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Research on Green Finance, Technological Innovation, and Industrial Structure Upgrading in the Yangtze River Economic Belt

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Abstract: Along with the fact that China is in a critical period of economic structural transformation, industrial structural upgrading and transformation are imminent. The empirical research in this paper mainly constructs four groups of fixed effects models. The purpose is to investigate the impact mechanisms of green finance (GF), technological innovation (TI), and industrial structure upgrading (ISU) in 11 provinces (cities) along the Yangtze River Economic Belt (YREB) from 2011 to 2020. Based on the research method of the fixed effects model, this paper can analyze the association between GF, TI, and ISU in a more concise and intuitive way. The research conclusions mainly include the following three points. Firstly, both GF and TI are able to significantly contribute to the ISU of the YREB. Furthermore, GF can also promote TI to a certain extent. Second, TI serves as a partial intermediary in the process of GF's favorable contribution to the ISU. In other words, green finance can act as an intermediary by enhancing technological innovation capacity so as to effectively accelerate the ISU of the YREB. Thirdly, this paper finds that there exists a degree of regional heterogeneity in the process of GF and TI affecting ISU in the YREB. For one thing, GF in the eastern part of the YREB can strongly accelerate the ISU. However, there is no obvious impact effect in the central and western regions. For another, TI in the eastern part of the YREB has, likewise, contributed positively to the ISU. In comparison, TI in the central region has a clearly negative effect on the ISU while there is no significant influence effect in the western region. In conclusion, this paper innovatively integrates GF, TI, and ISU into a framework for research. This paper not only widens the theoretical research domain of industrial structure upgrading but also provides practical guidance for the restructuring and transformation of industries in the YREB.



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1. Introduction

With technological renewal and industrial reorganization, they are not only driving the rapid development of new technologies and industries but also bringing about great changes in our way of life and production. With the progress of science and technology, people can better master advanced technology, enhance production efficiency, and expand market space, thus accelerating the adjustment of economic structure. Meanwhile, as the industrial structure is upgraded, more and more high-tech industries and services enter the market, injecting new vitality into the regional economy and promoting sustainable economic development. Furthermore, industrial structure upgrading (ISU) is also a deciding factor in boosting cleaner production and achieving carbon neutrality targets. Because climate change has formed an unprecedented scale effect in the world, climate



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issues have gradually begun to concern people around the world. Global CO₂ emissions increased by 40 percent from 2000 to 2019. This means that people are releasing more carbon dioxide in their daily production and life. Among these, energy consumption and industrial production account for the largest share of carbon emissions [1]. In fact, the ISU can be useful in decreasing carbon emissions and greatly promoting cleaner production, resulting in a more low-carbon and eco-friendly industrial value chain [2]. For China, a crucial national strategic development region is the YREB (Figure 1). Its total size is roughly 2,052,300 square kilometers. The overall population of the Yangtze River Economic Belt (YREB) is nearly 599 million, amounting to 42.9% of China. The gross domestic product of the YREB is nearly CNY 40.3 trillion, taking up 44.1% of China. In addition, the YREB, with its development advantages and strong economic foundation, plays a non-leading demonstration role in pushing forward the optimization of China's economic structure. However, it currently faces several issues, including the industrial structure's simplification, aggregation, and rationalization, despite having a sizable industrial structure. Furthermore, it also has the problems of unbalanced regional development and regional protection obstacles. There are even regional protections and regional barriers between some regions. As a matter of fact, this paper conducts research on industrial structure optimization and upgrading, which not only optimizes the overall layout of industries in the YREB but also encourages the transformation of the economic structure of the YREB towards an eco-friendly direction.



Figure 1. Map of China with purple shading indicating the non-YREB provinces/municipalities and blue indicating the YREB provinces/municipalities.

As China has entered the middle and late stages of industrialization, the ISU has been a hot topic in theory and practice. First of all, a growing number of research has discovered some connection between green finance (GF) and ISU, along with the development of an eco-friendly economy. Particularly, ISU and GF have entered a stage of differentiated development in several provinces. Secondly, the digital economy and technological revolution are two new carriers of China's ISU [3]. Recently, researchers have started to notice the correlation between environmental regulation and ISU. They argue that environmental regulation itself can directly affect ISU [4]. For example, the government imposes stricter environmental restrictions on high-emission industries, forcing them to carry out industrial renewal and optimization. Additionally, environmental regulation can also actively contribute to green economic growth through multiple stages of pass-through mechanisms [5]. In the context of China having become the world's largest emitter of greenhouse gases [6],

the implementation of low-carbon policies by local governments can also have a positive impact on the ISU [7]. Low-carbon policies force enterprises to embark on technological innovation (TI), thereby promoting continuous ISU.

At present, we find that the research perspectives on the influencing factors of ISU in the latest studies are diverse. However, the research on ISU in the latest studies is usually based on a single perspective. This paper creatively studies the ISU of the YREB from two research perspectives: GF and TI. Meanwhile, the latest research on ISU usually selects a region to be analyzed or analyzes from the perspective of a country. This paper innovatively develops a regional heterogeneity study in order to analyze the ISU of the YREB in a more comprehensive way. It is concluded that GF and TI have different effects on ISU in different regions of the YREB. Additionally, this paper chooses the fixed effects model as the research methodology. The most important reason is that the fixed effects model can explore the mechanisms of GF and TI on ISU more concisely and intuitively. On the basis of the original research method, this paper also adds the mediation effect analysis and regional heterogeneity analysis. In summary, the framework of this paper consists of an introduction, literature review, research design and methodology, empirical study, research conclusions, and corresponding recommendations. It should be noted that the research in this paper not only makes up for the deficiencies in the latest research but also provides a broadening of the theoretical research scope of ISU.

2. Literature Review

2.1. Green Finance and Industrial Structural Upgrading

GF is an essential tool for achieving harmonious growth in terms of environmental protection and economic benefits. Furthermore, according to academic studies, green finance is also an essential tool for promoting rational industrial restructuring and green-oriented economic transformation in China [8]. For instance, some academic scholars have used a social network analysis method to investigate the correlation between GF and ISU [9]. This means that the ISU and GF have reached a stage of differentiated development. Similarly, some scholars have specifically examined the efficiency of the effects of the high-speed development of GF on the restructuring of industrial structures by constructing VAR models and DEA models [10]. From an energy perspective, some scholars argue that GF plays a moderating role, possibly through accelerating the speed of technological innovation in renewable energy [11], thus having a degree of potential impact on the ISU. However, other scholars claim that energy intensity is remarkably decreased with the development of GF. The results of the empirical tests, obtained through the establishment of a mediation model, show that ISU plays a mediating role in this influence process [12].

In sum, theoretical studies on GF and ISU fall into two main categories. On the one hand, some scholars have suggested, through empirical modeling, that GF may have a direct impact on accelerating the pace of ISU. On the other hand, some scholars have concluded that GF may have a potential indirect impact on promoting ISU, through the introduction of relevant mediating, moderating, and regulating variables. The theoretical mechanisms of GF on ISU in the YREB are as follows. First, GF can provide the necessary funds and relevant resource allocation for the restructuring and adjustment of the industrial structure. Further, green finance can also drive the overall industrial value chain in an environment-friendly direction. As such, Hypothesis 1 is proposed.

Hypothesis 1. *GF can significantly contribute to the ISU of the YREB.*

2.2. Technological Innovation and Industrial Structural Upgrading

With the low-carbon transformation of the global economic system, academic studies have discovered that the ISU can have a potential effect on the reduction of carbon emissions. First of all, ISU can directly cut carbon emissions [13]. Additionally, through the mediating influence of TI, ISU can also indirectly lower carbon emissions [2]. Moreover, green technological innovation is an important factor in reducing carbon emissions [14]. The

ISU plays an indispensable role in this process [15]. As China's green economy grows [16], environmental regulations play an indispensable role in the low-carbon transition from industrialisation [17]. Other studies have shown that environmental regulation has obvious externalities on TI [18]. Through exploring technological progress as a mediating variable, the research discovered that formal environmental regulation drove ISU while informal environmental regulation decelerated the rate of ISU [19]. Additionally, the heterogeneous TI acts as a nexus in the process of digital economic sustainability facilitating ISU, which facilitates the construction of clean and intelligent industrial chains [3]. In the discussion and analysis of eco-efficiency in China, it was observed that the ISU had a potentially crucial influence on overall eco-efficiency while technological R&D had a dampening effect on industrial restructuring [20].

In a nutshell, academic research usually concurs that technical advancements and industrial structural upgrading tend to interact and have an impact on one another. Reviewing the previous literature, we find that the following theoretical mechanisms exist for TI and ISU in the YREB. TI itself can have a direct promotional effect on ISU. Secondly, TI can also promote ISU indirectly. It plays a mediating role in the process of other influencing factors impacting ISU. Therefore, Hypothesis 2 is proposed.

Hypothesis 2. *TI can positively contribute to the ISU of the YREB.*

2.3. Green Finance and Technological Innovation

Based on a group of academic research papers, the sustainable development of GF is an indispensable factor in fostering an ever-increasing level of green technology [21]. Against the backdrop of China's world-leading development of digital finance [22], the study finds that green credit has a significant facilitating effect on digital technology innovation [23]. At the enterprise level, green finance may greatly facilitate green innovation and the green development of enterprises in high-carbon sectors [24]. According to mechanistic studies, green finance can not only accelerate the technological progress of enterprises by fully integrating resources and rationally allocating funds but can also promote the technological update iteration of heavily polluting enterprises through appropriate green financial policies [25]. In terms of economics, green finance primarily incorporates the idea of environmental protection into the financial sector. As a result, GF can support sustainable economic growth by encouraging technical innovation to enhance environmental quality [26]. Recent academic study has focused heavily on how to leverage green finance policies to promote technological innovation. As an illustration, research has demonstrated that green fiscal policy can specifically increase enterprises' research investments and promote industrial upgrading, which, in turn, has a positive impact effect on enhancing enterprises' green technological innovation capacities [27]. Furthermore, it has been demonstrated that green tax policy has a dampening effect on the improvement of green technological innovation in the short term. In the long run, it has a significant effect on the improvement of green technological innovation [28].

In other words, technological innovation essentially drives the sustainable development of GF while GF provides the institutional safeguards for it. Specifically, the theoretical mechanism of GF and TI in the YREB is shown below. At the micro level, GF can not only successfully encourage the technological progress of enterprises but can also significantly reduce the expenditures of these enterprises on R&D and technological transformation. At the macro level, GF policies can also strongly promote the technological progress of the whole society. Thus, Hypothesis 3 is proposed.

Hypothesis 3. *GF is able to significantly boost TI in the YREB.*

2.4. The Mediating Role of Technological Innovation

From the viewpoint of technological progress, some scholars have used a GMM model to verify that the development of GF can accelerate the speed of industrial restructuring and optimization. The findings demonstrate that the ISU is positively impacted by control variables, including economic openness, government support, and environmental regulation [29]. From a geographical standpoint, the mediating function of technological innovation has also been researched. For instance, some researchers constructed a panel model using data collected from 78 cities along the Yellow River Basin. The findings demonstrate that both official and informal environmental regulation can have a positive and beneficial impact on industrial restructuring. Additionally, environmental regulation can also indirectly speed up industrial restructuring and transformation by setting technological progress as a mediating variable [4]. The research also finds that the growth and progress of green technology have played, to a certain degree, an intermediary role in the process of GF influencing ISU [30]. Relevant scholars believe that only when the financing scale and subsidy ratio of enterprises in the environmental protection industry exceed a certain critical value, technological progress can play an intermediary role in the process of GF affecting industrial restructuring and transformation [31].

Because of the aforementioned circumstances, TI frequently acts as a mediating factor in academic research into GF and ISU. In light of previous research, the theoretical mechanism of the mediating role of TI is shown below. TI can directly provide development power for ISU. Additionally, TI is also a key mediator of other factors acting on ISU. Hence, Hypothesis 4 is proposed.

Hypothesis 4. *TI plays a partial intermediary role in the process of GF affecting the ISU in the YREB.*

3. Research Design

3.1. Data Source and Sample Selection

This paper selects Anhui, Chongqing, Guizhou, Yunnan, Hunan, Shanghai, Jiangsu, Jiangxi, Sichuan, Hubei, and Zhejiang as the research objects. The research interval is the period from 2011 to 2020. The raw data for this study mainly come from web pages, databases, statistical yearbooks, and statistical bulletins. They are the National Bureau of Statistics, Wind Financial Database, Choice Financial Database, CCER Database, China Science and Technology Statistical Yearbook, China Environmental Statistical Yearbook, China Energy Statistical Yearbook, and China Foreign Direct Investment Statistical Bulletin. Additionally, the linear interpolation approach has been used to fill in a few of the missing data.

3.2. Indicator Selection

3.2.1. Explained Variable: Industrial Structural Upgrading

The industrial structure is one of the most important indicators of a country's level of economic development. As a matter of fact, ISU can not only be beneficial in reducing the unemployment rate in the society but can also help to alleviate environmental and energy problems, which makes ISU very necessary. In the first place, in order to measure the overall industrial restructuring of the YREB more clearly, this study adopts the index of the ISU of the YREB as an explained variable to set up three fixed effects models. Apart from this, on the basis of collating and analyzing the previous literature, this study specifically adopts the final ratio of the gross output value of the tertiary industry divided by the gross output value of the secondary industry of each province (city) along the YREB to represent the index of the ISU of different provinces (cities). As a result, the industrial upgrading index of the YREB from 2011 to 2020 was calculated and collated.

3.2.2. Core Explanatory Variable: Green Finance

This paper specifically constructs a GF evaluation system from three aspects: green investment, green support, and carbon finance (Table 1). Secondly, this paper adopts

the entropy value method to assign objective weights to each indicator and the sum of the total weights is 1. A larger proportion of weight means that the indicator has a greater impact on GF and vice versa. Following that, the values of each indicator and the corresponding weights are multiplied and the obtained values are summed up, which results in a comprehensive green finance index. Additionally, the development of GF is impacted differently by several indicators. The sustainable development of GF is prompted to grow by positive indicators, while the ongoing development of GF is hampered by negative ones. Therefore, this paper deliberately labels green investment as a negative indication, green support as a positive indicator, and carbon finance as a positive sign before calculating the weight of each indicator. In the end, the proportion of green investment is 15.44%, the proportion of carbon finance is 60.20%, and the proportion of green support is 24.36%.

Table 1. Green finance evaluation system.

Primary Indicator	Computational Method	Attribute	Weight
Green support	Environmental protection expenditure/Fiscal general budget expenditure	+	24.36%
Carbon finance	RMB loan balance/Carbon dioxide emissions	+	60.20%
Green investment	Industrial pollution control completed investment/Regional gross domestic product	−	15.44%

3.2.3. Mediator Variable: Technological Innovation

In previous studies, technological innovation has been measured in a variety of ways, including the proportion of R&D personnel, the size of contracts in the technology market, and the number of patent applications filed per year, etc. In actual practice, the factors affecting the output of R&D in technology are complex and the transformation cycle of research outcomes in technology is relatively long. Consequently, this study chooses the indicator of technological innovation input to accurately assess the capacity of technology development and technology utilization in 11 provinces (cities) along the YREB. Specifically, this study uses the ratio of experimental internal expenditure on research and development (R&D) funding to gross domestic product (GDP) to evaluate the region's capacity for technology development and technology utilization.

3.2.4. Control Variables

In this paper, various variables that may affect ISU are used as control variables to explore the mechanism of action between GF, TI, and ISU. As Table 2 shows, there are six main indicators of control variables in this study, which are government intervention, urbanization level, capital investment level, opening up level, energy consumption level, and education level.

3.3. Research Methods

This study mainly adopts the entropy value method to measure the indicators in the green finance evaluation system. The entropy value method is a method of objectively allocating the weights of each indicator. Moreover, the sum of all the weights is 1. Therefore, it is mainly used to provide a calculation basis for the related comprehensive evaluation system. In the green financial evaluation system, if the effect of an indicator on green finance is smaller, the weight of this indicator based on the calculation will also be smaller and vice versa. In summary, the core calculation steps of the entropy value method mainly include the following five steps.

Table 2. Variable symbols and definitions.

Name	Symbol	Definition
Industrial structural upgrading	ISU	Gross Tertiary Sector/Gross Secondary Sector
Green finance	GF	Entropy method calculation
Technological innovation	TI	Research and experimental development funds internal expenditure/GDP
Government intervention	GI	Local fiscal expenditure/GDP
Urbanization level	UL	Urban population/Regional total population
Capital investment level	CI	Fixed asset investment/GDP
Opening up level	OL	Foreign direct investment/GDP
Energy consumption level	EC	Total energy consumption/GDP
Education level	EL	$(6 \times \text{number of pupils in primary school} + 9 \times \text{number of pupils in lower secondary school} + 12 \times \text{number of pupils in upper secondary school} + 16 \times \text{number of pupils in university})/\text{total number of people}$

3.3.1. Data Standardization Processing

This study standardizes each indicator to remove the impact of various measurement units of various indicators. However, different processing formulas were used as different normalization methods were applied to the positive and negative indicators:

$$\text{Positive Indicator : } Y_{ij} = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})} \quad (1)$$

$$\text{Negative Indicator : } Y_{ij} = \frac{\max(X_{ij}) - X_{ij}}{\max(X_{ij}) - \min(X_{ij})} \quad (2)$$

i represents each region, j represents each index, and Y_{ij} is the initial value of the j index in the i region.

3.3.2. Calculation of Indicator Weights

$$P_{ij} = \frac{Y_{ij}}{\sum_{i=1}^n Y_{ij}} \quad (3)$$

P_{ij} represents the sample weight of the j index in the i region.

3.3.3. Calculation of Indicator Information Entropy

$$E_j = -(\ln n)^{-1} \sum_{i=1}^n P_{ij} \ln(P_{ij}) \quad (0 \leq E_j \leq 1) \quad (4)$$

E_j represents the entropy value calculated by the j index.

3.3.4. Calculation of Indicator Weights

$$G_j = 1 - E_j \quad (5)$$

$$W_j = \frac{G_j}{\sum_{j=1}^m G_j} \quad (6)$$

G_j represents the difference coefficient and W_j represents the final weight of the j index.

3.3.5. Calculation of Final Score

Finally, this research adopts the method of linear weighting and summing, in which the standardized value of each index is first multiplied by the corresponding weight to

obtain the value and, then, the obtained values are summed up. The final summed value is the green finance composite index of the YREB.

$$S_i = \sum_{j=1}^m X_{ij}W_j \quad (7)$$

3.4. Model Setting

The fixed effects model (FEM) is a modeling approach to data analysis that is mainly applied to panel data. The FEM is the opposite of the random effects model; its true effects do not change arbitrarily. In order to clearly investigate the influence mechanism between GF, TI, and ISU in the YREB, this study constructs four fixed effects models, as shown below:

$$CY_{it} = \alpha_0 + \alpha_1 GF_{it} + \alpha_i Control_{it} + \lambda_i + \varepsilon_{it} \quad (8)$$

$$CY_{it} = \beta_0 + \beta_1 TH_{it} + \beta_i Control_{it} + \lambda_i + \varepsilon_{it} \quad (9)$$

$$GF_{it} = \gamma_0 + \gamma_1 TH_{it} + \gamma_i Control_{it} + \lambda_i + \varepsilon_{it} \quad (10)$$

$$CY_{it} = \delta_0 + \delta_1 GF_{it} + \delta_2 TH_{it} + \delta_i Control_{it} + \lambda_i + \varepsilon_{it} \quad (11)$$

Specifically, subscript i represents the province (city) ($i = 1, 2, 3, \dots$), subscript t represents the year ($t = 2011, 2012, 2013, \dots$), CY_{it} represents the regional industrial structure upgrading, GF_{it} represents the regional green financial development composite index, TH_{it} represents the regional technological innovation, $Control_{it}$ represents the relevant control variables, λ_i represents the inclusion of individual fixed effects, and ε_{it} represents random error terms. In addition, Model (1) is used to explore the link between GF and ISU in the YREB; Model (2) is used to explore the link between TI and ISU in the YREB; Model (3) is used to explore the link between TI and GF along the YREB; and Model (4) is mainly used to work out whether there is a mediating effect between GF, TI, and ISU in the YREB.

4. Analysis of Empirical Results

4.1. Descriptive Analysis

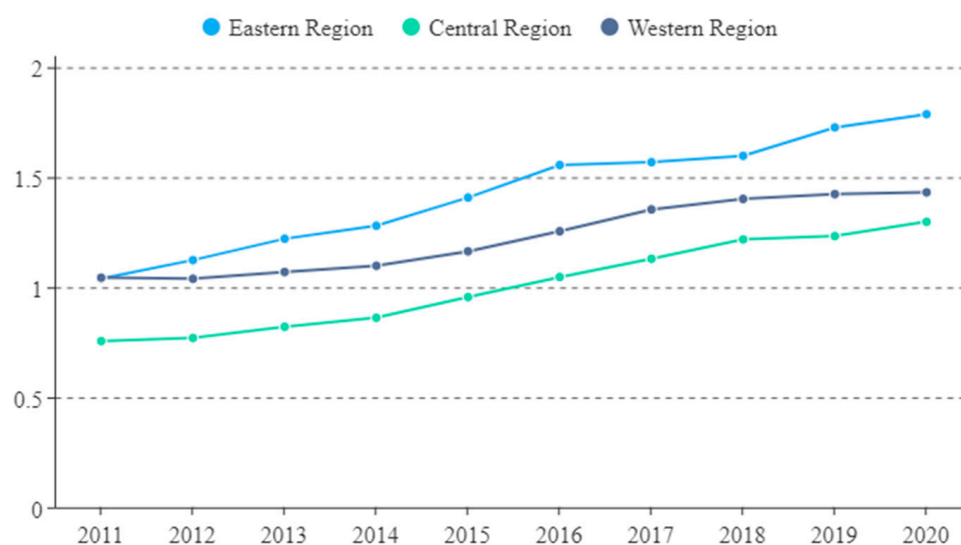
The collected panel data were collated and analyzed to obtain a descriptive analysis (Table 3). We can conclude that the overall sample size is 110 and the standard deviation of each index is small. This conclusion shows that the overall development gap between the 11 provinces (municipalities) along the YREB has continued to diminish; the corresponding data dispersion is also smaller. In detail, the minimum value of the ISU is 0.619 for Jiangxi Province in 2011. Its maximum value is 2.788 for Shanghai in 2020. The minimum value of the GF is 0.167 for Guizhou Province in 2011. Its maximum value is 1.686 for Shanghai in 2020. The minimum value of the TI is 0.006 for Yunnan Province in 2011. Its maximum value is 0.041 for Shanghai in 2020. Among them, we can conclude that in the eastern region along the YREB, the provinces (cities) with stronger economic power are usually at the leading level in ISU, GF, and TI. On the other hand, the western provinces (cities) along the YREB with less developed economies tend to have lower levels of ISU, GF, and TI. It should be noted that Shanghai's 2020 values for ISU, GF, and TI are the largest in the overall sample. This indicates that Shanghai not only has the highest economic strength but also leads in ISU, GF, and TI.

Table 3. Descriptive analysis.

VarName	Observations	Minimum	Maximum	Mean	Standard Deviation	Median
CY	110	0.619	2.788	1.204	0.399	1.152
GF	110	0.167	1.686	0.698	0.356	0.640
TH	110	0.006	0.041	0.018	0.008	0.017
Gov	110	0.121	0.409	0.222	0.067	0.210
City	110	0.350	0.896	0.580	0.134	0.557
Capital	110	0.211	1.153	0.760	0.231	0.804
FDI	110	0.000	0.060	0.006	0.009	0.003
EC	110	0.306	1.615	0.561	0.220	0.508
ECO	110	7.589	11.429	8.990	0.809	8.948

In this paper, all of the provinces (cities) along the YREB are classified into three regions, namely, the eastern, central, and western. They are classified primarily on the basis of geographic location. The purpose is to further explore and more intuitively summarise the laws that exist between ISU, GF, and TI. Furthermore, average trend line charts for TI, GF, and ISU are also drawn in this research. It should be noted that the eastern region of the YREB includes three provinces: Zhejiang, Jiangsu, and Shanghai. Then, Hunan, Anhui, Hubei, and Jiangxi are the four provinces that make up the YREB's center section. Finally, Yunnan, Sichuan, Chongqing, and Guizhou are the four provinces that make up the western portion of the YREB.

Figures 2–4, respectively, show the line graphs of ISU, the line graphs of GF, and the line graphs of TI in the provinces (cities) along the YREB during the period from 2011 to 2020. By analyzing the data, we can clearly observe that the YREB as a whole shows remarkable improvements in the three indicators of ISU, GF, and TI. The results show that the comprehensive strength of the YREB has been significantly enhanced in the last decade, accompanied by the government's continuous implementation of the development strategy of the YREB. Secondly, by comparing and analyzing the three regions of the YREB, it can be concluded that the ISU, GF, and TI of the eastern region as a whole are the highest among the three. The reason for this conclusion is the result of a number of factors; however, further empirical modeling is needed to verify the influence mechanism between ISU, TI, and GF. Furthermore, the eastern area of the YREB has the lowest level of both ISU and GF. Yet, the western part of the YREB is at the lowest level of TI. As a consequence, we can conclude that the western region needs to continuously strengthen its TI capabilities. But, the central region not only needs to coordinate the development of GF and the ISU but also needs to shorten the development gap between itself and the two other regions.

**Figure 2.** ISU in the YREB.

4.2. Hausman Test

The Hausmann test is used to test whether the individual or time effects of a model are correlated with the explanatory variables. Thereby, the Hausman test could be applied to determine whether a fixed or random effects model should be chosen for this paper. The results are shown in Table 4. Among them, $\chi^2(5) = 17.571$, $p = 0.014 < 0.05$. As a result, this paper chose the fixed effects model.

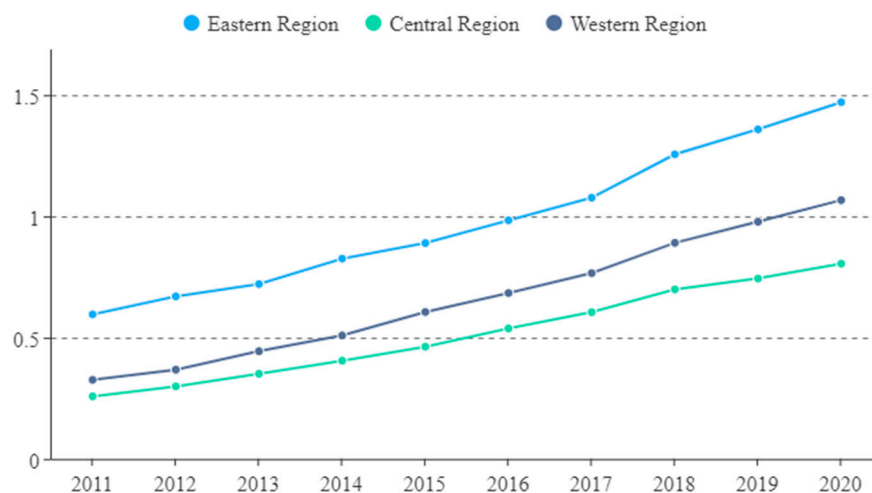


Figure 3. GF in the YREB.

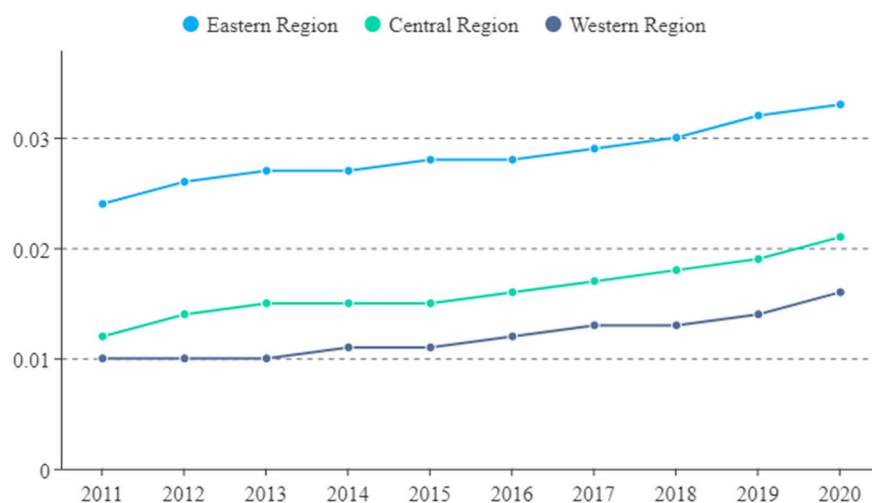


Figure 4. TI in the YREB.

Table 4. Hausman test results.

Variables	(b) Fixed Effects Model	(B) Random Effects Model	(b − B) Regression Coefficient Difference	(b − B)' [(V _b − V _B) ^{−1}] (b − B)
GF	0.441	0.412	0.028	$\chi^2(5) = 17.571, p = 0.014$
TI	38.176	31.485	6.691	
GI	1.804	3.450	−1.646	
UL	−1.350	−0.593	−0.757	
CI	−0.034	−0.236	0.202	
OL	4.640	4.005	0.635	
EC	−0.427	−0.483	0.056	
EL	−0.045	−0.046	0.001	

4.3. Fixed Effects Test

This paper mainly used stata17.0 software as a tool to empirically investigate the influence mechanism between GF, TI, and ISU by using a fixed effects model. Among them, the individual effects in this paper were fixed and the time effects were not fixed. Table 5 shows the regression results output by stata17.0.

Table 5. Regression results of green finance, technological innovation and industrial structure upgrading.

	(1)	(2)	(3)	(4)
	ISU	ISU	TI	ISU
GF	0.7292 *** (8.7992)		0.0082 *** (9.9654)	0.4193 *** (3.7646)
TI		64.0896 *** (8.8670)		37.6487 *** (3.8621)
GI	2.3542 *** (2.8402)	2.2899 *** (2.7643)	0.0139 * (1.6781)	1.8322 ** (2.3362)
UL	−0.4938 (−0.8073)	−0.9287 (−1.4485)	0.0218 *** (3.5771)	−1.3148 ** (−2.1612)
CI	0.0240 (0.1180)	−0.4078 ** (−2.2467)	0.0027 (1.3353)	−0.0778 (−0.4071)
OL	5.3678 *** (3.0245)	4.9743 *** (2.8083)	0.0096 (0.5409)	5.0076 *** (3.0226)
EC	−0.2825 * (−1.7342)	−0.7770 *** (−5.1950)	0.0053 *** (3.2592)	−0.4818 *** (−3.0044)
EL	−0.0638 * (−1.9226)	−0.0311 (−0.9381)	−0.0005 (−1.3855)	−0.0465 (−1.4895)
_cons	1.1392 **	1.0788 **	−0.0045	1.3086 ***
Individual fixed effect	YES	YES	YES	YES
Time fixed effect	NO (2.4922)	NO (2.3803)	NO (−0.9877)	NO (3.0556)
N	110.0000	110.0000	110.0000	110.0000
r2	0.8492	0.8503	0.8847	0.8705
r2_a	0.8214	0.8226	0.8634	0.8449
F	74.0394 ***	74.6557 ***	100.8804 ***	76.4482 ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.3.1. Green Finance and Industrial Structural Upgrading

Model (1) takes ISU as an explained variable. Meanwhile, it takes GF as an explanatory variable. The remaining variables are control variables. The model is used to clarify how GF affects the ISU. The result shows a coefficient of 0.7292 for GF. It passes the 1% significance test. From this, it can be concluded that GF has an effective driving effect on the ISU. In other words, the sustainable development of GF will greatly accelerate the pace of ISU. GF can directly guide financial resources to be continuously invested in green industries and projects, thereby alleviating environmental problems. In addition, GF is also conducive to promoting the ISU, thus accelerating the transformation of the entire industrial scale towards modernization. As such, the result of Model (1) confirms Hypothesis 1.

4.3.2. Technological Innovation and Industrial Structural Upgrading

Model (2) takes ISU as an explained variable and TI as a key explanatory variable. The remaining variables are control variables. The model aims to investigate whether there is an impact effect of TI on the ISU. According to the results, we can conclude that technological innovation has a regression coefficient of 64.0896. It passes the 1% significance test. This data point reveals that TI has a remarkable positive correlation with ISU. Continuous innovation and progress in the field of technology are vital driving forces for upgrading the whole industrial chain. Only by breaking through the key technological barriers, the industrial structure can realize the renewal iteration in the real sense. Therefore, TI has

played a proactive role in promoting the ISU. As a result, the result of Model (2) validates Hypothesis 2.

4.3.3. Green Finance and Technological Innovation

Model (3) takes TI as an explained variable. Also, this model takes GF as an important explanatory variable. The remaining variables are control variables. As a matter of fact, the purpose of the model is to test whether there is an influence mechanism between the two variables, TI and GF. According to the regression output, we can find that the coefficient for GF is 0.0082. It passes the 1% significance test. From this result, we can conclude that GF can positively contribute to TI, to a certain extent. For one, the green industry is able to lower its production costs and simplify its production processes through TI, thus promoting the expansion of the scale of the green industry. Meanwhile, TI can also powerfully push the ISU, thus forcing the development of GF. In short, TI not only serves as the cornerstone of green financial development but also as the source of power for the sustainable development of GF. Therefore, the result of Model (3) confirms Hypothesis 3.

4.3.4. Mediating Effects of Technological Innovation

Model (4) takes GF and TI as two important explanatory variables. Simultaneously, this model also takes ISU as an explained variable. The rest of the variables serve as controls. This model is used to figure out the role played by TI in both ISU and GF. The regression output displays that TI has a coefficient of 37.6487 and GF has a coefficient of 0.4193. They both passed the 1% significance test. The above-mentioned results suggest that GF and TI simultaneously have a notably positive impact on the ISU. What is more, it is worth noting that the coefficient of GF in Model (1) is 0.7292. However, the coefficient of GF in Model (4) is 0.4193. Both coefficients pass the 1% significance test. Nevertheless, the latter coefficient is clearly much lower than the previous one. Based on the use of the comparative analysis method, this study found that the only factor influencing the difference between the regression coefficients of the two models is the explanatory variable of TI. From this, we can conclude that TI serves as an intermediary in this process of GF influencing the ISU. For one thing, TI can comprehensively transform and modernize the traditional industrial chain. Regarding the other thing, GF can encourage TI in the direction of protecting the environment and improving efficiency; this green technological progress will further promote industrial structure optimization. Consequently, the results of Model (4) support Hypothesis 4.

4.4. Robustness Test

This paper chooses to lag the core explanatory variables by one period for regression analysis. The purpose is to test the stability of the four previous fixed effects models. The results are presented in Table 6. First of all, the table shows that the coefficient of GF in Model (1) is 0.7426. It passes the 1% significance test. This result indicates that GF can favorably contribute to the ISU. That means GF can positively promote the ISU. In conclusion, Hypothesis 1 is valid. Secondly, Model (2) passes the lag one-period test for TI. The coefficient of TI is 61.9743. It passes the 1% significance test. In fact, it is significant. The result suggests that the ISU can be greatly aided by TI. In summary, Hypothesis 2 is valid. Next, Model (3)'s lagged one-period GF coefficient, which is equal to 0.0082 and passes the 1% significance test, is also significant. According to this discovery, green finance can considerably foster technological innovation. In conclusion, Hypothesis 3 is valid. Finally, the lagged one-period green finance coefficient of Model (4) is 0.5455. It is lower than the green finance coefficient of Model (1), which is 0.7426. Simultaneously, it passes the 1% test of significance. This result indicates that TI plays a partial mediating role in the process of GF significantly contributing to the ISU. Given this, all of the previous fixed effects regression models have passed the one-period lag stationarity test of the core explanatory variables.

Table 6. Stability test.

	(1)	(2)	(3)	(4)
	ISU	ISU	TI	ISU
L.GF	0.7426 *** (9.4147)		0.0082 *** (10.3247)	0.5455 *** (4.8021)
L.TI		61.9743 *** (7.7327)		24.7462 ** (2.3532)
GI	2.4746 *** (3.0358)	2.8102 *** (3.1498)	0.0120 (1.4713)	2.2245 *** (2.7795)
UL	−0.4529 (−0.7685)	−0.1311 (−0.2021)	0.0246 *** (4.1638)	−0.7898 (−1.3361)
CI	0.0916 (0.4790)	−0.3553 * (−1.8337)	0.0015 (0.7593)	0.0192 (0.1019)
OL	4.0720 ** (2.4596)	2.6589 (1.4622)	−0.0010 (−0.0576)	3.5937 ** (2.2132)
EC	−0.3633 ** (−2.2119)	−0.7501 *** (−4.3668)	0.0052 *** (3.1695)	−0.4534 *** (−2.7587)
EL	−0.0309 (−1.0356)	−0.0049 (−0.1484)	−0.0003 (−0.9156)	−0.0178 (−0.6026)
_cons	0.8358 * (1.8313)	0.3055 (0.6241)	−0.0056 (−1.2179)	0.7757 * (1.7438)
N	99.0000	99.0000	99.0000	99.0000
r2	0.8656	0.8381	0.8926	0.8743
r2_a	0.8374	0.8041	0.8701	0.8461
F	74.5509 ***	59.9084 ***	96.1948 ***	69.5785 ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5. Analysis of Regional Heterogeneity

5.1. Regional Heterogeneity Analysis of Green Finance and Industrial Structural Upgrading

This paper analyzes the regional heterogeneity of GF and ISU (Table 7). The output reveals that the GF coefficient for the eastern region is 0.5588. It has passed the 1% test of significance. It follows from this that the positive correlation between GF and ISU is most significant in the eastern part of the YREB. Nevertheless, the western area's coefficient is 0.1764. The central area's coefficient is −0.2066. Neither one passes any significance test. Summarising the above analysis, this paper concludes that the impact effect of GF on ISU in the other two regions of the YREB other than the eastern region is insignificant in comparison. Correspondingly, GF in the eastern region with a strong economic foundation has a very pronounced positive effect on the ISU. Above all, the GF system in the economically developed regions in the east is more mature and the economic strength is more powerful, which can better coordinate the development of GF and the ISU. Subsequently, the central region lacks a good ecological system and the western region lacks sufficient technology and talent. These are not conducive to the formation of a virtuous circle in which GF and ISU promote each other in the western and central areas. Therefore, there is a certain regional heterogeneous development between GF and the ISU in the YREB.

5.2. Regional Heterogeneity Analysis of Technological Innovation and Industrial Structural Upgrading

This paper analyzes the regional heterogeneity of both TI and ISU in the YREB (Table 8). The output implies that the coefficient of TI in the eastern part of the YREB is 48.2347. It passes the 1% significance test. From this, it can be concluded that the TI in the eastern part of the YREB has a positive correlation with the ISU. In the opposite manner, the regression coefficient of TI in the central region was −15.8321, which passes the 10% significance test. Thus, TI in the central part of the YREB has a more pronounced negative impact on the ISU. Nevertheless, the regression coefficient for TI in the western region is −12.7219. It did not pass any test of significance. This finding means that there is no obvious correlation between ISU and TI in the western part of the YREB. In brief, TI in the eastern part of

the YREB can be beneficial in contributing to the ISU while the TI in the central region has a more pronounced negative effect on its ISU. Additionally, the enhancement of the technological innovation capacity in the western region does not have a clearly influential effect on the ISU. Developed eastern regions often have a large number of scientific research talents, advanced R&D machinery and equipment, and abundant financial support. This is conducive to the formation of a mature TI system in the eastern region so as to contribute to the transformation of the overall industrial chain. However, the industrial structure of the central region is dominated by traditional heavy industry, with a weaker capacity for independent innovation and less investment in TI. The western region not only lacks the necessary talents and technologies but the industry as a whole is at the middle and lower end of the scale. All in all, there is a certain degree of regional heterogeneity between TI and the ISU in the YREB.

Table 7. Regression results of green finance and industrial structure upgrading.

	Eastern	Central	Western
	ISU	ISU	ISU
GF	0.5588 *** (3.3203)	−0.2066 (−1.1961)	0.1764 (1.4766)
GI	−0.1253 (−0.0581)	0.4502 (0.4680)	2.9752 *** (3.5231)
UL	−4.7951 *** (−6.3739)	5.4216 *** (6.9962)	4.0229 *** (3.8638)
CI	−0.3287 (−0.7279)	−0.5671 *** (−3.3962)	0.3852 * (1.9216)
OL	3.3465 (1.6884)	0.8476 (0.1225)	−0.4112 (−0.0973)
EC	−2.4999 *** (−4.2835)	−0.4173 ** (−2.6060)	0.4954 *** (2.8420)
EL	−0.0525 (−1.5695)	−0.0503 (−1.2714)	0.1095 * (1.7699)
_cons	6.1708 *** (8.9407)	−0.7183 (−1.1753)	−3.3293 *** (−3.9438)
N	30.0000	40.0000	40.0000
r2	0.9674	0.9696	0.9138
r2_a	0.9527	0.9592	0.8840
F	84.7035 ***	132.2502 ***	43.8906 ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 8. Regression results of technological innovation and industrial structure upgrading.

	Eastern	Central	Western
	ISU	ISU	ISU
TI	48.2347 *** (3.8810)	−15.8321 * (−1.9840)	−12.7219 (−0.8996)
GI	1.7794 (1.0440)	0.7141 (0.7688)	3.2053 *** (3.7082)
UL	−3.8421 *** (−5.4497)	5.9465 *** (7.6937)	6.1732 *** (5.5223)
CI	−1.0301 *** (−2.8464)	−0.5890 *** (−3.6582)	0.2964 (1.4785)
OL	2.5146 (1.4839)	−1.4634 (−0.2150)	0.4027 (0.0918)
EC	−2.6093 *** (−5.3702)	−0.2372 (−1.5398)	0.6936 *** (3.4528)
EL	−0.0547 * (−1.7625)	−0.0405 (−1.0924)	0.1488 ** (2.3709)
_cons	4.7436 *** (5.5774)	−1.0620 (−1.6968)	−4.5910 *** (−5.3643)
N	30.0000	40.0000	40.0000
r2	0.9711	0.9719	0.9098
r2_a	0.9581	0.9623	0.8787
F	96.0984 ***	143.4803 ***	41.7783 ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

6. Conclusions and Recommendations

6.1. Conclusions

Taking the perspective of TI and GF, this paper launches a series of studies on the influence mechanism of GF, TI, and ISU in the YREB. Moreover, the paper also deeply analyzes the role of TI in the whole mechanism. To start with, the research objective of this paper is to figure out what mechanism exists between TI, GF, and ISU in the YREB. The research conclusions include the following three points. Firstly, both GF and TI can significantly promote the ISU of the YREB. Additionally, GF can also promote TI to a certain extent. Second, TI acts as a partial intermediary in the process of GF actively promoting ISU. In other words, green finance can act as an intermediary by enhancing technological innovation capacity so as to effectively accelerate the ISU of the YREB. Third, this paper discovers that GF in the eastern part of the YREB can significantly promote ISU while others have no discernible impact effects. Similarly, TI in the eastern part of the YREB can also significantly promote ISU. In contrast, TI in the central region inhibits ISU to a certain extent while there is no obvious effect in the western region. In view of this, we put forward targeted practical recommendations based on the research conclusions. First, the Chinese government should encourage more people to participate in the green financial market through favorable policies and reasonable mechanisms to improve the green financial market so as to promote the healthy development of GF in the YREB. The development of GF in the YREB lays a solid foundation for the ISU. Second, the Chinese government needs to actively introduce scientific research talents and increase investment in scientific research so as to continuously enhance the TI capacity of the YREB. Enhancing the TI capacity of the YREB is a very important driving force for the ISU. Third, the Chinese government should formulate different policies for different regions to promote ISU based on the development advantages and geographical differences of different regions in the YREB.

In summary, this paper aims to investigate what kind of influence mechanism exists among GF, TI, and ISU in the YREB. First of all, the conclusions of this paper provide practical guidance for the comprehensive upgrading of the industrial structure and the strategic adjustment of the economic structure of the YREB. Secondly, the findings of this paper can also be actively expanded to other similar economic regions. For example, policymakers can refer to the findings of this paper when formulating policies related to GF and ISU. Additionally, scholars can also refer to the research perspective and methodology of this paper when they investigate GF or ISU in other similar economic regions. Looking ahead, relevant research can not only further explore and discover other influencing factors on ISU through other research methods but can also explore the reasons for the differentiated development of industrial results among different regions.

6.2. Recommendations

- (1) The Chinese government should quicken the pace of development of GF, thereby actively promoting the ISU of the YREB. In reality, heavy industrialization makes up a disproportionately large share of the YREB's industrial structure. Faced with this situation, the Chinese government should actively utilize the regulating function of the financial industry to allocate more resources to high-efficiency, low-energy-consuming green industries, thereby promoting the ISU of the YREB in an environment-friendly manner. To begin with, the government can encourage more investors and financial institutions to participate in the GF market through more favorable tax and fiscal policies, thus attracting more participants to the GF market. Alternatively, the government may also provide financial subsidies to incentivize financial institutions to launch diversified green financial products so as to expand the market scale of GF;
- (2) The Chinese government needs to increase its financial investment in TI. The government also needs to strengthen the coordinated development between TI and ISU. TI is the core driver of ISU. In actuality, the YREB has significant potential for technological development because it is home to nearly half of the nation's academics and technological R&D personnel as well as 1/3 of the nation's research institutes

and universities. In order to construct a new pattern of the coordinated development of industry and technology in the YREB, the Chinese government should increase financial investment in TI in the region, improve incentive policies for technological innovation, and actively introduce technical talents;

- (3) The Chinese government should formulate regional development strategies that take into account local conditions and encourage each region to aggressively develop its competitive industries. In reality, the YREB's various areas have varying resource endowments and development advantages. Additionally, the YREB's eastern region has advanced significantly in terms of ISU while the central and western parts have lagged somewhat. As a result, the YREB's eastern region enjoys both geographic and scale advantages. It should prioritize the development of industries at the top of the value chain rather than just concentrating on inventing new technologies and developing new products. Comparatively, the YREB's central and western areas have a comparative advantage in terms of the labor force. Firstly, the central and western regions should vigorously pursue GF and TI. Secondly, the central and western areas should seize the chance to absorb the industrial spillover and transfer from the developed eastern regions and, then, gradually form and develop their advantageous industries.

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