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China's Political Risk and Transition to Cleaner Energy: Evaluating the Role of Political Economy for COP27

Xiao Gu, Xiaohan Gu, Weizheng Wang, Difei Hu

Xiao Gu (e-mail: xiaogu20190140@163.com): School of Marxism, Hangzhou Polytechnic, Hangzhou, China

Xiaohan Gu (e-mail: guxiaohan6688@outlook.com): Faculty of Law, University of Salamanca, Salamanca, Spain

Weizheng Wang (e-mail: wangweizheng0657@outlook.com): Institute of Agricultural Information, Chinese Academy of Agricultural Sciences, Beijing, China

Difei Hu (*corresponding author*, e-mail: hudifei6688@outlook.com; hudifeigz@163.com): Public Administration School, Jinan University, Guangzhou, China

Abstract

In the pursuit of sustainable development, economies such as China are placing a paramount emphasis on significantly augmenting the utilization of renewable energy sources. This marks a departure from conventional research approaches that solely focused on macroeconomic determinants while investigating patterns of renewable energy consumption. Thus, this research pursues to witness the relationship between the political risk index (*PRI*), renewable electricity output (*RELOP*), public-private partnership investment in energy (*PPINENR*), and renewable energy consumption (*RECNS*) in China from 1984 to 2022. For data estimations, this study utilizes time series methods, which include DF-GLS and Johansen cointegration for unit root and long-run equilibrium with FMOLS, DOLS and CCR as primary methods. The research also employs the least squares method with break years and robust least squares as robustness check methods while for causal relationships, we deploy the Granger causality approach. The outcomes assert that variables are found stationary at differences and long-run equilibrium is confirmed among variables. The empirical estimations predict that *GDP* and *PPINENR* reduce the *RECNS* in China in both short and long term. Furthermore, *PRI* and *RELOP* enhance renewable energy consumption in the short as well as long run. Therefore, policymakers should mostly focus on the encouraging role of *PPINENR* towards renewable electricity to enhance *RECNS* in developing economies, particularly in China. To achieve the targets of COP27, China should increase its focus on the efficient utilization of public-private partnership investments and also manage the political risks in the economy to promote renewable energy consumption and achieve a sustainable environment. Moreover, the causality analysis unearths that *PRI* could be utilized along with other variables to enhance *RECNS* in China. The robustness check asserts similar and robust outcomes.

Keywords: Political risk index, renewable electricity output, public-private partnership investment in energy, renewable energy consumption, GDP, China

JEL Classification: O13, Q42, Q43, P28

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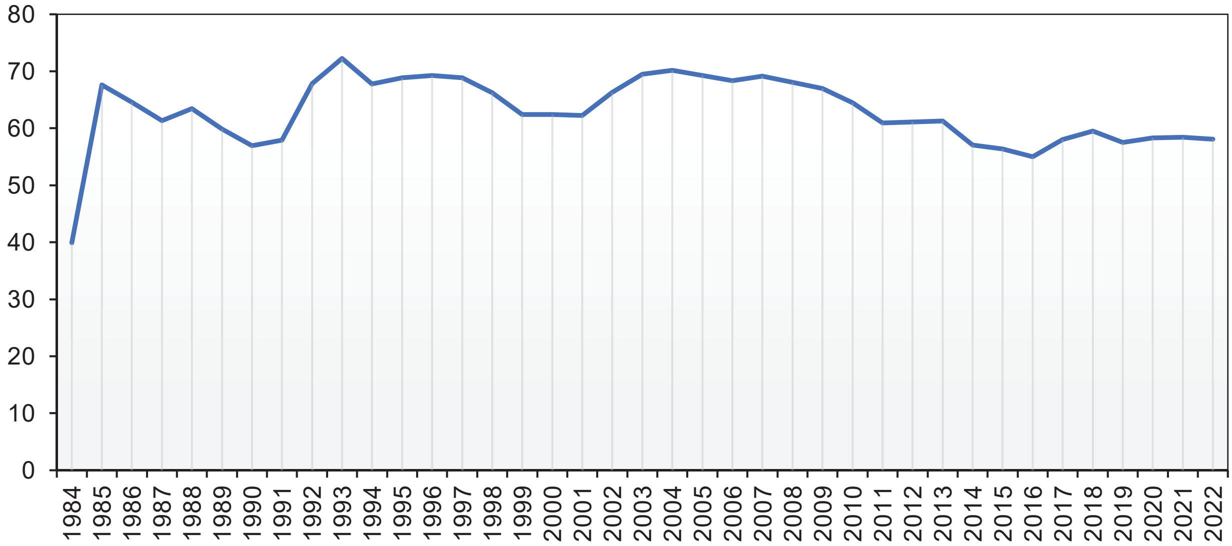
1. Introduction

Climate change has once again become a contentious topic as global emissions continue to rise, despite the goals set by the Paris Agreement on Climate Change. The international community convened for COP27 under the United Nations to establish new targets aimed at reducing emissions and promoting renewable, eco-friendly energy instead of reliance on fossil fuels. Unfortunately, environmental damage is escalating rather than diminishing, largely due to the excessive extraction of natural resources and continued reliance on fossil fuels instead of transitioning to sustainable energy sources (Song *et al*., 2023). One of the challenges lies in the volatility and fluctuations of natural resources on international markets, which can impede the import of fossil fuels needed for economic growth in many countries. Additionally, the rapid economic expansion of emerging and developing economies has contributed to the accelerated pace of climate change, posing global threats to the environment (Soares *et al*., 2023; Zhou *et al*., 2023). Various studies have explored ways to achieve sustainable development, with an emphasis on resource conservation and efficient management. Yet, the risk of volatility and dispersion of resources remains a persistent concern.

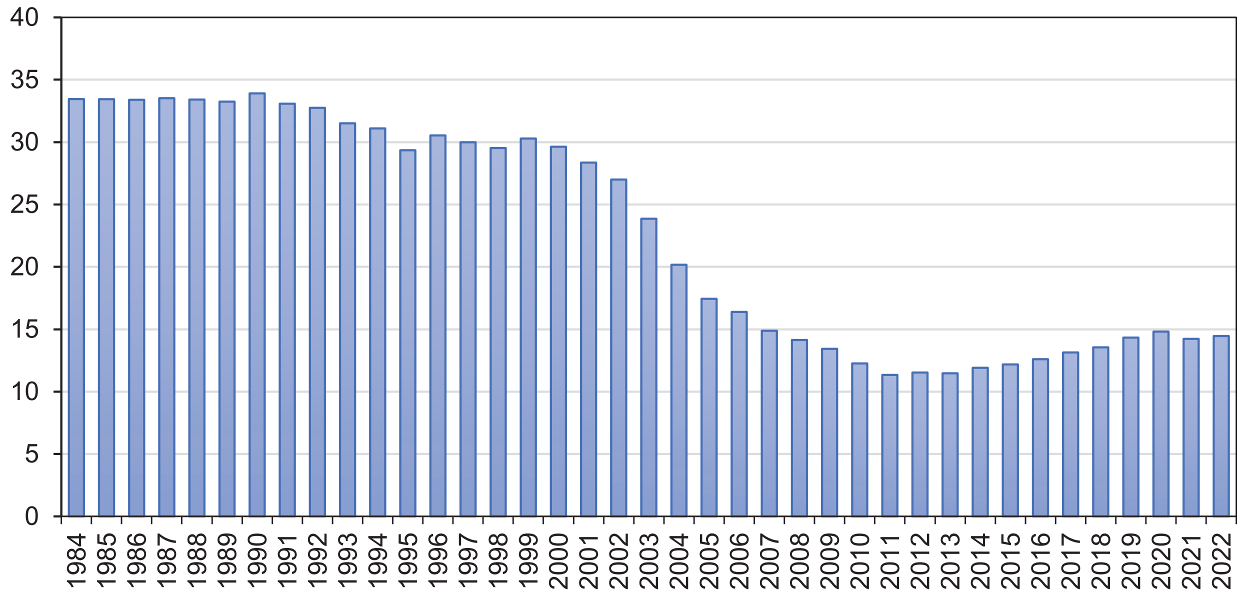
Figure 1: Political risk index of China



Note: Horizontal axis denotes years, and a vertical axis denotes *PRI* values.
Source: PRS (2023)

This study aims to explore essential elements that can lead to widespread adoption of renewable energy, and how economic and political factors play a crucial role in achieving sustainability goals, especially in countries such as China and other developing economies. While efficient resource management and stringent environmental policies are important for reducing emissions, it is suggested that a comprehensive approach involving various factors should be considered. For example, China heavily relies on coal reserves for over 80% of its energy needs, which poses a significant challenge in transitioning to renewable energy sources. Figure 1 illustrates China's political risk index, which has remained relatively stable at around 65, due to its complex economic system. Despite being one of the largest carbon emitters globally, China is committed to sustainable development as a participant in COP27 (Cergibozan, 2022; Zhang *et al*., 2022). The focus of this study is to examine how China's political economy is influencing the acceptance of renewable energy products and efficient technology projects while still ensuring economic growth (Azam *et al*., 2021). By understanding the interplay between economic and political factors, valuable insights can be gained to address sustainability issues effectively in China and other developing economies.

Figure 2: Output of renewable energy consumption in China



Note: Horizontal axis denotes years and the vertical axis denotes *RECNS* values.
Source: World Bank Group (2023)

In China, the use of clean energy is vital and growing, making a substantial contribution to the nation's efforts to battle climate change and achieve equitable growth. China has been aggressively pushing clean energy sources to lessen its reliance on fossil fuels and ameliorate environmental effects due to its large population and expanding economy. Government regulations and incentives, such as feed-in tariffs and subsidies, which have stimulated significant investments in renewable energy projects, are some of the main factors influencing the adoption of renewable power (J. Zhao *et al*., 2022). Additionally, China has made significant strides concerning production and technological advances, resulting in economies of scale that lower the costs and increase the accessibility of renewable energy equipment such as solar panels and wind turbines (Chao *et al*., 2023). Additionally, global agreements and partnerships have allowed the transfer of technology and expertise, helping China quickly increase its capacity for renewable power. As a result, renewable energy has gained importance in China's energy mix, promoting sustainability and assisting in the nation's transition to a more environmentally friendly and sustainable existence. Figure 2 provides the statistics of renewable energy consumption in China from 1984–2022 (World Bank Group, 2023).

Furthermore, the role of GDP and public-private partnership investment in energy are also considered the essential drivers of renewable energy consumption. The GDP has a significant impact on the use of energy from renewable sources through a variety of pathways, both favourable and unfavourable. On the plus side, increased economic activity is typically correlated with higher GDP levels, which encourages further investments in renewable energy infrastructure and technologies (Iqbal *et al*., 2023b). As economies develop, nations prioritize environmental protection and sustainability, which may lead to increased use of renewable energy. Furthermore, a population that is better educated and concerned about the environment and that supports renewable energy efforts and legislation tends to have a higher GDP per capita. However, there can also be unfavourable effects. Rapid economic development can occasionally result in a rise in the usage of energy, which, if improperly managed, might result in a rise in the use of non-renewable energy sources and reverse the gains from the adoption of renewable sources. Furthermore, countries with robust economies reliant on fossil fuels can be reluctant to switch to renewable energy since doing so might disrupt current sectors and result in immediate economic difficulties (Lawal, 2023).

Investments made through public-private partnerships (*PPINENR*) influence the use of renewable energy in a variety of ways, both favourably and unfavourably. Positively, *PPINENR* investments allow public and private organizations to combine their resources, knowledge and technological capabilities, promoting the rapid development and implementation of renewable energy projects. This partnership may boost the availability and capacity of renewable energy sources, therefore lowering reliance on fossil fuels and minimizing environmental effects (Udeagha and Ngepah, 2023). *PPINENR* may also draw in international capital, which helps the adoption of innovative renewable technology. However, difficulties might develop, such as competing goals between public and private partners, administrative roadblocks and possible dangers of excessive dependence on profit-driven organizations. To guarantee that *PPINENR* initiatives in renewable energy support sustainable growth and fair energy access while reducing negative consequences, meticulous preparation, open rules and effective risk administration are essential (Ning *et al*., 2023).

This research aims to thoroughly examine the relationship between various factors, namely the political risk index (*PRI*), renewable electricity output (*RELOP*), public-private partnership investment in energy (*PPINENR*), economic growth (*GDP*) and renewable energy consumption (*RECNS*) in China, an emerging economy. By focusing on China, the study seeks to contribute to the understanding of renewable energy projects in line with SDGs for 2030 and their alignment with the objectives of COP27. One key aspect that sets this research apart is the inclusion of novel variables such as *PRI*, *RELOP* and *PPINENR*, which have not been extensively studied in the region. While there is existing literature on the impact of these variables on *RECNS* in various regions, there is a notable lack of research specifically addressing China and similar emerging economies. To ensure a comprehensive analysis, the study employs a time series approach using data spanning from 1984 to 2022. Various time series methods are applied, including DF-GLS for unit root analysis, Johansen cointegration for assessing long-run equilibrium, and FMOLS, DOLS and CCR as primary analytical methods. Additionally, robustness checks are conducted using least squares with break years and robust least squares. To explore causality, the study uses the Granger causality test. The findings of this research carry significant importance as they shed light on factors that can drive the adoption of renewable energy and help China achieve its targets set at COP27. Furthermore, the study's insights can prove valuable to researchers and scholars studying this area of renewable energy and sustainable development. By understanding the linkage between the variables studied, policymakers and stakeholders can make informed decisions to promote renewable energy usage and support China's sustainable growth journey.

The remainder of the study is organized as follows: In Section 2, a comprehensive review of the existing literature is presented. Following that, Section 3 delves into the methodological framework employed for this research. Section 4 elucidates the pivotal findings that emerged from the study. Subsequently, Section 5 undertakes a thoughtful discussion of these findings, including their policy implications. Finally, the study culminates with a conclusive summary in the last section.

2. Literature Review

2.1 Political risk index and renewable energy consumption

The literature on the relation of the variables is scant, particularly in the current perspective between the political risk index (*PRI*) and renewable energy consumption (*RECNS*). Moreover, extensive literature work does not discuss the relationship between *PRI* and *RECNS*. However, the work discussing said issue is presented in this section of the research. For instance, in the MINT economies, Adebayo *et al*. (2023) studied the relationship between political risks, renewable energy and CO_2 emissions. The research also checked the role of trade, GDP and financial risks. The research observed that political and financial risks improve renewable energy and enhance the environment. Moreover, the EKC hypothesis for the economies is validated and a unidirectional link is confirmed between variables. In OECD economies, Z. Zhao *et al*. (2023) inspected the role of geopolitical risk on the demand for green energy consumption and development. The demand function of renewable energy included CO_2 emissions, NRR, income and globalization. The research found that geopolitical risk pointedly reduces the renewable energy demand in OECD economies and also has a detrimental impact on sustainable environmental policies. Furthermore, Z. Wang *et al*. (2023) scrutinized the influence of political and financial risks on the environment and usage of renewable energy (REC) in the ASEAN economies by including panel methods such as CUP-FM. The research observed that decreasing political and financial risks reduces environmental degradation, which leads to improvement in REC in ASEAN economies. Moreover, a bidirectional link was found between political risk and REC. The study recommended that political risks should be managed to promote green and efficient technologies in the ASEAN economies. M. Ahmad *et al*. (2023) inspected the role of country risk, including political, financial and economic risk impact on the environment. The research confirmed that restraining country risk factors will increase the usage of renewable energy and decrease CO_2 emissions. Cergibozan (2022) scrutinized the connection between country risk and renewable energy, and confirmed that reducing a country's risk and maintaining political stability will enhance the use of hydroelectricity and solar energy. The conclusions assert that countries should reduce risk and increase the usage of green energy. Zhang *et al*. (2022) evaluated the role of political risk in private and state-owned renewable energy firms. The outcomes asserted that state green energy firms are more resilient towards risks than private firms. The authors recommended that subsidies from the state should be offered to reduce the influence of different risks in the economies.

2.2 GDP, renewable electricity output and renewable energy consumption

Current studies consider GDP per capita to be the main determinant of renewable energy consumption. For instance, Lawal (2023) evaluated the influence of GDP along with other social and environmental factors on RE in selected African economies by encompassing the GMM panel method. The outcomes show that GDP and renewable energy have a positive linkage, and the author also established feedback hypothesis between variables. The policy outcomes suggested that the pollution haven hypothesis is present in many African economies; therefore, there is a need for investment in green energy technologies. Yang and Song (2023) scrutinized the linkage between GDP and REC with the effective role of human capital and investment. The outcomes asserted that energy efficiency and renewable energy consumption increases due to GDP per capita and decreases due to FDI and human capital. Chu *et al*. (2023) also studied the determinants of renewable energy, with energy security and economic complexity as the main determinants. The research used panel methods such as panel quantile regression in the top 23 energy consumer economies. The outcomes reveal that economic complexity is more negative in upper quantiles than in lower quantiles while energy security stimulates REC in both lower and upper quantiles. Iqbal *et al*. (2023a) investigated the role of various determinants of renewable energy production, which also included economic expansion in Pakistan. The outcomes asserted that increasing GDP, CO_2 emissions and financial progress will increase the production of renewable energy in Pakistan. Similarly, Iqbal *et al*., 2023b) also asserted that GDP stimulates renewable energy consumption in Pakistan. Mohamed Yusoff *et al*. (2023) concluded that economic expansion is bi-directionally correlated with renewable energy in Malaysia, where CO_2 emissions reduce the use of these technologies in the long run. Moreover, M. Ahmad *et al*. (2023) observed that GDP and country risk Granger cause energy transition.

Studies on the relationship between renewable electricity output (*RELOP*) and renewable energy consumption are limited due to the interchangeable use of these terms in the previous research work. However, some studies that explain the relationship between both variables exist; for example, U. S. Ahmad *et al*. (2022) observed that RE usage increased and improved when fossil fuel alternatives such as hydroelectric power generation and renewable electricity increased in Pakistan. Moreover, the research also asserted that alternative sources of energy Granger cause renewable energy. J. Zhao *et al*. (2022) also claimed that enhancing the transition to renewable alternative sources of energy, including electricity, is the sole factor to improve renewable energy development and generation in developing economies. The study recommended that developing regions should provide certain initiatives to reduce the use of dirty energy sources and increase the use of green energies. Sun *et al*. (2019) investigated the role of green technology in energy efficiency, covering a sample of 71 mixed economies globally by deploying a frontier approach. The outcomes showed that green innovation is one of the leading factors in energy efficiency, which indirectly suggests the enhancement of renewable energy. Certain recent research (Jin and Huang, 2023; Pasini *et al*., 2023; Samour *et al*., 2023) has asserted that renewable electricity is one of the leading factors in reducing CO_2 emissions and enhancing the environment in different regions and nations around the world.

2.3 Public-private partnership investment and renewable energy consumption

Balcilar *et al*. (2023) studied the linkage between public-private partnership investment (*PPINENR*) in energy and green technologies, which include renewable energy in Turkey. The research also encompassed controlling effects of FDI, GDP and trade. The outcomes reveal that there is a positive connection between *PPINENR* and REC. The author further reiterated that investments from both sectors should be increased to enhance the usage of efficient technologies. Udeagha and Ngepah

(2023) observed that public-private partnership investments in energy increase CO_2 emissions, while technical investments in renewables improve environmental sustainability. The author also confirmed the Granger cause effect between variables on both sides. Ning *et al*. (2023) evaluated the role of public-private partnership investment in energy (*PPINENR*) along with the controlling variables of energy use, economic development and power prices on the environment in Pakistan by using the ARDLS method and time series data. The outcomes asserted that *PPINENR* has a negative influence on CO_2 emissions in the short run but a positive influence in the long run. The research recommended that significant *PPINENR* is required in green energies and technologies to promote energy efficiency and a sustainable environment in the long run. Ayhan and Üstüner (2022) also claimed that *PPINENR* encourages renewable energy infrastructure in Turkey and also established the infrastructure which is based on economic expansion. Akomea-Frimpong *et al*. (2023) also studied the role of *PPINENR* and asserted that *PPINENR* promotes the use of clean energy in Ghana while also reducing poverty and striving for SDGs in the economy.

2.4 Summary and gaps in the literature

This literature review focuses on various variables related to renewable energy consumption. According to most authors, an increase in political risk tends to decrease the use of renewable energy. On the other hand, factors such as the growing importance of renewable electricity, sustainable economic expansion and public-private partnership investments in energy have the potential to increase the adoption and consumption of renewable energy products. The study also emphasizes that transitioning to renewable energy and promoting its development is crucial for achieving high environmental quality. However, the existing research has limitations, as it lacks comprehensive perspectives on renewable energy and is often specific to certain regions and economies. Additionally, there is limited evidence regarding the influence of the political risk index, green innovation and renewable electricity on renewable energy consumption, with some indications of asymmetry. Given these gaps in the literature, the study aims to empirically examine the relationships between the political risk index, renewable electricity output, public-private partnership investment in energy, GDP and renewable energy consumption. By doing so, the research seeks to provide valuable insights and policy recommendations that can promote and develop renewable energy while ensuring environmental sustainability in the region. This novel study has the potential to spark discussions on the interconnections between the variables under consideration, shedding light on critical issues and opportunities in the field of renewable energy. Through its empirical findings, the research intends to offer valuable guidance for decision-makers to implement effective policies to encourage renewable energy adoption and development in the region.

3. Theoretical Framework, Model Specification and Estimation Techniques

3.1 Theoretical framework

The current research studies the relation of the political risk index (*PRI*), renewable electricity output (*RELOP*) and renewable energy consumption (*RECNS*). The research also scrutinizes the role of *GDP* and public-private partnership investment in energy (*PPINENR*). The *PRI* is one of the important features in renewable energy and the environment in developed and emerging economies. The term political risk index (*PRI*) directs policies and objectives regarding the environment and strengthening environmental policies. A lower political risk index paves the way for improvement in technological sectors, particularly green technology such as renewable energy products, and builds confidence in investors to provide investments in the environment-improving sector. Moreover, a favourable *PRI* can also enhance international trade, particularly in the renewable energy sector, which can also lead to an increase in the *RECNS*. Furthermore, a positive *PRI* strengthens environmental policies and promotes awareness regarding green technologies, which primes the production and consumption of renewable energy products. Since China is one of the politically stable economies in the world, we expect a positive influence of *PRI* on *RECNS*, *i.e.*, $\delta_1 = \delta RECNS/\delta PRI > 0$.

Renewable electricity output (*RELOP*) is also one of the substantial elements in renewable energy consumption (*RECNS*). There are different channels through which *RELOP* posits an effect on *RECNS*. With the accessibility of *RELOP* in the economy, consumers may turn from fossil fuels to *RECNS*. Since *RELOP* is energy-efficient, it can help provide disposable income for citizens and they can invest more in renewable energy products, which are environment-friendly technology. Moreover, progress in *RELOP* technologies can make clean energy more attractive to governments and the adoption of *RECNS* easier in the economies. The increasing focus and research on *RELOP* will decrease its costs and make it more affordable and available, which could increase the use of *RECNS*. Thus, we propose a positive effect of *RELOP* on *RECNS* in China, *i.e.*, $\delta_2 = \delta RECNS/\delta RELOP > 0$.

There are different channels and theories through which *GDP* influences *RECNS*. Some of them are established, such as endogenous growth theory and EKC hypothesis. The former is related to human capital and technological progress, which are the main drivers of *GDP*. It is evident from the theories that when the economy grows, it is more acceptable to stimulate research and development processes that can foster renewable technologies and innovate energy-efficient products in the economy. The theoretical background of the EKC hypothesis is similar to other theories as there is an inverted U-shape connection between CO_2 emissions and *GDP*. In the initial stages, the economy increases and so do the CO_2 emissions; however, at the next stage the *GDP* increases substantially and invests more in energy-efficient and renewable energy products, which increases environmental protection and stimulates the use of *RECNS*. Therefore, we observe that China is still in the emerging phase and mostly dependent on fossil fuels for rapid economic expansion; we expect a negative influence of *GDP* on *RECNS*, *i.e.*, $\delta_3 = \delta RECNS / \delta GDP > 0$.

Public-private partnership investment in energy (*PPINENR*) is one of the leading factors in the environment and renewable energy infrastructure. *PPINENR* can pave the way for *RECNS* by alleviating the costs of energy and reducing risks and pooling resources and investments towards efficient investments in renewable energy projects. Moreover, the principal agent theory is another mechanism through which *PPINENR* can combine the benefits of public and private sectors by working to reduce irregularities and designing rules and regulations which make investment in renewable energy more attractive. *PPINENR* reduces the risk through sharing, which enhances the confidence of investing more in *RECNS*. Thus, we expect the impact of *PPINENR* on *RECNS* to be positive, *i.e.*, $\delta_4 = \delta RECNS / \delta PPINENR > 0$.

3.2 Model specification

Given the above objectives, previous work and theoretical understanding, this study proposes the following model:

$$RECNS_t = \alpha_1 + \beta_2 PRI_t + \beta_3 RELOP_t + \beta_4 GDP_t + \beta_5 PPINENR_t + M_t \tag{1}$$

Equation (1) includes the intercept term β_0 and the expected slopes α associated with each variable under consideration. The subscript 't' in these equations indicates a particular period, while ε embodies the presence of random error within the regression model. Moreover, the predicted variable is renewable energy consumption (*RECNS*), which is taken as renewable energy usage out of total energy used in the economy from different sources. Furthermore, the explanatory variables are *PRI*, which is the political risk index, and *RELOP* as renewable electricity output, which is measured as renewable electricity output out of total electricity output. *GDP* is economic growth and expressed in US dollars 2015 constant, while *PPINENR* is public-private partnership investment in energy in current US dollars. The research is established on single-country analysis, which uses time series data spanning from 1984 to 2022, while the data for variables are extracted from different sources: the *PRI* data are from PRS (2023), while the data for the remaining variables are extracted from World Bank Group (2023).

3.3 Econometric tools

The econometric methods used in the study provide empirical support for our research. The research commences with the DF-GLS unit root method, which investigates the co-variates for any specific roots in the unit root circle. The method is an extension of the ADF test, to observe variables by taking their lags and finding out whether it is stationary or non-stationary at level. The method is efficient because it also relaxes heteroskedasticity. The null hypothesis is void when the co-variates are found stationary at difference, *i.e.*, [I(1)]. The equation provided for the DF-GLS is expressed below:

$$\Delta Y_t = \beta_0 + \Delta Y_{t-1} + \mu t \tag{3}$$

Having proven the stationarity of variables, we determine the long-run equilibrium between the depicted variable and its co-variates. The test works using an error correction method and identifies the relation among the variables. The JC test ensures that variables move together, particularly in the long run. The JC test also includes a combination of several variables. The JC test accepts no cointegration at the null hypothesis. Other than the unit root and cointegration methods, this study applies primary methods, namely FMOLS, DOLS and CCR. The three methods are similar yet robust and valid for time series data. FMOLS and DOLS provide ground for variables to be related in the long term despite being cointegrated or having stationary properties. Both methods take the lags of the predicted variable and their co-variates to first find out the stationary series and then long-run elasticities among variables. The methods are robust and valid while also accounting for heteroskedasticity, serial correlation and autocorrelation, and endogeneity issues asymptotically. The equation for DOLS is expressed below:

$$J_t = L_t\beta + \sum_{j=-q}^{q} \Delta G_t + j\delta_i + F_{1t} \tag{4}$$

For robustness check, the research employs both parametric approaches, where the first approach is least squares with break years. The least square method is a statistical tool that provides a fitting line to reduce the errors between actual and expected values. The break years are taken to express the shocks and trends that occurred during the years in the economy. The robustness is checked to find out whether the estimates are still robust after taking breaks in the variable series. The second test is robust least squares, involving the outliers and influential observations which may have been left in the primary methods. To investigate the causal relationship, the research employs the Granger causality method, related to the causal relationship between explanatory variables and predicted variables. The method is related to the concept that when one explanatory variable faces changes, it will transfer its changes to the predicted variable.

4. Results and Discussion

Table 1: Descriptive statistics

Variables	*GDP*	*PRI*	*PPINENR*	*RELOP*	*RECNS*
Mean	5.69324	62.90800	1.669023	19.12897	22.70843
Median	3.60266	62.41667	1.33432	18.82125	23.86000
Maximum	1.66567	72.25000	5.08653	23.92682	33.91000
Minimum	6.187654	39.91667	9710000.235	15.03704	11.34000
Std. dev.	4.960922	6.121524	1.31242	2.465218	9.022616
Skewness	0.784026	−1.242863	0.715072	0.396975	−0.015731
Kurtosis	2.252785	6.049761	2.583716	2.155374	1.199736
Jarque–Bera	4.902819	25.15480	3.605233	2.183592	5.268150
Probability	0.086172	0.000003	0.164867	0.335613	0.071785

Source: Authors' own calculations

The research begins by conducting a descriptive analysis presented in Table 1. The average values, including mean, median and maximum-minimum values, show a positive and increasing trend. However, there is considerable dispersion observed between the maximum and minimum range of values. On further examination, it is noticed that the standard deviation (SD) values are relatively lower than the mean, indicating a lack of significant dispersion among the values. To assess the distribution of the data, skewness and kurtosis measures are employed. The results show that *PRI* and *RECNS* exhibit negative skewness, while *GDP*, *RELOP* and *PPINENR* have positive skewness. Regarding kurtosis, all variables, except *PRI*, fall within the threshold limit, suggesting normal tail and right-side distribution. However, *PRI* exceeds the threshold, indicating potential outliers. Given the importance of normality inaccurate estimations, the researchers also used the Jarque and Bera (1987) test. The test reveals that most values are not statistically significant, except *GDP*, *PRI* and *RECNS*. This leads to the rejection of the null hypothesis of normal data distribution for these three variables.

Table 2: Unit root test results (DF-GLS)

Variables	Level (0)	D (1)
GDP	−1.110013	−3.091726***
PPINENR	−4.356820	–
PRI	−3.020917	–
RECNS	−2.585847	−4.565377***
RELOP	−1.896848	−7.898975**

Note: $p < 0.01$, 0.05 and 0.1 shows significance at 1%, 5%, and 10%.
Source: Authors' own calculations

Table 2 demonstrates the DF-GLS unit root outcomes. The outcomes indicate that except *PPINENR* and *PRI*, which are statistically significant at level, the other variables are found stationary at difference which indicates that statistical values of these variables are lesser than the critical values. Thus, we conclude that since all variables are not stationary at level but some of them at difference, we accept the alternative hypothesis of the data being stationary at difference [I(1)].

Table 3: Johansen cointegration

Hypothesized number of CE (s)	Eigenvalue	Max eigenvalue	0.05 critical value	Prob.**
None*	0.613306	82.39780	69.81889	0.0036
At most 1	0.425926	47.24330	47.85613	0.0570
At most 2	0.315625	26.70838	29.79707	0.1090
At most 3	0.199504	12.67617	15.49471	0.1272
At most 4*	0.113147	4.442796	3.841465	0.0350

Note: Max. eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level; * denotes rejection of the hypothesis at the 0.05 level; ** MacKinnon–Haug–Michelis (1999) *p*-values.
Source: Authors' own calculations

Table 3 presents the outcomes of assessing the long-run equilibrium between variables, a crucial prerequisite for establishing cointegration in our research. Before applying the final method, it is essential to settle the occurrence of long-run equilibrium among the data. To realize this, we exploit the JC test, which employs the error correction method to determine the cointegration of variables. The results obtained from the JC test confirm that equilibrium is predominantly present across the values, leading us to conclude that long-run equilibrium does indeed exist among the variables.

Table 4: Primary results from FMOLS, DOLS and CCR

Dependent variable: RECNS

Variable	**FMOLS**	**DOLS**	**CCR**
	Coefficient [std er] (*p*-values)	**Coefficient [std er] (*p*-values)**	**Coefficient [std er] (*p*-values)**
GDP	−0.391998*** [0.042656]	−0.380927*** [0.057591]	−0.363312*** [0.042279]
PRI	2.553010*** [0.263387]	2.434189*** [0.355484]	2.238880*** [0.280679]
PPINENR	−0.038415*** [0.031771]	−0.037416** [0.042829]	−0.052562*** [0.038304]
RELOP	1.566839*** [0.322315]	1.616226* [0.419546]	1.825431*** [0.319165]

Note: $p < 0.01$, 0.05 and 0.1 shows significance at 1%, 5%, and 10%.
Source: Authors' own calculations

The main outcomes of the research are provided in Table 4 selectively. The outcomes of Table 4 are presented empirically through parametric methods which include FMOLS, DOLS and CCR. The empirical outcomes of the research indicate that *GDP* and public-private partnership investment in energy (*PPINENR*) reduce renewable energy consumption (*RECNS*). In actual figures, a percentage increase in *GDP* and *PPINENR* leads to a decrease in *RECNS* by −0.39%, −0.38%, −0.36%, and −0.038%, −0.037% and −0.052% respectively. Moreover, the influence of *PRI* and *RELOP* is found to be positive and stimulating over *RECNS* in both the short and long run. A percentage increase in *PRI* and *RELOP* will increase *RECNS* by 2.55%, 2.43%, 2.23% and 1.56%, 1.61% and 1.82% correspondingly. The overall results are significant and conclusive.

The negative impact of *GDP* on the adoption of renewable energy in China and similar regional economies can be attributed to several factors. Two significant channels through which this influence occurs are the rebound effect and the growth effect, both of which hinder the consumption of renewable energy. As the economy experiences rapid expansion, it leads to increased opportunities and higher incomes, which, in turn, drive up the demand for goods, services and energy. However, due to the lower costs of fossil fuels compared to renewable energy sources, there is a prevailing preference for using fossil fuels over renewables. Despite being one of the leading economies and making efforts towards renewable energy consumption (*RECNS*) under the COP27 targets, China faces challenges in establishing the essential infrastructure and facilities for renewable energy. Issues with transmission lines pose a hindrance to a complete transition to renewables and may also affect production and manufacturing, which currently rely on the cheaper energy provided by fossil fuels. Moreover, the political economy adds another layer of difficulty, as implementing the necessary policies for a large-scale transition to renewable energy becomes a complex task for the government. The outcomes of the research are analogous to the opinions of Azam *et al*. (2021) and Q. Wang *et al*. (2022).

The Political Risk Index (*PRI*) plays a crucial role in promoting the adoption of renewable energy consumption (*RECNS*). Higher *PRI* scores put pressure on governments to invest more in green technologies and renewables while reducing dependence on imported fossil fuels. China, in particular, benefits from stable renewable energy products compared to the volatility of imported fossil fuels. Moreover, the *PRI* fosters *RECNS* by highlighting the environmental risks associated with fossil fuels, driven largely by the awareness and demands of citizens in various economies. International efforts, exemplified by COP26, COP27 and the Sustainable Development Goals (SDGs), further underscore the urgency of addressing the detrimental impact of fossil fuels on the climate and environment. Several factors contribute to the growing adoption of *RECNS*, especially in line with the goals set by COP27. One such factor is the declining costs of renewable energy products, making them more attractive and accessible. Additionally, the increasing demand for efficient and sustainable energy arises from concerns over energy security threats and environmental hazards. International organizations also play a significant role in this transition, providing financial and technical assistance to support the region's sustainability objectives. As a result, the momentum towards renewable energy adoption is gaining traction, driven by both domestic and international efforts to mitigate the adverse effects of fossil fuels on the planet and secure a more sustainable future. The outcomes of the research are analogous to the opinions of Z. Wang *et al*. (2023).

Furthermore, the utilization of public-private partnership investment in energy (*PPINENR*) holds a promising potential in promoting renewable energy consumption. However, in some emerging economies such as China, there has been a stronger emphasis on utilizing fossil fuels to facilitate rapid economic expansion, rather than investing in renewable energy projects. This preference for non-renewable energy sources has led to a diversion of both public and private investments away from renewables. Compounding the issue, governments in these regions may not be providing sufficient financial and economic support for renewable energy initiatives, which acts as a deterrent for potential public-private partnership investments in the sector. Nevertheless, recent developments suggest a changing trend, as the effectiveness of the second parametric method and its outcomes indicate an increasing role of *PPINENR*. In recent times, there is evidence of both public and private sectors joining forces to fund projects in renewable energy consumption and new sources (*RECNS*) while also focusing on risk-sharing objectives in the region. As a consequence of COP27, priorities have been set to address these challenges and move towards sustainable development. The targets agreed at COP27 include fostering risk-sharing mechanisms, financing projects that promote efficient technologies, scaling up renewable energy products and generating employment opportunities. These efforts collectively aim to pave the way for a sustainable energy future (Liu *et al*., 2022; Ning *et al*., 2023).

Conversely, renewable electricity output (*RELOP*) increases *RECNS*, which indicates that improving *RELOP* in economies may attract distributors and buyers towards renewable electricity. Thus, introducing such projects will ensure that private firms invest more in renewable energy projects. Increasing investment in *RELOP* may increase the renewable energy infrastructure in economies and focus more on renewable energy projects than on fossil fuels. Encouraging the use of *RELOP* will ensure energy efficiency and reduce the costs of fossil fuels, which can further be invested in renewable energy projects and efficient technologies. The positive connection is also proved by the research of Rashed *et al*. (2021).

Table 5: Robustness check via least squares with structural breaks (parametric approach)

Variable	Coefficient	Std. error	*t*-statistic	Prob.
		1984–2003		
GDP	−0.025009	0.028840	−0.867173	0.3921
		2004–2008		
GDP	−0.043027	0.027754	−1.550270	0.1306
		2009–2022		
GDP	−0.056555	0.027129	−2.084652	0.0449
		Non-breaking variables		
PRI	0.439902	0.172332	2.552650	0.0155
PPINENR	−0.019675	0.011876	−1.656729	0.1071
RELOP	0.936303	0.145515	6.434423	0.0000

Note: $p < 0.01$, 0.05 and 0.1 shows significance at 1%, 5%, and 10%.
Source: Authors' own calculations

Similarly, the results were investigated for robustness using the least squares method with break years, as shown in Table 5. The outcomes are similar and valid: despite taking break years, the effect of *GDP* has remained negative on *RECNS* in China. Moreover, in the non-breaking variable series, the outcomes of *PPINENR* are insignificant while the results of *PRI* and *RELOP* are similar to the previous parametric method estimations. Besides, it is also asserted that *GDP* is negative but inconclusive in the early breaking years, which indicates that in the previous decades, *GDP* may not have played an essential role in the development of renewable energy, and since attention has been paid to sustainable development mostly after 2010, such as through COP26 and COP27 development targets. Thus, we conclude that the results are similar to the main parametric method and valid.

Table 6: Robustness check via robust least squares

Variable	Coefficient	Std. error	t-statistic	Prob.
GDP	−0.373017	0.038099	−9.790811	0.0000
PRI	2.505476	0.235164	10.65415	0.0000
PPINENR	−0.029170	0.028333	−1.029570	0.3032
RELOP	1.370836	0.277544	4.939173	0.0000

Note: $p < 0.01$, 0.05 and 0.1 shows significance at 1%, 5%, and 10%.
Source: Authors' own calculations

Table 6 presents the results of our analysis, where it is asserted that the variable *PPINENR* shows no significant impact. However, the outcomes of the other variables remain consistent and robust when subjected to the main parametric methods. It was observed that robust least squares effectively handle influential observations and account for outliers. As a result of considering these outliers, we have concluded that, except *PPINENR*, all other modelled variables are significant and lead to conclusive findings. Based on the robustness check, we can confidently state that our results are comparable to those obtained from the main methods and can be applied empirically in both the short and long term.

Table 7: Granger causality test

Hypothesis	*F*-statistic	Prob.
GDP–RECNS	6.11683	0.0000
RECNS–GDP	1.86587	0.1807
PRI–RECNS	8.70313	0.0056
RECNS–PRI	8.79273	0.0054
PPINENR–RECNS	0.00060	0.9805
RECNS–PPINENR	0.23929	0.6278
RELOP–RECNS	32.2989	2.E-06
RECNS–RELOP	4.51408	0.0408

Notes: *RECNS* is the dependent variable; $p < 0.01$, 0.05 and 0.1 shows significance at 1%, 5%, and 10%.

Source: Authors' own calculations

Table 7 predicts the causal relationship of variables. The outcomes of the causal relationship assert that *GDP* and *RELOP* have one-way causality while *PRI* has a bidirectional causal connection with *RECNS*. Thus, we conclude that any changes in policy level in these factors could influence changes in the predicted variable.

5. Conclusion and Policy Recommendations

The prospects of renewable energy consumption in emerging economies have been the subject of limited literature. Existing studies primarily focus on regional analysis, leading to asymmetric outputs. However, there remains a lack of comprehensive research on the various factors that determine the potential for renewable energy adoption in these economies. Thus, this study pursued to observe the relationship between the political risk index (*PRI*), renewable electricity output (*RELOP*), public-private partnership investment in energy (*PPINENR*) and renewable energy consumption (*RECNS*) in China from 1984 to 2022. For data estimations, this study utilized time series methods, which included DF-GLS and Johansen cointegration for unit root and long-run equilibrium with FMOLS, DOLS and CCR as primary methods. The research also employed the least squares method with break years and robust least squares as robustness check methods while for causal relationships, we deployed the Granger causality approach. The outcomes asserted that variables are found to be stationary at differences and long-run equilibrium is confirmed among variables. The empirical estimations predict that *GDP* and *PPINENR* reduce the *RECNS* in China in both short and long term. Furthermore, *PRI* and *RELOP* enhance renewable energy consumption in the short and also in the long run. Therefore, policymakers should mostly focus on the encouraging role of *PPINENR* towards renewable electricity to enhance *RECNS* in developing economies, particularly in China. To achieve the targets of COP27, China should increase its focus on the efficient utilization of public-private partnership investments and also manage the political risks in the economy to promote renewable energy consumption and achieve a sustainable environment. Moreover, the causality analysis revealed that *PRI* could be utilized along with other variables to enhance *RECNS* in China. The robustness check confirmed similar and robust outcomes.

Establishing the conclusions from the estimations, this study provides the following policy implications. Firstly, authorities should implement regulations and policies that should increase the decoupling process of *GDP* from carbon-intensive industries and promote the energy efficiency by increasing renewable energy consumption. Moreover, to achieve rapid economic expansion, authorities must reduce the use of fossil fuels by increasing energy efficiency and developing efficient technologies, which shall enhance both *GDP* and renewable energy consumption. Secondly, we conclude that *PPINENR* decreases the use of RECN, which is mostly the design process of investment in more energy-intensive products. However, authorities should increase regulations and incentives to divert the investments more towards *RECNS* projects in the economy. Thirdly, as *PRI* increases *RECNS*, authorities should promote the use of R&D projects, invest in efficient technologies, promote awareness about climate change and reduce reliance on fossil fuels. Fourthly, renewable electricity also increases *RECNS*. Thus, authorities should increase further investments in grid infrastructures, develop more market-based solutions that could compete with traditional fuels, and increase public awareness regarding the use of clean energies.

5.1 Future research directions and limitations

The current study focuses exclusively on China, but there is potential for future research to expand its scope to include other economies such as OECD or G7 nations, as well as developing ASEAN or G20 countries. By doing so, researchers can explore the additional impact of financial development, governance, human capital and fiscal decentralization on the regional economic coherence and national stability (*RECNS*) in these respective economies.

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