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Green Investment, Technological Progress, and Green Industrial Development: Implications for Sustainable Development

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Abstract: Environmental reformation of old-fashioned sectors and the establishment of new pro-ecological businesses via green investment are the main driving forces behind the revolution in the Chinese industrial sector. Green investment aids in the growth of environmentally friendly industries. Hence, the primary objective of the analysis is to investigate the impact of green investment and technological progress on green industrial development. The results of the unit root tests encourage us to apply the ARDL model. The short and long-run estimates attached to R&D expenditures are positively significant, confirming that increasing R&D expenditures help improve the industrial structure. Similarly, the short and long-run estimates attached to green finance investment are positively significant, signifying that green investment benefits the industrial structure. Empirical findings show that technology significantly aggravates industrial structure development in only the long run. Thus, for green industrial development in China, there is a need to increase green investment and technological development up to top-level design.

Keywords: green investment; technology; green industrial development; sustainable development; China

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1. Introduction

A green economy is the essence of sustainable development of the environment and the economy. From the environmental protection perspective, green economy development will help industrial society to comprehend the energy revolution in the process of consumption, circulation, and production so that the high emissions, high pollution, and energy intensity can be controlled [1]. From the economic development perspective, the green revolution can efficiently promote the growth process of regulating and stabilizing growth and economic structure. Moreover, the International Labor Organization (ILO) denoted that green economic transformation can significantly add approximately 60 million new jobs throughout the world. Thus, all economies around the globe are devoted to developing a green economic structure. For example, the EU launched a green economic development plan in 2009 and invested a huge amount to finance this plan. The Obama administration introduced the Reinvestment Act in 2009 and facilitated the development of renewable energy projects to increase energy efficiency. The Chinese government always tries to explore an effective model to develop a green economy and promote sustainable growth and economic development [2,3]. The Chinese government initially financed the development of the renewable energy industry but cannot fulfill the need for sustainable growth [4].

The United Nations Environment Programme (UNEP) specifies that financing is the main hurdle in the way to stimulating green economy transformation. Green investment is considered the main channel to finance green projects and structure a green financial system. Due to sustainable development and green economy practices, green investment has become a fundamental financial policy, such that financial leverage can be utilized to affect industrial structure development [5,6]. Additionally, green investment can control environmental pollution by introducing green energy technology [7,8]. In this context, financial institutions recognize the function of upgrading and optimizing industrial structure through green investment [9]. Thus, the economies should guide the circulation and allocation of capital in the industrial sector through the enactment of financial policies and improvement in proficiency of resource allocation by enhancing the green investment in sunrise industries, and promoting the upgrading and adjustment of industrial structures [10,11].

There is no standard definition of green investment; thus, the concept of green investment needs to be defined clearly. From the macroeconomic point of view, Eyraud et al. [12] described green investment as a kind of investment that is necessary to reduce CO_2 emissions and GHG emissions; thus, green investment is often called ecological investment and environment security investment. From the microeconomic perspective, green investment is associated with corporate environmentalism and green management, and it enhances the financial expenditures of the company on environmental governance that can be considered a special practice in the field of corporate social responsibility [13,14]. Ates et al. [15] described green investment as an investment that involves environmental design, logistics, and production. Voica et al. [16] defined it as the investment that is required for climatic changes and clean and renewable energy projects. In the narrow sense, green investment is such an investment that is required for environmental protection. While in a broader sense, green investment considers various aspects of society, the economy, and the environment.

Green technologies proved to be a catalyst in achieving green economic growth, whereas promoting clean and green technologies also help to reduce carbon emissions [17]. In order to effectively curb CO_2 emissions, promoting technical efficiency can play a crucial role [18], and this implication also finds its support in the current literature [19] alongside the role of technologies concerning renewable energy in improving environmental quality [20] which are significant in increasing the production of green energy that exerts less burden on the natural resources and consequently helps to control further damage to the environment. Hence, green innovation has emerged as one of the most critical factors in promoting energy efficiency, eventually lowering the demand for energy and CO_2 emissions [21]. Technological progress has long-lasting effects on green industrial development.

The key factor behind industrial structure development in China is the green upgrading of outdated industries and the creation of new eco-friendly industries via green investment [22]. Green investment supports eco-friendly industrial development. Green investment imposes limitations on loans to high-pollution and high-energy-consuming enterprises. It helps accelerate the upgrading and transformation of industrial structures, promotes the reorganization and merging of pollution-emitting enterprises, and comprehends the twofold development of technology and industries [23,24]. The green investment policies are conducive to the development of the affordability of banks, which enables them to attain green profits and enhance their ability to achieve environmental sustainability [25,26]. Green investment can enhance the reputation of financial institutions and meet the requirements of investors. Green investment helps the organization to make suitable decisions about growth and to better handle operational risks in order to achieve profit [27].

Very limited empirical research has been performed on the nexus between green credit and the upgrading and development of the industrial structure. Xu and Li [28] examined the effect of green credit on industrial development and concluded that green credit updates the industrial structure up to a significant level. Zhu [29] explored the impact of green credit on industrial structure development and concluded that it promotes industrial structure development up to a certain extent. Li et al. [30] investigated the impact of green credit on the secondary and tertiary level industries and found that green credit significantly promotes overall industrial structure. Cheng et al. [31] explored the utilization of energy efficiency and concluded that the current level of energy input is overused.

The existing studies have inspected the role of green credit; however, the empirical analysis of the impact of green investment and technology on industrial structure development is not developed yet [32,33]. It is worth mentioning that the current stock of literature has not clearly defined the concept of green investment. Moreover, the existing literature fully neglects the role of green investment in industrial structure development [34]. In this regard, this study is the first one examining the impact of green investment on industrial structure development in China. China is one of the biggest CO_2 emitters in the world and has become a leader as well in taking climatic actions. China's pollution control investment is also growing at a large scale, as the investment has increased from 116.6 billion yuan to 953.9 billion yuan from 2000 to 2017 [35]. This demonstrates that China is fully determined to control environmental pollution.

In China, the problems of extreme energy use and severe ecological degradation have gained more and more attention. According to the BP [36], China's energy requirement amounted to 24.3% of worldwide consumption and more than 75% of total global demand in 2019, making it the most significant driver of the world's energy markets. The Chinese economy has seen remarkable growth since the country's reforms and liberalization. Since 1999, attempts at 'eco-industrial' growth have been funded by the State Environmental Protection Administration (SEPA) in order to promote 'eco-industrial' efforts in China. The "primary, secondary, tertiary" industrial structure of China has progressively given way to the "tertiary, secondary, primary" structure. The system still has several issues, nevertheless, including a low internal level, an illogical division between primary, secondary, and tertiary industries, a disproportionately large share of industries that pollute and use a lot of energy, and more [37]. In addition to creating major environmental issues such as smog and climate change, the economy's fast growth may adversely impact the sustainable future of China [38].

Green finance is a key factor in restructuring the economy and the industrial sector because the environmental effects are considered in green finance [39]. This is so that environmentally friendly enterprises may obtain the economic and social means they need to grow while preventing the "two high and one excess" sector from expanding by chopping off its funding source. Thus, green finance might be utilized to improve the industrial structure, maximize resources, and eventually create a resource- and environmentally friendly society [40]. Additionally, it is crucial to investigate how green financing affects industrial reasonability. Just like green finance, the development of the industrial structure has been aided by technical advancement, which has simultaneously driven weaker and stronger evolutionary paths. Although the influence of technological innovation on industrial transformation has been steadily growing, its orientation seems to swing back and forth between positive and negative. The encouragement of technical innovation by industrial growth has led to a tendency of dynamic changes going from weak to powerful.

Various studies have identified various determinants of industrial development, such as economic growth and renewable energy consumption [41–45]. However, no study has been done on the impact of green investment on green industrial development in the context of China. There are also scarce studies that found technological progress's impact on green industrial development. The empirical literature is found to be completely silent about the simultaneous impact of green investment and technological progress on green industrial development in China. Several gaps have been identified in the existing literature. Firstly, previous studies on green industrial development did not incorporate green investment in analysis. However, green investment is the core determinant of green industrial development. Secondly, none of the previous studies have considered the role of technological progress in green industrial development and did not incorporate technological progress variables in the model framework. Previous studies have focused on long-run estimates; however, the current study is providing short-run estimates as well.

To fill all these gaps, an up-to-date comprehensive study is required that can explore the influence of green investment and technological progress on green industrial development.

Despite knowing the significant role of green investment and technological innovation in sustainable development, very limited empirical research work has been done on the impact of green investment and technical progress on industrial structure in China. The existing literature mainly focuses on the role of green investment and technological innovation in environmental and economic development, and sufficient effort is required in the exploration of the nexus between green investment, technological innovation, and industrial structure development. That is why our study explores the role of green investment and technology development in transforming industrial structures in China. Our study makes significant contributions to the existing literature and modeling frameworks. It contributes to the literature as this study is the first to explore the impact of green investment on industrial structure development. This study contributes to the modeling aspect as it provides the intensity of the relationship both in the long run and short run. However, the previous studies provide only long-run estimates without considering the short-run estimates.

The long and short-term linkages among concern variables are examined through ARDL modeling. This method has some benefits over other methods. First, it is comparatively better in the small sample. Second, if the model variables are I(1), I(0), or mixed, then ARDL can be applied. Therefore, pre-unit root testing is not mandatory for the application of the ARDL model. The ARDL method is more useful for estimating short-run and long-run effects in a single equation [46]. Lastly, the issues of serial correlation, endogeneity, and heteroskedasticity, and the ARDL can control such problems by including a short-run dynamic process, as our main objective is to examine the short and long-run impact of green investment and technological progress on green industrial development. To fulfill this objective, we have applied ARDL. The ARDL approach is the dominant and workhorse approach in time series modeling [47]. The ARDL model has been extensively used in the energy–environment literature due to the fluctuating nature of macro variables and has been utilized by a large number of studies [48].

Green investment and industrial development are growing phenomena in China. The significance of our study is that green investment exerts a useful impact on economic development and industrialization. No existing study has explored the impact of green investment and technology in industrial structure development, and our study is filling this gap. This study will suggest green investment and technological progress policies to promote green industrial structures in China. The results findings provide more valuable insights for sustainable development. This study will open up the way for new research directions.

2. Data, Model, and Method

Theoretical Framework

Given the importance of technological innovation and green investment in transforming the industrial structure, this study's main objective is to investigate how both these factors contribute to green industrial development in China. Technological advancement might hasten modernization and change in industry. According to Okorie et al. [49], industrial advancement is facilitated by production cost reduction and technical innovation. Technological advancement and modernization of the industrial structure have a long-term, stable link. Technological advancement may help with optimizing industrial structures to some degree. Technology innovation, according to Quitzow [50], may help develop new sectors, which also include environmentally friendly energy technologies crucial for promoting the green transformation of the industrial structure.

As far as the link between green investment and industrial development is concerned, it is also supported by theoretical and empirical findings. This idea was first put out by Schumpeter [51], who claimed that financial companies might redistribute capital and direct capital flow to developing sectors via credit growth, eventually optimizing the industrial structure. The same idea is also supported by some other studies [52]. Green finance can accelerate the procedure of turning savings into investments by effectively encouraging innovation within the financial sector and in financial instruments. Such investments are crucial in the green transformation of the industrial structure. Consequently, following the above theoretical and empirical literature, we assembled the following model:

$$IS_t = \varphi_0 + \varphi_1 GI_t + \varphi_2 TECH_t + \varphi_3 FD_t + \varphi_4 GDP_t + \varphi_5 Trade_t + \varepsilon_t \quad (1)$$

with industrial structure (IS), green investment (GI), technology (TECH), financial development (FD), GDP per capita (GDP), and trade openness (trade). Following Drucker and Feser [53], industrial structure (IS) was the dependent variable in this study. It was measured as ratio of the manufacturing sector to the services sector. The independent variable green investment was measured by two proxies. These were R&D expenditures (RD) and green finance investment (GF). RD expenditures were taken as % of GDP. However, investment in multiple renewable energy sources was used to measure green finance investment. This study used technology (i.e., total patent applications), financial development index (FD), GDP per capita at 2015 constant USD, and trade as % of GDP. The data were selected based on data availability, so the data span for this study ranged from 1996 to 2020. This study obtained the required data series from the World Bank and IRENA. The fundamental drawback of the aforementioned model is that they are only adequate for long-run estimations. As opposed to this, the analysis's main objective was to examine both short- and long-term estimations, which can only be done if the aforementioned equation is written in the error correction format recommended by Pesaran et al. [54]:

$$\begin{aligned}\Delta IS_t = {} & \varphi_0 + \sum_{k=1}^{n} \beta_{1k} \Delta IS_{t-k} + \sum_{k=0}^{n} \beta_{2k} \Delta GI_{t-k} + \sum_{k=1}^{n} \beta_{3k} \Delta TECH_{t-k} + \sum_{k=0}^{n} \beta_{4k} \Delta FD_{t-k} + \sum_{k=1}^{n} \beta_{5k} \Delta GDP_{t-k} \\ & + \sum_{k=0}^{n} \beta_{6k} \Delta Trade_{t-k} + \varphi_1 IS_{t-1} + \varphi_2 GI_{t-1} + \varphi_3 TECH_{t-1} + \varphi_4 FD_{t-1} + \varphi_5 GDP_{t-1} \\ & + \varphi_6 Trade_{t-1} + \varepsilon_t\end{aligned} \quad (2)$$

The ARDL model created by Pesaran et al. [54] is represented by Equation (2). While investigating the cointegration connection in a time series analysis, this approach is one of the best. Numerous time series cointegration techniques have been developed to date. These estimating methods do, however, have several visible flaws. These methodologies' primary prerequisite is that all variables are integrated into the same sequence, i.e., I (1). Moreover, if the number of observations is limited, these estimating strategies will not work well. Furthermore, these estimating methods are limited to long-term estimations and are unable to produce short-term forecasts. The ARDL approach established by Pesaran et al. [54] is independent of each of these flaws and offers a number of additional benefits. ARDL manages the cointegrating features of the variables; it is possible to investigate the variables with alternative orders of integration, such as I(0), I(1), or a combination of both. This eliminates the need for checking the stationary of the variables by applying a unit root test. The ARDL model is also very effective at addressing a small sample problem. Both short-run and long-run outcomes may be estimated using the ARDL estimations. The short-run estimates in the aforementioned Equation (2) are denoted by first-differenced signs, and the long-run estimates are deduced from φ_2 to φ_6 after normalizing on φ_1. However, if the long-run outcomes are not cointegrated, they are regarded as bogus. Additionally, Pesaran et al. [46] suggested an ECM test and F-test for checking cointegration among the variables and developed separate critical values for these tests. By integrating a short-run dynamic framework and using the ARDL methodology as an estimating tool, we can also address the concerns of serial correlation and endogeneity [55].

Table 1 provides outcomes for descriptive statistics for all concerned variables, such as IS, RD, GF, TECH, FD, GDP, and trade. The mean values for all series were found to be positive. The mean value for the dependent variable (i.e., IS) was 0.738, with maximum score of 1.089 and minimum score of 0.483. The mean of RD was 1.499, with maximum range of 2.401 and minimum range of 0.563. GF was also independent variable with mean value of 2.850, with maximum range of 6.811 and minimum score of −3.291.

Table 1. Descriptive statistics.

	IS	RD	GF	TECH	FD	GDP	TRADE
Mean	0.738	1.499	2.85	12.47	0.497	8.393	3.78
Median	0.749	1.446	3.24	12.57	0.516	8.458	3.755
Maximum	1.089	2.401	6.811	14.29	0.654	9.246	4.166
Minimum	0.483	0.563	−3.291	10.03	0.344	7.411	3.479

3. Empirical Analysis

Table 2 displays the results for unit root tests for all variables, i.e., RD, IS, GF, TECH, FD, GDP, and trade. Two unit root tests were applied to confirm the unit root properties of the data. Both tests provided dissimilar findings. According to the DF-GLS test, GF and GDP are I(0) stationary series whereas IS, RD, Tech, FD, and trade are I(1) stationary series. However, according to the PP test, only GF is I(0) stationary series whereas all other series are I(1) stationary.

Table 2. Unit root tests.

	DF-GLS		PP	
	I(0)	I(1)	I(0)	I(1)
IS	0.012	−2.987 ***	−2.120	−3.254 **
RD	0.452	−4.256 ***	−0.524	−5.321 ***
GF	−3.254 ***		−3.201 *	
TECH	−0.201	−4.325 ***	−2.102	−4.658 ***
FD	0.257	−4.587 ***	0.125	−4.758 ***
GDP	−1.658 *		−1.489	−2.875 *
Trade	−1.365	−3.658 ***	−1.632	−3.587 ***

Note: ** $p < 0.05$; * $p < 0$; *** $p < 0.01$.

The unit root test results confirm that the series included in the analysis are either stationary at level or at first difference. As a consequence, we need to concentrate on a technique that can handle a combination of I(0) and I(1) variables, and the ARDL is tailor-made in this circumstance. Therefore, in order to account for both short-term and long-term effects, we used the ARDL model developed by Pesaran et al. (54). Table 3 displays the long- and short-run results for estimated models. RD reports a positive effect on IS in the long run, and it is significant. It shows that industrial structure improves due to an increase in RD expenditures. The obtained results report that in response to a 1% upsurge in RD expenditures, IS was enhanced by 0.458% in China. GF is another proxy measure for green investment, which displays a significant positive impact on IS in the long run. It shows that due to significant enlargement in green finance investment, industrial structure expands. The obtained results report that in response to a 1% upsurge in GF, IS enhanced by 0.698% in China. This study has considered the role of environmental finance on industrial structure performance which is quite similar to green investment. This study reported that environmental finance positively enhances the industrial structure. This study highlighted that environmental determinants such as environmental finance and green investment must be enlarged to improve the industrial structure. Green investment and industrial development both need to be harmonized for improvement in industrial structure. Green finance might be utilized to improve the industrial structure, maximize resources, and eventually create a resource- and environmentally friendly society [56]. Additionally, it is crucial to investigate the process through which green financing affects industrial reasonability [40]. Acemoglu et al. [56] concurred and claimed that the advancement of green finance might result in innovation growth, which can enhance total factor productivity and afterward support industrial efficiency. Additionally, the financial sector may be used to fight environmental deterioration by modifying the industrial structure and economy. Xu et al. [57] provided evidence that improving the financial situation is crucial for modernizing the industrial structure. Studies performed by Doval and Negulescu [58] and Cheng et al. [31] described that green financial support is mandatory to improve the financial structure.

Table 3. Long and short-run estimates.

	(1)				(2)			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob. ***	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob. ***
Short-run								
RD	0.106 **	0.050	2.124	0.063				
GF					0.004 *	0.002	1.950	0.091
TECH	0.017	0.026	0.654	0.530	0.008	0.030	0.265	0.798
TECH(-1)	0.048 **	0.019	2.547	0.031	0.051 **	0.021	2.469	0.039
TECH(-2)	0.052 **	0.020	2.559	0.031	0.057 ***	0.022	2.602	0.032
FD	0.027	0.130	0.209	0.839	0.032	0.159	0.203	0.845
FD(-1)	0.287	0.193	1.489	0.171	0.159	0.175	0.910	0.389
FD(-2)	0.645 ***	0.162	3.991	0.003	0.768 ***	0.216	3.560	0.007
GDP	0.294 ***	0.102	2.867	0.019	0.382	0.254	1.500	0.172
TRADE	0.222 ***	0.037	5.982	0.000	0.244 ***	0.055	4.461	0.002
TRADE(-1)	0.053	0.043	1.212	0.257	0.079	0.050	1.560	0.158
TRADE(-2)	0.044	0.040	1.109	0.296	0.047	0.044	1.061	0.320
C	1.365 **	0.567	2.405	0.040	0.441	0.347	1.268	0.241
Long-run								
RD	0.458 **	0.230	1.999	0.048				
GF					0.698 ***	0.093	7.482	0.000
TECH	0.508 **	0.198	2.558	0.031	0.475 **	0.225	2.114	0.067
FD	1.432 *	0.865	1.677	0.102	3.040 *	1.723	1.765	0.116
GDP	1.272 *	0.656	1.940	0.084	0.574	0.464	1.238	0.251
TRADE	0.543 **	0.211	2.570	0.030	0.560 *	0.288	1.946	0.088
C	5.908	3.752	1.574	0.150	2.088	2.216	0.942	0.374
Diagnostics								
F-test	9.652 ***				7.985 ***			
ECM(-1) *	−0.231 ***	0.022	−10.28	0.000	−0.311 ***	0.026	11.92	0.000
LM	1.325				1.653			
RESET	2.148				2.021			
CUSUM	S				S			
CUSUM-sq	S				S			

Note: ** $p < 0.05$; * $p < 0$; *** $p < 0.01$.

The results show that TECH and IS are significantly and positively associated in the long run in both models. It shows that a 1% increase in TECH leads to a 0.508% increase in IS in model 1 and 0.475% in model 2. The positive link between TECH and IS is supported by various studies such as [59,60]. It is justified as technology development can foster industrial development through the elimination of discrimination and reduction in transaction costs that reduces production costs and improves productivity. Technology can enable the establishment of social network innovations, exchange ideas regarding innovation, promote productivity, and also enhance industrial development. Our results are similar to the findings of some past studies [61,62]. According to Chege and Wang [63], the synergy between innovation and industrial improvement has risen over time. Liu et al. [64] observed that regional commercialization and technical innovation are crucial for advancing industrial structure, with urban agglomerations' technical revolution playing a vital role in this process. However, Cui and Tang [65] think otherwise and highlight that industrial transformation in China is still low despite technological development.

FD, GDP, and TRADE are control variables in our model. The nexus between FD and IS variables is found to be significantly positive in both models describing that a 1% rise in FD increases IS by 1.432% in model 1 and 3.040% in model 2. In our model, GDP and IS are significantly and positively associated in the long run in one model only. It shows that a 1% increase in GDP enhances IS by 1.272% in model 1. The relationship between IS and TRADE is found to be significantly positive in both models, showing that a 1% increase in TRADE enhances IS by 0.543% in model 1 and 0.560% in model 2.

The short-run estimates postulate that RD reports an increasing impact on IS, which means increases in RD enhance IS significantly. Likewise, GF is positively attached to IS, confirming that an increase in GF leads to significant enlargement in IS. Henceforth, it is confirmed that green investment is a fundamental measure to enhance the industrial structure in China. Tech association with IS variables is found insignificant, revealing that TECH has no impact on IS in the short run. Similarly, an insignificant association is observed between FD and IS in the short run. GDP reports a positive influence on IS in model 1 only, whereas this association is reported as insignificant in model 2. Trade is a positive association with IS in the short run in both models, revealing that an increase in trade tends to enhance IS in China in the short term.

The results of diagnostics tests are given in Table 3. These tests include F-test, ECM, specification test, stability test, and autocorrelation test. The results for F-test (ECM) term confirm that long-run cointegration associations exist among variables. Additionally, the negative sign attached to ECM terms shows that the instability will converge towards equilibrium in the long-term, and it will converge almost 23% in a span of one year, according to model 1, and 31% according to model 2. No autocorrelation issue is found in the models, as displayed by LM test findings. Moreover, our models are correctly specified as described by the RESET test results. The condition of stability is also achieved in both models, as shown by the results of the CUSUM and CUSUM-sq tests. In Table 4, the results of the granger causality confirm the one-way causal link moving from RD to IS and GF to IS.

Table 4. Causality test.

Null Hypothesis:	F-Stat	Prob.	Null Hypothesis:	F-Stat	Prob.
RD →IS	3.744	0.044	GF →IS	6.828	0.004
IS →RD	0.675	0.522	IS →GF	1.479	0.254
TECH →IS	3.162	0.067	TECH →IS	3.162	0.067
IS →TECH	1.189	0.327	IS →TECH	1.189	0.327
FD →IS	2.598	0.102	FD →IS	2.598	0.102
IS →FD	2.221	0.137	IS →FD	2.221	0.137
GDP →IS	6.824	0.006	GDP →IS	6.824	0.006
IS →GDP	1.120	0.348	IS →GDP	1.120	0.348
TRADE →IS	0.874	0.434	TRADE →IS	0.874	0.434
IS →TRADE	0.415	0.667	IS →TRADE	0.415	0.667
TECH →RD	1.701	0.211	TECH →GF	0.779	0.474
RD →TECH	16.87	0.000	GF →TECH	0.273	0.764
FD →RD	3.556	0.050	FD →GF	1.041	0.374
RD →FD	6.321	0.008	GF →FD	0.202	0.819
GDP →RD	3.801	0.042	GDP →GF	3.968	0.037
RD →GDP	3.151	0.067	GF →GDP	1.335	0.288
TRADE →RD	0.080	0.924	TRADE →GF	1.198	0.325
RD →TRADE	2.690	0.095	GF →TRADE	1.603	0.229
FD →TECH	1.236	0.314	FD →TECH	1.236	0.314
TECH →FD	5.088	0.018	TECH →FD	5.088	0.018
GDP →TECH	4.283	0.030	GDP →TECH	4.283	0.030
TECH →GDP	3.655	0.047	TECH →GDP	3.655	0.047
TRADE →TECH	0.429	0.658	TRADE →TECH	0.429	0.658
TECH →TRADE	1.086	0.359	TECH →TRADE	1.086	0.359
GDP →FD	5.331	0.015	GDP →FD	5.331	0.015
FD →GDP	2.100	0.152	FD →GDP	2.100	0.152
TRADE →FD	2.030	0.160	TRADE →FD	2.030	0.160
FD →TRADE	3.504	0.052	FD →TRADE	3.504	0.052
TRADE →GDP	3.616	0.048	TRADE →GDP	3.616	0.048
GDP →TRADE	1.248	0.311	GDP →TRADE	1.248	0.311

4. Conclusions and Implications

The core of environmentally and economically sustainable growth is the green economy. From the standpoint of ecological sustainability, the growth of a sustainable economy will assist the industrial nation in understanding the energy transition in the processes of demand, mobility, and manufacturing in order to reduce waste, contamination, and decarbonization. As far as sustainable economic growth is concerned, the green transformation of the economy can play a crucial role by controlling and stabilizing the economic system and progress. In order to drive the economy on the path of sustainability, green investment is crucial. Green investment is a type of investment that is more environmentally friendly and sustainable. The growth of banks' competitiveness, which allows them to produce green revenues and strengthens their capacity to achieve sustainable development, is facilitated by green investment strategies. Green investments may satisfy investor demands and improve the reputations of financial organizations. Environmental reformation of outmoded sectors and the establishment of new pro-ecological businesses via green investment are the main driving forces behind the revolution in the Chinese industrial sector. Green investment aids in the growth of environmentally friendly industries. Hence, the primary objective of the analysis is to investigate the impact of green investment and technology on industrial structure development.

The results of this study are estimated by applying the ARDL model. The short and long-run estimates attached to RD expenditures are positively significant, confirming that increasing RD expenditures help improve the industrial structure. Similarly, the short and long-run estimates attached to green finance investment are positively significant, signifying that green investment benefits the industrial structure. Furthermore, technological development promotes long-term industrial development, and estimates are significant. Furthermore, the results of the granger causality confirm the one-way causal link moving from RD to IS and GF to IS. We also construe that one-way causality runs from TECH to IS.

We have utilized the findings of this study to provide some policy suggestions. The most important finding of the analysis is that research and development activities and green finance help improve the industrial structure. Therefore, policymakers must try to promote investment in research and development activities that may spur the process of technological development in the country, which is crucial for the transformation of the industrial sector. Moreover, the promotion of green finance through banks and financial institutions can promote green industrial activities that may also help the industrial transformation. Moreover, there is a need to design a green finance plan, which is more practical and diverse. Since China's provinces have diverse development levels, the administration must use distinct ways to encourage the coordination of green financing and changes to industrial structure. Consequently, the related green finance strategies must be created taking into account each province's characteristics and resource availability. Since technology development is crucial in increasing industrial development, policymakers must focus on increasing the share of environment-related innovations in total innovations produced by society. In this regard, increasing the investment in R&D activities can do the job because R&D activities can help to modify the industrial structure. In order to change the industrial structure, businesses need to increase their investments in technological innovation. As a result, the government needs to establish taxes and other preferred policies that concentrate on business R&D expenditures, such as a pre-tax deduction policy, preferential treatment for purchasing innovative goods and technologies, and incentivized financial lending practices.

Despite some important contributions, this study has a few limitations and needs to be taken care of in the future. For instance, this study only focuses on China, which can only provide inferences in the context of developing and emerging economies. Hence, in the future, empirics should also perform the analysis in the context of developing economies. Moreover, a few other measures should also be used as control variables, such as financial inclusion, financial development, financial depth, etc., which are crucial in transforming the industrial structure alongside green investment. Another limitation of this study is the oversimplified nature of empirical and statistical analysis; hence, in the future, the analysis may look at more sophisticated techniques such as dynamic ARDL, QARDL, and NARDL, which are more suitable for capturing dynamic effects, countering non-normalcy in data, and providing asymmetric estimates, respectively. Moreover, future studies may focus on panel data analysis by collecting data on advanced and emerging economies that can provide more useful results and increase this study's scope.

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References

1. Shuai, S.; Fan, Z. Modeling the role of environmental regulations in regional green economy efficiency of China: Empirical evidence from super efficiency DEA-Tobit model. *J. Environ. Manag.* **2020**, *261*, 110227. [CrossRef] [PubMed]
2. Gu, Y.; Su, D. Innovation orientations, external partnerships, and start-ups' performance of low-carbon ventures. *J. Clean. Prod.* **2018**, *194*, 69–77. [CrossRef]
3. Ahmed, M.; Hafeez, M.; Kaium, M.A.; Ullah, S.; Ahmad, H. Do environmental technology and banking sector development matter for green growth? Evidence from top-polluted economies. *Environ. Sci. Pollut. Res.* **2023**, *30*, 14760–14769. [CrossRef] [PubMed]
4. He, L.; Zhang, L.; Zhong, Z.; Wang, D.; Wang, F. Green credit, renewable energy investment and green economy development: Empirical analysis based on 150 listed companies of China. *J. Clean. Prod.* **2019**, *208*, 363–372. [CrossRef]
5. Wang, X.; Wang, Q. Research on the impact of green finance on the upgrading of China's regional industrial structure from the perspective of sustainable development. *Resour. Policy* **2021**, *74*, 102436. [CrossRef]
6. Mo, Y.; Ullah, S.; Ozturk, I. Green investment and its influence on green growth in high polluted Asian economies: Do financial markets and institutions matter? *Econ. Res.-Ekon. Istraživanja* **2022**, *31*, 1–11. [CrossRef]
7. Ali, S.; Yan, Q.; Razzaq, A.; Khan, I.; Irfan, M. Modeling factors of biogas technology adoption: A roadmap towards environmental sustainability and green revolution. *Environ. Sci. Pollut. Res.* **2023**, *30*, 11838–11860. [CrossRef]
8. Zhang, Y.; Khan, I.; Zafar, M.W. Assessing environmental quality through natural resources, energy resources, and tax revenues. *Environ. Sci. Pollut. Res.* **2022**, *29*, 89029–89044. [CrossRef]

9. Sun, C. The correlation between green finance and carbon emissions based on improved neural network. *Neural Comput. Appl.* **2022**, *34*, 12399–12413. [CrossRef]
10. Ji, Q.; Zhang, D. How much does financial development contribute to renewable energy growth and upgrading of energy structure in China? *Energy Policy* **2019**, *128*, 114–124. [CrossRef]
11. Zahoor, Z.; Latif, M.I.; Khan, I.; Hou, F. Abundance of natural resources and environmental sustainability: The roles of manufacturing value-added, urbanization, and permanent cropland. *Environ. Sci. Pollut. Res.* **2022**, *29*, 82365–82378. [CrossRef]
12. Eyraud, L.; Clements, B.; Wane, A. Green investment: Trends and determinants. *Energy Policy* **2013**, *60*, 852–865. [CrossRef]
13. Li, Z.Z.; Li RY, M.; Malik, M.Y.; Murshed, M.; Khan, Z.; Umar, M. Determinants of carbon emission in China: How good is green investment? *Sustain. Prod. Consum.* **2021**, *27*, 392–401. [CrossRef]
14. Li, L.; Li, G.; Ozturk, I.; Ullah, S. Green innovation and environmental sustainability: Do clean energy investment and education matter? *Energy Environ.* **2022**, *15*, 1–15. [CrossRef]
15. Ateş, M.A.; Bloemhof, J.; Van Raaij, E.M.; Wynstra, F. Proactive environmental strategy in a supply chain context: The mediating role of investments. *Int. J. Prod. Res.* **2012**, *50*, 1079–1095. [CrossRef]
16. Voica, M.C.; Panait, M.; Radulescu, I. Green investments–between necessity, fiscal constraints and profit. *Procedia Econ. Financ.* **2015**, *22*, 72–79. [CrossRef]
17. Ullah, S.; Ozturk, I.; Majeed, M.T.; Ahmad, W. Do technological innovations have symmetric or asymmetric effects on environmental quality? Evidence from Pakistan. *J. Clean. Prod.* **2021**, *316*, 128239. [CrossRef]
18. Hafeez, M.; Rehman, S.U.; Faisal, C.N.; Yang, J.; Ullah, S.; Kaium, M.A.; Malik, M.Y. Financial efficiency and its impact on renewable energy demand and CO_2 emissions: Do eco-innovations matter for highly polluted Asian economies? *Sustainability* **2022**, *14*, 10950. [CrossRef]
19. Mensah, C.N.; Long, X.; Dauda, L.; Boamah, K.B.; Salman, M.; Appiah-Twum, F.; Tachie, A.K. Technological innovation and green growth in the Organization for Economic Cooperation and Development economies. *J. Clean. Prod.* **2019**, *240*, 118204. [CrossRef]
20. Li, X.; Ullah, S. Caring for the environment: How CO_2 emissions respond to human capital in BRICS economies? *Environ. Sci. Pollut. Res.* **2022**, *29*, 18036–18046. [CrossRef]
21. Wei, L.; Ullah, S. International tourism, digital infrastructure, and CO_2 emissions: Fresh evidence from panel quantile regression approach. *Environ. Sci. Pollut. Res.* **2022**, *29*, 36273–36280. [CrossRef] [PubMed]
22. Shen, Y.; Su, Z.W.; Malik, M.Y.; Umar, M.; Khan, Z.; Khan, M. Does green investment, financial development and natural resources rent limit carbon emissions? A provincial panel analysis of China. *Sci. Total Environ.* **2021**, *755*, 142538. [CrossRef] [PubMed]
23. Zahan, I.; Chuanmin, S. Towards a green economic policy framework in China: Role of green investment in fostering clean energy consumption and environmental sustainability. *Environ. Sci. Pollut. Res.* **2021**, *28*, 43618–43628. [CrossRef] [PubMed]
24. Liu, H.; Saleem, M.M.; Al-Faryan MA, S.; Khan, I.; Zafar, M.W. Impact of governance and globalization on natural resources volatility: The role of financial development in the Middle East North Africa countries. *Resour. Policy* **2022**, *78*, 102881. [CrossRef]
25. Ng, A. Green Investing and Financial Services: ESG Investing for a Sustainable World. In *The Palgrave Handbook of Global Sustainability*; Springer International Publishing: Cham, Switzerland, 2021; pp. 1–12.
26. Zakari, A.; Tawiah, V.; Khan, I.; Alvarado, R.; Li, G. Ensuring sustainable consumption and production pattern in Africa: Evidence from green energy perspectives. *Energy Policy* **2022**, *169*, 113183. [CrossRef]
27. Sueyoshi, T.; Wang, D. Radial and non-radial approaches for environmental assessment by data envelopment analysis: Corporate sustainability and effective investment for technology innovation. *Energy Econ.* **2014**, *45*, 537–551. [CrossRef]
28. Xu, X.; Li, J. Asymmetric impacts of the policy and development of green credit on the debt financing cost and maturity of different types of enterprises in China. *J. Clean. Prod.* **2020**, *264*, 121574. [CrossRef]
29. Zhu, X. Does green credit promote industrial upgrading?—Analysis of mediating effects based on technological innovation. *Environ. Sci. Pollut. Res.* **2022**, *29*, 41577–41589. [CrossRef]
30. Li, B.; Zhang, J.; Shen, Y.; Du, Q. Can green credit policy promote green total factor productivity? Evidence from China. *Environ. Sci. Pollut. Res.* **2023**, *30*, 6891–6905. [CrossRef]
31. Cheng, Q.; Lai, X.; Liu, Y.; Yang, Z.; Liu, J. The influence of green credit on China's industrial structure upgrade: Evidence from industrial sector panel data exploration. *Environ. Sci. Pollut. Res.* **2022**, *29*, 22439–22453. [CrossRef]
32. Liu, H.; Alharthi, M.; Atil, A.; Zafar, M.W.; Khan, I. A non-linear analysis of the impacts of natural resources and education on environmental quality: Green energy and its role in the future. *Resour. Policy* **2022**, *79*, 102940. [CrossRef]
33. Liu, H.; Khan, I.; Zakari, A.; Alharthi, M. Roles of trilemma in the world energy sector and transition towards sustainable energy: A study of economic growth and the environment. *Energy Policy* **2022**, *170*, 113238. [CrossRef]
34. Azam, W.; Khan, I.; Ali, S.A. Alternative energy and natural resources in determining environmental sustainability: A look at the role of government final consumption expenditures in France. *Environ. Sci. Pollut. Res.* **2023**, *30*, 1949–1965. [CrossRef] [PubMed]
35. National Bureau of Statistics of China. *Chinese Statistical Yearbook*; China Statistics Press: Beijing, China, 2018.
36. Zheng, S.; Li, J.; Wang, H.; Dukhaykh, S.; Wang, L.; Li, B.; Peng, J. Do Product Characteristics Affect Customers' Participation in Virtual Brand Communities? An Empirical Study. *Front. Psychol.* **2022**, *12*, 792706. [CrossRef]
37. Ullah, S.; Ozturk, I.; Usman, A.; Majeed, M.T.; Akhtar, P. On the asymmetric effects of premature deindustrialization on CO_2 emissions: Evidence from Pakistan. *Environ. Sci. Pollut. Res.* **2020**, *27*, 13692–13702. [CrossRef] [PubMed]
38. Yuelan, P.; Akbar, M.W.; Hafeez, M.; Ahmad, M.; Zia, Z.; Ullah, S. The nexus of fiscal policy instruments and environmental degradation in China. *Environ. Sci. Pollut. Res.* **2019**, *26*, 28919–28932. [CrossRef]

39. Huang, S.Z. Do green financing and industrial structure matter for green economic recovery? Fresh empirical insights from Vietnam. *Econ. Anal. Policy* **2022**, *75*, 61–73. [CrossRef]
40. Jiakui, C.; Abbas, J.; Najam, H.; Liu, J.; Abbas, J. Green technological innovation, green finance, and financial development and their role in green total factor productivity: Empirical insights from China. *J. Clean. Prod.* **2023**, *382*, 135131. [CrossRef]
41. Huang, S.; Bai, Y.; Tan, Q. How does the concentration of determinants affect industrial innovation performance?–An empirical analysis of 23 Chinese industrial sectors. *PLoS ONE* **2017**, *12*, e0169473. [CrossRef]
42. Liu, K.; Qiao, Y.; Zhou, Q. Analysis of china's industrial green development efficiency and driving factors: Research based on MGWR. *Int. J. Environ. Res. Public Health* **2021**, *18*, 3960. [CrossRef]
43. Maroof, Z.; Hussain, S.; Jawad, M.; Naz, M. Determinants of industrial development: A panel analysis of South Asian economies. *Qual. Quant.* **2019**, *53*, 1391–1419. [CrossRef]
44. Mohsen, A.S.; Chua, S.Y.; Sab, C.N.C. Determinants of industrial output in Syria. *J. Econ. Struct.* **2015**, *4*, 19. [CrossRef]
45. Sun, Y.; Du, D. Determinants of industrial innovation in China: Evidence from its recent economic census. *Technovation* **2010**, *30*, 540–550. [CrossRef]
46. Akhtar, P.; Ullah, S.; Majeed, M.T.; Usman, A. Exchange Rate Volatility and Trade Flows of Pakistan with Major Trading Partners: Is there an Asymmetric Third-Country Effect? *J. Int. Commer. Econ. Policy* **2022**, *13*, 2250016. [CrossRef]
47. Chen, R.; Ramzan, M.; Hafeez, M.; Ullah, S. Green innovation-green growth nexus in BRICS: Does financial globalization matter? *J. Innov. Knowl.* **2023**, *8*, 100286. [CrossRef]
48. Zheng, S.; Cui, J.; Sun, C.; Li, J.; Li, B.; Guan, W. The Effects of the Type of Information Played in Environmentally Themed Short Videos on Social Media on People's Willingness to Protect the Environment. *Int. J. Environ. Res. Public Health* **2022**, *19*, 9520. [CrossRef]
49. Okorie, O.; Russell, J.; Cherrington, R.; Fisher, O.; Charnley, F. Digital transformation and the circular economy: Creating a competitive advantage from the transition towards Net Zero Manufacturing. *Resour. Conserv. Recycl.* **2023**, *189*, 106756. [CrossRef]
50. Quitzow, R. Dynamics of a policy-driven market: The co-evolution of technological innovation systems for solar photovoltaics in China and Germany. *Environ. Innov. Soc. Transit.* **2015**, *17*, 126–148. [CrossRef]
51. Schumpeter, J.A. *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle (1912/1934)*; Transaction Publishers: Piscataway, NJ, USA, 1982.
52. Gao, L.; Tian, Q.; Meng, F. The impact of green finance on industrial reasonability in China: Empirical research based on the spatial panel Durbin model. *Environ. Sci. Pollut. Res.* **2022**, *15*, 1–17. [CrossRef]
53. Drucker, J.; Feser, E. Regional industrial structure and agglomeration economies: An analysis of productivity in three manufacturing industries. *Reg. Sci. Urban Econ.* **2018**, *42*, 1–14. [CrossRef]
54. Pesaran, M.H.; Shin, Y.; Smith, R.J. Bounds testing approaches to the analysis of level relationships. *J. Appl. Econom.* **2001**, *16*, 289–326. [CrossRef]
55. Bahmani-Oskooee, M.; Usman, A.; Ullah, S. Asymmetric impact of exchange rate volatility on commodity trade between Pakistan and China. *Glob. Bus. Rev.* **2020**, *10*, 1–19. [CrossRef]
56. Acemoglu, D.; Aghion, P.; Bursztyn, L.; Hemous, D. The environment and directed technical change. *Am. Econ. Rev.* **2012**, *102*, 131–166. [CrossRef]
57. Xu, Q.; Zhong, M.; Cao, M. Does digital investment affect carbon efficiency? Spatial effect and mechanism discussion. *Sci. Total Environ.* **2022**, *827*, 154321. [CrossRef]
58. Doval, E.; Negulescu, O. A model of green investments approach. *Procedia Econ. Financ.* **2014**, *15*, 847–852. [CrossRef]
59. Du, K.; Cheng, Y.; Yao, X. Environmental regulation, green technology innovation, and industrial structure upgrading: The road to the green transformation of Chinese cities. *Energy Econ.* **2021**, *98*, 105247. [CrossRef]
60. Hidayatno, A.; Destyanto, A.R.; Hulu, C.A. Industry 4.0 technology implementation impact to industrial sustainable energy in Indonesia: A model conceptualization. *Energy Procedia* **2019**, *156*, 227–233. [CrossRef]
61. Qiao, P.H.; Ju, X.F.; Fung, H.G. Industry association networks, innovations, and firm performance in Chinese small and medium-sized enterprises. *China Econ. Rev.* **2014**, *29*, 213–228. [CrossRef]
62. Abbas, J.; Sağsan, M. Impact of knowledge management practices on green innovation and corporate sustainable development: A structural analysis. *J. Clean. Prod.* **2019**, *229*, 611–620. [CrossRef]
63. Chege, S.M.; Wang, D. Information technology innovation and its impact on job creation by SMEs in developing countries: An analysis of the literature review. *Technol. Anal. Strateg. Manag.* **2020**, *32*, 256–271. [CrossRef]
64. Liu, R.; Zhu, X.; Zhang, M.; Hu, C. Innovation incentives and urban carbon dioxide emissions: A quasi-natural experiment based on fast-tracking green patent applications in China. *J. Clean. Prod.* **2023**, *382*, 135444. [CrossRef]
65. Cui, W.; Tang, J. Innovation convergence clubs and driving factors within urban agglomeration. *Econ. Model.* **2023**, *121*, 106199. [CrossRef]