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How Do Financial Risk and Banking Globalization Affect Renewable Energy? A Nonlinear Analysis

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ABSTRACT

Renewable energy is a panacea for global issues like climate change and energy security. However, deploying renewable energy plants is costly and requires too much initial investment. Therefore, reducing financial risk and enhancing banking sector globalization can significantly enhance renewable energy consumption (REC). Previously, most empirical studies utilized the symmetric assumption; however, we have employed the asymmetric assumption to analyze the effect of financial risk and banking sector globalization on REC in this analysis. Thus, the primary research question in this analysis aims to answer is whether financial risk and banking sector globalization affect the REC symmetrically or asymmetrically, using linear and nonlinear ARDL methods. The linear model results indicate that banking globalization, GDP, and environmental policy stringency are associated with an increase in REC; however, financial risk is associated with a decrease in REC. On the other side, the nonlinear model result highlights that positive changes in banking globalization, fall in financial risk, GDP, carbon emissions, and environmental policy stringency increase the long-run REC, while the rise in financial risk and fall in banking globalization reduce the long-run REC. In the short run, banking globalization and GDP increase the REC in the linear model, while the rise in financial risk reduces the REC in the nonlinear model. Thus, by reducing financial risk and promoting banking globalization, policymakers can increase REC by providing greater financial access to businesses and individuals.

Keywords: Renewable Energy, Financial Risk, Banking Sector Globalization
JEL Classifications: F36, G32, Q42

1. INTRODUCTION

The discourse on renewable energy consumption (REC) is currently prominent in the global energy landscape, spurred by the urgency to tackle climate change, reduce reliance on fossil fuels, and achieve a sustainable energy future. Renewable energy (RE) sources provide a clean and abundant alternative to conventional energy sources, which are finite and environmentally damaging (Panwar et al., 2011). Fossil fuels not only contribute significantly to greenhouse gas emissions, which lead to climate change, but also pose various environmental, social, and economic challenges (Xu and Ullah, 2023). These include air and water pollution, habitat destruction, geopolitical conflicts, and price volatility. REC represents a shift toward harnessing and utilizing energy sources that are naturally replenished and have minimal environmental impact. The benefits of REC extend beyond environmental considerations (Dincer, 2000). They also include energy diversification, job creation, and improved energy security. By reducing dependence on fossil fuels and transitioning to RE sources, countries can enhance their energy independence and resilience, reduce energy costs, and create new employment opportunities in the growing RE sector (Brunet et al. 2022).

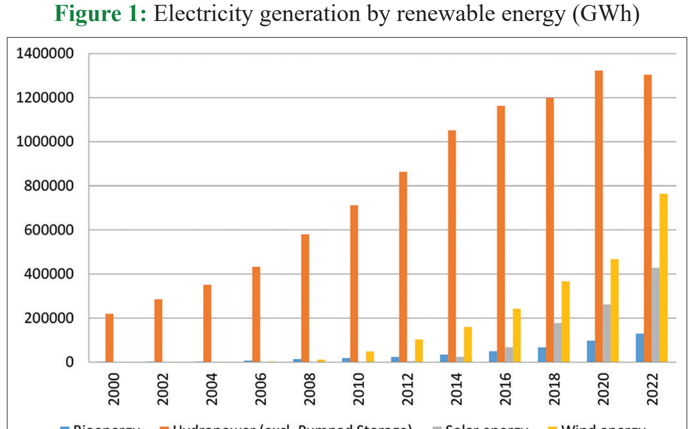
China has made significant progress towards increasing its REC in recent years, but there are still challenges that hinder the growth of this sector. Financial risk is a crucial factor that affects the investment decisions of RE projects. The high capital costs associated with RE projects and the long payback period for these investments make investors more sensitive to potential financial risks (Lee and Zhong, 2015). Furthermore, fluctuations in government policies and regulations may introduce uncertainty for investors, causing hesitation in committing to RE projects. One of the most significant financial risks that affect RE investments in China is the issue of intermittent power supply. The RE sector in China is dominated by wind and solar power, which are prone to fluctuations in output due to factors such as weather conditions and seasonal changes. This variability in power supply makes it challenging to predict revenue streams, creating uncertainties in return on investment. As a result, many investors are hesitant to invest in RE (Polzin and Sanders, 2020). Several studies have examined the impact of financial risk on REC. For instance, Wang and Dong (2022) found that higher financial risks, such as regulatory uncertainties and policy instability, hinder RE investments and dampen REC. These risks increase the cost of capital and reduce investor confidence, making RE projects less attractive. Similarly, Umar et al. (2021) highlighted that credit risk, market risk, and policy risk negatively affect REC, especially in emerging economies.

Another critical factor that impacts REC in China is the banking sector globalization. The global banking system is becoming increasingly interconnected, with more foreign banks investing in China's financial markets. While this can provide new opportunities for RE financing, it also creates new risks. One significant risk associated with banking sector globalization is the exposure of China's financial system to global financial shocks (Singh and Roca, 2022). With more foreign banks operating in China, the country's financial system is more connected to the global financial system, making it more vulnerable to financial crises and economic downturns. This could potentially impact the accessibility of financing for RE projects in China. Moreover, the global financial system's regulatory environment also affects RE investments in China. As global regulations on environmental and social governance (ESG) issues become more stringent, investors and banks may become more selective in their investments. This can create challenges for RE projects in China that may not meet these ESG criteria (Tolliver et al., 2021). The role of banking sector globalization in promoting the energy sector has been explored in the literature. Chen et al. (2023) found that the presence of foreign banks in a country positively affects energy investments and consumption. These banks bring in international expertise, capital, and access to global financial markets, thereby facilitating the financing of energy projects. Moreover, Amuakwa-Mensah and Näsström (2022) highlighted that the presence of international banks positively influences REC by promoting investment flows and technological transfers.

Existing literature reveals that despite these challenges, banking sector globalization provides new opportunities for financing RE projects in China. Zhang et al. (2022) reported that the increasing interconnectedness of the global banking system makes it easier for RE companies to access capital from international investors and financial institutions. The potential exists for an increase in the availability of financing for RE projects, thereby aiding in the acceleration of the transition towards a more sustainable energy system. While there have been several studies examining the impact of financial risk and banking sector globalization on REC in China, there are still significant gaps in the existing literature. One significant gap in the existing literature is the lack of studies that have simultaneously explored the impact of financial risk and banking sector globalization on REC in China. Another gap in the literature is the lack of studies that have examined the impact of overall financial risk on REC. While some studies have looked at the impact of regulatory risk, credit risk, or market risk on the energy sector but overlooked the impact of overall financial risk on REC. Finally, there is also a gap in the literature regarding the impact of banking sector globalization on REC. Most existing studies have examined the impact of banking globalization on the overall energy sector, without considering REC. Considering these gaps, our study aims to explore the effect of financial risk and banking globalization on REC in China.

The study on the impact of financial risk and banking sector globalization on REC in China is of significant importance for several reasons. First, as the world's top emitter, China is shifting toward RE to reduce its environmental problems. The development of RE sources in China is presented in Figure 1. Understanding the factors that impact REC in China is essential for promoting a more sustainable and resilient energy system. Second, the financial risks associated with REC in China are significant, and addressing these risks is critical for attracting more investment in this sector. Third, banking sector globalization presents both challenges and opportunities for REC in China. Understanding the impact of foreign banks on REC in China is essential for promoting a more diversified and resilient financing ecosystem for RE projects. The research has contributed to the current body of literature. Firstly, the study contributes to a better understanding of the impact of financial risk and banking globalization on REC in China. Secondly, this study makes a significant contribution to the existing literature by employing advanced econometric methods, specifically the nonlinear ARDL model. These sophisticated techniques enable a more robust estimation of the relationships between financial risk, banking sector globalization, and REC in China. By utilizing the NARDL model, this study can provide valuable insights into both the long-run (LR) and short-run (SR) dynamics, while also accounting for the impacts of positive and

Figure 1: Electricity generation by renewable energy (GWh)



Data sources: IMF, 2025

negative shocks associated with financial risk and banking sector globalization in China. Finally, the outcomes of this study will enhance our comprehension of the factors that either facilitate or impede REC in China. Additionally, it will offer valuable insights into policy measures that can effectively address the obstacles of financing and technology, thus promoting REC.

2. EMPIRICAL METHODOLOGY AND DATA

Financial risk has both direct and indirect effects on REC. Financial risk affects the cost of capital for RE. Higher perceived risks associated with RE technologies, such as technological uncertainties, regulatory changes, and market fluctuations, result in higher interest rates and strict lending conditions (Zhao et al., 2021). This increases the cost of borrowing and make it more challenging for RE developers to secure affordable financing. Financial risk impact investor confidence in RE projects. Uncertainties related to the profitability and long-term viability of RE investments can make investors hesitant to allocate their capital to such projects (Li et al., 2022). This can lead to reduced investment flows into the RE sector, limiting the availability of funds for project development and ultimately hindering consumption growth. Globalization of the banking sector also provides RE projects with access to a wider pool of capital. International banks with a global presence have the capacity to invest in RE initiatives across different countries. This increased availability of capital can support the development and expansion of RE projects, leading to higher levels of consumption. International banks bring in diverse funding options, including funds from various countries and regions (Anton and Nucu, 2020).

This study is conducted within the context of financial risk and globalization theory. This theory suggests that financial risk is an inherent part of investment decision-making. It encompasses various dimensions, including market, credit, liquidity, and operational risks (Baiardi et al., 2013). In the context of RE projects, financial risk theory helps to understand the uncertainties and potential negative outcomes associated with project financing, revenue generation, and market dynamics. Globalization theory explores the interconnectedness and integration of economies and financial systems worldwide (Kofman & Youngs, 2008). It emphasizes the increasing mobility of capital, the integration of financial markets, and the expansion of cross-border activities by multinational corporations (Ahmed, 2016). The theory offers perspectives on how the globalization of the banking sector impacts the accessibility of capital, financial flows, and investment prospects for RE projects in diverse countries and regions. This model is:

$$REC_t = \Psi_0 + \Psi_1 FR_t + \Psi_2 BG_t + \Psi_3 GDP_t + \Psi_4 CO_{2t} + \Psi_5 EPS_t + \varepsilon_t \quad (1)$$

Eq. (1) is renewable energy consumption (REC) that relies on financial risk (FR), banking sector globalization (BG), GDP per capita (GDP), CO_2 emissions (CO_2), and environmental policy stringency (EPS). We expect the elasticity of financial risk (Ψ_1) to be negative, suggesting that financial risk increases uncertainty for both consumers and producers, which negatively impacts REC. While the study anticipates a positive relationship between banking globalization and REC. Equation (1) depicting LR effects. To analyze the SR impacts of variables in this equation, reforming it within an error correction framework is crucial. Following the effective approach recommended by Pesaran et al. (2001) for concurrently estimating SR and LR coefficients, we thus adopt the resulting error correction model.

$$\begin{aligned}\Delta REC_t &= \Psi_0 + \sum\nolimits_{k=1}^{n}\varphi_{1k}\Delta REC_{t-k} + \sum\nolimits_{k=0}^{n}\varphi_{2k}\Delta FR_{t-k} \\ &+ \sum\nolimits_{k=0}^{n}\varphi_{3k}\Delta BG_{t-k} + \sum\nolimits_{k=1}^{n}\varphi_{4k}\Delta GDP_{t-k} \\ &+ \sum\nolimits_{k=0}^{n}\varphi_{5k}\Delta CO2_{t-k} + \sum\nolimits_{k=0}^{n}\varphi_{6k}\Delta EPS_{t-k} \\ &+ \Psi_1 REC_{t-1} + \Psi_2 FR_{t-1} + \Psi_3 BG_{t-1} \\ &+ \Psi_4 GDP_{it-1} + \Psi_5 CO2_{it-1} + \Psi_6 EPS_{t-1} + \varepsilon_t \quad (2)\end{aligned}$$

The above equation (2) resembles the linear ARDL framework proposed by Pesaran et al. (2001), which is based on error correction modelling. This approach simultaneously offers SR and LR estimates. The SR impacts are deduced from the coefficients associated with variables that have been first-differenced, and the LR impacts are determined by the estimations of Ψ_2-Ψ_3, which have been normalized on Ψ_1. According to Bahmani-Oskooee et al. (2023), these tests are comparable to evaluating the relevance of the lagged error-correction element in Engle and Granger's (1987) methodology. However, for the LR estimates to be considered accurate, Pesaran et al. (2001) suggest using the F-test or t-test (ECM_{t-1}) to determine the cointegration.

Conventional approaches to investigate the potential presence of cointegration among variables. Nevertheless, these approaches are subject to some constraints. Firstly, these techniques require that all series included in the model must have an order of integration of 1 (I(1)). Furthermore, these approaches cannot provide consistent findings when dealing with a short sample. Pesaran et al. (2001) introduced the ARDL model as an improvement over previous cointegration approaches, addressing their shortcomings. The ARDL model has the benefit of being equally applicable to variables that are integrated of order zero, order one, or a combination of both. Furthermore, the ARDL model performs well in situations with minimal sample size. The ARDL does not require mandatory pre-unit root testing. However, if the model includes any stationary variables at I(2), we cannot use the ARDL cointegration strategy. Nevertheless, if the equation includes any stationary variables at I(2), we cannot utilize the ARDL cointegration strategy. This is because the I(2) variables invalidate the bounds of F-statistic values. The main assumption behind models like (2) is that all regressors (FR and BG) have symmetric effects on the dependent variable. The primary drawback of linear time series models is that they assume variables to be linear when most of them exhibit nonlinear characteristics. Therefore, it is more appropriate to apply the nonlinear model. To convert the ARDL into NARDL, we rely on the partial sum technique of Shin et al. (2014) and decompose the variables of FR and BG into two parts, as shown below:

$$FR^{+}{}_{t} = \sum_{n=1}^{t} \Delta FR^{+}{}_{t} = \sum_{n=1}^{t} max\ (\Delta FR^{+}{}_{t}, 0) \tag{3a}$$

$$FR^{-}{}_{t} = \sum_{n=1}^{t} \Delta FR^{-}{}_{t} = \sum_{n=1}^{t} min\ (\Delta FR^{-}{}_{t}, 0) \tag{3b}$$

$$BG^{+}{}_{t} = \sum_{n=1}^{t} \Delta BG^{+}{}_{t} = \sum_{n=1}^{t} max\ (\Delta BG^{+}{}_{t}, 0) \tag{3c}$$

$$BG^{-}{}_{t} = \sum_{n=1}^{t} \Delta BG^{-}{}_{t} = \sum_{n=1}^{t} min\ (\Delta BG^{-}{}_{t}, 0) \tag{3d}$$

The series (3a and 3c) serves to denote positive shifts in the variables of financial risk and banking globalization, while negative changes are depicted by the series (3b and 3d). Substituting partial sum variables into Equ. (2) results in the following equation:

$$\begin{aligned} \Delta REC_t = {} & \Psi_0 + \sum\nolimits_{k=1}^{n} \varphi_{1k} \Delta REC_{t-k} + \sum\nolimits_{k=1}^{n} \varphi_{2k} \Delta FR^{+}{}_{t-k} \\ & + \sum\nolimits_{k=1}^{n} \varphi_{3k} \Delta FR^{-}{}_{t-k} + \sum\nolimits_{k=1}^{n} \varphi_{4k} \Delta BG^{+}{}_{t-k} \\ & + \sum\nolimits_{k=1}^{n} \varphi_{5k} \Delta BG^{-}{}_{t-k} + \sum\nolimits_{k=1}^{n} \varphi_{6k} GDP_{t-k} \\ & + \sum\nolimits_{k=1}^{n} \varphi_{7k} CO2_{t-k} + \sum\nolimits_{k=1}^{n} \varphi_{8k} EPS_{t-k} + \Psi_1 REC_{t-1} \\ & + \Psi_2 FR^{+}{}_{t-1} + \Psi_3 FR^{-}{}_{t-1} + \Psi_4 BG^{+}{}_{t-1} + \Psi_5 BG^{-}{}_{t-1} \\ & + \Psi_6 GDP_{t-1} + \Psi_7 CO2_{t-1} + \Psi_8 EPS_{t-1} + \varepsilon_t \end{aligned} \tag{4}$$

Equ. (4), referred to as an error-correction model, is widely acknowledged as a nonlinear ARDL model, which introduces nonlinearity by incorporating partial sum variables. The bounds testing technique described above by Pesaran et al. (2001) is then shown by Shin et al. (2014) to be equally relevant to model (4).

To explore the impact of financial risk and banking sector globalization on REC, the study collects data for China over the period 1995-2021. Renewable energy consumption (REC) in our study is measured from total energy consumption from all sources i.e. nuclear, renewables, and others. REC data is collected from EIA. Financial risk (FR) is measured through an index that ICRG calculates. Banking sector globalization (BG) is measured as foreign banks among total banks in % and data is obtained from GFFD. Our model is composed of three control variables. Control variables are selected from previous studies (Lei et al., 2022; Li and Ullah, 2022). These control variables include GDP per capita (constant at 2015 US$), CO2 emissions (in kilotons), and environmental policy stringency index. Existing literature infers that these control variables directly influence REC (Li and Ullah, 2022). The GDP and CO2 data series are obtained from the WDI, whereas EPS data is sourced from the OECD. The descriptive statistics reported in Table 1 indicate that all mean values are positive. The obtained mean scores are reported as: 1.806 for REC, 4.513 for FR, 2.612 for BG, 8.388 for GDP, 15.66 for CO2, and 1.393 for EPS. The obtained S.D scores are reported as: 0.898 for REC, 0.017 for FR, 0.500 for BG, 0.638 for GDP, 0.493 for CO2, and 1.170 for EPS. The J-B test is conducted to verify the normality of the chosen data series. The results of the J-B test indicating that all the data series demonstrate a non-normal distribution.

3. EMPIRICAL RESULTS AND DISCUSSION

The first and most crucial step in time series analysis is to determine whether the selected variables are stationary at I(0) or I(1). DF-GLS and the Zivot-Andrews (ZA) are two renowned tests used in this investigation. The ZA unit root test is superior to the ADF because it considers the structural break when analysing the unit root test, whereas the ADF does not. Table 2 presents the outcomes of the unit root tests. Results reveal that, except for EPS, all other variables become stationary after the first differencing in the DF-GLS test. The ZA test posits that FR, BG, and EPS are I(0), while REC, GDP, and CO2 are I(1). According to these findings, the variables utilized in the study are of mixed order of integration, or I(0) and I(1).

Since the findings of the unit root tests suggest that variables are either I(0) or I(1), which induces us to employ ARDL, which can handle I(0) and I(1) variables. These techniques permit the simultaneous estimate of both SR and LR outcomes, as shown in Table 3. The results display that the positive impact of BG, GDP, and EPS on REC is confirmed by the linear ARDL in LR. In LR, REC is increased by 0.276%, 1.537%, and 1.491%, respectively, for every 1% increase in BG, GDP, and EPS. In contrast, the LR estimated coefficient of FR reduces REC-a 1% increase in the FR results in a 0.809% fall in REC. According to the linear model, SR increases in BG promote REC by 0.066%; however, the rest of the estimates are insignificant in SR.

The estimates of BG_POS, GDP, CO2, and EPS are positive in the nonlinear model; a 1% increase in BG_POS, GDP, CO2 emissions, and EPS promotes REC by 0.130%, 1.772%, 0.927%, and 1.676%, respectively. However, a 1% increase in BG_NEG causes the REC to fall by 1.469%. Conversely, FR_POS and FR_NEG are negatively linked to the REC in the LR - a 1% increase in FR_POS reduces REC by 1.120%, and a 1% increase in FR_NEG promotes REC by 0.204%. Our findings are supported by various studies (Wang and Dong, 2022). This finding infers that financial risk reduces REC through both supply-side and demand-side channels. On the supply-side, financial risk reduce the availability of capital for RE investments, making it more difficult for RE projects to secure the necessary financing. This leads to delays or cancellations of RE projects, resulting in a reduction in the overall supply of RE (Adebayo et al., 2023). Financial risk also increases the cost of capital, which can make RE projects less profitable and less attractive to investors, thus reducing the overall REC (Anton and Nucu, 2020). On the demand-side, financial risk reduces the willingness of energy consumers to purchase RE. This occurs if consumers perceive RE as being riskier than traditional energy sources, such as fossil fuels, and are therefore less willing to invest in RE projects,

Table 1: Variable description and descriptive statistics

Variables	Definitions	Mean	Median	Max	Min	Standard Deviation	Skewness	Kurtosis	Jarque-Bera	Prob
REC	Total energy consumption from nuclear, renewables, and other (quad Btu)	1.806	1.843	3.242	0.579	0.898	0.050	1.569	9.259	0.010
FR	Financial risk index	4.513	4.517	4.538	4.476	0.017	−0.581	2.232	8.720	0.013
BG	Foreign banks among total banks (%)	2.612	2.900	3.203	1.649	0.500	−0.454	1.587	12.70	0.002
GDP	GDP per capita (constant 2015 US$)	8.388	8.458	9.364	7.294	0.638	−0.144	1.629	8.831	0.012
CO_2	CO_2 emissions (kt)	15.66	15.78	16.31	14.93	0.493	−0.349	1.514	12.12	0.002
EPS	Environmental policy stringency index	1.393	0.809	3.206	0.035	1.170	0.365	1.397	13.96	0.001

Table 2: Unit root results

Variables	DF-GLS		ZA			
	I (0)	I (1)	I (0)	Break period	I (1)	Break period
REC	−0.037	−1.614*	−2.798	2003q1	−6.325***	1997q2
FR	0.152	−1.904*	−6.654***	2008q2		
BG	−0.931	−2.007**	−8.658***	2006q1		
GDP	1.074	−2.709***	−1.023	1998q2	−4.356*	2007q1
CO_2	−0.394	−2.322**	−2.658	2002q1	−5.652***	1998q3
EPS	−1.753*		−4.658**	2011q2		

Table 3: Estimates of REC (ARDL & NARDL)

Variable	ARDL				NARDL			
	Coef.	S-E	t-Stat	Prob.	Coef.	S-E	t-Stat	Prob.
Long-run								
FR	−0.809*	0.428	−1.893	0.083				
FR_POS					−1.120***	0.260	−4.305	0.000
FR_NEG					−0.204***	0.054	−3.779	0.013
BG	0.276**	0.123	2.242	0.028				
BG_POS					0.130**	0.061	2.117	0.088
BG_NEG					1.469***	0.524	2.806	0.038
GDP	1.537**	0.672	2.287	0.037	1.772***	0.308	5.755	0.002
CO_2	0.290	0.252	1.150	0.268	0.927***	0.299	3.096	0.027
EPS	1.491**	0.732	2.037	0.045	1.676**	0.685	2.446	0.016
Short-run								
FR	−0.661	12.94	−0.051	0.960				
FR_POS					−0.126***	0.034	−3.761	0.000
FR_POS(−1)					−0.058*	0.031	−1.853	0.067
FR_NEG					−0.412	0.410	−1.005	0.335
BG	0.066*	0.035	1.865	0.065				
BG_POS					0.328	0.253	1.298	0.219
BG_NEG					0.839	0.622	1.349	0.181
BG_NEG(−1)					−1.131	0.828	−1.365	0.176
BG_NEG(−2)					−0.062	0.042	−1.470	0.145
GDP	1.063	0.760	1.399	0.187	0.320	0.264	1.210	0.250
GDP(−1)	1.586*	0.926	1.713	0.107	0.016	0.016	1.038	0.302
CO_2	0.493	0.365	1.350	0.197	0.119	0.093	1.270	0.228
CO_2 (−1)	0.328	0.387	0.848	0.413	0.115	0.079	1.471	0.167
EPS	0.033	0.054	0.613	0.549	0.012	0.010	1.218	0.226
EPS(−1)					−0.014	0.029	−0.465	0.643
C	11.84***	2.935	4.036	0.002	4.783**	2.326	2.056	0.043
Diagnostics								
F	5.145***				9.658***			
ECM(−1)*	−0.723***	0.102	−7.098	0.000	−0.750***	0.058	−12.91	0.000
LM	1.325				0.365			
RESET	2.014				1.025			
CUSUM	S				S			
CUSUM-sq	S				S			
Wald-FE-LR					9.688***			
Wald-FR-SR					1.325			
Wald-BG-LR					8.055***			
Wald-BG-SR					2.012			

***P<0.01; **P<0.05; *P<0.10

thus reducing REC (Xu et al., 2019). This means that financial risk reduces REC by increasing the uncertainty and perceived risks linked with RE investments. This increased risk leads to a higher required rate of return for investors, which increases the cost of capital for RE projects. As a result, RE projects have become less profitable and less attractive to investors, reducing the supply of RE. In addition, increased risk and uncertainty can also reduce the willingness of energy consumers to purchase RE, further reducing REC.

This finding is supported by Rafindadi and Mika'Ilu (2019), who revealed that banking sector globalization increased REC through both financing and technology transfer channels (Anton and Nucu, 2020). On the financing side, banking sector globalization increases the availability of capital for RE investments. This occurs through foreign direct investment, international lending, and the issuance of international green bonds. Foreign capital helps bridge the funding gap for RE projects, which increase the REC (Paramati et al., 2017). Additionally, foreign banks have greater expertise and experience in financing RE projects, which leads to more efficient and effective investment decisions. On the technology transfer side, banking sector globalization promotes the transfer of RE technology and expertise across borders. Foreign banks provide access to the latest technology and best practices in RE, which can help improve the efficiency and effectiveness of RE projects. This results in lower costs and higher energy yields, which increases the REC (Mazzucato and Semieniuk, 2018). Ahmed et al. (2023) stated that banking sector globalization increases REC by increasing the availability of capital and technology for RE investments. This increased availability of capital and technology leads to a lower cost of capital and higher efficiency and effectiveness of RE projects. As a result, RE becomes more competitive with traditional energy sources, which increases the REC.

The SR estimates of all the coefficients are insignificant except FR. Numerous diagnostic tests have confirmed the accuracy of our analysis. According to Table 3, neither the LM nor RESET tests can identify serial correlation or model misspecification. The CUSUM tests indicate the stability of our parameters. The cointegration between the parameters is examined using the F-test and ECM test, and both sets of findings confirm the validity of the variables' LR relationship. The LR asymmetric effects of FR and BG on REC are also endorsed as the estimates of Wald are significant.

For estimating the causal link between the variables, we have employed the asymmetric causality test, the results of which are reported in Table 4. The results volume is too large; therefore, we have only presented some significant causal results. For instance, among the important results, we only observe a two-way causal link between FR_POS↔REC, FR_POS↔GDP, GDP↔BG_POS, and CO2↔GDP. However, we find a unidirectional causality running from BG_POS → REC, BG_NEG → REC, GDP→ REC, CO2→

Table 4: Asymmetric causality test

Null hypothesis	F-Stat	Prob.	Null Hypothesis:	F-Stat	Prob.
FR_POS→REC	5.404**	0.014	GDP→FR_NEG	0.133	0.876
REC→FR_POS	3.152*	0.066	FR_NEG→GDP	0.224	0.801
FR_NEG→REC	1.761	0.199	CO_2→FR_NEG	0.102	0.904
REC→FR_NEG	0.001	0.999	FR_NEG→CO_2	0.799	0.464
BG_POS→REC	5.012**	0.014	EPS→FR_NEG	0.140	0.870
REC→BG_POS	1.573	0.233	FR_NEG→EPS	27.30***	0.000
BG_NEG→REC	4.460**	0.026	BG_NEG→BG_POS	2.242	0.134
REC→BG_NEG	0.107	0.900	BG_POS→BG_NEG	0.326	0.726
GDP→REC	16.95***	0.000	GDP→BG_POS	5.136**	0.017
REC→GDP	0.580	0.569	BG_POS→GDP	2.783*	0.087
CO_2→REC	5.491**	0.013	CO_2→BG_POS	5.924**	0.010
REC→CO_2	1.763	0.197	BG_POS→CO_2	0.263	0.771
EPS→REC	1.052	0.368	EPS→BG_POS	0.231	0.796
REC→EPS	4.850**	0.019	BG_POS→EPS	5.847**	0.011
FR_NEG→FR_POS	0.016	0.984	GDP→BG_NEG	0.032	0.968
FR_POS→FR_NEG	0.543	0.590	BG_NEG→GDP	7.385***	0.004
BG_POS→FR_POS	1.060	0.366	CO_2→BG_NEG	1.225	0.316
FR_POS→BG_POS	7.458***	0.004	BG_NEG→CO_2	2.260	0.132
BG_NEG→FR_POS	9.494***	0.001	EPS→BG_NEG	0.333	0.721
FR_POS→BG_NEG	1.854	0.184	BG_NEG→EPS	1.174	0.331
GDP→FR_POS	2.555*	0.104	CO_2→GDP	6.572***	0.006
FR_POS→GDP	15.68***	0.000	GDP→CO_2	2.517**	0.106
CO_2→FR_POS	2.577	0.102	EPS→GDP	1.147	0.338
FR_POS→CO_2	4.770	0.021	GDP→EPS	3.016*	0.072
EPS→FR_POS	2.145	0.145	EPS→CO_2	0.200	0.820
FR_POS→EPS	1.686	0.212	CO_2→EPS	3.063*	0.069
BG_POS→FR_NEG	0.218	0.806			
FR_NEG→BG_POS	0.038	0.963			
BG_NEG→FR_NEG	0.103	0.903			
FR_NEG→BG_NEG	0.409	0.670			

REC, REC→ EPS, FR_POS→BG_POS, BG_NEG→FR_POS, FR_NEG→EPS, CO2→BG_POS, BG_POS→NEG, GDP→CO2, GDP→EPS, and CO2→ EPS.

4. CONCLUSIONS AND POLICY IMPLICATIONS

China has positioned itself as a key participant in the worldwide shift towards RE, setting ambitious goals for RE utilization and making substantial investments in RE technologies. However, despite these efforts, there are still barriers to the REC in China, including financial risk and limited access to finance. Financial risk, which includes risks related to policy and regulation, technology, and market uncertainties, increases the cost of capital, making them less attractive to RE investors. Additionally, limited access to financing, particularly in rural areas and for SMEs, further constrains the development of RE projects. At the same time, banking sector globalization potentially plays a positive role in promoting REC. By providing access to international financing and expertise, banking sector globalization help overcome the financing and technology barriers to RE adoption. However, the impact of banking sector globalization and financial risk on REC is not yet explored, particularly in the context of China. Thus, our study aims to fill this gap by examining the impact of financial risk and banking sector globalization on REC in China. The study has used nonlinear ARDL to estimate the effects of financial risk and banking sector globalization on REC in China. The findings of the study are reported as follows: The linear model results show that BG, GDP, and EPS lead to a rise in REC; however, the FR leads to a decrease in REC. On the other side, the nonlinear model result highlights that BG_POS, FR_NEG, GDP, CO2, and EPS increase the REC in LR, while the FR_POS and BG_NEG reduce the REC in LR. In the SR, the BG and GDP increase the REC in the linear model, while the FR_POS reduces the REC in the nonlinear model.

There are several policy suggestions that can be adopted to promote REC in China. Policy measures should be implemented to reduce financial risk for RE projects, including clear and stable policy and regulatory frameworks, improvements in technology and market infrastructure, and measures to promote investor confidence and mitigate project risks. Efforts should be made to increase access to financing for RE projects, particularly in rural areas and for SMEs. This can be achieved through targeted lending programs, subsidies, and the development of innovative financing mechanisms. Policies should be put in place to encourage banking sector globalization, including measures to attract foreign investment, facilitate international lending, and encourage the issuance of international green bonds. Additionally, efforts should be made to promote technology transfer and expertise sharing, which help improve the usefulness of RE projects. Investments should be made in RE infrastructure, including transmission and distribution systems, to ensure that RE can be effectively integrated into the grid. Efforts should be made to increase public awareness of the benefits of RE and promote a culture of sustainable energy consumption. This includes education and awareness campaigns, as well as incentives and subsidies for households and businesses that adopt RE technologies.

Our study acknowledges several limitations. The study includes the role of GDP, environmental policy, and carbon emissions in the model. Future research should consider incorporating additional variables that may influence the relationship between financial risk, banking globalization, and REC. For instance, factors like government policies, technological advancements, and public awareness campaigns should be examined to provide a more comprehensive analysis. The study focuses specifically on China's context, and the findings may not be directly generalizable to other nations. Different economic, political, and regulatory conditions may influence the relationship between financial risk, banking globalization, and REC in different contexts. Conducting a comparative analysis across different countries or regions would allow for a better understanding of how the impact of financial risk and banking sector globalization on REC varies across different contexts. Such comparative studies should provide valuable insights into best practices and policy implications. Future research should focus on identifying specific policy implications that effectively address financial risks and leverage banking sector globalization to promote REC. This would assist policymakers and stakeholders in designing targeted measures to foster a more sustainable and resilient energy sector.

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