

Article

Can Green Finance Be a Regulator of “Water–Energy–Food” Synergy? Evidence from the Yangtze River Delta

Yuchao Wang

Business School, Hohai University, Nanjing 211100, China; 211313020002@hhu.edu.cn; Tel.: +86-182-6262-6923

Abstract: The synergistic relationship between water, energy, and food faces increasing challenges. Green finance as a policy tool promotes high-quality and efficient development of water, energy, and food subsystems. However, whether it can improve the synergistic relationship of “water–energy–food” (WEF) still needs to be studied. Using the panel data of 38 prefecture-level cities in the Yangtze River Delta (YRD) from 2013 to 2021, and network DEA and panel regression models, we study the impact of green finance on the level of synergy of “water–energy–food”. The results of the study show that green finance can promote the synergy level of “water–energy–food” in the Yangtze River Delta city cluster, which was first inhibited and then promoted from 2013 to 2021. The impacts of green finance on the efficiency of the three subsystems are also characterized by a “U” shape. However, linear impacts show differences, with green finance improving the efficiency of the water subsystem but not the energy and food subsystems. The implementation of China’s national strategies empowers green finance. The digital strategy, the “dual carbon” strategy, and the new urbanization strategy have increased the effectiveness of green finance in contributing to the level of water–energy–food synergy. Regional heterogeneity analysis shows that the promotion effect of green finance mainly exists in non-resource-based cities, non-main grain-producing areas, and non-cities along the South-to-North water diversion route and large cities. Finally, this paper puts forward relevant policy recommendations.

Keywords: green finance; water, energy, and food nexus; carbon emissions; network DEA



Citation: Wang, Y. Can Green Finance Be a Regulator of “Water–Energy–Food” Synergy? Evidence from the Yangtze River Delta. *Sustainability* **2024**, *16*, 4931. <https://doi.org/10.3390/su16124931>

Academic Editors: Elena Maria Otazo Sánchez and Ramón Razo Zárate

Received: 30 April 2024

Revised: 6 June 2024

Accepted: 6 June 2024

Published: 8 June 2024



Copyright: © 2024 by the author. 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

The United Nations included “Clean water and sanitation”, “Affordable and clean energy”, and “Zero hunger” among the sustainable development goals, with the intention of drawing the world’s attention to water, energy, and food management. Water, energy, and food (WEF), as important basic resources for the development of human civilization, are not only related to the sustainable development of cities and regions but also to the basic survival of human beings [1]. However, the Sustainable Development Goals Report 2023: Special Edition shows that globally, 2.2 billion people still face water insecurity, 2.4 billion face food insecurity, and 675 million people lack access to electricity [2]. Human well-being will be further challenged as the global population increases, extreme weather becomes more frequent, and geopolitical conflicts intensify [3]. In response, the Chinese Government has put forward the concept of high-quality development, which calls for a change in the mode of economic development and the implementation of a green and coordinated development approach. Highly synergistic development of the WEF system will be realized by solving the problem of rough development of the water, energy, and food industry chain and the supply chain, and by promoting the high-quality and high-efficiency development of a single subsystem. Green finance provides a new tool for managing the WEF nexus by driving the transition to high-quality economic development in line with the concept of sustainability.

Because of the high correlation of production, water, energy, and food form a naturally tightly nested system around human society [4]. The smooth and coordinated supply and

exchange of elements between subsystems is a matter of urban safety and sustainable development. Therefore, after the concept of the WEF nexus was proposed at the 2011 Bonn Conference, scholars have extensively studied the WEF nexus from different perspectives. Firstly, while emphasizing the triple relationship, the conflict between water, energy, and food subsystems must not be ignored. On the one hand, none of the subsystems of water, energy, and food can be in a state of resource scarcity, and there is a need to realize synergistic development among the three. Disorders or inefficiencies in any of the subsystems will be superimposed on other subsystems, thus causing serious impacts on regional economic and social development (e.g., energy shortages will affect water treatment, and water scarcity will affect irrigated agriculture and power plant cooling) [5]. On the other hand, the three are in competition with each other. For example, the expansion of the energy industry will crowd out agricultural water use, which will be exacerbated with the development of non-traditional energy sources such as shale gas [6]. Scholars around the world have measured and analyzed WEF synergy, vulnerability, and relatedness in different regions using coupled coordination models, system dynamics, network models, and other methods [7]. This study has found that the level of WEF synergy worldwide shows obvious regional differences, especially in some developing countries where the level of WEF synergy even shows a downward trend [8]. Even in regions where the level of WEF synergy has increased, there are still problems such as the backwardness of individual subsystems and greater volatility of the overall level of synergy [9]. Therefore, there is a need to adopt tools or approaches that follow the principles of sustainability in order to increase the resilience of economic development to shocks of adverse impacts.

The practice of green finance began in the United States in the 1980s with the Superfund Act, where stakeholders (banks, etc.) may have potential obligations for environmental governance. The role of green finance for WEF and sustainable economic development is becoming increasingly important due to continued financial support for water resource management, new energy development, and green agriculture [10,11]. Green finance promotes the development and synergy of resource-based industries by alleviating financial constraints in order to support activities such as technological innovation and equipment upgrading [11,12]. However, in terms of green governance of the economy, green finance is still flawed and brings about a governance paradox. First, green finance faces the dilemma of project choice. Due to the relatively short development time, the regional development of green finance is unbalanced [13] and there are natural imbalances in the distribution of water, energy, and food [3]. This makes it difficult to synchronize scarce financial resources to support multiple resource subsystems in the same region. Second, the impact of green finance on different subsystems may be different [14]. However, the focus of green finance is centered on the energy subsystem [15], which may thus exacerbate the imbalance between the water, energy, and food subsystems. China has made efforts in this regard, with regulators issuing policies such as the Green Finance Guidelines for the Banking and Insurance Industry to guide the development of green finance. For many more developing countries, however, the lack of financing for sustainable development is a serious impediment to the development of WEF. In this context, it is particularly important to systematically study the impact of green finance on WEF synergy.

The above review of the current state of existing research reveals that there is an abundance of independent research on WEF synergy and green finance. However, there are still areas for further enrichment in current research. Firstly, technological advancement and other factors have been recognized as effective means to increase the level of WEF synergy. However, these initiatives require sustained investment. Financing in the resource sector has become more difficult as a result of increasing fiscal pressures on the government sector due to climate change [16]. Therefore, researchers realize the role of green finance in WEF synergy [17]. However, there are obvious gaps in current research. The main discussion stays at the theoretical level, or only addresses the relationship between a single subsystem and green finance, without linking the WEF as a whole to green finance. At the same time, the shortcomings exposed by green finance also make its effectiveness

questionable [13]. Therefore, the question of whether green finance can contribute to the efficient development of the water, energy and food subsystems and further enhance the synergies among the three has become a pressing one to be answered.

Secondly, high-quality development places greater demands on the production and synergy of the WEF [18]. Therefore, the WEF relationship needs to be revisited by replacing scale synergy with efficiency synergy. In addition, carbon emissions have been included in the WEF nexus relationships in numerous studies due to their direct relevance to the climate environment. These studies analyze the environmental adaptation of WEF synergy by treating carbon as a stand-alone system on the same level as water, energy, and food [19]. In reality, however, a large percentage of carbon comes directly from the production processes of the resource system. Sun et al. did not consider the impact of carbon emissions when they measured WEF synergy efficiency from flow relationships within the system [4]. Therefore, carbon reduction performance needs to be measured from within the WEF system to reflect the sustainability of the WEF system as well as to clarify the effectiveness of green finance.

Third, policies within the system, such as water and energy policies, directly specify the development standards of the resource sector and have an impact on WEF synergy, which has been emphasized by researchers [20]. However, a number of broader policies and their impacts have been overlooked which are not directly directed at the WEF system but have a subtle influence on it. For example, the Chinese government has put forward a digital strategy, a “dual carbon” strategy, and a new urbanization strategy, the connotations of which coincide with the concept of sustainable development, to promote high-quality development of China’s economy. These strategies not only provide new opportunities for resource management and coordination but also help traditional finance break through bottlenecks [21,22]. Therefore, there is a need to further analyze how the impact of green finance on the WEF synergy will change from these strategic perspectives.

Fourth, there is a consensus on the serious impact of natural endowments on WEF synergy. However, there are two opposing views of the consequences of this impact. One view is that a shortage of a particular resource in a region could cause a “barrel effect” that would undermine the synergy of WEF as a whole. In non-resource-producing areas, not only is the security of scarce resources threatened but it also adversely affects WEF synergy [23]. The other view is that the more abundant a region’s resources are, the less efficiently they are utilized and the less synergistic WEF is, resulting in a “resource curse” [24]. Therefore, if green finance can improve WEF synergy, whether it can do so by filling in the gaps in the barrel, or by breaking the “resource curse”, or both, needs to be further explored.

In order to fill the abovementioned research gaps, this paper attempts to explore the following aspects while proposing some innovations: (1) It places green finance and water–energy–food under the framework of sustainable development, not only discussing the impact of green finance on the overall system but also analyzing in detail how green finance affects each subsystem to ultimately realize the synergistic governance of WEF, which would offer a solution to the controversial issue of the effectiveness of green finance. (2) Few scholars have attempted to conduct WEF-related research from the perspective of policy mix of multi-dimensional national strategies; this paper includes the digital strategy, the “dual carbon” strategy, and the new urbanization strategy into the scope of the study, analyzes the impact of the policy mix of multi-dimensional national strategies on the synergistic governance of WEF in the Yangtze River Delta region, and provides references to the response of local governments to the national strategies and the optimization of the policy tool mix. (3) This paper conducts a heterogeneity analysis based on the abundance of water, energy, and food, as well as the size of the city, to explore how green finance can make up for the “barrel shortboard” of regional resources to achieve synergistic governance of WEF and to provide theoretical support for the use of green policy tools by the local government to optimize the market-based allocation system of resources and environmental factors.

The remaining sections of the paper are organized as follows: Section 2 presents the research hypotheses of this paper while reviewing previous literature and theories; Section 3

introduces the research sample, the empirical model used, and the selection of relevant variables; Section 4 focuses on the presentation and interpretation of the empirical results; Section 5 is the summary and outlook summarizing the conclusions of this paper while putting forward corresponding policy recommendations and pointing out the research deficiencies of this paper and the space for future research.

2. Theoretical Analysis and Research Assumptions

2.1. Literature Review

The study of WEF is centered around two parts: the synergistic internal relationship of the WEF system, and the feedback relationship between the WEF system and the outside world. The internal interrelationships of WEF mainly concern the correlation and synergy among the subsystems of WEF and realize the sustainable development of WEF through the optimization and adjustment of the internal resource structure of the system through linear planning, system dynamics, and other methods [3]. As the WEF nexus research deepens, factors such as land, soil, carbon emissions, and weather are considered in nexus relationships, and thus the integrated management of the WEF is becoming more complex [25]. Researchers have conducted studies in different areas such as resource-rich, resource-poor, urban, rural, and cross-border areas [22,26]. It was found that despite the different natural conditions, all these regions exposed certain problems of synergistic resource management. The development of digital technology provides a good tool for managing WEF synergy. Liu et al. provide an optimization scheme that can improve water use, energy efficiency, and food output through system dynamics simulation and machine learning approach [22]. The study of the relationship between the WEF system and external feedback, on the other hand, directs the research perspective toward how external factors affect the WEF synergy. These include the economic level, industrial structure, technological level, population density, climatic conditions, etc. [27,28].

The researchers found that green finance can improve environmental conditions and achieve high-quality development while promoting economic growth, and emphasized the role that green finance plays in resource efficiency. Green finance improves water use efficiency [29], energy efficiency [12], and agricultural productivity [21], and reduces carbon emissions as well as other environmental issues arising from the resource production process (often affecting other resources) [11]. Nepal et al. further found that, by promoting green technological advances, green finance improves the resilience of the resource system [30]. In addition, green finance has also been used to realize the efficient use of resources by adjusting the industrial structure, mainly by reducing financial support for inefficient and highly polluting enterprises and increasing support for high-tech enterprises [30,31]. The impact of green finance has also a clear spatial spillover effect, not only promoting the local area but also influencing other areas [32]. Despite the outstanding advantages of green finance, its development still faces a number of challenges. Sarpong et al. found that China's green financial development efficiency had experienced a process of rising and then falling, and showed obvious regional differences, with the highest in the east, the second in the center, and the lowest in the west [33]. Jiang et al. also found that the regional gap in China's green finance development continues to widen, with Jiangsu, Zhejiang, Shanghai, and Beijing having higher attractiveness in the green finance linkage network [34]. The relationship between green finance and "greenwashing" behavior is debated. While some studies have argued that green finance can reduce "greenwashing", others have found that financial institutions are contributing to "greenwashing" behavior, which deviates from the original purpose of green finance [35,36]. Therefore, green finance still needs to be developed and improved, changing the development goal from quantity-oriented to quality-oriented, promoting financial product innovation, and strengthening supervision and management.

2.2. The Impact of Green Finance on the WEF Synergy

Public goods and externality theories related to market failures [37], resource dependence theory related to firm behavior [38], and neoclassical growth theory [39] related to economic growth explain why green finance improves WEF synergy [40]. Meanwhile, the EKC hypothesis implicitly suggests that the impact of green finance on WEF synergy may be nonlinear [41]. Water, energy, and food are not public goods in the full sense of the word, but the natural environment, which is inextricably linked to them, is an important public good. The benefits of environmental management enjoyed by producers may not be sufficient to cover the costs incurred; therefore, producers have little incentive to take the initiative to manage the environment. Taking the environmental problems of water resources as an example, the lack of necessary treatment links in the production of energy and food will lead to serious pollution of surface waters and groundwater. Treatment equipment for energy-consuming enterprises is expensive, while small farmers are not environmentally conscious and it is difficult for the government to regulate their actions effectively. The production of water, energy, and food also inevitably generates carbon emissions, and the resulting environmental problems backfire on WEF. Therefore, there is a need for low-cost and high-value green finance to be invested in relevant areas to support enterprises in purchasing wastewater treatment equipment and promoting green-scale production in agriculture.

When enterprises are faced with financial constraints, they are reluctant to make changes [42]. As green finance has a certain policy purpose, the Government, through formulating guiding policies and conducting green performance assessments on financial institutions, encourages financial institutions to invest more funds in green enterprises, thus alleviating the problem of externalities [43]. The additional sources of financing give enterprises the incentive and capital to adjust their production methods. In addition to this, while accessing funds, enterprises must make more detailed environmental disclosures [44]. Therefore, whether it is to obtain bank funds or to make a good impression on other stakeholders, enterprises will adopt resource-saving programs such as energy and water conservation and low pollution in order to meet the requirements of sustainable development. Governments cannot change their mode of economic development and enterprises cannot change their mode of production without the support of technological elements. As mentioned in the neoclassical growth theory, the most important factor in promoting the sustainable development of a green economy is technology. Green finance promotes the research and development and the use of green technologies through cost control, financing constraints, risk-sharing mechanisms, and other means [39]. The growth of green technologies leads to an efficient use of resources.

Therefore, as shown in Figure 1, green finance, driven by policy orientation, provides a green channel for improving the efficiency of resource utilization and the level of WEF synergy. Green finance eases the financial constraints on infrastructure construction [45], resource technology innovation [30], and system structure adjustment [29,31]. This not only promotes the efficiency of each subsystem but also drives the development of other subsystems [11]. Water bonds fund water infrastructure and increase agricultural productivity [45]. Green finance supports the development of sustainable energy and irrigated agriculture while reducing the consumption of water by both. Through renewable technologies and advanced production methods, green finance supports agriculture to replace fossil fuels with new energy and reduce the use of fertilizers and pesticides [46]. This reduces agricultural pollution of water and dependence on traditional energy sources, and reduces carbon emissions [13]. In conclusion, green finance influences the direction of economic development, adjusts the allocation of financial resources among industries, and enhances the WEF synergy level [17].

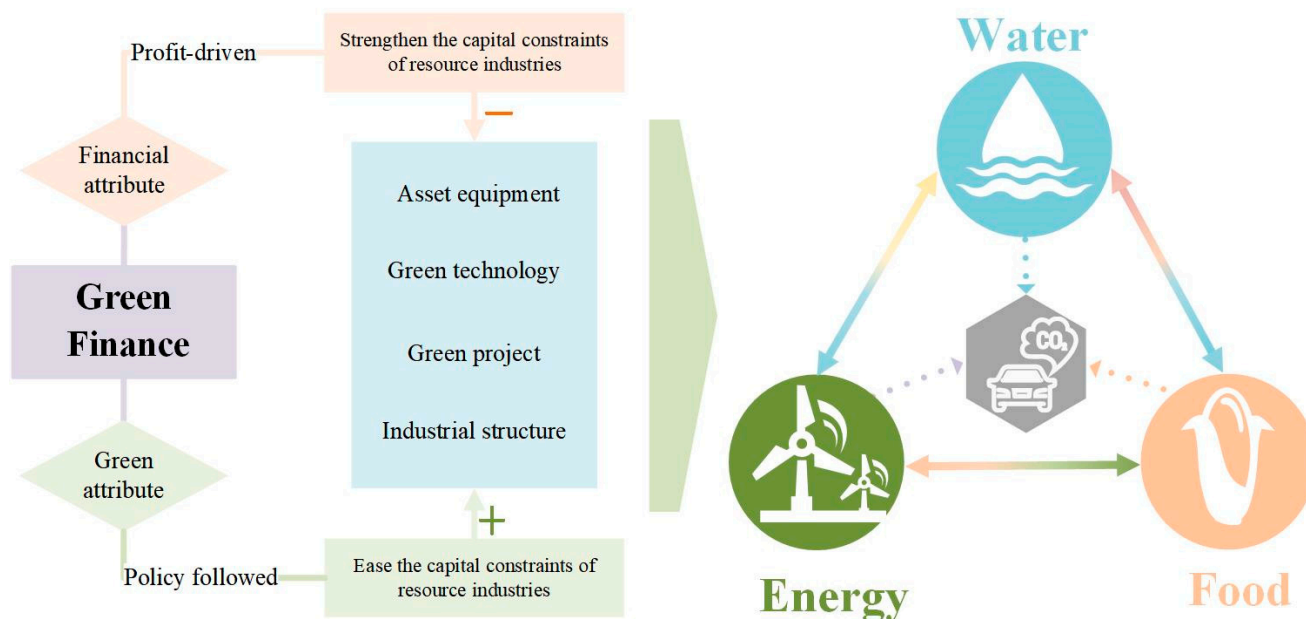


Figure 1. Mechanism map of green finance influencing WEF synergy.

At the same time, under the profit-driven orientation, green finance may also be green in name only. Green finance has the attributes of “green” and “finance” with different objectives [47]. Therefore, green finance may not provide significant positive incentives for resource-based industries in the short term. The “green” attribute requires that the financial sector should serve the green development of the economy. The “financial” attribute makes financial institutions avoid resource-based industries with high investment and long return cycles. Therefore, at the early stage of the development of green finance, the concept of green development of financial institutions has not yet been fully formed. The resource industry still faces high financing constraints [48]. Currently, green finance, which is limited in scale and fragmented, also struggles to meet diversified development needs [47]. In addition, the EKC hypothesis suggests that although green finance provides financing to high-resource-consuming firms, for enterprises, this adjustment will affect normal production and operation in the short term, thus reducing the productivity of resources [41]. Moreover, the relationship between green finance and carbon emissions tends to be characterized by short-term inhibition and long-term inhibition. Furthermore, the reduction of green finance–industry investment–carbon emission is a gradual transmission process, thus delaying the effectiveness of the transmission mechanism mentioned earlier [49].

Based on this, hypotheses H1–H2 are proposed in this paper:

H1. *Green finance can improve the level of WEF synergy.*

H2. *Green finance can have a non-linear impact on the level of WEF synergy.*

2.3. Mechanisms for Green Finance to Influence WEF Synergy under Strategic Scenarios

2.3.1. Moderating Role of Digital Strategy

The digital strategy transforms industrial resources into digital information through the process of industrial digitization. This improves the management of factor resources, such as talent, capital, and technology, and realizes economies of scale. The development of digital China has enabled areas such as agriculture and the water cycle to leverage advanced digital technologies to enhance the management of resources. This also promotes the greening of enterprises and improves their environmental performance [50].

The green financial system is still in its infancy, the development of green financial products is still insufficient, and the green assessment mechanism is still imperfect. The digital strategy guides the digital transformation of the financial sector, influencing how

green finance develops and what it ultimately achieves [51]. The introduction of digital technology provides endogenous impetus to green finance and promotes its growth in scale. By reducing information asymmetry, digital technology helps green finance to select industries and enterprises that meet the requirements of a green economy as well as those with a high level of creditworthiness [52]. Digital finance uses new technology to control the use of funds and ensure that they are used for specific projects. Thus, a digital strategy can strengthen the effect of green finance in enhancing WEF synergy.

2.3.2. Moderating Role of “Dual Carbon” Strategy

Initially focused on the energy sector, the “dual carbon” strategy has evolved to include areas such as water conservation and low-carbon food production [53]. The “dual carbon” strategy can urge enterprises to establish a sense of sustainable development and adopt energy-saving and water-saving production methods. Appropriate environmental management policies can also promote technological progress in industries such as energy and food [54]. Therefore, the “dual carbon” strategy can help improve the efficiency of water, energy, and other resources.

Green finance still faces the problem of low resource allocation efficiency. The lag of economic benefits makes financial institutions less motivated to implement green finance. In order to realize the goal of “dual carbon”, the government has introduced environmental policies. This also provides guidelines for the green development of the financial sector and improves the quality of green financial services [43]. Market-based environmental regulatory policies can guide financial institutions to develop green finance through financial and policy support. Command-based environmental regulation policies prompt financial institutions to strengthen the management of green funds by strengthening regulation and standardizing industrial development; this synergistic effect of environmental regulation is more prominent in green credit. Therefore, the “dual carbon” strategy can strengthen the effect of green finance to enhance the level of WEF synergy.

2.3.3. Threshold Effect of New Urbanization Strategy

The new urbanization strategy proposed by China, with sustainable development as its connotation, advocates industrial upgrading, low-carbon development, and intensive resource management. These initiatives and actions will change the structure and intensity of resource consumption. A study has shown that increased levels of urbanization improve the efficiency of water use [55]. Urbanization can also promote land transfer and improve the efficiency of agricultural production. With the improvement of urbanization levels and quality, its scale, factor agglomeration, and technology effects are prominent. This will enhance the utilization of resources such as water and energy and ease the conflict of demand for resources.

New urbanization makes green projects the focus of construction, providing more investment opportunities for green finance. At the same time, the impact of different stages of urbanization on resource stability is variable. Blind expansion at the primary stage of urbanization is detrimental to the production and utilization of resources such as energy and food [56]. With the shift from traditional urbanization to new urbanization, this adverse impact will also be attenuated or turned into a facilitating relationship [57]. Therefore, at the primary stage of urbanization, the promotion effect of green finance on WEF synergy is not obvious. However, as the level of urbanization rises, the role of green finance in promoting WEF synergy gradually becomes apparent.

Based on the above analysis, the following hypotheses are proposed in this paper:

H3. *The digital strategy and the “dual carbon” strategy will enhance the contribution of green finance to the level of WEF synergy.*

H4. *The effect of green finance on the level of WEF synergy varies with the advancement of the new urbanization strategy.*

3. Materials and Methods

3.1. Samples

The Yangtze River Delta (YRD) region is one of the most densely populated, economically active, and industrially diverse regions in China. There are large gaps in the supply of water, energy, and food for living and production. While environmental problems are improving, water pollution and air pollution from agriculture, industry, and life still exist. Therefore, taking the YRD city cluster (Taizhou, Jinhua, and Zhoushan were not included in this paper due to missing data on these three cities) as a research target can effectively analyze the synergistic relationship of WEF and the impact of green finance on it. It can also summarize the experience of a typical region as an example, which can provide a reference for better exerting the benefits of green finance. Since the green credit data of banks mainly come from their disclosed social responsibility or environmental, social, and governance (ESG) reports and the development of green finance in China is relatively short, relevant data have been disclosed mainly since 2013. Therefore, the time span of the data in this paper is 2013–2021. We collected data to obtain panel data for 38 YRD cities from 2013–2021, resulting in 342 samples. The list of selected cities is contained in Appendix A.

3.2. Model Setting

3.2.1. Network DEA Model

The products of the three subsystems of water, energy, and food flow into each other, and the efficiency gains of individual subsystems are constrained by the other subsystems. For example, the water subsystem produces usable water that will supply energy and food production, respectively. The use of agricultural machinery and fertilizers also consumes energy products. Network DEA divides the production of a unit into different segments, using some outputs of the previous segment as inputs for the next segment. The advantage is that it shows the product flow relationship between the subsystems. The model not only obtains integrated efficiency but also measures the water subsystem efficiency (WE), energy subsystem efficiency (EE), and food subsystem efficiency (FE) separately. Therefore, in this paper, the network DEA model is chosen to measure efficiency [4]. As shown in Figure 2, in calculating the efficiency of the energy subsystem, the water subsystem output industrial water use is used as an input in addition to the normal indicators. In calculating the efficiency of the food subsystem, the water subsystem's agricultural water use and the energy subsystem's agricultural power consumption are used as inputs. The detailed formulas can be found in Appendix B. This paper specifically uses MaxDEA software (Ultra 8) to calculate the WEF efficiency.

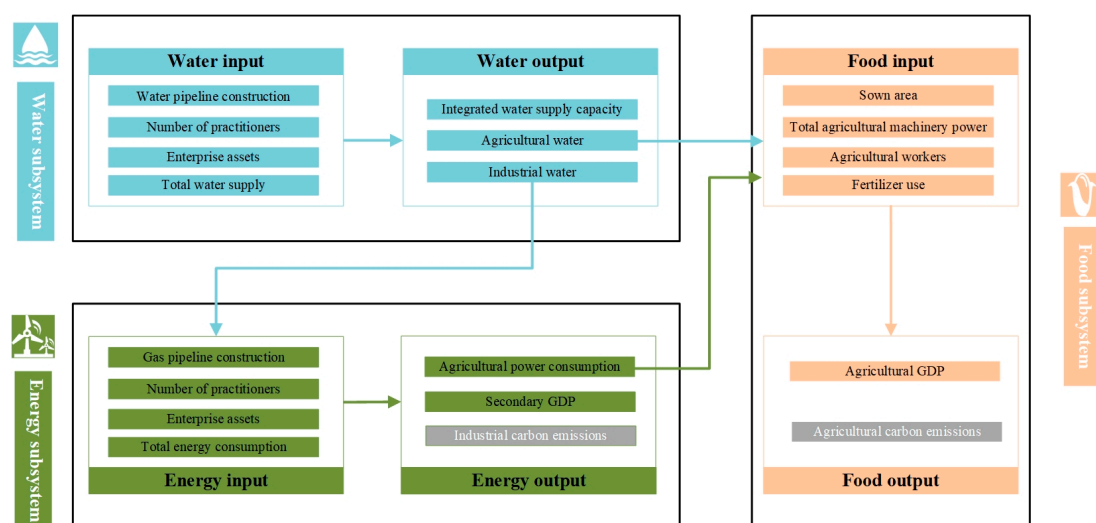


Figure 2. Decomposition of input–output relationship for WEF network efficiency.

We comprehensively considered the basic WEF framework and constructed the WEF input–output indicator system applied to network DEA. Specifically, we selected input indicators from the perspective of resources, capital, and labor, and output indicators from the perspective of economic performance and environmental performance. WEF input–output indicators and inter-system product flow relationships are shown in Figure 2.

3.2.2. Coupled Coordination Degree Model

To further measure the level of synergy among the three subsystems of water, energy, and food, this paper adopts a coupled coordination degree model. Under the notion of sustainable and high-quality development, the concept of high-efficiency development replaces the concept of scale development, which puts forward higher-level requirements for WEF synergy. That is, the synergy of the three should be based on the high efficiency of resource production and utilization. Therefore, in this paper, the water subsystem efficiency (WE), the energy subsystem efficiency (EE), and the food subsystem efficiency (FE) are used as evaluation indices for the three subsystems. They are substituted into the coupled coordination degree model to measure the WEF synergy level.

$$C = 3 \times \frac{(WE \times EE \times FE)^{1/3}}{WE + EE + FE} \quad (1)$$

$$T = \frac{1}{3} \times (WE + EE + FE) \quad (2)$$

$$DWEF = \sqrt{C \times T} \quad (3)$$

In Equation (1), C is the coupling degree between the systems, which is determined by the development efficiency of each system. In Equation (2), T is the coordination level. In Equation (3), $DWEF$ is the coupling coordination degree, which represents the synergy level of WEF. Its value range is $[0, 1]$, and the larger value indicates a higher level of synergy.

3.2.3. Fixed Panel Model

In order to verify the effect of green finance on the level of WEF synergy, this paper establishes a panel regression model based on fixed effects:

$$DEWF_{it} = \alpha_0 + \alpha_1 gf_{it} + \beta_1 Control_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (4)$$

Equation (4) is set up to test hypothesis H1, where i denotes the city and t denotes the year. $DEWF_{it}$ is an explanatory variable indicating the level of WEF synergy of city i in the year t ; gf_{it} is a core explanatory variable indicating the level of green finance development of city i in year t ; $Control_{it}$ is a set of control variables; ν_t indicates time fixed effect; μ_i indicates individual fixed effect; and ε_{it} is an error term.

$$DEWF_{it} = \alpha_0 + \alpha_1 gf_{it} + \alpha_2 gf_{it}^2 + \beta_1 Control_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (5)$$

Equation (5) is set up to test hypothesis H2. gf_{it}^2 is the quadratic term of the core explanatory variables.

3.2.4. Simultaneous Equation Model

The water, energy, and food subsystems both support and compete with each other. On the one hand, as mentioned earlier, the subsystems provide each other with means of production. On the other hand, the development of one subsystem may be detrimental to the other subsystems. For example, the increased use of pesticides has increased food production while leaving water resources heavily polluted. Unreasonable hydropower development has increased the pressure on the water supply of rivers. It follows that changes in one subsystem will quickly feedback to other subsystems. There are strong interactions between the three subsystems; therefore, when analyzing the impact of green finance on

the efficiency of each subsystem, it is necessary to reduce the impact of interrelationships between subsystems on the regression results. For this purpose, this paper constructs a simultaneous equation model.

$$WE_{it} = \beta_0 + \beta_1 gfit + \beta_2 L.EE_{it} + \beta_3 L.FE_{it} + \beta_4 cc_{it} + \beta_5 rgdp_{it} + \beta_6 inno_{it} + \beta_7 wt_{it} \quad (6)$$

$$WE_{it} = \beta_0 + \beta_1 gfit + \beta_2 gfit^2 + \beta_2 L.EE_{it} + \beta_3 L.FE_{it} + \beta_4 cc_{it} + \beta_5 rgdp_{it} + \beta_6 inno_{it} + \beta_7 wt_{it} \quad (7)$$

$$EE_{it} = \theta_0 + \theta_1 gfit + \theta_2 WE_{it} + \theta_3 cc_{it} + \theta_4 rgdp_{it} + \theta_5 inno_{it} + \theta_6 ind_{it} \quad (8)$$

$$EE_{it} = \theta_0 + \theta_1 gfit + \theta_2 gfit^2 + \theta_2 WE_{it} + \theta_3 cc_{it} + \theta_4 rgdp_{it} + \theta_5 inno_{it} + \theta_6 ind_{it} \quad (9)$$

$$FE_{it} = \rho_0 + \rho_1 gfit + \rho_2 WE_{it} + \rho_3 EE_{it} + \rho_4 cc_{it} + \rho_5 rgdp_{it} + \rho_6 inno_{it} + \rho_7 pop_{it} \quad (10)$$

$$FE_{it} = \rho_0 + \rho_1 gfit + \rho_2 gfit^2 + \rho_2 WE_{it} + \rho_3 EE_{it} + \rho_4 cc_{it} + \rho_5 rgdp_{it} + \rho_6 inno_{it} + \rho_7 pop_{it} \quad (11)$$

In Equations (6)–(11), WE , EE , and FE denote water efficiency, energy efficiency, and food efficiency, respectively.

3.2.5. Moderated Effect Model

Equation (12) is set up to test H3, where DR_{it} is the moderating variable, denoting the level of financial digitization (df) and the strength of environmental regulation (er). DR_gfit denotes the interaction term of the core explanatory and moderating variables.

$$DEWF_{it} = \alpha_0 + \alpha_1 gfit + \theta_1 DR_{it} + \theta_2 DR_gfit + \beta_1 Control_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (12)$$

3.2.6. Threshold Effect Model

Equation (13) is set up to test H4, where sh_{it} is a threshold variable indicating the level of new urbanization and λ_i denotes the threshold value of the corresponding variable.

$$DEWF_{it} = \alpha_0 + \eta_1 gfit \times I(sh_{it} \leq \lambda_i) + \eta_2 gfit \times I(sh_{it} > \lambda_i) + \beta_1 Control_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (13)$$

3.3. Variable Selection

The explanatory variable in this paper is the level of WEF synergy (DWEF). It is calculated by the coupled coordination degree model.

The core explanatory variable of this paper is the level of green finance development (gf). Green finance includes a variety of financial products including green credit, green securities, and green funds. However, China's green finance is currently dominated by green credit. By the end of 2021, the balance of green credit reached 15.9 trillion yuan and the balance of green loans for electricity, heat, gas, and water production and supply industry was 4.41 trillion yuan. For the specific measurement method, this paper collected green credit balance data from major 24 listed banks and searched for the number of bank outlets in each prefecture-level city. On this basis, a weighted method was used to calculate the green credit balance of each prefecture-level city [58]. The 24 banks are listed in Appendix C.

Moderating and threshold variables: The moderating variables in this paper are the level of financial digitization (df) and the strength of environmental regulation (er). They serve as proxies for the digital strategy and the “dual carbon” strategy, respectively. The level of financial digitization is expressed as the logarithmic value of the digital inclusive finance index released by the Digital Finance Research Center of Peking University. The strength of the environmental regulation is represented by setting a dummy variable. Taking China's low-carbon pilot cities as a criterion, if city i belongs to the pilot cities, it takes the value of 1; otherwise, it takes the value of 0. The threshold variable in this paper is the level of new urbanization (city), which serves as a proxy variable for the new urbanization strategy. The new urbanization level is expressed as the ratio of the urban resident population to the total resident population.

Control variables: Based on existing studies [27,28], this paper selects population growth (pop), climate change (cc), economic level (rgdp), innovation level (inno), industrial

structure (ind), and sewage treatment (wt) as control variables from social, economic, and environmental levels. On the selection of specific indicators, population growth is expressed as the resident population growth rate. Climate change is represented by processing weather data into standardized annual average temperature absolute values over a 30-year window period. The economic level is expressed as the logarithmic value of per capita gross regional product. The innovation level is expressed as the city innovation index published by the Industrial Development Research Center of Fudan University. The industrial structure is expressed as the ratio of the tertiary industry to GDP. Sewage treatment is expressed as the centralized treatment rate at sewage treatment plants.

3.4. Data Source

The data for the WEF synergy level measurements come from the Statistical Yearbook of Prefecture-Level Cities, the Water Resources Bulletin, and the Energy Statistics Yearbook. The green finance data come from the social responsibility or ESG reports of each bank.

Moderating variables: The level of financial digitization comes from the Digital Finance Research Center of Peking University [59], the list of low-carbon pilot cities from the Circular on National Low Carbon City Pilot Work, and the data for the level of new-type urbanization come from the China Urban Statistical Yearbook. The data for the control variables are mainly from the China Urban Statistical Yearbook, of which the climate data are from the National Meteorological Science Data Center of China, and the data for the level of innovation are from the Industrial Development Research Center of Fudan University [60]. Drawing on relevant literature [61], this paper uses the interpolation method and the moving average method to address some missing data.

4. Results

4.1. Spatial and Temporal Evolution of WEF Synergy Level in YRD Cities

We used ArcGIS (10.8) to map the spatial and temporal variation in the WEF synergy level, as shown in Figure 3. The level of WEF synergy in the YRD region increased from 2013 to 2021. This was due to the introduction of the Yangtze River Delta Integrated Development Plan, which facilitated the cooperation of water, energy, and other resources in the region. Some cross-regional infrastructures were introduced. Although the study regions are different, the level of WEF synergy in the Beijing–Tianjin–Hebei region was also significantly improved after the integrated development of the region in the study by Wang et al. [62]. This suggests that cross-regional synergistic development can help alleviate regional resource constraints. The WEF synergy level rises faster in cities dominated by the eastern coastal region. However, the WEF synergy level in the western region has limited improvement and remains at a medium level.

Subregionally, the level of WEF synergy is relatively high in Jiangsu and Zhejiang Provinces. Jiangsu Province has the South-to-North Water Diversion Project in its territory, and Zhejiang Province is also making great efforts to build water infrastructure. This guarantees the supply of water resources for energy and food subsystems in the region. Jiangsu and Zhejiang Provinces are also vigorously developing new energy industries, adjusting their energy structure, and reducing their reliance on hydropower. Both provinces have high levels of agricultural modernization and high agricultural water use efficiency. The reduction of chemical fertilizer use has reduced energy consumption. As a result, the subsystems of the two regions have achieved benign development and are more coordinated.

The level of WEF synergy is lower in Shanghai and Anhui Province. The process of industrial restructuring in Shanghai has reduced investment in food and other subsystems, while the dense population requires vast resources. The use and consumption of resources are higher than their production and supply. Anhui Province is both a major agricultural producer and under the jurisdiction of some resource-based cities, with serious competition for water between industry and agriculture. The traditional energy industry is in transition due to the carbon reduction strategy, and it is difficult to develop wind

power and photovoltaic industries due to natural conditions and red-line restrictions on arable land. Therefore, the level of synergy between the subsystems in Shanghai and Anhui Province still needs to be improved. The measurement results are consistent with the conclusions of Ding and Deng's study for WEF in Shanghai, but the level of WEF in Anhui Province in their study was higher than that in Jiangsu and Zhejiang Provinces [63]. The possible reason for this is that after taking into account the inter-system flows and efficiency utilization issues, Jiangsu and Zhejiang Provinces have more advanced resource utilization technologies and higher resource coordination capacity, despite the higher total indicators of water resources and grain production in Anhui Province. As a result, the level of WEF synergy in Jiangsu Province and Zhejiang Province exceeds that of Anhui Province.

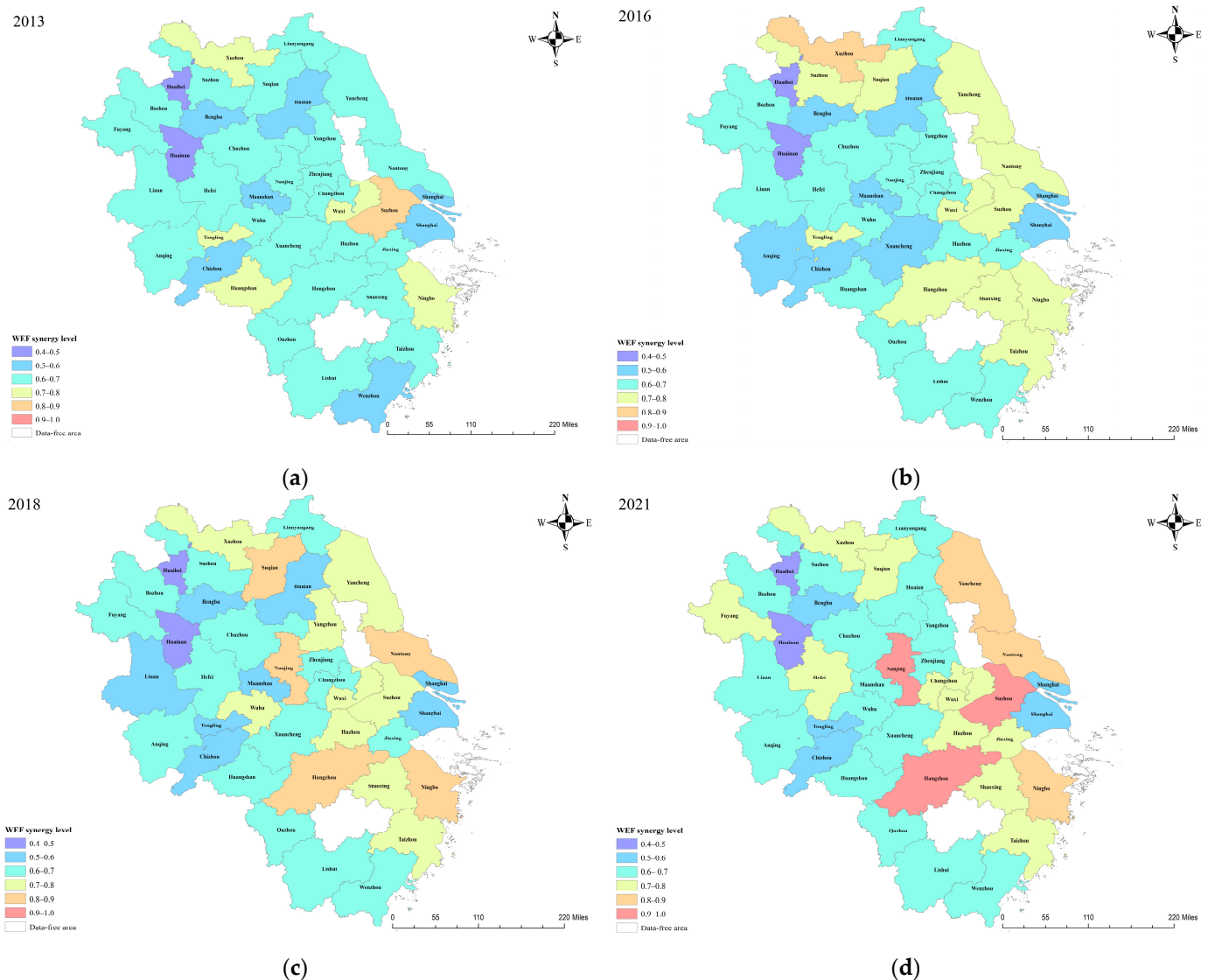


Figure 3. The spatial and temporal evolution of WEF synergy level in YRD cities: (a) the WEF synergy level of each city in 2013; (b) the WEF synergy level of each city in 2016; (c) the WEF synergy level of each city in 2018; (d) the WEF synergy level of each city in 2021.

4.2. Benchmark Regression Results

The results of benchmark regression are shown in Table 1. Column (1) indicates the degree of linear influence of green finance on the level of WEF synergy. Column (2) is the non-linear influence of green finance on the level of WEF synergy. In column (1), the regression coefficient of green finance is positive at a 1% significance level, indicating that the development of green finance does promote the level of WEF synergy. Green

finance expands access to financing for water, energy, and food subsystems. This has provided funds for the construction of infrastructure such as water conservancy, energy, and farmland in the region, and accelerated green technology innovation in related fields. Development plans for water resources and energy in the YRD region often include green finance as a safeguard. Individual resource planning will involve the management of other resources. For example, agricultural planning will control the amount of water used and fertilizers to reduce the amount of use. Thus, green finance can promote WEF synergy.

Table 1. Benchmark regression results.

Variable	(1)	(2)
Gf	0.0848 *** (3.45)	−0.2600 *** (−4.63)
gf_{it}^2		0.0278 *** (6.72)
Pop	0.0014 *** (3.52)	0.0012 *** (3.23)
Cc	−0.0022 (−0.56)	−0.0039 (−1.06)
Rgdp	0.0433 * (1.71)	0.0823 *** (3.39)
Inno	−0.0418 ** (−2.45)	−0.0206 (−1.27)
Ind	−0.4618 *** (−3.95)	−0.1954 * (−1.68)
Wt	0.0018 ** (2.09)	0.0012 (1.51)
Constant	−0.0778 (−0.30)	0.3687 (1.47)
Individual—Time	Y	Y
N	342	342
R ²	0.2257	0.3303

***, **, and * represent significance levels of 1%, 5%, and 10%, respectively; the value in () is the t statistic.

In column (2), the coefficient of the primary term of the green finance development level is significantly negative and the coefficient of the secondary term is significantly positive. This indicates that the impact of green finance on the level of WEF synergy is characterized by a “U” shape of inhibition followed by promotion. This phenomenon is also found in some studies on the relationship between green finance and the single system. For example, Wang et al. argue that green finance is also non-linear for energy structure improvement [64]. In the early stage of green finance practice in China, there are unfavorable factors such as inadequate implementation of credit policies, vague policy details, unclear implementation standards, and lack of environmental information [65]. It is difficult to effectively support multi-system transitions in WEF. With the expansion of the scale of green finance and the enrichment of product varieties, green finance can play an effective role in more aspects. Green finance can take into account the financial needs of different industries and promote the balanced development of the WEF system. Therefore, the influence of green finance on the synergy level of WEF follows a process of first inhibiting and then promoting.

4.3. Further Analysis

Whether green finance has the same impact on the efficiency of different subsystems while supporting overall development needs to be further explored. Therefore, we further examine the impact of green finance on the efficiency of different subsystems for water, energy, and food. The regression results are shown in Table 2.

Table 2. Regression results of green finance impacting WEF subsystems.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	WE		EE		FE	
gf	0.2543 *** (2.63)	−1.1139 *** (−6.00)	−0.4994 *** (−2.63)	−1.7544 *** (−3.26)	−0.3626 * (−1.83)	−1.7947 ** (−2.31)
gf_{it}^2		0.0954 *** (8.42)		0.1136 *** (2.66)		0.1471 ** (2.35)
L.EE	0.0178 (0.50)	−0.1340 *** (−4.20)				
L.FE	0.1459 *** (3.95)	−0.1475 *** (−3.34)				
WE			0.3584 (0.98)	−1.0709 ** (−2.40)	2.2336 *** (4.97)	−1.0205 (−1.36)
EE					0.0590 (0.46)	−0.3874 *** (−2.66)
Constant	1.8610 (1.35)	4.2508 *** (2.70)	−2.2835 * (−1.77)	0.6145 (0.36)	−0.4453 (−0.54)	2.4208 *** (2.94)
Controls	Y	Y	Y	Y	Y	Y
Individual—Time	Y	Y	Y	Y	Y	Y
N	304	304	304	304	304	304

***, **, and * represent significance levels of 1%, 5%, and 10%, respectively; the value in () is the t statistic.

Columns (1), (3), and (5) show the direct linear effects of green finance on the efficiency of water, energy, and food subsystems, respectively. The regression results show that green finance can significantly promote the efficiency of the water subsystem but inhibit the efficiency of the energy subsystem and the food subsystem. A possible reason for this is that, because of “greenwashing”, green funds may not be actually spent on energy improvement projects and therefore not be effective in promoting energy subsystem efficiency. This finding can be explained in part by the study by Zhang [66]. However, the focus is different: the study examines the more administrative attributes of green finance regulation, while the green finance in this paper reflects more market behavior. At the same time, green finance focuses on areas of investment, mainly in electricity, heat, gas, and water production. Less attention has been paid to the agricultural sector, where green finance has shown a failure to improve the efficiency of the food subsystem.

Columns (2), (4), and (6) show the results of the non-linear impact of green finance on the efficiency of water, energy, and food subsystems, respectively. The regression results show that the impact of green finance on the efficiency of each subsystem is also characterized by a significant “U” shape. This indicates that with the development of green finance, its impact on the efficiency of the energy and food subsystems will also change from negative to positive. This is similar to Xu et al.’s study, which found that the effect of green finance on energy efficiency tripled after crossing the threshold [32]. The possible reason for this is that the effect of green finance on the sustainable transformation of the energy subsystem and carbon emission reduction requires a longer time [67]. Li et al. found an inverted “U” shaped relationship between green finance and agricultural productivity, contrary to the findings of this paper [13]. However, the current share of agriculture in green finance investment is very small, and thus an increase in green finance inputs will lead to higher benefits.

4.4. Robustness and Endogeneity Tests

First, the explanatory variable is replaced and the regression model is changed. In this paper, the WEF integrated production efficiency is taken as the newly explained variable. At the same time, considering the data characteristics of the efficiency measurement value, this paper adopts the Tobit model for regression. The regression results are generally consistent with the findings of the benchmark regression. Secondly, this paper uses the two-step system GMM method to further exclude the endogenous influence. In the model,

the development level of green finance with a lag of one stage is taken as the instrumental variable. Adopting the system GMM method needs to first be tested accordingly. The data in this paper can be tested to use the system GMM method. The regression results remain consistent with the benchmark regression. Finally, this paper uses the PSM-DID model for analysis. China announced the list of green finance reform and innovation pilot zones in 2017, and Zhejiang Province is the only province in the YRD region selected. Therefore, this paper takes the promulgation of this policy as an experimental node to verify the impact of green finance policy implementation on WEF synergy. Before conducting the empirical evidence, this paper's propensity score matching method organizes the samples and conducts a parallel trend test. The regression results show that the implementation of green financial policies effectively promotes the level of WEF synergy. Therefore, the theory of the main hypotheses H1 and H2 of this paper is verified. The relevant regression results are detailed in Table 3.

Table 3. Robustness and endogeneity test results.

Variable	(1)	(2)	(3)	(4)	(5)
	xttobit		GMM		DID
gf	0.3578 *** (4.76)	−0.0310 (−0.21)	0.1703 *** (4.00)	−0.4008 *** (−6.92)	
gf_{it}^2		0.0313 *** (3.01)		0.0242 *** (6.50)	
DID					0.0293 ** (2.27)
L.DWEF			0.8030 *** (12.73)	0.2927 *** (9.14)	
Constant	0.2396 (0.36)	0.9249 (1.34)	−0.5419 * (−1.82)	0.5844 * (1.88)	0.9091 ** (2.56)
Controls	Y	Y	Y	Y	Y
Individual—Time	Y	Y	Y	Y	Y
N	342	342	304	304	304
LR test <i>p</i> -value	0.000	0.000			
Log-likelihood value	155.49	159.97			
Wald test	115.44 ***	128.72 ***			
AR(1)			0.042	0.020	
AR(2)			0.175	0.346	
Sargan			0.914	0.473	
Hansen			0.876	0.757	

***, **, and * represent significance levels of 1%, 5%, and 10%, respectively; the value in () is the *t* statistic.

4.5. Mechanism Analysis of National Strategies in Green Finance Influencing WEF Synergy

4.5.1. Moderating Effect Analysis

Table 4 shows the moderating effect results. Column (1) shows the result of the moderating effect of financial digitization. The coefficient of the interaction term between green finance and financial digitization is 0.1051 and significantly positive. It indicates that the digitalization of finance can play a complementary role to green finance. The digitalization of finance provides a more efficient and safer operating mechanism for green finance. As a result, the level of WEF synergy can be improved. This finding is supported by the research by Hemanand et al. [68]. Artificial intelligence and fintech can improve the ability of financial institutions to gather information. This information can fully disclose the sustainability information of alternative projects. Therefore, through digital transformation, the financial industry is able to screen order resource projects that meet the needs of WEF synergistic development. Instead, it can avoid investing funds in industries that are highly polluting and energy-intensive.

Table 4. Moderating effect results.

Variable	(1)	(2)
Gf	−0.0083 (−0.15)	0.0585 ** (2.34)
Df	0.0712 (0.63)	
gf_df	0.1051 *** (6.50)	
Er		−0.0150 (−1.09)
df_er		0.0483 *** (4.38)
Constant	−0.6752 * (−1.96)	−0.1868 (−0.74)
Controls	Y	Y
Individual—Time	Y	Y
N	342	342
R ²	0.3363	0.2832

***, **, and * represent significance levels of 1%, 5%, and 10%, respectively; the value in () is the t statistic.

Column (2) shows the result of the moderating effect of environmental regulation. The coefficient of the interaction term between green finance and environmental regulation is positive. It indicates that the combination of market-oriented green finance mechanisms and administrative policy guidelines can clarify the green development objectives of financial institutions. In Deng and Zhang's study, it was found that green finance and environmental regulation can contribute to sustainable development separately, but the impacts of the interaction between green finance and environmental regulation were not taken into account [37]. The study by Chang et al. found that environmental regulations can moderate the relationship between green finance and enterprise green innovation positively [43]. Green technology innovation is key to WEF synergy. As enterprises carry out green innovation, resources are also efficiently utilized. Subject to the Government's efforts to strengthen environmental management, financial institutions will take into account the impact of potential environmental risks. They will be more inclined to select projects that conserve energy and water, thereby improving the efficiency of resource utilization and the relevance of green finance.

4.5.2. Threshold Effect Analysis

The threshold value of new-type urbanization is 82.90, and it passes the single threshold effect test at the significance level of 1%. Table 5 presents the results of the threshold effect. Specifically, when the urbanization level is lower than the threshold value of 82.90, the regression coefficient of green finance to the WEF synergy level is 0.0437. When the urbanization level is higher than the threshold value of 82.90, the regression coefficient of green finance on the WEF synergy level is 0.0726, which is statistically significant at 1%. The estimated coefficient value and significance level are increased. This indicates that when the urbanization level of a region is higher or meets the requirements of new urbanization [32], the effect of green finance in promoting the WEF synergy level is more significant. In Tang et al.'s study, the effect of urbanization on the eco-efficiency of urban resources is inhibitory and then facilitating [69]. This paper also finds a similar phenomenon in the relationship between green finance and WEF synergy. However, different from its focus, this paper argues that the transformation of the urbanization development mode not only directly promotes the utilization efficiency of resources but also improves the willingness to invest in green finance by optimizing the investment environment of green finance so as to satisfy the various expenditure needs of the resource system to reach the synergistic state.

Table 5. Threshold effect regression results.

Variable	(1)	(2)
	City $\leq$ 82.90	City $>$ 82.90
city $\leq$ 82.90	0.0437 ** (2.17)	0.0726 *** (3.63)
Constant		−0.0911 (−0.41)
Controls		Y
Individual—Time		Y
N		342
R ²		0.3659

*** and ** represent significance levels of 1% and 5%, respectively; the value in () is the t statistic.

4.6. Differences in the Effects of Green Finance on Different Endowment Areas

Some cities have natural shortages of resources due to natural endowments and other reasons. The serious shortage of a certain resource, such as water or energy, cannot meet the demand of other system production, which seriously affects the WEF synergy of the region as well as the sustainable development of the region. Under the constraints of such unfavorable conditions, a question arises whether green finance can play the role of resource allocation, guide funds to build infrastructure, or upgrade the original technology of the shortage type of resources. Thus, the improvement in the supply capacity of scarce resources and the reduction in the imbalance of water resources, energy, and food, followed by WEF synergy, need further research. For example, in regions where resources such as oil and coal are scarce, green finance invests in the construction of new types of energy facilities, such as solar and wind power, to improve the region's ability to supply energy, thereby meeting the production needs of the water and food subsystems.

Therefore, this paper divides the sample into four control groups based on the abundance of different resources in the cities. It is divided according to whether it is a resource-based city, whether it is a main grain producing area, whether it is a city along the South-to-North water diversion route, and whether it is a large city. Resource cities are classified on the basis of whether the prefecture-level city is within the National List of Resource Cities; major grain producing areas are classified on the basis of whether the province in which the prefecture-level city is located in a major grain producing area; cities along the South-to-North water diversion cities are classified on the basis of whether the prefecture-level city is within the water supply area of the South-to-North Water Diversion East Project; and large cities are classified on the basis of whether they are Type II or above. The regression results are shown in Table 6.

Table 6. Heterogeneity results.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
gf	−0.0079 (−0.22)	0.0877 *** (2.61)	0.0209 (0.80)	0.3059 *** (4.65)	0.1135 (1.24)	0.0817 *** (3.04)	0.0017 (0.08)	0.1354 ** (2.53)
Constant	−0.5996 * (−1.94)	0.4622 (1.15)	−0.2227 (−0.84)	1.5371 * (1.72)	0.1460 (0.11)	−0.1749 (−0.61)	−0.0544 (−0.27)	−0.4199 (−0.75)
Individual—Time	Y	Y	Y	Y	Y	Y	Y	Y
N	98	244	252	90	72	270	171	171
R ²	0.5199	0.2380	0.2885	0.5002	0.2077	0.2723	0.3954	0.3244

(1) is a sample of resource-based cities, and (2) is a sample of non-resource-based cities; (3) is the main grain-producing area sample, and (4) is the non-main grain-producing area sample; (5) is listed as the sample of cities along the South-to-North water diversion route, and (6) is listed as the sample of cities not along the South-to-North water diversion route; (7) is a sample of large cities, and (8) is a sample of small and medium-sized cities. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively; the value in () is the t statistic.

Columns (1)–(2) show that green finance can significantly contribute to the level of WEF synergy in non-resource cities, but the effect is not significant in resource cities. The results in Columns (3)–(4) show that green finance can significantly promote the WEF system towards a higher level of synergy in non-food-producing areas, but this effect is not significant in food-producing areas. Columns (5)–(6) show that the positive effect of green finance on the level of WEF synergy is more significant in cities not along the South-to-North water diversion route than in cities along the South-to-North water diversion route. Columns (7)–(8) show that green finance contributes better to the WEF synergy in large cities compared to small and medium-sized cities. Peng et al. found that improvements in agricultural resource endowments have a favorable impact on WEF synergies [70]. The findings of this paper further illustrate that green finance enhances WEF synergy by complementing the shortcomings in the barrel and improving the endowment of scarce resources. The YRD has encouraged the integration of green finance and the development of water rights trading and carbon finance markets. The development of green finance has supported the cross-regional deployment of resources, improved the region's resource endowment, and harmonized the supply and demand for water, energy, and food.

5. Conclusions and Policy Implications

5.1. Conclusions

Using data from 38 cities in the YRD region for the period 2013–2021 as a research sample, this paper uses regression models to explore how green finance affects the level of synergy between water, energy, and food. The findings of this paper are as follows:

- (1) The WEF synergy level of the YRD city cluster shows an upward trend in general. However, it shows the distribution characteristics of high in the east and low in the west. Despite the high demand for resources in the YRD region, Zhang et al. found that Jiangsu and Zhejiang Provinces can import virtual water, implied energy, and implied arable land through trade networks, thus alleviating the problem of insufficient local resource supply [7]. This also explains to some extent why the study in this paper found the WEF synergy in Jiangsu and Zhejiang Provinces higher than in Anhui Province, compared to some studies. Having solved the problem of resource scarcity, Zhejiang and Jiangsu Provinces have achieved sustainable WEF synergy by virtue of higher resource utilization efficiency [71].
- (2) Green finance promotes the water subsystem efficiency and WEF synergy level in YRD cities but does not improve the energy and food subsystem efficiency. However, the nonlinear regression results show that the effect of green finance on both the WEF synergy level and the efficiency of each subsystem is inhibited before being promoted. These findings in general support the hypothesis that green finance can improve the level of WEF synergy. However, they also further expose some problems of green finance. In the previous period, in order to pursue rapid development, it failed to consider WEF synergy in a comprehensive manner, resulting in the inability of green finance to effectively support the efficiency improvement of various resource subsystems. This suggests that green finance, while expanding, is not supported in the same way in each of the areas involved. For example, the investment in agriculture is much lower than in the energy sector. At the same time, “greenwashing” leads to wasted funds for green finance and even exacerbates the waste of resources by investing funds in projects that are not in line with sustainable development. Therefore, it is necessary to standardize the criteria for green finance investment and to deploy funds to areas and fields where funds are scarce.
- (3) The digital strategy and the “dual carbon” strategy can positively regulate the impact of green finance on the level of WEF synergy. After urbanization crosses the threshold, the effect of green finance on the level of WEF synergy is more significant. Hou et al. found that the degree of informatization can enhance the environmental benefits of green finance, and that green finance improves the environment through digital finance [72]. After considering environmental factors, this paper further finds that

digital strategy also enhances the contribution of green finance to WEF synergy. Huang et al. found that the economic consequences of green finance become worse under stricter environmental regulations. However, they also mentioned that the non-linear relationship is complex and does not imply that lower environmental regulations are better [61]. Therefore, environmental policies should be formulated in light of the characteristics of the region, such as the level of economic development and the level of technology. The above findings suggest that, in order to enhance synergies among sustainable policies, green finance needs to be deeply integrated with national strategies and, through the new technologies and models promoted by those strategies, look in a new direction for the development of the resource industry and improve the resource allocation capacity of green finance.

- (4) Compared with the comparison group, green finance enhances WEF synergy in non-resource cities, cities in non-main food-producing areas, cities not along the South-to-North water diversion route, and large cities. This suggests that green finance promotes WEF synergy primarily by supporting the development of regional scarce resources. For relatively abundant resources, green finance has to further increase the efficiency of abundant resources to reduce the consumption of abundant resources on other resources. Thus, while some studies have shown that green finance mitigates the problem of lower sustainable money growth rates in natural resource-rich countries than in countries with fewer natural resources, this does not tell us whether this economic growth is based on the synergy of resource systems. At the same time, Liu et al. found that green finance can indeed attenuate the negative impact of the resource curse on factor productivity to a certain extent (although the inhibitory effect is still larger overall) [73]. This paper does not deny this improvement function of green finance and only states that this effect is not significant enough to be demonstrated in the WEF synergy or that it needs to be further enhanced.

5.2. Policy Implications

Based on the results of this study, this paper puts forward the following recommendations for the government's reference in managing resources and formulating policies for green financial development, as well as for financial institutions and high-resource-consuming enterprises.

- (1) Strengthening interregional integration of resources and realizing resource complementarity: Zhi et al. mentioned that the current water supply network between cities in the YRD still needs to be upgraded [74]. As mentioned earlier, strengthening trade links can also optimize the spatial allocation of resources. Therefore, integrated development should be promoted and administrative and trade barriers between regions should be reduced. The integrated development of resources is inseparable from the development of cross-regional infrastructure, so it is necessary to improve the layout of cross-regional water resources, energy, and other facilities. Large-scale resource facilities will be used as blood vessels connecting cities, meeting the development needs of regions with high resource consumption, and improving the economic efficiency of resource-exporting regions. In addition, the original infrastructure should be transformed with intelligent equipment. The Internet of Things and other technologies should be utilized to improve real-time monitoring and flexible scheduling of resources in order to ensure that regional resource supply meets demand.
- (2) Optimizing green financial policies and promoting the digital transformation of green finance: The government should enhance green finance categorization standards, both by strictly defining the criteria for projects to qualify for green ratings and by balancing the financing needs of the WEF system. It should eliminate "greenwashing" while preventing the waste of resources caused by the influx of funds into a single system. Regional governments should take into account the structure of local resource endowments and formulate green finance development strategies. For example, in setting up green financial reform demonstration zones, China has set different

development goals based on the different economic and natural conditions of each region. Financial institutions should actively introduce financial technology and utilize it to create a green information base and enhance project screening capabilities, and make full use of past green information such as ESG disclosure reports and environmental violation tickets of enterprises.

- (3) Focus on urban development planning and make good use of environmental regulatory policies: Governments should balance the relationship between agriculture and industry, and between urban and rural areas, when formulating urban development plans. This should include mitigating disputes over agricultural and industrial water use and limiting the squeeze on agricultural land by industrial land for energy and other uses. When making investment choices, financial institutions should carefully consider policy risks and actively invest in projects consistent with sustainable development, such as green energy, green agriculture, and water recycling. For high-energy-consuming and high-polluting enterprises, now is the best time to transform. It is necessary to make full use of low-cost green finance to eliminate backward production methods. Otherwise, they will face increasingly stringent policy restrictions.

5.3. Limitations and Future Research

This paper examines the impact of green finance on the level of WEF synergy and analyzes the impact of some of China's strategies on the relationship between the two. However, there are still some limitations.

First, future research needs to further analyze the mediating mechanism by which green finance affects the level of WEF synergy. This paper finds that green finance can effectively enhance the level of WEF synergy. However, it needs to be further verified whether green finance can enhance resource utilization and synergy through indirect channels such as promoting green technological innovation and industrial restructuring, as mentioned in related studies. The refinement of related issues will enrich the theory of green finance affecting WEF synergy.

Second, there may be variability in the ways and effects of different green finance instruments in influencing the WEF synergistic governance. There are various types of green finance, including bonds, stocks, and insurance, in addition to green credit. Different financial instruments have different functions. For example, unlike other instruments, insurance mainly plays the function of risk dispersion. Therefore, future research can comparatively analyze the differences in the impact of different green financial instruments on the level of WEF synergy in order to further resolve the controversy over the effectiveness of green finance.

Third, effective solutions must be provided for green finance to break the "resource curse". In this paper, we find that green finance promotes WEF synergy mainly by compensating for the shortcomings of resources. However, in line with some studies, we believe that as the amount of resources increases, green finance needs to break the "resource curse" and further improve resource efficiency to meet the demand for the WEF synergy. Therefore, more discussion is needed on how to improve this effect of green finance.

Finally, researchers can expand the study on the impact of green finance on WEF synergy from the perspective of spatial effects. The WEF synergistic governance requires intergovernmental cooperation, and the economic effects of green finance also have spatial spillover effects. Therefore, exploring whether green finance has a spatial spillover effect on the level of WEF synergy and how it affects the level of WEF synergy in other regions can help provide more valuable references for governments to strengthen resource cooperation and joint governance of WEF.

Funding: This research was funded by The National Social Science Fund of China, grant number 19ZDA084.

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 corresponding author.

Conflicts of Interest: The author declares no conflicts of interest.

Appendix A

Table A1. List of sample cities.

Province/Municipality	Prefecture Level City
Shanghai Municipality	-
Jiangsu Province	Nanjing, Suzhou, Wuxi, Nantong, Changzhou, Xuzhou, Yangzhou, Yancheng, Zhenjiang, Huai'an, Lianyungang, Suqian
Zhejiang Province	Hangzhou, Ningbo, Huzhou, Jiaxing, Shaoxing, Wenzhou, Quzhou, Lishui, Taizhou
Zhejiang Province	Hefei, Wuhu, Bengbu, Huainan, Maanshan, Huaibei, Tongling, Anqing, Huangshan, Fuyang, Suzhou, Chuzhou, Lu'an, Xuancheng, Chizhou, Bozhou

Due to the lack of data on the number of employees and enterprise assets in the water resources, energy, and agriculture industries in the statistical yearbooks of Taizhou City, Jinhua City, and Zhoushan City, this paper excludes these three cities from the study sample in the sample.

Appendix B

Let there be n DMUs ($j = 1, \dots, n$), D production stages, m_d , s_{1d} , s_{2d} , denoting the number of inputs, desired outputs, and non-desired outputs in stage d , respectively, and (d, h) denoting the transfer relationship from sector d to sector h . The vectors of inputs, desired outputs, and non-desired outputs are $X = (x_j^d) \in R^{m_d \times n}$, $Y = (y_j^d) \in R^{s_{1d} \times n}$, $B = (b_j^d) \in R^{s_{2d} \times n}$, and the vector of intermediate outputs linking sector d to sector h is denoted as $Z = (z_j^{(d,h)}) \in R^{(d,h) \times n}$, ($j = 1, \dots, n$; $d = 1, \dots, D$; $h = 1, \dots, D$).

Also, let $X > 0$, $Y > 0$, $B > 0$, $Z > 0$, p_o be the efficiency values of each DEU ($o = 1, \dots, n$); then the specific formula is

$$\min p_o = \frac{\sum_{d=1}^D W^d [1 + \frac{1}{m_d} \sum_{i=1}^{m_d} \frac{s_{io}^{xd}}{x_{io}^d}]}{\sum_{d=1}^D W^d [1 + \frac{1}{s_{1d} + s_{2d}} (\sum_{k=1}^{s_{1d}} \frac{s_k^{yd}}{y_{ko}^d} + \sum_{l=1}^{s_{2d}} \frac{s_l^{bd}}{b_{lo}^d})]} \quad (A1)$$

$$\text{s.t.} \begin{cases} x_{io}^d \geq \sum_{j=1, j \neq o}^n \lambda_j^d x_j^d - s_{io}^{xd}, \forall i, d \\ y_{ko}^d \leq \sum_{j=1, j \neq o}^n \lambda_j^d y_j^d - s_k^{yd}, \forall k, d \\ b_{lo}^d \geq \sum_{j=1, j \neq o}^n \lambda_j^d b_j^d - s_l^{bd}, \forall l, d \\ \sum_{j=1, j \neq o}^n \lambda_j^d z_j^{(d,h)} = \sum_{j=1, j \neq o}^n \lambda_j^h z_j^{(d,h)}, \forall (d, h) \\ s_{io}^{xd} \geq 0, s_k^{yd} \geq 0, s_l^{bd} \geq 0, \lambda_j^d \geq 0, \lambda_j^h \geq 0, \sum_{j=1, j \neq o}^n \lambda_j^d = 1, \sum_{j=1, j \neq o}^n \lambda_j^h = 1, \forall i, j, k, l, d, (d, h) \end{cases} \quad (A2)$$

Appendix C

Table A2. List of 24 banks.

	Name
Bank list	Ping An Bank, Bank of Ningbo, Bank of Shanghai, Pudong Development Bank, Huaxia Bank, Minsheng Bank, China Merchants Bank, Bank of Jiangsu, Bank of Nanjing, Industrial Bank, Everbright Bank, Bank of Beijing, Bank of Shanghai, Agricultural Bank of China, Bank of Communications and Industrial and Commercial Bank of China, Construction Bank, Bank of China, Postal Savings Bank, CITIC Bank, Bank of Suzhou, Hangzhou Bank, Zheshang Bank, Guangfa Bank, Bohai Bank.

Taking into account the availability of data, the institutions in the table were selected based on the list of systemically important banks issued by the People's Bank of China and the China Banking and Insurance Regulatory Commission.

References

1. Chaibi, M.T.; Soussi, M.; Karnib, A. Enhancing community well-being in African drylands through technology-based solutions in the water-energy-food-ecosystems nexus. *Environ. Sci. Water Res.* **2023**, *10*, 85–104. [\[CrossRef\]](#)
2. United Nations. The Sustainable Development Goals Report 2023: Special Edition. Available online: <https://unstats.un.org/sdgs/report/2023/> (accessed on 5 June 2024).
3. Saint Bois, A.; Boix, M.; Montastruc, L. Multi-actor integrated modeling approaches in the context of Water-Energy-Food Nexus systems: Review. *Comput. Chem. Eng.* **2024**, *182*, 108559. [\[CrossRef\]](#)
4. Sun, C.Z.; Yan, X.D.; Zhao, L.S. Coupling efficiency measurement and spatial correlation characteristic of water-energy-food nexus in China. *Resour. Conserv. Recycl.* **2021**, *164*, 105151. [\[CrossRef\]](#)
5. Li, Y.; Zhang, R.L. A Review of Water-Energy-Food Nexus Development in a Just Energy Transition. *Energies* **2023**, *16*, 6253. [\[CrossRef\]](#)
6. Rosa, L.; Rulli, M.C.; Davis, K.F.; D'Odorico, P. The Water-Energy Nexus of Hydraulic Fracturing: A Global Hydrologic Analysis for Shale Oil and Gas Extraction. *Earth's Future* **2018**, *6*, 745–756. [\[CrossRef\]](#)
7. Zhang, B.; Wang, Q.; Liu, Y.; Zhang, Y.W.; Wu, X.F.; Sun, X.D.; Qiao, H. Uneven development within China: Implications for interprovincial energy, water and arable land requirements. *J. Environ. Manag.* **2020**, *261*, 110231. [\[CrossRef\]](#)
8. Muhirwa, F.; Shen, L.; Elshkaki, A.; Zhong, S.; Hu, S.H.; Hirwa, H.; Chiaka, J.C.; Umarishavu, F.; Mulinga, N. Ecological balance emerges in implementing the water-energy-food security nexus in well-developed countries in Africa. *Sci. Total Environ.* **2022**, *833*, 154999. [\[CrossRef\]](#)
9. Cheng, Y.T.; Wang, J.L.; Shu, K.S. The coupling and coordination assessment of food-water-energy systems in China based on sustainable development goals. *Sustain. Prod. Consum.* **2023**, *35*, 338–348. [\[CrossRef\]](#)
10. Lv, W.; Zhang, Z.; Zhang, X. The role of green finance in reducing agricultural non-point source pollution—An empirical analysis from China. *Front. Sustain. Food Syst.* **2023**, *7*, 1199417. [\[CrossRef\]](#)
11. Wang, R.; Wang, F.Y.; Bie, F. Does Green Finance and Water Resource Utilization Efficiency Drive High-Quality Economic Development? *Sustainability* **2022**, *14*, 15733. [\[CrossRef\]](#)
12. Lee, C.-C.; Wang, C.-S.; He, Z.; Xing, W.-W.; Wang, K. How does green finance affect energy efficiency? The role of green technology innovation and energy structure. *Renew. Energy* **2023**, *219*, 119417. [\[CrossRef\]](#)
13. Li, G.J.; Jia, X.M.; Khan, A.A.; Khan, S.U.; Ali, M.A.; Luo, J.C. Does green finance promote agricultural green total factor productivity? Considering green credit, green investment, green securities, and carbon finance in China. *Environ. Sci. Pollut. Res.* **2023**, *30*, 36663–36679. [\[CrossRef\]](#)
14. Xu, J.Q.; She, S.X.; Gao, P.P.; Sun, Y.P. Role of green finance in resource efficiency and green economic growth. *Resour. Policy* **2023**, *81*, 103349. [\[CrossRef\]](#)
15. De Deus, J.L.; Crocco, M.; Silva, F.F. The green transition in emerging economies: Green bond issuance in Brazil and China. *Clim. Policy* **2022**, *22*, 1252–1265. [\[CrossRef\]](#)
16. Giovanis, E.; Ozdamar, O. The impact of climate change on budget balances and debt in the Middle East and North Africa (MENA) region. *Clim. Change* **2022**, *172*, 34. [\[CrossRef\]](#)
17. Lu, S.B.; Lu, W.J.; Xu, M.; Taghizadeh-Hesary, F.; Tang, Y. Water-energy-food security under green finance constraints in Southwest China. *Energy Econ.* **2023**, *118*, 106478. [\[CrossRef\]](#)
18. Lian, Y.; Shang, Y.F.; Qian, F.B. Spatial effects of green finance development in Chinese provinces under the context of high-quality energy development. *Econ. Chang. Restruct.* **2024**, *57*, 23. [\[CrossRef\]](#)
19. Tong, L.; Luo, M.D. Spatiotemporal Evolution Characteristics and Driving Factors of Water-Energy-Food-Carbon System Vulnerability: A Case Study of the Yellow River Basin, China. *Sustainability* **2024**, *16*, 1002. [\[CrossRef\]](#)
20. Blicharska, M.; Smithers, R.J.; Kuchler, M.; Munaretto, S.; van den Heuvel, L.; Teutschbein, C. The water-energy-food-land-climate nexus: Policy coherence for sustainable resource management in Sweden. *Environ. Policy Gov.* **2024**, *34*, 207–220. [\[CrossRef\]](#)

21. Wan, S.; Lee, Y.H.; Sarma, V.J. Is Fintech good for green finance? Empirical evidence from listed banks in China. *Econ. Anal. Policy* **2023**, *80*, 1273–1291. [\[CrossRef\]](#)
22. Liu, G.Y.; Du, S.P.; Gao, Y.; Xiong, X.P.; Lombardi, G.V.; Meng, F.X.; Chen, Y.; Chen, C.C. A study on energy-water-food-carbon nexus in typical Chinese northern rural households. *Energy Policy* **2024**, *188*, 114100. [\[CrossRef\]](#)
23. Hua, E.; Han, X.X.Q.; Bai, Y.W.; Engel, B.A.; Li, X.; Sun, S.K.; Wang, Y.B. Synergy of water use in water-energy-food nexus from a symbiosis perspective: A case study in China. *Energy* **2023**, *283*, 129164. [\[CrossRef\]](#)
24. Huang, D.; Li, G.; Chang, Y.; Sun, C. Water, energy, and food nexus efficiency in China: A provincial assessment using a three-stage data envelopment analysis model. *Energy* **2023**, *263*, 126007. [\[CrossRef\]](#)
25. Gazal, A.A.; Jakrawatana, N.; Silalertruksa, T.; Gheewala, S.H. Water-energy-land-food nexus for bioethanol development in Nigeria. *Biomass Convers. Biorefin.* **2024**, *14*, 1749–1762. [\[CrossRef\]](#)
26. Gao, J.; Xu, J. Research on the Spatiotemporal Characteristics of the Coupling Coordination Relationship of the Energy-Food-Water System in the Xinjiang Subregion. *Sustainability* **2024**, *16*, 3491. [\[CrossRef\]](#)
27. Lv, C.M.; Hu, Y.G.; Ling, M.H.; Luo, A.J.; Yan, D.H. Comprehensive evaluation and obstacle factors of coordinated development of regional water-ecology-energy-food nexus. In *Environment, Development and Sustainability*; Springer: Berlin/Heidelberg, Germany, 2023; pp. 1–25. [\[CrossRef\]](#)
28. Jin, B.Y.; Shi, R.; Chen, S.L.; He, Y.; Zhao, M.J. Analysis of the factors influencing the water-energy-food system stress in China. *Environ. Sci. Pollut. Res.* **2023**, 1–17. [\[CrossRef\]](#)
29. Zhu, M.; Sun, M.; Elahi, E.; Li, Y.; Khalid, Z. Analyzing the Relationship between Green Finance and Agricultural Industrial Upgrading: A Panel Data Study of 31 Provinces in China. *Sustainability* **2023**, *15*, 9813. [\[CrossRef\]](#)
30. Nepal, R.; Zhao, X.M.; Liu, Y.; Dong, K.Y. Can green finance strengthen energy resilience? The case of China. *Technol. Forecast. Social Change* **2024**, *202*, 123302. [\[CrossRef\]](#)
31. Lin, Y.K.; Zhong, Q.M. Does green finance policy promote green total factor productivity? Evidence from a quasi-natural experiment in the green finance pilot zone. *Clean. Technol. Environ.* **2024**, 1–15. [\[CrossRef\]](#)
32. Xu, J.J.; Wang, J.C.; Li, R.; Gu, M.X. Is green finance fostering high-quality energy development in China? A spatial spillover perspective. *Energy Strateg. Rev.* **2023**, *50*, 101201. [\[CrossRef\]](#)
33. Sarpong, F.A.; Sappor, P.; Nyantakyi, G.; Agyeiwaa, O.E.; Ahakwa, I.; Cobbinah, B.B.; Kir, K.F. Green financial development efficiency: A catalyst for driving China's green transformation agenda towards sustainable development. *Environ. Sci. Pollut. Res.* **2023**, *30*, 60717–60745. [\[CrossRef\]](#)
34. Jiang, T.Y.; Xu, J.J.; Yu, Y.; Jahanger, A.; Balsalobre-Lorente, D. The spatial pattern and association network of green finance development: Empirical evidence from China. *Nat. Resour. Forum* **2024**, 1–25. [\[CrossRef\]](#)
35. Ling, F.; Zhen, S.; Liang, C.; Zhao, Z.Y. Green Bonds and Corporate Environmental, Social, and Governance Greenwashing: Evidence from China. *Singap. Econ. Rev.* **2024**, 1–29. [\[CrossRef\]](#)
36. He, Q.; Wang, Z.; Wang, G.; Zuo, J.; Wu, G.; Liu, B. To be green or not to be: How environmental regulations shape contractor greenwashing behaviors in construction projects. *Sustain. Cities Soc.* **2020**, *63*, 102462. [\[CrossRef\]](#)
37. Deng, W.Y.Y.; Zhang, Z.L. Environmental regulation intensity, green finance, and environmental sustainability: Empirical evidence from China based on spatial metrology. *Environ. Sci. Pollut. Res.* **2023**, *30*, 66228–66253. [\[CrossRef\]](#)
38. Dong, D.; Gao, X.; Sun, X.; Liu, X. Factors affecting the formation of copper international trade community: Based on resource dependence and network theory. *Resour. Policy* **2018**, *57*, 167–185. [\[CrossRef\]](#)
39. Wan, K.; Cao, L.; He, Y.R. Can green bonds promote corporate green technology innovation?—Evidence from China. *Appl. Econ.* **2024**, 1–13. [\[CrossRef\]](#)
40. Yi, H.; Hao, L.; Liu, A.R.; Zhang, Z.Y. Green finance development and resource efficiency: A financial structure perspective. *Resour. Policy* **2023**, *85*, 104068. [\[CrossRef\]](#)
41. Geng, Q.Q.; Wang, Y.; Wang, X.Q. The impact of natural resource endowment and green finance on green economic efficiency in the context of COP26. *Resour. Policy* **2023**, *80*, 103246. [\[CrossRef\]](#)
42. Fu, C.; Lu, L.; Pirabi, M. Advancing green finance: A review of sustainable development. *Digit. Econ. Sustain. Dev.* **2023**, *1*, 20. [\[CrossRef\]](#)
43. Chang, K.W.; Luo, D.; Dong, Y.Z.; Xiong, C. The impact of green finance policy on green innovation performance: Evidence from Chinese heavily polluting enterprises. *J. Environ. Manag.* **2024**, *352*, 119961. [\[CrossRef\]](#)
44. Zhen, Z.; Lu, B. The impact of green finance on corporate carbon disclosure: Financial regulation as a moderator. *Finance Res. Lett.* **2024**, *63*, 105273. [\[CrossRef\]](#)
45. Lazurko, A.; Venema, H.D. Financing High Performance Climate Adaptation in Agriculture: Climate Bonds for Multi-Functional Water Harvesting Infrastructure on the Canadian Prairies. *Sustainability* **2017**, *9*, 1237. [\[CrossRef\]](#)
46. Shah, M.I.; AbdulKareem, H.K.K.; Zulfiqar, K.; Abbas, S. Examining the agriculture induced Environmental Kuznets Curve Hypothesis in BRICS Economies: The role of Renewable Energy as a Moderator. *Renew. Energy* **2022**, *198*, 343–351. [\[CrossRef\]](#)
47. Li, J.; Khan, A.A.; Abu Sufyan Ali, M.; Luo, J. Does farmers' agricultural investment is impacted by green finance policies and financial constraint? From the perspective of farmers' heterogeneity in Northwest China. *Environ. Sci. Pollut. Res.* **2022**, *29*, 67242–67257. [\[CrossRef\]](#)

48. He, L.Y.; Liu, R.Y.; Zhong, Z.Q.; Wang, D.Q.; Xia, Y.F. Can green financial development promote renewable energy investment efficiency? A consideration of bank credit. *Renew. Energy* **2019**, *143*, 974–984. [\[CrossRef\]](#)
49. Bakry, W.; Mallik, G.; Nghiem, X.-H.; Sinha, A.; Vo, X.V. Is green finance really “green”? Examining the long-run relationship between green finance, renewable energy and environmental performance in developing countries. *Renew. Energy* **2023**, *208*, 341–355. [\[CrossRef\]](#)
50. Umar, M.; Khan, S.A.R.; Yusoff Yusliza, M.; Ali, S.; Yu, Z. Industry 4.0 and green supply chain practices: An empirical study. *Int. J. Product. Perform. Manag.* **2022**, *71*, 814–832. [\[CrossRef\]](#)
51. Du, M.; Zhang, R.; Chai, S.; Li, Q.; Sun, R.; Chu, W. Can Green Finance Policies Stimulate Technological Innovation and Financial Performance? Evidence from Chinese Listed Green Enterprises. *Sustainability* **2022**, *14*, 9287. [\[CrossRef\]](#)
52. Yang, X. Role of green finance and investment in sustainable resource development in China. *Resour. Policy* **2023**, *86*, 104219. [\[CrossRef\]](#)
53. Zuo, Q.; Wu, Q.S.; Ma, J.X.; Zhang, Z.Z.; Li, H. Research framework and prospect of water resource behavior regulation under carbon peak and carbon neutrality goals. *Water Resour. Prot.* **2023**, *39*, 8–14, 56.
54. Liu, J.L.; Ran, M.S. Effect of the Intensity of Environmental Regulation on Production Technology Progress in 17 Industries: Evidence from China. *Pol. J. Environ. Stud.* **2014**, *23*, 2071–2081.
55. Bao, C.; Fang, C. Study on the Quantitative Relationship Between Urbanization and Water Resources Utilization in the Hexi Corridor. *J. Nat. Resour.* **2006**, *21*, 301–310.
56. Zhao, Y.; Zhang, X.; Xu, J.; Smith, J.S.; Xia, J.; Jia, H. Water-energy-environment nexus under different urbanization patterns: A sensitivity-based framework for identifying key feedbacks. *J. Clean. Prod.* **2023**, *408*, 137243. [\[CrossRef\]](#)
57. Shi, C.F.; Shang, T.; Zhi, J.Q.; Na, X.H. Research on the impact of China’s new urbanization on industrial water utilization efficiency—Based on spatial spillover effects and threshold characteristics. *Water Sci. Technol.* **2023**, *87*, 1832–1852. [\[CrossRef\]](#)
58. Wu, Y.X.; Gao, L.; Guo, Z.; LIN, L. The Impact Mechanism and Heterogeneity of Green Credit on Environmental Pollution Control: An Empirical Study in the Yangtze River Delta Region of China. *Rev. Ind. Econ.* **2023**, *11*, 69–90. [\[CrossRef\]](#)
59. 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. [\[CrossRef\]](#)
60. Kou, Z.L.; Liu, X.Y. *FIND Report on City and Industrial Innovation in China*; Fudan Institute of Industrial Development, School of Economics, Fudan University: Shanghai, China, 2017. Available online: <https://ride.fudan.edu.cn/info/1020/1274.htm> (accessed on 5 June 2024).
61. Huang, Y.; Chen, C.; Lei, L.; Zhang, Y. Impacts of green finance on green innovation: A spatial and nonlinear perspective. *J. Clean. Prod.* **2022**, *365*, 132548. [\[CrossRef\]](#)
62. Wang, J.; Zhou, H.; Tso, G.K.F.; Hsun, C.P.; Tu, C.; Zheng, T. Integrated safety assessment of water-energy-food systems based on improved substance element extensions. *J. Water Clim. Change* **2023**, *14*, 4617–4634. [\[CrossRef\]](#)
63. Ding, J.P.; Deng, M.H. Coupling coordination analysis of water-energy-food-ecology in the Yangtze River Delta. *Water Supply* **2022**, *22*, 7272–7280. [\[CrossRef\]](#)
64. Wang, B.; Wang, Y.; Cheng, X.Q.; Wang, J.Y. Green finance, energy structure, and environmental pollution: Evidence from a spatial econometric approach. *Environ. Sci. Pollut. Res.* **2023**, *30*, 72867–72883. [\[CrossRef\]](#)
65. Zhang, B.; Yang, Y.; Bi, J. Tracking the implementation of green credit policy in China: Top-down perspective and bottom-up reform. *J. Environ. Manag.* **2011**, *92*, 1321–1327. [\[CrossRef\]](#)
66. Zhang, D.Y. Green financial system regulation shock and greenwashing behaviors: Evidence from Chinese firms. *Energy Econ.* **2022**, *111*, 106064. [\[CrossRef\]](#)
67. Zhang, Y.; Liu, Z.; Baloch, Z.A. Combining effects of private participation and green finance for renewable energy: Growth of economy as mediating tool. *Renew. Energy* **2022**, *195*, 1028–1036. [\[CrossRef\]](#)
68. Hemanand, D.; Mishra, N.; Premalatha, G.; Mavaluru, D.; Vajpayee, A.; Kushwaha, S.; Sahile, K. Applications of Intelligent Model to Analyze the Green Finance for Environmental Development in the Context of Artificial Intelligence. *Comput. Intell. Neurosci.* **2022**, *2022*, 2977824. [\[CrossRef\]](#)
69. Tang, M.G.; Li, Z.; Hu, F.X.; Wu, B.J. How does land urbanization promote urban eco-efficiency? The mediating effect of industrial structure advancement. *J. Clean. Prod.* **2020**, *272*, 122798. [\[CrossRef\]](#)
70. Peng, W.J.; Zheng, H.; Robinson, B.E.; Li, C.; Li, R.A. Comparing the importance of farming resource endowments and agricultural livelihood diversification for agricultural sustainability from the perspective of the food-energy-water nexus. *J. Clean. Prod.* **2022**, *380*, 135193. [\[CrossRef\]](#)
71. Xiang, Y.B.; Shao, W.; Dai, Z.J.; Zhang, Y.X.; Ding, S.F. Regional Differences and Convergence of Urban Water Use Efficiency in the Yangtze River Economic Belt. *Water* **2023**, *15*, 2440. [\[CrossRef\]](#)
72. Hou, H.; Zhu, Y.B.; Wang, J.; Zhang, M.L. Will green financial policy help improve China’s environmental quality? the role of digital finance and green technology innovation. *Environ. Sci. Pollut. Res.* **2023**, *30*, 10527–10539. [\[CrossRef\]](#)

73. Liu, Y.; Wang, J.D.; Dong, K.Y.; Taghizadeh-Hesary, F. How does natural resource abundance affect green total factor productivity in the era of green finance? Global evidence. *Resour. Policy* **2023**, *81*, 103315. [[CrossRef](#)]
74. Zhi, Y.L.; Chen, J.F.; Qin, T.; Wang, T.; Wang, Z.Q.; Kang, J.L. Spatial Correlation Network of Water Use in the Yangtze River Delta Urban Agglomeration, China. *Front. Env. Sci.* **2022**, *10*, 924246. [[CrossRef](#)]

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.