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The Impact of Renewable Energy Sources on Financial Development, and Economic Growth: The Empirical Evidence from an Emerging Economy

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Abstract: Developing energy from renewable sources and modernizing the energy system are critical components of China's efforts to combat climate change. Policymakers and authorities have made significant attempts to bring them. However, one of the major impediments to China's energy revolution is financial limitations, which are inextricably linked to the country's economic growth. The present research paper intends to investigate the relationship between economic growth and sustainable financial development on the use of energy from renewable sources in both the short and long run in the context of China. To achieve this, the researchers have utilized the panel data consisting of 10 years from 2011 to 2020. When compared to cross-sectional and time-series data samples, the panel data model offers many benefits. For starters, the panel data includes information on the passage of time and the cross-sectional area. Another benefit of using panel-data models with a larger degree of freedom is that they provide more stable and reliable estimates across short periods across cross-sections. In the case of the short run, there is a positive relationship between economic and financial development and the use of energy from renewable sources in the context of all of China. While in the case of long-term effects, the results indicate the adverse impact of financial development on the use of energy from renewable sources in the western regions of China. These results were deduced using the causality test Granger proposed to determine the path of the causal relationship and the direction of the relationship between the variables. These results indicated that the relationship between economic and financial development in east China was unidirectional, and the nature of the underlying relationship was causal. Meanwhile, in east and west China, economic development in China as a whole has been unidirectionally increasing energy from renewable sources. Our empirical findings suggest many strategies for promoting the growth of energy from renewable sources.

Keywords: financial development; renewable energy; economic growth; China

1. Introduction

The financial sector is comprised of the institutions, tools, and markets—as well as the legal and regulatory framework—that enable transactions to be completed through the extension of credit to individuals and businesses. Financial sector growth is fundamentally about reducing the 'costs' that have been incurred by the financial system. When information was made more readily available, contracts were more easily enforced, and transactions were more easily completed, the process culminated in the establishment of financial contracts, markets, and intermediaries. A result of different types and combinations of informational costs, enforcement costs, and transaction costs in conjunction with different legal, regulatory, and tax systems in different countries and throughout history has motivated a variety of different financial contracts, markets, and intermediaries.

China is highly reliant on energy derived from fossil fuels, with fossil fuels providing 90% of the country's total energy. Fossil fuel combustion, particularly coal combustion, is a major source of air pollution in China and greenhouse gas (GHG) emissions. According to statistics from the World Resource Institute (W.R.I., 2012), China is the world's biggest producer of greenhouse gases (GHGs). China, along with the USA, are responsible for almost a third of worldwide GHG emissions. Faced with mounting concerns about global climate change, the leaders of these nations came together on 12 November 2014, and signed a historic commitment to work together to decrease emissions. China's commitment is to peak GHG emissions in 2030 and to grow non-fossil fuel energy to approximately 20% of total energy use. However, it is still up for debate whether policies and measures can be taken to attain such a lofty objective without negatively impacting economic performance.

Another problem is that China's economy is highly dependent on the global energy market, particularly the global crude oil market, which accounts for more than half of China's total consumption [1]. Changes in the worldwide oil market may have a major effect on China's economy, particularly recent price fluctuations and the Middle East's hostilities. China's policymakers are increasingly concerned about energy security and the economy's ability to expand sustainably. The 11th five-year plan (F.Y.P.; 2006–2010) was presented, the Chinese authorities have been under pressure to address the country's interests in environmental responsibility and energy security. As a result, they are looking into upgrading energy production and consumption structure because of the sector's strategic importance. While it is essential to keep improving energy efficiency, finding new clean, renewable energy sources has increased importance.

The Renewable Energy Law, enacted by the National People's Congress in 2005, demonstrates the government's commitment to renewable energy development. China's energy structure, upgrade, regulations, laws—and a generally supportive policy climate—are critical elements [2]. In China, introducing the Renewable Energy Law (REL) in 2005 was critical regulatory support for the renewable energy industry. According to Zhang [1], the renewable energy industry has accelerated since REL was implemented. Over the past decade, new policies have been published regularly. Liu (2019) critically analyzes China's relevant policies, dividing them into specialized regulations and unspecialized laws that promote the growth of renewable energy sources. The renewable energy industry has several challenges, but one of the most significant is access to finance. Earlier research on China's renewable energy strategy by Zhang, et al [3], for example, stresses the significance of financial assistance for renewable energy projects.

This research will attempt to address the issue of how economic growth and financial development affect Renewable Energy Consumption (REC) and whether causal connections exist between these three variables at national and regional levels against the backdrops mentioned above and regional variations in China. Several nations have studied the effect of financial development on REC, but few studies have looked at China specifically from a regional viewpoint as this one does. We use panel data to bridge the knowledge gap and perform the research from a national and regional standpoint. First, using a cross-province panel model, PMGARDL (Pooled Mean Group-Autoregressive Distributed Lag), the long- and short-term effects of China's economic and financial expansion on REC are examined. This takes place from 2011 to 2020. Second, the Dumitrescu and Hurlin panel causality test is used to see a causal link between REC, financial development, and economic growth [4].

By doing this, we can add to the body of knowledge already available on the theoretical connection between China's financial growth and its use of energy from renewable sources. China has also committed to increasing production of energy from renewable sources to 50% of total energy requirements by 2030 [5]. To meet this goal, the power sector responsible for producing energy from renewable sources must be strengthened immediately. There are not enough public investments to sustain the finances needed for energy from renewable sources. Therefore, both private and government-backed financial institutions have to finance the changes in the energy sector [6]. This study will also assist the Chinese policymakers in terms of designing and implementing policies regarding the promotion of renewable energy as the main stay for economic and social development. Given that use of renewable energy not only promotes economic development, but also has a positive impact on the overall environment as well.

To summarize, this research is organized into the following sections: Section 2 conducts a comprehensive assessment of the relevant literature. The methods and data sources are discussed in detail in Section 3, which follows. The findings are detailed in Section 4. Section 5 brings this research to a close by discussing the paper's policy implications.

2. Literature Review

Ever-increasing GHG emissions are responsible for global climate changes; a rising worldwide consent favors the development of energy from renewable sources as a means of reducing reliance on fossil fuels. While energy from renewable sources is increasing rapidly EIA [7], its share of overall energy use continues to be modest. Recently, a substantial body of research has been developed to predict energy growth from renewable sources.

Ali and Khan [8] conducted detailed studies on the factors affecting the production and consumption of energy from renewable sources and their causal relationship between economic and financial development using various variables related to energy pricing overall social development. At the same time, their findings were further verified by Sadorsky [9], who added the emissions and general financial development to the existing list, while these findings were backed [10]. Salim and Rafiq [11] studied the drivers of energy from renewable sources used in six key developing countries—including China—by utilizing the panel and time-series data. The research indicated that increasing environmental degradation and economic progress are two key variables for promoting energy from renewable sources in the case of China. A literature study reveals that academics prefer to employ the supply-side when looking at this problem [12]. There are two types of supply-side studies: those that look at the economics of production and those that look at technological development.

2.1. Relationship between Renewable Energy Consumption and Financial Development

Qamruzzaman and Jianguo [13] used panel non-linear ARDL to analyze data for 113 countries from 1990 to 2017 to determine the connection between REC and FD. The ARDL panel non-linear test revealed a long-term unbalanced connection between variables. For BRICS nations, Liu, Ma [14] used the 3SLS technique to examine the connection between FD and REC from 1999 to 2015. There was a good correlation between FD and REC, according to the study's findings. Anton and Nucu [15] used a fixed-effect panel model to examine the effect of FD on REC. They utilized European Union country-level yearly data from 1990 to 2015 for 28 nations (EU). There was a statistically significant positive correlation between FD and REC, according to the researchers. For 192 nations, Khan [16] utilized the panel quantile regression technique to explore the relationship between the use of energy from renewable sources and economic development.

The evolution of equity market influences on REC in BRICS countries was studied by [17]. Meanwhile, Hassine and Harrathi [18] concluded that stock market performance had a great impact on the adoption of REC as one of the major sources of energy in the case of GCC nations, using the data from 1980 up to 2012. They concluded that the nature of the relationship was positive. At the same time, Burakov [19] conducted similar research in

Russia and came to the same conclusion. They used the vector error correction model to make their estimates (VECM). The findings confirmed the existence of a positive correlation between short-term and long-term factors. In addition, by using the ARDL technique, Khoshnevis, Yazdi, and Shakouri [20] found a favorable correlation between REC and FD in China by utilizing the Gregory–Hansen and Hatemi-J cointegration and ARDL bounds tests on the annual data from 1974–2014. Pata [21] examined the relationship between Turkey's FD and REC per capita and found cointegration amongst the variable in the long run.

While Ari and Cergibozan [22] found a bi-directional relationship as far as Turkey was concerned. Eren and Taspinar [23] applied the DOLS technique using the data spanning from 1971–2011 from India and concluded that financial development positively impacted the production and consumption of energy from renewable sources [24]. They used the ARDL panel method to explore the relationship between FDI and REC using the data from 1990 to 2013, consisting of 28 EU countries. They concluded the existence of a positive relationship between the FDI and REC.

Sweerts and Dalla Longa [25] examined the effect of financial status on electricity generation in 46 African countries by considering renewable and fossil-based technologies.

According to the authors, with an increase in the production volume of renewable energy, the overall cost tends to come down. Therefore, renewable energy producers can compete with the energy produced from fossil fuel-based sources in the long run. Charfeddine and Kahia [26] further add that in the case of the Middle East and North African countries, the growth in the use of renewable energy and CO_2 is weakly explained by the economic development of the region. At the same time, Anton and Nucu [15] disagree with the notion and state that economic growth indeed explains the increase in production and consumption of renewable energy. They had conducted their research on 28 European Union countries.

2.2. Relationship between Renewable Energy Consumption and Economic Growth

Menegaki [27] indicated a lack of relationship between economic growth and the use of energy from renewable sources. The study supported the hypothesis of neutrality, as there was inadequate use of energy from renewable sources in EU member countries. At the same time, the production and consumption of energy from renewable sources were shown to have a positive impact on the real GDP of the residential sector, as indicated by Farhani and Shahbaz [28]. The research focused on the economic growth, emission of CO_2, and production and consumption of energy from renewable sources in North Africa and the Middle East regions. They found a causal relationship between the variables in the long term.

Apergis and Payne [29] indicated the bidirectional causal relationship use of energy from renewable sources and economic growth in both the long and short run. Thus, validating the hypothesis of feedback. They had used a model of panel vector error correction using the 20 years of data from OECD countries. Sebri and Ben-Salha [30] reported similar findings using the data from Central American countries spanning from 1990 and 2007. The BRICS countries also indicated similar patterns from 1971 and 2010, as they also exhibited a bidirectional relationship between the variables mentioned above, as was the case of China from 1977 to 2011 [31].

Shahbaz and Loganathan [32] utilized the vector error correction model for his research on Pakistan from 1972 to 2011, and his findings also validated the hypothesis of feedback. These findings were further validated by research of Kahia and Aïssa [33], on MENA's Net Oil Importing Countries and also concluded and validated the hypothesis of feedback, as they conducted their research using the same variables on data from 49 developing countries spanning from 1990 to 2012. Koçak and Şarkgüneşi [34] also came to a similar conclusion of their research on the Black Sea and Balkan countries. Payne [35] contradicts these findings as they found no evidence to support the Granger causation between the variables mentioned above, using the Toda–Yamamoto causality tests on US data. Therefore, they validate the hypothesis of neutrality. Menegaki [27] found this discrepancy in energy from renewable sources used in Europe between 1997 and 2007. This is due to the lack of short- and long-run Granger causality, supporting the neutrality hypothesis. Vaona [36] also supports this hypothesis based upon his study of Italian data in 1961 and 2000.

Research by Alam and Murad [37] indicates a positive impact of economic growth on the use of energy from renewable sources in the long term. Still, it indicates a negative impact in the short term in the case of OECD countries, as the causality results were different for the long and short term. Rahman and Velayutham [38] held that in South Asian countries the use of energy from renewable sources was causally related to economic progress. Meanwhile, Kahia and Aïssa [33] and Apergis and Payne [29] concluded the existence of a bi-directional relationship between economic progress and use of energy from renewable sources, their findings are further validated by those of Belaid and Zrelli [39], followed by Cherni and Jouini [40], along with those of Van Hoang and Shahzad [41]. While Menegaki [27] refutes these findings as their research indicated no such relationship, and his findings are further validated by Destek [42].

Regulations, rules, and a generally favorable policy climate all play a part in China's attempts to modernize its energy structure, and they are all important. The Renewable Energy Law (REL), which governs the country's renewable energy sector, was first implemented in 2005. According to Ji and Zhang [43] the renewable energy sector has experienced a significant increase in growth after the implementation of REL. Additionally, a regular stream of new policies has been developed throughout the past decade. According to critical research by Liu amd Guan [44], China's relevant laws are separated into specialized regulations and non-specialized regulations, both of which indirectly favor the rise of renewable energy sources [2].

The renewable energy sector has faced many important problems, the most notable of which has been financing constraints. As an example, Zhang and Cai [45] analyze China's renewable energy policy and emphasize the need for financial aid for renewable energy projects, among other things.

When it comes to emerging markets, Wu and Broadstock [46], discovered that financial growth and institutional quality had a positive influence on real estate costs. According to the findings of Kutan, Paramati [17], there is a link between the development of the stock market and foreign direct investment (FDI) in the Renewable Energy Credits (REC) sector. According to Sweerts and Dalla Longa [25], the financial status of African countries has an impact on the quantity of electricity generated by renewable and fossil-based technologies in the continent's 46 countries.

According to the data, a reduction in financial expenditures contributed to an increase in the usage of renewable energy sources. Charfeddine and Kahia [26] investigated the relationship between renewable energy certificates (RECs) and financial development on economic growth and carbon emissions. The findings revealed that renewable energy and financial development in the countries of the Middle East and North Africa were only marginally responsible for economic growth and CO_2 emissions. REC was shown to be positively influenced by financial development in 28 EU countries, according to Anton and Nucu [15] who studied the impacts of financial development on the REC throughout 1990 to 2015.

3. Methodology

3.1. Data and Sample

For the present research, we focus our attention on the latest data from the period of 2011 to 2020 based upon 20 Chinese provinces and autonomous regions of China, including municipalities [1], was used to test the impact of economic growth and financial development on the consumption of renewable energy sources. As a result, we'll be looking at data from 2011 to 2020. A metric of REC (billion kwh) was developed by Destek and Aslan [47] based on data from the China Electric Power Yearbook, which includes the major sources, both renewable and non-renewable sources of energy production. Renewable energy sources include hydro, solar, and wind power, while nonrenewable sources include nuclear and fossil fuel-based sources. Data from the China Static Yearbook illustrates economic growth and financial development, respectively, using financial value addition and GDP. In addition, empirical studies use metrics on a per capita scale, per-capita consumption of energy produced from renewable sources, per capita financial value-added, and per-capita of the GDP to remove the impact of population size. In addition, every data in this article is processed using the natural logarithm to guarantee data stability. The growth of the economy and financial development are explanatory variables in the estimated model data. In the meanwhile, REC statistics for 2020 for 20 provinces are available. Because of the vast geographical variations within China, this research takes a national and regional approach. Twenty provinces have been split up into three geographic areas. Given the fact that China occupies the third position in the world when it comes to area ad for purpose of the present research the provinces are divided into three regions: eastern China (Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan), central China (Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan), and western China (Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang).

3.2. Models

This study uses Chinese provinces' panel data to examine the relationship and causalities amongst production and consumption of renewable energy, financial development, and economic growth. When compared to cross-sectional and time-series data samples, the panel data model offers many benefits. For starters, the panel data includes information on the passage of time and the cross-sectional area. Another benefit of using panel-data models with a larger degree of freedom is that they provide more stable and reliable estimates across short periods across cross-sections [48]. Heterogeneities at individual levels can be overlooked in other types of data because panel data considers them.

3.2.1. PMG-ARDL Model

Using a panel PMG-ARDL model, short- and long-term relationships between variables may be studied in detail. According to Pesaran, Shin [49], the ARDL model, which they developed, has significant benefits over typical panel models. For starters, the ARDL model may be used to stationary variables (I (0), I (1), or a mixture of I (0) and I (1)), but not I (0) and I (1), (2). Second, a single equation in the ARDL model incorporates both short- and long-term connections. In addition, this model can address issues of endogeneity, heteroscedasticity, autocorrelation, and multicollinearity econometrically. PMG estimator was shown to be more trustworthy by Pesaran and Shin [49] as compared to other estimators, hence this article continues to acquire the equations inside an ARDL framework. As a result, the PMG estimator for long-run ARDL model coefficients assumes the same long-run coefficients, intercepts, and error terms across groups, but different short-run coefficients, intercepts, and error terms between groups. The PMG estimator, on the other hand, can handle the selection of lag orders. Both dependent and independent variables have distinct lags in the equation

$$\mathrm{REC}_{i,t} = \alpha_i + \sum_{j=1}^{p} \beta_{ij}\mathrm{REC}_{i,t-j} + \sum_{j=1}^{q} \delta_{i,j} Z_{i,t-j} + e_{i,t} \tag{1}$$

where the production and consumption of renewable energy are represented by REC on a per capita basis, FD represents the financial development on a percapita basis, and economic development on per capita basis is represented by EG. The, $t = 1; 2; \ldots; t$ denoted by the dimension of time, while $i = 1; 2; \ldots\ n$ denotes the cross sectional dimension.

$$Z_{it} = (\mathrm{FD}, \mathrm{EG})a_i \tag{2}$$

In Equation (2), Z_{it} denotes the vector of explanatory variables, the term FD stands for fiancnial development and EG stands for economic growth, they are measured in terms of increase in per capita value for the different regions of China.

The explanatory variables' vector is represented by $Z_{i,t}$, while the fixed effects related to the provinces are represented by α_i. $\beta_{i,j}$ denotes the lagged values of production and consumption of renewable energy is represented by $\text{REC}_{i,t}$ along with its parameter. Meanwhile, δ_{ij} lagged consists of the financial development on a percapita basis and economic development on per capita basis, which are the explanatory variables represented by FD and EG. The error term is denoted by ε_{it}. Following the PMG-ARDL technique in error correction model (ECM) form, we use

$$\Delta\text{REC}_{it} = \text{ECT}_{i,t} + \sum_{j=1}^{p-1} \theta^*{}_{ij}\Delta\text{REC}_{i,t-j} + \sum_{j=0}^{q-1} *_{i,j}\Delta Z_{i,t-j} + e_{i,t} \tag{3}$$

where,

$$\text{ECT}_{i,t} = \phi i\text{REC}_{i,t-1} - \phi i\text{REC}_{i,t},\ \phi_i = -\left(1 - \sum_{j=1}^{p} \theta_{ij}\right),\ \phi i = \frac{\sum_{j=0}^{q} \vartheta_{i,j}}{(1-\sum_{j=1}^{p} \theta_{i,j})} = \frac{\sum_{j=0}^{q} \vartheta_{i,j}}{\phi_i},\ \theta^*_{i,j} = -\sum_{s=j+1}^{q} \theta^*_{i,s},\ \text{and}\ \vartheta^*_{i,j} = -\sum_{s=j+1}^{q} \vartheta^*_{i,j}$$

In Equation (3), the speed of item adjustment from short term to long term via independent variables for relationship equilibrium is represented by $\text{ECT}_{i,t}$. The value of this relationship is -1 and zero, and the value of t-statistics is significant.

Under these conditions, the relationship is deemed to be long-term. On the other hand, if the value of these stats is greater than zero then the underlying long-term relationship amongst independent and dependent variables is deemed to be nonexistent. The other remaining items represent the short-term relationship amongst the dependent variable REC and independent variables of FD and EG. ϕ_i is the coefficient of vector for a long-term relationship of the explanatory variables. One of the main tasks of this research also pertains to determining the value of the coefficient of the long-term relationship φ_i and the adjustment term's speed represented by ϕ_i.

3.2.2. Panel Causality Test

The Dumitrescu and Hurlin panel causality test was performed to determine the direction of either long-term or short-term relations ships between the dependent and independent variables. As these variables can be determined by using Equation (3). This test was developed using the Granger causality tests as a base and is specified in Equation (4)

$$y_{it} = \sum_{j=1}^{d} a_i{}^{(d)}\ y_i, t-d + \sum_{j=1}^{d} b_i{}^{(d)}\ x_i, t-d + e_i, t \tag{4}$$

Equation (4) x and y both refer to the production and consumption of renewable energy represented by REC, Economic growth is presented EG and while financial development is represented by FD. The lagging length is represented by d, while $\alpha i^{(d)}$ is the represents coefficient of auto regressiveness and $\beta_i{}^{(d)}$ is the coefficient of regression that allows for accounting the differences.

4. Results

4.1. Panel Unit Root Test

Given the nature of the research, the variables must be stationary before using the panel cointegration test since non-stationary data frequently indicates erroneous regression findings. Regarding panel unit root tests, there are two major types: those that use the same or different assumptions and their parameter relate to autoregressive [50,51] and those that do not. The LLC and IPS tests were used, with LLC being a widely used technique for testing the matching set of assumptions about the autoregressive parameter. The IPS method is extensively used to test many assumptions related to autoregressive parameters. Panel unit root tests are tabulated; results are provided in Table 1. Given that the majority of data series are nonstationary at level 0 (the initial value), all of the variables are found to be stationary at the first difference 1 (1).

Table 1. Panel unit root test.

Variables	East		Central		West		Country Level	
	LLC	IPS	LLC	IPS	LLC	IPS	LLC	IPS
Ln_REC	1.20	32	1.42	4.54	−2.32	4.43	2.26	9.32
Δ_{Ln}_REC	−3.74 ***	−4.34 ***	−3.42 **	−3.21 ***	−3.43 ***	−4.42 ***	−5.61 ***	−8.23 ***
Ln_FD	2.42 ***	1.32 **	2.32 *	−1.34	0.64	3.42	−0.16	−7.43
Δ_{Ln}_FD	−5.84 **	−4.24 ***	−0.20 ***	−1.54 *	−2.53 **	−2.43 **	−5.51 **	−6.32 **
Ln_EG	−3.43 ***	−0.80	−2.27 **	−1.98	−1.42 *	−1.32	−4.22 **	−4.21
Δ_{Ln}_EG	−2.53 **	−2.31 **	−2.32 *	−2.26 **	−2.34 *	−1.43 **	−3.21 *	−3.43 ***

***, **, *, represent significance levels of 1 percent, 5 percent, and 10 percent. REC denotes renewable energy consumption, while FD financial development, and EG stands for economic growth. LLC denotes Livin-Lin-Chu and IPS denotes Im-Pesaran-Shin.

4.2. Panel Cointegration Test

Table 2 demonstrates the outcomes of the cointegration test. The null hypothesis is rejected based on the results, favoring the alternate hypothesis for four panels PP Statistic, panel ADF Statistic, Group PP Statistic, and Group ADF-Statistic at a significance level of 95% and 99%. Therefore, the panel cointegration test findings show that consumption of energy produced from renewable sources, financial development, and economic progress have cointegration connections at the nationwide level and the level of different geographic regions of China.

Table 2. Panel cointegration test.

Statistics	East	Central	West	Country Level
Panel V Test	1.87 *	−0.09	1.32	−2.82
Panel rho	−0.63	0.87	−1.53	1.99
Panel PP	−2.76 ***	−2.87 **	−5.33 ***	−3.82 ***
Panel ADF	−4.52 ***	−3.54 ***	5.76 ***	−5.84 ***

***, **, *, represent significance levels of 1 percent, 5 percent, and 10 percent.

4.3. Panel Regression Results (PMG-ARDL Approach)

This research utilized the panel model of PMG-ARDL to analyze the short and long-run dynamics of the connections between final development, economic growth, use of renewable Energy in mainland China, and different geographical regions of China—i.e., central east and west regions separately. Table 3 summarizes the PMG-ARDL estimate findings. According to Table 3, where ECT (−1) has a substantially negative value, China's overall economic growth and financial development have long-term connections with REC. At the 99% significance level, the financial value-added and GDP converge by 0.26 and 0.79 percent, respectively, to the long-term equilibrium relationship. According to the findings, the independent variables have a 26% and 79% annual impact on the path, indicating an equilibrium-based long-term relationship. However, the ECT (−1) coefficient was insignificant in the East region of China, while in the central region, it was outside the validation range. According to the present research findings, there is no long-term relationship between economic growth, financial development, and energy from renewable sources in the east and west regions of China.

Table 3. Panel regression results (PMG-ARDL approach).

	East	Central	West	Country Level
		Long Run Relationship		
Ln_FD	−4.3287 ***	−0.2743 ***	−0.8237 ***	−1.3261 ***
Ln_EG	4.2566 ***	0.7712 ***	1.8923 ***	2.8923 ***
ECT (Lag1)	−0.54615	−1.6523 ***	−0.7922 ***	−0.2671 ***
		Short Run Relationship		
ΔLn_REC	−0.5613 **	0.8716 *	0.2278	−0.6756 *
ΔLn_REC (Lag1)	−0.8261 **	0.5641 **	0.1212	−0.1562 **
ΔLn_REC (Lag2)	−0.8126	0.3726	0.0232	−0.8136 ***
ΔF	−1.8721	0.5836 **	0.6171 **	0.8621 ***
ΔLn_FD (Lag1)	−1.2687 ***	0.6532	0.5413 *	0.0651
ΔLn_FD (Lag2)	−1.5236	0.5903	0.7415 **	0.3378
ΔLn_EG	1.8279	−0.7236	0.2264	0.6121
ΔLn_EG (Lag1)	1.5267	0.6252	−1.0165	0.4371
ΔLn_EG (Lag2)	1.1526	−0.5612	−1.5673	1.1756
Constant	−3.1251	5.3541	4.2378	0.4862 ***
Trent		0.1786 ***		0.7611 ***

***, **, *, represent significance level of 1 percent, 5 percent, and 10 percent. REC denotes renewable energy consumption, while FD financial development and EG stands for Economic Growth.

4.4. Results of the Panel Causality Test

Panel regression results were also supplemented by application of causality test, commonly known as PMG-ARDL test. The results of this test tend to indicate the underlying causal relationship between different variables, which in this case are the economic and financial development of China and production and consumption of renewable energy. The results of PMG-ARDL panel estimation test are provided in Table 4. According to the results provided in Table 4, there exists a unidirectional causal relationship amongst the production and consumption of renewable energy denoted by REC and independent variables of financial development in denoted by FD across all regions of China, these results indicate that financial development across China had encouraged growth in renewable energy sector. This also points to fact that increase in production and consumption of renewable energy tends to support overall financial development of Chinese financial sector as they tend to profit from overall positive impact brought on by REC.

Table 4. Results of panel causality test.

H_0		FD- > REC	RE- > FD	EG- > REC	REC- > EG	EG- > FD	FD- > EG
National Level	W-Stat	7.00 ***	4.95	10.50 ***	3.56	14.79 ***	5.95
	Direction of Causality	Yes	No unidirectional	Yes	No unidirectional	Yes	No unidirectional
Eastern China	W-Stat	9.5 ***	3.00	9.56 ***	4.00	1.53	1.52
	Direction of Causality	Yes	No unidirectional	Yes	No unidirectional	No	No
Central China	W-Stat	8.00	4.99 **	7.90	2.77	15.12 ***	3.46
	Direction of Causality	No	Yes unidirectional	No	No	Yes	No unidirectional
Western China	W-Stat	5.95	5.67	13.12 ***	1.56	16.56 ***	6.99
	Direction of Causality	Yes	No	Yes	No unidirectional	Yes	No unidirectional

***, ** denote significance level of 1%, 5%, and 10%, respectively.

Therefore, supportive policies and regulations should be implemented to enhance the development of the renewable energy sector. The results also demonstrate that there is a significant causality from economic growth to REC in China as a whole, eastern China, and western China. This result is in line with those of Burakov [19], Rahman and Velayutham [38], and Narayan and Smyth [52]. Additionally, the findings show a one-way causality from economic growth to financial development over the considerable period, suggesting that economic growth influence the REC through stimulating the development of the financial sector.

REC in west China and the whole of China has major negative and good impacts on economic growth and financial development in the long run. If the 1% rise in financial development added per capita is significant, the REC per capita falls by 1.32 and 0.82 percent for the whole Chinese mainland and west China, respectively. According to the findings, long-term financial development in China will keep the REC at bay. As a result of this relationship being unfavorable, under-developed financial sectors may be to blame. The quality and quantity of the finances provided by these under-developed financial institutions lead to greater expenses, which hinders the prospects of investments in technology and infrastructure projects about promoting energy from renewable sources [25,53].

Growth in energy from renewable sources has been hampered in China by a lack of financial development Ji and Zhang [43]. The stock market, in particular, is inefficient at promoting the expansion of energy from the renewable sources industry. As China's economy grows, so does the REC for west China and all of China. In the case of the entire China and west region of China at a 1% significance level, the growth coefficients indicate that a 1% increase in the per capita GDP leads to increases in per capita REC of 2.89 % and 1.89%. The results of the present study are in line with the findings of Alam and Murad [37] and Sadorsky [9] followed by that of da Silva, Cerqueira [54]. They are also following the results held by Chen [55] where the study subject includes developing nations belonging to the Sub-Saharan African region, countries of OECD, and China. Economic expansion, on the other hand, may lead to new energy from renewable sources technology, which will help the industry expand.

The short-term connections between variables vary from the long-term ones. REC in the Chinese mainland, the west, and central regions are affected positively and negatively by economic growth and financial development, respectively, although the effects of economic growth are not substantial. The per capita REC will rise by 0.86%, 0.58%, and 0.61% in mainland China, and central and west regions of China in the future, when per capita financial value-added increases by 1%. The literature which discusses the casual relationship between economic and financial growth and energy from renewable sources can best be termed as limited. Still, the studies that have looked at it have shown that financial growth has a favorable impact on REC [15,43], which is in line with our results.

There is a short-term negative correlation between REC and economic growth, which is consistent with research done in Turkey and the OECD nations by Alam and Murad [37] flowed by Dogan [56], in case of the short time horizon findings show that financial development and growth of the economy have adverse as well as positive effects on REC, respectively. However, these effects are not statistically significant in the eastern region of China.

5. Conclusions and Practical Implications

Energy from renewable sources development is frequently hazardous and expensive, particularly in the beginning. To establish a favorable climate for the growth of this industry, policy support is required. The financial climate is one of the most critical pillars. A recent systemic approach, based on present literature and Chinese moves towards establishing a green financial system, finds that economic progress has contributed substantially to the development of energy from the renewable sources sector in China in 10 years. This paper investigates this contribution using time-series data and a recently developed systemic approach.

Using panel data techniques spanning the years 2011 to 2020, this research examines the dynamic connections and causation between economic growth, financial growth, and usage of energy from renewable sources in China. According to the cointegration test findings, energy consumption from renewable sources, financial development, and growth of GDP in China and the other three areas are all at long-term equilibrium. PMG-ARDL panel estimates show that long-term financial and economic growth in China, particularly in West China, has a major impact on energy from renewable sources use. There is a strong unidirectional link between China's financial growth and its energy use from renewable sources, as shown by the Granger causality tests, particularly in East China. While this is going on, China's overall economic development—including East and West China—will help boost demand for Energy from renewable sources. This research may be useful in advising policymakers on encouraging the expansion of the energy from renewable sources industry, especially from a financial and economic growth perspective.

To curb the menace of pollution, there urgent need to promote energy from renewable sources projects by increasing the overall investment in the renewable energy sector. Several policy implications are drawn from this study's findings. In the case of China, the local authorities should encourage the production and consumption of energy from renewable sources by incorporating local legislation to encourage the growth of the industry. The results show that the economy's expansion and the financial sector's development have varying effects in China's various areas when it comes to energy from renewable sources. For starters, West China's rapid economic growth may encourage the use of energy from renewable sources shortly. Financial sectors have a significant impact on renewables, and governments in West China should set up institutional structures that make it easy to finance energy from renewable sources projects.

Some policy implications were drawn from the research findings. The first conclusion of our study is to suggest that China has a market-based system in place to assist with the transition to a green economy. The broad growth of financial markets has the potential to have a largely beneficial influence on the renewable energy sector as a whole as well. Through more effective and affordable financing choices, market growth and credit reform can indirectly aid in the development of renewable energy resources. It is also important to encourage international investment in the renewable energy sector. Furthermore, a comprehensive set of policy actions is necessary, notably in the lending sector. The results of this study should be treated with caution due to the limited sample size and probable sensitivity of the numerical results to major fluctuations in the variables used. Regardless, the general message should remain the same. This study, which looked at historical data, should be taken into consideration by Chinese policymakers, who should establish policies that encourage the development of the renewable energy sector. According to statistical data, China needs a green financing system.

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