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THE UNEQUAL GREEN TRANSITION: RENEWABLE ENERGY AND INCOME (IN)EQUALITY IN SOUTHEAST EUROPE

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Abstract
To investigate the relationship between the utilization of renewable energy sources and the income inequality in Albania, Serbia, Croatia, Bulgaria, and Romania, this study makes use of time series data collected from the year 2000 until the year 2022. These economies, which are located in Southeastern Europe, have experienced certain events that make them especially important for analyzing times of economic growth and stagnation. The ARDL bounds testing methodology is an appropriate approach for examining the energy-inequality link in countries experiencing both random shocks (outliers) and persistent shocks (structural breaks), which we employ in our analysis. Inequality has been linked to health and well-being, economic development, and environmental issues, among other variables. Empirical validation of the relationship between inequality and renewable energy is essential to inform policy decisions since the social benefits and positive externalities of reducing income disparity may speed up the adoption of renewable energy. The GINI coefficient functions as the dependent variable in our estimated model. The selected independent variables include renewable energy consumption per capita, gross domestic product per capita, real gross fixed capital formation, exports, imports, and the political instability index, among others. According to the preliminary empirical findings, the energy-led growth theories of the chosen nations are supported. According to our analysis, in some countries, political instability obstructs economic growth and development. This finding supports earlier hypotheses.

Keywords: *Renewable energy, income inequality, southeastern European countries.*
JEL Classification: Q42, D63, P48

1. INTRODUCTION

When it comes to the subjects of economics and sustainability studies, one of the most significant topics that should be discussed is the relationship that exists

between energy and economic expansion. There is a strong correlation between the process of industrialization and the expansion of the economy, which in turn leads to higher agricultural productivity and efficiency, as well as increased water consumption. Renewable energy is a significant contributor to economic growth (Acaravci & Ozturk, 2010; Stern, 2011; Merko *et al*., 2020; Triantafyllidou *et al*., 2023).

The renewable energy is commonly defined as energy generated from solar, wind, geothermal, tide and wave, wood, waste, and biomass. Compared to conventional energy, renewable energy is clean, safe and endless. The empirical findings show that renewable energy is crucial for economic growth and economic growth stimulates the use of more renewable energy sources (Heerink *et al*., 2001; Apergis & Danuletiu, 2014). However, it has been noted that that an increase in income inequality can affect all parts of society to have a shortsighted overview. The long-term effects of economic activities such as consumption cannot be enough taken into consideration (Berthe & Elie, 2015).

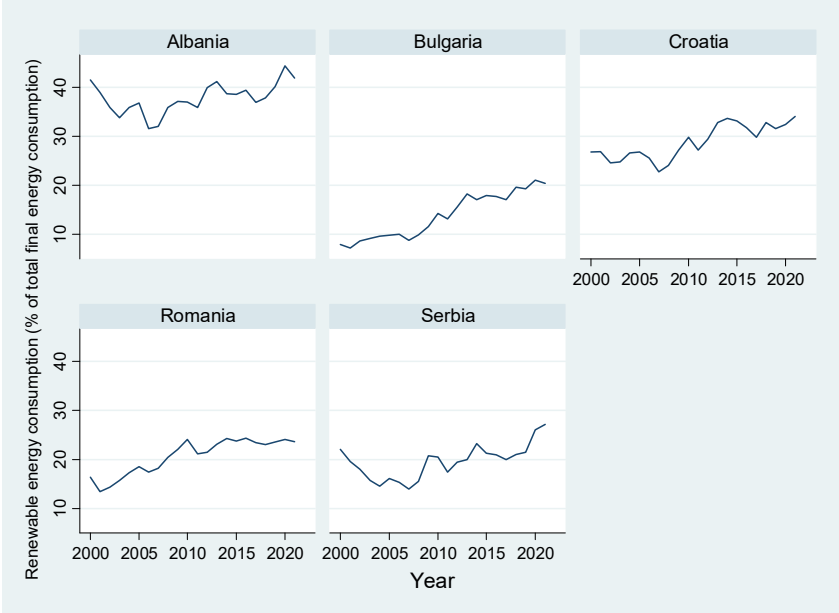
It is important to note that energy encompasses not only the movement of people and goods, but also the transportation and mobility of commercial commodities. Since climate change is a component that is contributing to the shift to methods of energy generation that are more ecologically friendly and renewable, there is a relationship between energy in general and the environment. Furthermore, there is a connection between energy and the environment (Apergis & Tang, 2013; Alper, 2016; Acheampong *et al*., 2018; Merko & Kalaj, 2025).

The association between income inequality and the consumption of renewable energy has been the focus of an extensive amount of research that has recently been carried out. Numerous studies have centered their attention on the factors that influence the use of renewable energy sources because of the ever-present significance of renewable energy. The emphasis put on income inequality is significant since it has been linked to a few outcomes that have the potential to impose an impact on renewable energy (Bozoklu & Yilanci, 2013; Kalaj & Merko, 2020; Chen *et al*., 2020).

2. BACKGROUND AND MOTIVATION

To give an answer to the research question we employ annual time series data from 2000 to 2022 for the following countries: Albania, Serbia, Croatia, Bulgaria, and Romania. The countries that were chosen are at various stages in the development of the energy market, and as a result, they are dealing with a multitude of challenges and opportunities. Table 1 shows the level of the renewable energy consumption measured as a percentage of the final energy consumption.

Table 1. Renewable energy consumption as % of final energy consumption



Source: Authors' calculation

The energy markets in selected countries have unique characteristics shaped by their histories, resources, and policy environments. Albania's energy market is heavily reliant on hydropower, which accounts for almost all its electricity generation. During periods of drought, it faces energy shortages and relies on imports. Albania has undertaken significant reforms to liberalize its energy market, improve regulatory frameworks, and attract foreign investment.

Serbia's energy mix is dominated by coal, particularly lignite, which fuels most of its electricity generation. Hydropower is the second-largest source of electricity. It is also exploring the potential of renewable energy sources like wind and solar. Serbia is gradually liberalizing its energy market, aiming to align with EU regulations. Croatia has a relatively diverse energy mix, including natural gas, hydropower, and renewables. It also imports electricity to meet demand. As an EU member, Croatia's energy market is integrated with the EU's energy policies and regulations (Ritchie, *et al*., 2024).

Bulgaria has a significant nuclear power capacity, providing a substantial portion of its electricity. Coal remains an important energy source, but the country is also increasing its investment in renewable energy, especially wind and solar. Bulgaria exports electricity to neighboring countries. Romania has a diverse energy mix, including natural gas, coal, nuclear, hydropower, and renewables. The country has substantial oil and natural gas reserves, making it relatively energy

independent compared to its neighbours. As an EU member, Romania aligns its energy policies with EU directives (Ritchie, *et al*., 2024).

3. DATA AND METHODOLOGY

In this study, a panel of the countries mentioned above for years from 2000 to 2022 are included. The data that we use comes from three different sources: World Development Indicators, the International Labour Organization, and Transparency International. Table 2 provides a brief description of the variables, in addition to the sources from which they were obtained.

Table 2. Description of variables

Dependent Variable	**Source**	**Description**
GINI Index	WB	The Gini index measures the extent to which the distribution of income or consumption among individuals or households within an economy deviates from a perfectly equal distribution. A Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality.
Explanatory variables		**Description**
GDP per capita	WB	Annual percentage growth rate of GDP per capita based on constant local currency. GDP per capita is gross domestic product divided by midyear population.
Political stability	IMF	Political Stability and Absence of Violence/Terrorism: Estimate
Unemployment rate	ILO	Unemployment refers to the share of the labor force that is without work but available for and seeking employment.
Openness	WB	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.
Renewable energy	WDI	Renewable energy consumption is the share of renewable energy in total final energy consumption.

We utilize the Arellano and Bond (1991) generalized method of moments (GMM) technique to estimate the correlation between GINI and Renewable energy. We employ a two-step technique due to the tendency of the one-way fixed effect model of Dynamic panel data to produce correlation between regressors and error. In practice, we define the functional form of the equations for GINI and Renewable energy in the following way:

$$GINI_{i,t} = \beta_0 + \beta_1 GINI_{i,t-1} + \beta_2 REN_{i,t} + \gamma X_{i,t} + \mu_{i,t} \quad (1)$$

where:
GINI i,t is gini index used to measure income inequality,
Ren i,t is renewable energy consumption as a share of total energy,
Xi,t is vector of variables including GDP per capita growth, consumer price index, unemployment rate, openness to trade etc.

To address our research inquiry regarding the correlation between inequality of income and corruption, we adopted the Dynamic Panel Data (DPD) model. These models incorporate one or more lagged dependent variables, enabling the representation of a partial adjustment mechanism (Blundell, *et al*., 2001; Bun & Windmeijer, 2010).

4. REGRESSION RESULTS

We conducted unit root tests to address the study question. These tests assist in determining if a time series variable is non-stationary and contains a unit root. The null hypothesis is typically characterized by the existence of a unit root, while the alternative hypothesis may indicate stationarity, trend stationarity, or an explosive root, contingent upon the specific test performed. Table 3 represents a summary of the unit root tests. Our variables are not negatively affected by stationarity, as evidenced by the results.

Table 3. Unit root tests

Variables	Im, Peasaran and Shin W-stat	ADF – Fisher Chi-square	PP – Fisher Chi-square
GINI index	-4.193***	192.276***	186.219***
GDP per capita	-7.778***	131.652**	165.601***
Political stability	-2.498***	141.415***	130.09***
Unemployment rate	-2.447***	163.374***	126.643**
Openness	-8.266***	173.354***	169.463***
Renewable energy	-2.443***	150.717***	162.134***

Source: Authors' calculation

Furthermore, we conducted a Granger causality test to gain deeper insights into the relationship between income inequality and the utilization of renewable energy (Granger, 2001). As demonstrated in tables 4 and 5, we conducted both the standard homogeneous test and the heterogeneous test (Dumitrescu & Hurlin, 2012).

Table 4. Granger causality test assuming homogeneity of coefficients

Null Hypothesis:	t-statistics	Prob.
a. Renew does not Granger Cause GINI	-.0168	0.224
b. GINI does not Granger Cause Renew	-.1427	0.007

Source: Authors' calculation

Table 5. Granger causality test assuming heterogeneity of coefficients

Null Hypothesis:	**W-Stat.**	**Zbar-Stat.**	**Prob.**
a. Renew does not homogeneously cause GINI	2.121	2.296	0.0217
b. GINI does not homogeneously cause Renew	2.514	3.411	0.0006

Source: Authors' calculation

The null hypothesis is rejected when the p-value is less than 0.05 (Granger, 2001). Referring to the coefficients of tables 4 and 5, we have insights on the relationship between income inequality and the use of renewable energy. When testing while assuming homogeneity, only inequality causes the use of renewables and not vice versa. Nevertheless, if we assume heterogeneity, we obtain a two-way causality, illustrated in table 5.

Table 6. System dynamic panel-data estimation, by country

Income Inequality	**(1)** Albania	**(2)** Serbia	**(3)** Croatia	**(4)** Bulgaria	**(5)** Romania
L. Gini index	-.2	.021**	.186	.561**	.802***
	(.314)	(.01)	(.343)	(.281)	(.244)
GDP per capita	-.005	.003*	-.16**	-.005	-.025
	(.149)	(.002)	(.066)	(.065)	(.046)
Political stability	-.159	-.002***	-.128**	.028	.011
	(.108)	(.001)	(.061)	(.032)	(.056)
Unemployment rate	.556**	-.004**	-.021	.057	-.175
	(.255)	(.002)	(.092)	(.106)	(.295)
Openness	.087	-.003***	.107**	-.015	-.019
	(.081)	(.001)	(.052)	(.023)	(.062)
Renewable energy	-.577**	.01*	.033	.006	-.411*
	(.285)	(.005)	(.136)	(.071)	(.224)
_cons	21.238	34.603***	40.106*	12.003	28.907*
	(17.256)	(.492)	(21.937)	(7.958)	(15.339)
Observations	22	22	22	22	22
Pseudo R^2	.32	.26	.31	.28	.41
Wald chi2	33.76	83.16	19.36	34.31	67.79

*** *p<.01,* ** *p<.05,* * *p<.1*

Based on the country-specific regression results, interesting findings can be noticed. The findings regarding the yearly growth of per capita GDP remain appropriate to both Croatia and Romania. In the cases of Serbia and Croatia, an increase in the levels of political stability is indicative of an improvement in income inequality, as indicated by theory and earlier empirical findings (Policardo & Carrera, 2018; Badur *et al*., 2023). This is not statistically significant in the remaining countries included in our investigation.

According to the model coefficients presented in Table 6, empirical findings indicate that increased use of energy from renewable sources increases to equality in both Albania and Romania. On the other hand, it does not appear that this is the case for all the countries that have been included in the sample. However, in the study there are some limitations due to the lack of data on variables that we could have used to investigate on the relationship between inequality and use of renewable energy.

5. CONCLUSIONS

This study investigates the theory that the use of renewable energy sources is a factor that contributes to economic equality. The findings of this research provide evidence to support the hypothesis in certain countries. The period from the year 2000 to the year 2022 is included by the panel data that we used for Southeast European countries. The results of the research we conducted indicate that the rise in the perception of renewable energy sources within a sample of countries is the cause of an increase in economic equality.

The results show that the overall sample's trade openness, unemployment, and GDP per capita growth all contribute to rising income disparity. This conclusion pertains to the current state of unemployment, which impacts the less fortunate segments of the population. Additionally, trade openness is implemented in a way that does not equally contribute to population growth everywhere.

The cases of Albania and Romania suggest that the utilization of renewable resources contributes to the observed income equality. The findings do not provide a definitive answer for the remaining countries in our study. The results offer important recommendations for policymakers.

Equitable income distribution and environmental quality, which are both essential elements of sustainable development objectives, can be accomplished together.

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