

Research Article | Araştırma Makalesi

The relationship between income inequality and renewable energy consumption: A dynamic panel data analysis for G-20 countries

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Abstract

Renewable energy (RE) represents a global transformation process with economic and environmental impacts, and countries are taking strategic steps to progress in this area. Income inequality is considered to play a critical role in this process. This study aims to determine the impact of income inequality on RE consumption (REC). The research covers data from 19 G20 member countries from 2001 to 2020. The empirical evidence obtained in the study is based on the two-step generalized method of moments (GMM) estimator derived by Arellano-Bond. Five variables are used in the study. These are REC, carbon dioxide (CO₂) emissions, trade openness, Gross Domestic Product (GDP) per capita, and the Gini index (GINI). This research shows that increasing income inequality in G20 countries hurts REC. However, according to the findings, the lagged impact of income inequality is significant. In addition, the effect of other variables (CO₂ emissions, trade openness, and GDP per capita) discussed in the study on REC is harmful and significant. In conclusion, the findings from the example of G20 countries provide evidence that an increase in income inequality has a lagged negative impact on REC and suggest that policymakers should consider income redistribution measures to promote REC.

Keywords: Income inequality, Renewable energy, Sustainable development, G20 countries. **JEL Codes:** O15, Q56, Q40

Gelir eşitsizliği ve yenilenebilir enerji tüketimi arasındaki ilişki: G-20 ülkeleri için dinamik panel veri analizi

Öz

Yenilenebilir enerji (RE) ekonomik ve çevresel etkileriyle küresel ölçekte öne çıkan bir dönüşüm sürecini temsil etmekte, ülkeler bu alanda ilerleme kaydetmek için stratejik adımlar atmaktadır. Gelir eşitsizliğinin bu süreçte kritik bir rol oynadığı düşünülmektedir. Bu çalışma, gelir eşitsizliğinin RE tüketimi (REC) üzerindeki etkisini belirlemeyi amaçlamaktadır. Araştırma, G20 üyesi 19 ülkenin 2001-2020 yılları arasındaki verilerini kapsamaktadır. Çalışmada elde edilen ampirik kanıtlar, Arellano-Bond tarafından geliştirilen iki aşamalı genelleştirilmiş momentler yöntemi (GMM) tahmincisine dayanmaktadır. Çalışmada beş değişken kullanılmıştır. Bunlar; REC, karbondioksit (CO₂) emisyonları, ticari açıklık, kişi başı Gayri Safi Yurtiçi Hasıla (GSYH) ve Gini endeksi (GINI)'dir. Bu araştırma, G20 ülkelerinde artan gelir eşitsizliğinin REC'e olumsuz etki ettiğini göstermektedir. Ancak bulgulara göre, gelir eşitsizliğinin gecikmeli etkisi anlamlıdır. Buna ek olarak, çalışmada ele alınan diğer değişkenlerin (CO₂ emisyonları, ticari açıklık ve kişi başı GSYH) REC üzerindeki etkisi negatif ve anlamlıdır. Sonuç olarak, G20 ülkeleri örneğinden elde edilen bulgular, gelir eşitsizliğindeki artışın REC üzerinde gecikmeli bir olumsuz etkisi olduğuna dair kanıtlar sunmakta ve politika yapıcıların REC'i teşvik etmek için gelirin yeniden dağıtılması önlemlerini dikkate almaları gerektiğini göstermektedir.

Anahtar Kelimeler: Gelir eşitsizliği, Yenilenebilir enerji, Sürdürülebilir kalkınma, G20 ülkeleri. **JEL Kodları:** O15, Q56, Q40

Introduction

Today, the increase in economic activity has a vital effect on environmental quality. In this context, researchers attribute particular importance to sustainable development. The effective implementation of sustainable environmental policies necessitates a comprehensive evaluation of interrelated regional social, economic, political, and ecological parameters. As is known, our relationship with energy, an essential factor in our daily life, is vital. Energy plays a crucial role in our daily lives, allowing us to engage in lighting, heating, cooling, industry, and transport. Moreover, it is widely recognized as a prerequisite for achieving long-term sustainability (Kashour, 2023; Hacıimamoglu et al., 2025). However, the increase in energy demand and CO₂ emissions obstruct a sustainable environment (Oğuztürk & Özbay, 2022).

Governments worldwide trust RE to reduce energy-related environmental issues (Gross et al., 2003). RE refers to sustainable energy from natural sources such as biomass, sun, and wind. Unlike fossil energy resources, these resources do not run out over time. They are also an alternative to non-renewable energies (Ege University Solar Energy Institute, 2023). Moreover, these resources can be used to produce electricity for all economic sectors, heat for industrial processes and buildings, and fuels for

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transportation (Bull, 2001). RE is a good option since underground resources are limited and decreasing. However, slow progress in renewable sources prevents the shift from fossil fuels, which is needed to decrease greenhouse gas emissions and meet increasing energy demand. Therefore, a structural change is becoming urgent in the energy system (REN21, 2022).

The worldwide interest in sustainable development has recently sped up REC (Bhattacharya et al., 2016). Additionally, the debate on RE has taken on a new dimension due to several factors, including the Russian invasion of Ukraine in early 2022 and rising energy prices (REN21, 2022). RE has become more prominent in nations' development goals and strategies. As the "World Energy Outlook 2022" report highlights, countries with a cost advantage in RE may capture a greater share of global value chains (IEA, 2022). RE is essential for this reason.

Developed and developing countries prioritize solving the energy crisis and inequality. RE is essential in combating global climate change and energy crises (Polcyn et al., 2022). The negative impacts of non-RE have been extensively debated and defined as a global public policy issue. Global climate policy has thus sought to encourage the adoption of RE (Churchill et al., 2021). Considering the shares of global primary energy (BP, 2022), RE is increasing. Europe, South & Central America particularly distinguish themselves in regional REC.

Income inequality is a decisive obstacle in long-term global and regional development processes. This question persists throughout the world. Reducing inequalities is vital for the viability of a balanced, inclusive, and sustainable development strategy. On the other hand, RE protects the environment and promotes sustainable and regional development. The impact of RE on the environment depends on government policies, geography, and infrastructure. Such conditions are indelibly connected to injustice and inequality at both global and local levels (McGee & Greiner, 2019). We can say that this subject is also the focus of the attention of researchers (Eyuboglu & Uzar, 2025; Haciimamoglu et al., 2025; Li et al., 2025; Acheampong et al., 2024; Alev & Ersezer, 2024; Ari, 2023; Khan et al., 2023; Amin et al., 2022; Churchill et al., 2021; Topcu & Tugcu, 2020). As Uzar (2020) emphasized, RE cannot be considered a factor independent of income inequality. In societies with fair income distribution, the demand for a clean environment may rise with collective awareness. Also, Ada-Cristina & Lucian-Liviu (2020) emphasize that there is comprehensive empirical proof that countries with less income inequality have lower carbon emissions rates. As a result, the income inequality variable is likely to affect RE.

This article investigates the link between income inequality and REC and aims to contribute to the existing literature in various ways. The main objective of the study is to determine the effect of income inequality on REC, specifically in G-20 countries, and to highlight essential policies in this regard. Due to the limited number of studies examining this effect, the findings of this research are expected to be useful for policymakers and new researchers interested in the subject.

The first part of this study, following the introduction, includes the literature. The second section presents the research material and methodology. The third section presents and discusses the research findings. This study concludes with a concluding chapter containing policy recommendations.

1. Literature Review

In this section, research on RE and income inequality is examined. Table 1 below presents the studies:

Table 1. Research on RE and income inequality

Authors	Scope	Methodology	Variable	Result
Eyuboglu & Uzar (2025)	Italy	Fourier Augmented ARDL model	Income inequality, CO ₂ emissions, trade openness, REC, and economic growth	Income inequality → REC (-) trade openness → REC (-) GDP → REC (+) CO ₂ emissions → REC (-)
Haciimamoglu et al. (2025)	17 countries	Method of moments quantile regression	CO ₂ emissions, economic growth, REC, square of economic growth, and wealth inequality	Wealth inequality → CO ₂ emissions (+) REC → CO ₂ emissions (-)

Li et al. (2025)	104 countries	Panel threshold model & unconditional quantile regression	Foreign direct investment, REC, population density, GDP per capita, industry (including construction), pump price for gasoline, energy intensity level of primary energy, inequality in disposable income, urban population, and inequality in market income	Income inequality → energy efficiency (-)
Acheampong et al. (2024)	166 countries	Panel system-GMM	REC, corruption, income inequality, redistribution, trade openness, foreign direct investment, foreign aid, education, GDP per capita, and inflation	Income inequality → REC (-)
Alev & Ersezer (2024)	MINT (Mexico, Indonesia, Nigeria, and Türkiye) countries	Panel VAR and panel Granger causality	REC, GDP per capita, and income inequality	Income inequality → REC (+) Income inequality → GDP (+)
Arı (2023)	G8 countries	Panel data analysis	GDP, REC, and income inequality	Income inequality → REC (+)
Khan et al. (2023)	Belt and Road Initiative countries	Dynamic panel estimation	Income inequality, GDP per capita, inflation deflator, REC, industrialization, foreign direct investment, urban population, CO ₂ emissions, domestic credit, and gross fixed capital formation	Income inequality → REC (-) GDP → REC (-) CO ₂ emissions → REC (-)
Amin et al. (2022)	123 countries	Heterogeneous panel analysis	REC, foreign direct investment, and income inequality	For the high-income countries and upper middle-income countries: REC → Income inequality (-) For the lower-middle-income countries: REC → Income inequality (+)
Mehmood et al. (2022)	BRICS countries	Panel pooled mean group (PMG) method	Income inequality, REC, CO ₂ emissions, GDP, trade openness, and corruption variable	Income inequality → REC (-) GDP → REC (-) trade openness → REC (+) CO ₂ emissions → REC (+)
Muhammad et al. (2022)	23 OECD countries	Augmented mean group (AMG) method	Income inequality, real oil prices, REC, CO ₂ emissions, trade openness, and economic growth	Income inequality → REC (+) trade openness → REC (+) CO ₂ emissions → REC (-) GDP → REC (+)
Oğuztürk & Özbay (2022)	BRICS countries and Türkiye	Panel data analysis	RE supply, CO ₂ emissions, GDP, and green innovation	CO ₂ emissions → RE supply (-) For India, Turkey, and South Africa: GDP → RE supply (-)
Sharma & Rajpurohit (2022)	India	Nonlinear autoregressive distributed lag (NARDL) model	REC, GINI, per capita income, non-RE, and human capital development	Income inequality → REC (-) per capita income → REC (+)

Yang et al. (2022)	20 OECD nations	AMG assessor	CO ₂ emissions, GDP per capita, REC, trade openness, gini coefficient, and real crude oil prices	Gini coefficient → REC (+) GDP → REC (+) CO ₂ → REC (-) trade openness → REC (+)
Churchill et al. (2021)	17 nations	Non-parametric techniques	REC, income inequality, GDP per capita, trade-to-GDP ratio, CO ₂ emissions, and real oil price	For a short period between 1995 & 2002: Income inequality → REC (-) From 2010 onwards: Income inequality → REC (+) Trade-to-GDP ratio → REC (-); But it's not statistically significant
Tan & Uprasen (2021)	The Association of Southeast Asian Nations member states	Panel auto-regressive distributed lag (ARDL) model	Income inequality, REC, CO ₂ emissions, GDP per capita, trade openness, education, and institutional quality	Income inequality → REC (-) trade openness → REC (-) GDP → REC (-)
Abdullah et al. (2020)	12 EU countries	Arellano & Bond GMM method	GDP, RE sources, including biofuels, labor, and gross fixed capital formation	RE sources → GDP (+)
Asongu, & Odhiambo (2020)	39 countries in Sub-Saharan Africa	GMM and quantile regressions	REC, income inequality, financial development, regulation quality, mobile phone penetration	Financial development → REC (+); But income inequality counteracts this effect
Topcu & Tugcu (2020)	23 developed countries	Panel system-GMM & dynamic common correlated effect estimator	REC, GINI, GDP per capita, inflation, unemployment, taxes, and subsidies	REC → GINI (-)
Uzar (2020)	43 developed and developing countries	Panel ARDL / PMG estimation	GINI, REC, trade openness, GDP per capita, CO ₂ emissions, and corruption	GINI → REC (-) CO ₂ → REC (+) trade openness → REC (-); But it is not statistically significant.

There is not enough controversy in the literature about the determining factors of REC, but some investigations have analyzed the link between REC and income disparity. Table 1 includes different research on the association between these variables. As seen in Table 1, this topic is explored using different variables (such as income inequality, REC, trade openness, GDP per capita, CO₂ emissions, inflation, unemployment, gross fixed capital formation, education, foreign direct investment, industrialization, corruption, taxes, and subsidies) for various country groups (such as OECD, EU, G8, BRICS, Sub-Saharan Africa, and MINT countries). Table 1 reveals no consensus about the influence of the income inequality variable on RE. However, based on the data in Table 1, we can say that the number of studies that found a negative link (Eyuboglu & Uzar, 2025; Acheampong et al., 2024; Khan et al., 2023; Mehmood et al., 2022; Sharma & Rajpurohit, 2022; Tan & Uprasen, 2021; Uzar, 2020) is higher. In conclusion, it is possible to state that the impact of income inequality on REC is recognized in the literature, but its exact impact remains unclear (Li et al., 2025).

As shown in Table 1, the influence of income inequality on REC has not been comprehensively analyzed for G20 countries. This gap in the literature serves as the primary motivation for this research, which aims to investigate whether a negative correlation exists between income inequality and REC in these nations. Energy efficiency, the use of RE, and income inequality are among the most prominent global issues today. According to the data in Table 1, the association between income inequality and REC is sometimes analyzed in isolation. At the same time, sometimes additional variables such as economic growth, CO₂ emissions, and trade openness are incorporated into the model. This paper contributes to the literature by analyzing the impact of income inequality on REC in G-20 countries, integrating these key variables, and offering recommendations and guidance for policymakers and future researchers based on the results derived from recent analyses.

2. Research Material And Methodology

REC is the dependent variable in some studies (Eyuboglu & Uzar, 2025; Acheampong et al., 2024; Ari, 2023; Khan et al., 2023; Mehmood et al., 2022; Muhammad et al., 2022; Sharma & Rajpurohit, 2022; Yang et al., 2022; Tan & Uprasen, 2021; Asongu & Odhiambo, 2020; Uzar, 2020). These studies incorporate variables like CO₂ emissions, trade openness, and gross domestic product into the model. Based on these studies, the model we established within the aim of this study is as in Equation 1 below:

$$REC_{it} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 CO_{2,it} + \beta_3 TO_{it} + \beta_4 GINI_{it} + \varepsilon_{it} \quad (1)$$

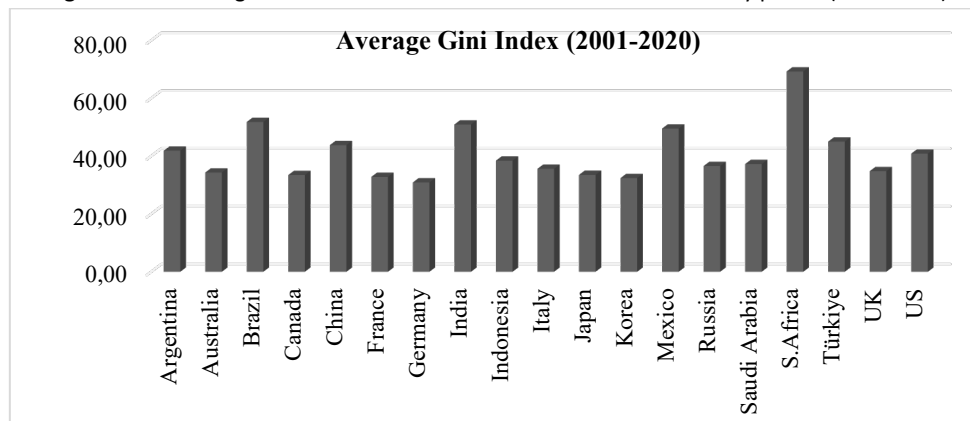
In Equation (1), $i = 1, 2, 3 \dots 19$ defines the country and $t = 2001, \dots 2020$ defines the period. GDP refers to GDP per capita (current US\$), REC represents the share of RE in total final energy consumption (%), TO refers to trade openness (the total of a country's exports and imports as a share of that country's GDP (in %)), CO_2 represents CO_2 emissions (metric tons per capita), and GINI refers to Gini index. The data source of the Gini variable is UNU-WIDER (2022), and the data source of other variables is World Bank (2023).

High inequality is undesirable, as it heightens social tensions and drives people to migrate due to poverty. Additionally, rising inequality within a nation has adverse environmental consequences (Hübler, 2017). Scholars argue that investing in human capital development in countries with increasing income can broaden the scope of job opportunities and open new pathways in the RE sector. They also emphasize that establishing programs to reduce income inequality is vital for ensuring energy justice (Sharma & Rajpurohit, 2022; Sarkodie & Adams, 2020). During this process, international trade encourages more productive firms to export due to increased competition (Melitz, 2003), facilitating access to innovative technologies and enhancing productivity. Considering this information, we have taken into account that economic growth, income inequality, and trade openness also influence the use of RE sources, and we have integrated these factors into the model of this study.

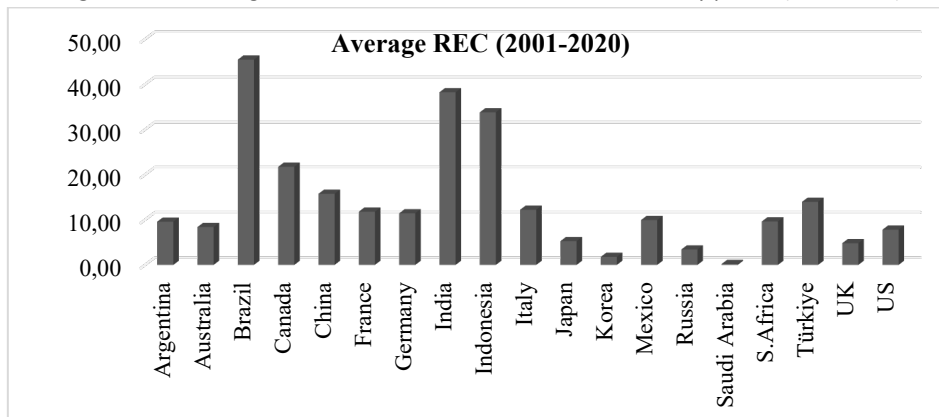
Air pollution is caused by numerous emission sources, both natural and anthropogenic, with the latter becoming globally dominant since the onset of industrialization. The combustion process, notably burning fossil fuels and biomass for energy production, is the most significant contributor to air pollution (WHO, 2021). CO_2 emissions are a key indicator of environmental awareness and sustainability (Issayeva et al., 2023). Each year of slower progress in energy efficiency results in higher levels of CO_2 emissions, and energy use in the global economy (IEA, 2024). For this reason, we have included CO_2 emissions as a variable in the model used in this study. The CO_2 emissions included in this study result from cement manufacturing and the combustion of fossil fuels. It also includes CO_2 produced during the consumption of liquid, solid, gas fuels, and gas flaring.

The primary function of the G20, comprising nineteen nations and the European Union, is to enhance global economic stability, enduring economic growth, and progress (Ali et al., 2024). G20 countries have a significant role in fostering global economic growth and development, and improving environmental quality. This group of nations has a significant impact on global emissions. Most of their energy supply comes from coal and oil, and a considerable portion of their energy mix is based on fossil fuels. Moreover, many G20 nations display similar trends in the share of transport CO_2 emissions, transport energy consumption, and economic development (Habib et al., 2021). Therefore, this study is based on this group of countries. This study covers nineteen G20 countries. These countries are Argentina, Australia, China, Canada, Brazil, Germany, France, India, Indonesia, Italy, Japan, Korea, Mexico, Russia, Saudi Arabia, S. Africa, Türkiye, UK, and US. This study is based on these countries, considering the availability of country datasets and their appropriateness for analysis. There is a lack of data after 2020. For this reason, the period range in this study includes the years 2001-2020. Figure 1 and Figure 2 below show the average Gini index and REC values of G20 countries for the study period (2001-2020).

Figure 1. The average Gini index value of the G20 countries for the study period (2001-2020)



Source: Author's compilation based on UNU-WIDER (2022).

Figure 2. The average REC value of the G20 countries for the study period (2001-2020)

Source: Author's compilation based on World Bank (2023).

According to Figure 1, the countries with the highest income distribution fairness are Germany, Korea, France, Canada, and Japan. South Africa, Brazil, India, and Mexico stand out with their high Gini index values. According to Figure 2, Brazil, India, Indonesia, Canada, and China lead in REC (% of total final energy consumption), while Saudi Arabia has the lowest value. Before discussing the method, it is necessary to examine the variables more closely. In this context, Table 2 provides the summary statistics for the variables.

Table 2. Summary Statistics of Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
REC	380	13.93853	12.55177	.01	50.05
GDP	380	22804.31	17899.66	449.91	68156.39
CO ₂	380	8.188316	5.120097	.88	20.17
TO	380	51.89489	17.37252	19.56	105.57
GINI	380	40.67674	9.369731	28.94	74.23
lnGDP	380	9.55086	1.157444	6.109047	11.12956

As shown in Table 2, the variables have 380 observations, and no deficiency exists. Table 3 shows the correlation matrix. Table 3 reveals that variable selection does not pose any issues due to the lack of a high correlation between the variables.

Table 3. Correlation Matrix

Variable	REC	lnGDP	CO ₂	TO	GINI
REC	1.0000				
lnGDP	-0.5597	1.0000			
CO ₂	-0.5601	0.6437	1.0000		
TO	-0.2875	0.1405	0.1568	1.0000	
GINI	0.3215	-0.5836	-0.3967	-0.2609	1.0000

According to the outcomes of Pesaran (2004) CD test (p -value= 0.00 < 0.05), there is a cross-section dependence in the model, and according to the findings of Swamy S test (p -value= 0.00 < 0.05), the series shows heterogeneous distribution. According to the outcomes of the Hadri LM test—a second-generation panel unit root test applied due to cross-sectional dependence—the variables used in this study are stationary. Hadri LM test results are given in Table 4.

Table 4. Hadri LM Test Results

Variable	Statistic	p-value
REC	z	43.6789
lnGDP	z	37.2543
CO ₂	z	46.6391
TO	z	29.0173
GINI	z	30.2295

In recent years, diverse kinds of estimators have been recommended to estimate regression coefficients (Gujarati & Porter, 2009). GMM is suitable for forecasting different variations of the fundamental unobserved effects model, such as models where unobserved heterogeneity interacts with observed covariates. Additionally, GMM is well-suited for obtaining efficient estimators that account for serial correlation (Wooldridge, 2001). An example is the serial correlation test based on GMM residuals proposed by Arellano & Bond (1991). The Arellano & Bond dynamic panel estimator is a general estimator designed for conditions with strictly non-exogenous independent variables, implying they are related to current and past realizations of the error (Roodman, 2009).

In this investigation, dynamic panel data analysis is employed as the method, and the impact of income inequality on RE is estimated with the two-step GMM estimator (difference GMM) derived by Arellano & Bond. Model estimation is first made using the ordinary least squares (OLS) method in this process. As is known, the choice of any method depends on the underlying goals and the satisfaction of the assumptions of that technique. That is why data can be pooled, and model forecasting can be done with OLS (Nobi et al., 2019). In this context, we employed this method during the initial phase of the analysis. The Hausman test can identify which of the random and fixed effects models will be used (Gujarati & Porter, 2009). For this reason, we used the Hausman test to choose between these estimators. We also applied autocorrelation and heteroskedasticity tests to test the reliability of the outcomes. Then we made the two-step GMM estimation.

3. Empirical Results And Discussion

This section provides empirical outcomes and examines the results. Model estimation is first made using the OLS method. The outcomes of the OLS method and the regression outcomes of the fixed and random effect models are given in Table 5.

Table 5. The Results of OLS, Fixed Effects, and Random Effects Analysis

Variables	OLS Method		Fixed Effects		Random Effects	
lnGDP	-3.984*** (0.631)	-3.878*** (0.662)	-2.367*** (0.356)	-2.480*** (0.377)	-2.380*** (0.356)	-2.497*** (0.377)
CO ₂	-0.786*** (0.126)	-0.795*** (0.130)	-1.570*** (0.136)	-1.486*** (0.136)	-1.554*** (0.132)	-1.480*** (0.132)
TO	-0.148*** (0.0295)	-0.154*** (0.0301)	0.0695*** (0.0174)	0.0755*** (0.0175)	0.0662*** (0.0174)	0.0711*** (0.0175)
GINI	-0.0985 (0.0665)		-0.526*** (0.0846)		-0.483*** (0.0815)	
L.GINI		-0.106 (0.0678)		-0.568*** (0.0816)		-0.523*** (0.0788)
Constant	70.11*** (7.641)	69.94*** (7.975)	67.21*** (5.569)	69.04*** (5.620)	65.62*** (5.994)	67.55*** (6.059)
Observations	380	361	380	361	380	361
R-squared	0.420	0.415	0.445	0.456		
Number of cno			19	19	19	19

Notes: *** indicates significance at the 1% level; standard errors are in parentheses.

The Hausman test result, used to decide between fixed effects and random effects estimators, is presented in Equation 2.

$$\text{chi2} (3) = (b-B)'[(V_b - V_B)^{-1}](b-B) = 14.14 \quad \text{Prob} > \text{chi2} = 0.0027 \quad (2)$$

The null hypothesis, defining that the “difference in unsystematic coefficients” is zero according to the outcomes of the Hausman test (Prob > chi2 = 0.0027), is also rejected. This result shows that the fixed effects estimator for this model is consistent.

Since panel data involves both time dimension and cross-section, problems that plague time series data (e.g., autocorrelation) and cross-sectional data (e.g., heteroscedasticity) need to be examined (Gujarati & Porter, 2009). In the classical model, the Wooldridge test can be used for autocorrelation. In fixed-effect models, autocorrelation can be tested with “the Durbin-Watson test of Bhargava, Franzini, & Narendranathan”, while the Modified Wald test can be applied for heteroskedasticity (Tatoğlu, 2020). In this context, the heteroskedasticity and autocorrelation test results applied in this research are presented in Table 6. According to the outcomes of the heteroskedasticity and autocorrelation tests, the null hypotheses stating that no heteroskedasticity and autocorrelation are rejected. The Arellano & Bond GMM estimator is used in the model due to the presence of both heteroskedasticity and autocorrelation. The two-stage GMM estimator weighs the moment conditions with a consistent forecast of covariance matrices (Windmeijer, 2005). As Tatoğlu (2018) emphasized, the two-stage GMM estimators correct the one-stage GMM estimators against the problem of autocorrelation and heteroskedasticity. The findings of the Arellano & Bond two-step GMM estimation applied in this study are reported in Table 6.

Table 6. Dynamic Panel GMM Estimations

Variables	(1)	(2)	(3)	(4)	(5)
	REC	REC	REC	REC	REC
lnGDP	-5.125*** (0.0514)	-4.007*** (0.107)	-4.030*** (0.109)	-4.009*** (0.134)	-4.356*** (0.185)
CO ₂		-1.628*** (0.274)	-1.735*** (0.283)	-1.633*** (0.239)	-1.839*** (0.220)
TO			-0.0141*** (0.00224)	-0.0133*** (0.00463)	-0.0153*** (0.00285)
GINI				-0.0961 (0.147)	
L.GINI					-0.391*** (0.146)
Constant	61.36*** (1.371)	65.49*** (1.501)	66.94*** (1.474)	70.05*** (6.661)	86.86*** (6.236)
Observations	380	380	380	380	361
Number of cno	19	19	19	19	19

Modified wald test: $\chi^2(19) = 2593.83$ & Prob > $\chi^2 = 0.0000$; Durbin - Watson test: Baltagi - Wu LBI = 0.4186389 & Durbin - Watson = 0.19667792; AR (2) (ρ) = 0.1586 & Sargan test = 17.446 (1.000)

Notes: *** indicates significance at the 1% level; standard errors are in parentheses.

According to the estimation results of dynamic panel data analysis, a 1% rise in GDP per capita decreases REC by 4.009%. A 1% increase in CO₂ emissions, and trade openness reduces REC by 1.633 and 0.0133%, respectively. In addition, a 1% rise in the Gini index in the relevant period reduces REC by 0.0961%, although this effect is insignificant. Furthermore, a 1% rise in the Gini index decreases REC by 0.391% in the next period, which is significant. These outcomes indicate that the effect of the Gini index is delayed. Based on these results, we can say that the increasing income inequality causes a further decrease in REC in the delayed period. From this perspective, we can say that income redistribution measures should be considered when formulating policies for REC. When we evaluate the two-stage GMM results, we can also state that the increase in REC can establish a significant feedback mechanism. Therefore, we can say that rational steps towards REC will affect the increase in environmental quality, and these policies will have a feedback on CO₂ emissions and energy efficiency.

Conclusion

Energy is a fundamental driver of economic growth, and global energy demand is expected to rise due to urbanization, technological advancements, population increase, and enhancements in business practices. However, the rise in energy consumption also contributes to environmental damage. The harmful effects of non-RE sources are acknowledged as a concern in global public policy (Destek et al., 2022; Muhammad et al., 2022). RE is very important globally, and nations are trying to develop it through strategic planning. However, the existence of unequal conditions in the world, both globally and regionally, constitutes a significant obstacle for nations to reach a more developed level. In this context, income inequality stands out as a critical factor that leads to significant differences in access to energy and the use of RE. To prevent the further deepening of existing inequalities, various strategic steps are being taken. In these processes, research on the subject plays a guiding role and makes significant contributions. Researchers examine various variables that impact REC and provide diverse recommendations in their studies. However, when we look at it, we can say that there is limited research on this issue, especially for the G20 country group. In this framework, in this research, we aimed to determine the effect of the income inequality variable on REC for 19 G20 member countries. We used dynamic panel data analysis and estimated this effect with the two-step GMM estimator derived by Arellano & Bond. For our research, we looked at the period from 2001 to 2020. We used five variables: GDP per capita, CO₂ emissions, REC, trade openness, and the Gini index.

Econometric findings indicate that income inequality harms REC with a period lag. These results are consistent with the findings of Eyuboglu & Uzar (2025), Acheampong et al. (2024), Khan et al. (2023), Mehmood et al. (2022), Sharma & Rajpurohit (2022), Tan & Uprasen (2021), and Uzar (2020). Moreover, these outcomes are coherent with the research findings of Amin et al. (2022) for high-income and upper-middle-income countries, and the research findings of Churchill et al. (2021) for a brief period between 1995 and 2002. In line with these findings, as emphasized by Baloch & Danish (2022), fair income distribution is an incentive for society to allocate funds to RE and support the demand for a clean environment. Sensitivity is increasing in societies with fair income distribution, and individuals are more motivated to promote RE to reduce environmental pollution (Baloch & Danish, 2022, p.1274). Additionally, structural and behavioral factors—including slow regulatory processes, long investment periods, high installation costs, and technological adaptation periods—explain the delayed impact on RE.

According to the results, the variables of trade openness, CO₂ emissions, and GDP per capita also hurt RE. There are studies in the literature with comparable results for these variables. For instance, Khan et al. (2023), Muhammad et al. (2022), and Yang et al. (2022) found the negative impact of CO₂ emissions on REC in their research. Similarly, Oğuztürk & Özbay (2022) determined the adverse effect of CO₂ emissions on RE supply. Moreover, numerous studies have demonstrated that increased fossil fuel consumption is associated with rising carbon emissions in both developed and developing countries worldwide (Muhammad et al., 2022). The global energy system must undergo a fundamental transformation from one primarily based on fossil fuels to one based on RE, increasing efficiency. However, fossil fuels continue to dominate the global energy mix (IRENA, 2018), and this structurally delays the transition to RE. Regarding trade openness, our findings are in line with studies by Churchill et al. (2021), Tan & Uprasen (2021), and Uzar (2020). Finally, our results for GDP are compatible with the works by Khan et al. (2023), Tan & Uprasen (2021), and Mehmood et al. (2022).

These findings, based on the example of G20 countries, demonstrate the impact of income inequality on RE. As a result, our findings show that income inequality should not be ignored while determining RE strategies in countries. It is also necessary to consider that increasing REC can establish a significant feedback mechanism. Increased use of RE will reshape the economy of G20 countries and make income distribution fairer through rational policies.

These research results allow us to make various inferences for the G20 countries to improve the current situation. For example, G20 countries can support projects and policies promoting the utilization of renewable resources in the energy mix. However, policymakers should also consider income redistribution measures to incentivise energy consumption in this process. Additionally, G20 countries could increase their interventions to control emissions from industrial sources and review their tax policies. Based on the results from this country's example and the global significance of the transition to RE, we can say that other countries can also facilitate and support the transition to RE sources by considering these factors. Finally, developing policies for the energy transition at the national level, within the framework of regional cooperation, is crucial. Formulating effective regional incentive mechanisms can significantly accelerate the transformation process in this context.

Note for future work!

This study analyzes the relationship between income inequality and REC by focusing on the G20 countries. Future studies in this field could investigate the connection between RE use/consumption and income inequality in other countries. Future research could also examine regional income inequality similarly or explore the relationship between other determinants, such as green innovation, foreign direct investments, and oil prices, with RE use/consumption.



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