from China. *Econ. Model.* **2020**, *86*, 317–326. [CrossRef]
57. Li, F.; Wu, Y.F.; Liu, J.L.; Zhong, S. Does digital inclusive finance promote industrial transformation? New evidence from 115 resource-based cities in China. *PLoS ONE* **2022**, *17*, e0273680. [CrossRef]

58. Kling, G. Measuring financial exclusion of firms. *Financ. Res. Lett.* **2021**, *39*, 101568. [CrossRef]
59. Shi, Y.; Gong, L.; Chen, J. The effect of financing on firm innovation: Multiple case studies on chinese manufacturing enterprises. *Emerg. Mark. Financ. Trade* **2019**, *55*, 863–888. [CrossRef]
60. Gomber, P.; Kauffman, R.J.; Parker, C.; Weber, B.W. On the Fintech Revolution: Interpreting the Forces of Innovation, Disruption, and Transformation in Financial Services. *J. Manag. Inf. Syst.* **2018**, *35*, 220–265. [CrossRef]
61. Zhong, K.Y. Does the digital finance revolution validate the environmental Kuznets curve? Empirical Findings from China. *PLoS ONE* **2022**, *17*, e0257498. [CrossRef]
62. Liu, J.M.; Jiang, Y.L.; Gan, S.D.; He, L.; Zhang, Q.F. Can digital finance promote corporate green innovation? *Environ. Sci. Pollut. Res.* **2022**, *29*, 35828–35840. [CrossRef]
63. Xu, X.H. Does green finance promote green innovation? Evidence from China. *Environ. Sci. Pollut. Res.* **2023**, *30*, 27948–27964. [CrossRef]
64. Wang, K.L.; Sun, T.T.; Xu, R.Y.; Miao, Z.; Cheng, Y.H. How does internet development promote urban green innovation efficiency? Evidence from China. *Technol. Forecast. Soc. Chang.* **2022**, *184*, 122017. [CrossRef]
65. Du, M.Y.; Hou, Y.F.; Zhou, Q.J.; Ren, S.Y. Going green in China: How does digital finance affect environmental pollution? Mechanism discussion and empirical test. *Environ. Sci. Pollut. Res.* **2022**, *29*, 89996–90010. [CrossRef]
66. Shen, Y.; Hu, W.X.; Hueng, C.J. Digital Financial Inclusion and Economic Growth: A Cross-country Study. *Procedia Comput. Sci.* **2021**, *187*, 218–223. [CrossRef]
67. Tone, K. A slacks-based measure of efficiency in data envelopment analysis. *Eur. J. Oper. Res.* **2001**, *130*, 498–509. [CrossRef]
68. Oh, D.H. A global Malmquist-Luenberger productivity index. *J. Product. Anal.* **2010**, *34*, 183–197. [CrossRef]
69. Baron, R.M.; Kenny, D.A. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *J. Personal. Soc. Psychol.* **1986**, *51*, 1173–1182. [CrossRef] [PubMed]
70. Ran, Q.Y.; Yang, X.D.; Yan, H.C.; Xu, Y.; Cao, J.H. Natural resource consumption and industrial green transformation: Does the digital economy matter? *Resour. Policy* **2023**, *81*, 103396. [CrossRef]
71. Xiao, Y.; Lu, L.W. Measurement of industrial green transformation efficiency in resource-based cities—Based on 108 resource-based cities's panel data. *Financ. Econ.* **2019**, *9*, 86–98.
72. Guo, F.; Wang, J.Y.; Wang, F.; Kong, T.; Zhang, X.; Cheng, Z.Y. Measuring China's digital financial inclusion: Index compilation and spatial characteristics. *China Econ. Q.* **2020**, *19*, 1401–1418.
73. Zhao, J.H.; He, G.H. Research on the impact of digital finance on the green development of Chinese cities. *Discrete Dyn. Nat. Soc.* **2022**, *11*, 3813474. [CrossRef]
74. Copeland, B.R.; Taylor, M.C. North-South Trade and the Environment. *Q. J. Econ.* **1994**, *109*, 755–787. [CrossRef]
75. Liu, Y.; Xiong, R.C.; Lv, S.G.; Gao, D. The Impact of Digital Finance on Green Total Factor Energy Efficiency: Evidence at China's City Level. *Energies* **2022**, *15*, 5455. [CrossRef]
76. Chen, W.J.; Mei, F.Q. Green Transformation Efficiency of Industries in China's Resource-Based Cities: Its Spatiotemporal Evolution and Driving Factors. *Ecol. Econ.* **2022**, *38*, 78–87. (In Chinese)
77. Jiang, X.X.; Wang, X.; Ren, J.; Xie, Z.M. The Nexus between Digital Finance and Economic Development: Evidence from China. *Sustainability* **2021**, *13*, 7289. [CrossRef]
78. Abdo, A.B.; Li, B.; Zhang, X.D.; Lu, J.; Rasheed, A. Influence of FDI on environmental pollution in selected arab countries: A spatial econometric analysis perspective. *Environ. Sci. Pollut. Res.* **2020**, *27*, 28222–28246. [CrossRef] [PubMed]
79. Xie, X.L.; Shen, Y.; Zhang, H.X.; Guo, F.J. Can digital finance promote entrepreneurship? Evidence from China. *China Econ. Q.* **2018**, *7*, 1557–1580.
80. Elhorst, J.P. *Spatial Econometrics: From Cross-Sectional Data to Spatial Panels*; Springer: Heidelberg, Germany, 2014; pp. 37–67.
81. Lesage, J.P.; Pace, R.K. *Introduction to Spatial Econometrics*, 1st ed.; CRC Press: New York, NY, USA, 2009.

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