European Journal of Government and Economics

Vol. 14, No. 1 (2025), pages 55-70
https://doi.org/10.17979/ejge.2025.14.1.11356
Submitted: Oct 10, 2024 Accepted: Apr 25, 2024 Published: Jun 20, 2025

Article

The influence of economic factors on sustainable energy consumption: a comparative approach between the OECD and Western Balkan countries

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Abstract. This study investigates the influence of economic factors—such as energy use, foreign direct investment, inflation, GDP per capita, trade, population growth, and unemployment—on sustainable energy consumption (SEC) and renewable energy consumption (REC) across 38 OECD and 6 Western Balkan countries from 2010 to 2022. Adopting a comparative approach, the research sheds light on how varying economic contexts shape energy sustainability outcomes in developed and emerging economies. Using panel data from the World Bank and The Global Economy Database, we estimate regression models (OLS, fixed effects, random effects) and employ the generalized method of moments (GMM). We accounted for potential endogeneity with the use of GMM and verified it with Arellano-Bond and Sargan tests. The analysis found that GDP per capita and the openness of a country to trade were positively connected to SEC. Also, inflation and unemployment can serve as disincentives for the use of renewable energy. The findings provide insights for effective energy sustainable development thinking, especially given the economic development and goals for sustainable energy outcomes.

Keywords: sustainable energy consumption; economic growth; inflation; foreign direct investment
JEL classification: B22 ; Q4 ; Q43

1. Introduction

Due to the effects of climate change and depleting petroleum reserves, sustainable energy systems must be used worldwide. While there has been a historical transition between the main energy sources, these changes have often lasted more than a century and were prompted by advances in technology, labor costs that were prohibitive, and resource shortages (Solomon & Krishna, 2011). In addition, national and international seminars, and conferences adequately address and explore the significance of renewable energy for environmental preservation, sustainable development, and diversification of the energy supply. The authors consider energy sustainable if its net effects on the biosphere do not significantly degrade its capabilities for supporting existing species in their current abundance and diversity, this is a very conservative definition, one requiring that such energy be less

harmful to the environment than most forms in use now. Global climate change threatens people's health, economic prospects, and basic food and water sources. Additionally, people could have false beliefs about the properties of various energy sources and how they affect the environment. A wide range of changes in household energy behavior is needed to realize a sustainable energy transition. The scope of subjects covered by sustainable energy is remarkably extensive. Therefore, in addition to energy and environmental technology, sustainable energy must also take into account the political, social, and economic aspects of human lifestyles (Tester et al., 2012). Sustainable energy solutions mean better efficiency, better cost-effectiveness, better resources used, better design and analyses, better energy security, and a better environment (Dincer & Zamfirescu, 2011). It's critical to comprehend the variables influencing the acceptance of energy system modifications and policies. Therefore, considering the role of sustainable energy in all spectrums of life especially in the economy, this study aims to investigate its effects with a rigorous methodological approach. Accept the variables selected namely, energy use per capita (EUP), foreign direct investment (FDI), inflation (INF), GDP per capita (GDPC), Trade (TR), population growth (POG), unemployment (UNE) and sustainable energy consumption (SEC). Future research papers could be extended by including some other economic factors, such as the efficiency of the institution's performance, taking into account the fact that the mechanism of the institutions is considered fundamentally in terms of the policies in energy and their application, as well as additional groups of counties in order to measure the influence of such economic factors on sustainable energy consumption as a permanent source of life.

The contribution of this study to the literature is multifaceted. First, it provides a clear comparison of the impact of economic factors on sustainable energy consumption between two groups of countries: the Western Balkans and OECD countries. This comparison is made by focusing on economic factors, development contexts, and policy implications. While existing research on sustainable energy consumption exists, there is limited literature directly comparing OECD countries (which are generally more economically developed) with the Western Balkan countries (which are transitioning economies). These groups have distinct economic structures, energy consumption patterns, and sustainability goals, making the comparative approach unique. Furthermore, many studies on sustainable energy consumption primarily focus on environmental or technological factors, often overlooking the crucial role of economic variables. By focusing specifically on economic factors, this study highlights how national economic conditions influence energy use patterns and sustainability. The study also addresses the gap in understanding how a country's development stage affects its energy consumption choices and sustainable practices. The economic context of the Western Balkans, with its infrastructure challenges and economic transition, contrasts with the more stable, industrialized economies of the OECD. By examining both groups, the study offers valuable insights into how policies might be tailored for developed versus developing countries, helping to shape more targeted energy policies that consider economic realities. Furthermore, it provides guidelines for policymakers to create more effective SEC-related policies.

The sections of this paper are arranged as follows: except for the first section, which unfolds the introduction part, the second one provides reviews of the literature, and the third section contains the research methodology and data of the panel evidence extracted from reliable sources for Western Balkan and OECD Countries. Further, section four provides the results generated using an appropriate methodology and discussion arising from the relevant topic. Section five provides the

discussion and findings and the last section provides the conclusion given by the authors. Additionally, the main argument for this study is that only a few studies have examined the influence of economic factors on sustainable energy consumption. Moreover, this study is characterized by using the comparative approach between two groups of counties, the methodology applied, the time period, and the variables included in the sample. Consequently, there is a gap in the literature that this study aims to fill.

2. Literature review

Since the middle of the 20th century, the growth of industry and population has resulted in a massive increase in the need for energy. As a result, countries worldwide are now prioritizing the development of new and renewable energy sources. Many empirical studies, conducted by various authors, and categorized by various countries and periods, examine the influence of economic factors on sustainable energy consumption. Renewable energy consumption on economic growth can be either positive, negative, or not significant. Renewable energy consumption should contribute to economic growth (Yildirim et al., 2012). Renewable energy consumption has positive impacts on economic growth (Alper et al., 2016; Shahbaz et al., 2020; Lin & Moubarak, 2014; Inglesi-Lotz, 2016). The positive effect of renewable energy consumption on economic growth for OECD countries was also examined by Wang & Wang (2020). However, this positive relationship varies as the threshold values change, indicating a nonlinear role in increasing the use of renewable energy to promote economic development for these countries. The significant impact of renewable energy consumption on economic growth in the Balkans and Black Sea is recognized by Koçak & Şarkgüneşi (2017). In Germany, a 1% increase in renewable energy consumption boosts German economic growth by 0.2194% (Rafindadi & Ozturk, 2017).

Chen et al. (2020) found that renewable energy consumption has no significant effect on economic growth in developed countries, but it has a positive and significant effect on economic growth in OECD countries. Ocal & Aslan(2013), for the region of Turkey, examined the negative impact of renewable energy consumption on economic growth, applying empirical tests from the ARDL approach. However, it is worth noting that developed countries have passed the phase of increasing the consumption of renewable energy compared to less developed countries, which are still in the initiation phase. However, moving from non-renewable energy to sustainable sources requires substantial investments, EU countries should pay closer attention to investment in research and development in order to sustain the plan for long-term advancement in sustainable power sources for feasible energy and economic development. (Adedoyin et al., 2020).

Sadiq et al. (2023), using the autoregressive distributed lag (ARDL) indicated that economic growth, FDI, inflation, and population growth were positively associated with SEC in China. By applying a panel ARDL estimations (Qamruzzaman & Jianguo, 2020) confirmed that in the long run, financial development, trade openness, and foreign capital flow positively influence renewable energy consumption. The analysis included three subgroups of countries namely, for low-income countries, middle-income countries, and upper-middle-income panels. Akpanke et al. (2023) found out that GDP in both short-run and long-run does not significantly impact RE while, FDI and public

sector credit, have a significant positive effect on RE use in the long run, moreover, inflation rate and broad money have a significant negative long-run and significant positive short-run effect on RE use also emphasizing that poor-financial resource countries must encourage FDI inflows to promote RE development. (Khandker et al., 2018) examined the relationship between FDI and renewable energy consumption in the context of Bangladesh applying Johansen's cointegration test confirming that variables are cointegrated in the long run and the Granger causality test reveals that there is a bidirectional causality between respective variables also, through Vector Error Correction Model (VECM), we found no causality between the variables in the short run. Many studies have discussed that foreign direct investments (FDI) potentially increase the production and dissemination of renewable energy since foreign firms have different experiences regarding environmental awareness in the host country. Pao et al. (2011) emphasize that FDI can help reduce CO2 emissions by promoting the adoption of cleaner technologies, particularly in the context of renewable energy. Apergis and Payne (2010) highlight the impact of FDI on renewable energy consumption and discuss how foreign investments can encourage energy efficiency and cleaner energy solutions in the U.S., also, this study suggests that FDI might not always contribute positively to renewable energy consumption, especially if it leads to investments in energy-intensive sectors. It highlights how FDI can sometimes be directed toward industries that increase reliance on non-renewable energy. Authir Stern (2004) discusses the link between trade liberalization, industrial development, and energy use. It argues that trade can sometimes contribute to higher energy consumption if environmental policies are not sufficiently strong. Ozturk and Acaravci (2010) analyze the relationship between energy consumption, economic growth, and inflation in Turkey. It suggests that inflationary pressures can have mixed effects on energy consumption depending on the stage of economic development and the type of energy sources in use. Stern (2011) discusses how economic factors such as inflation, trade, and FDI interact with energy consumption. While there is an assumption that these factors generally promote economic growth, the relationship with sustainable energy consumption is more complex, and in some cases, may be negative or insignificant, particularly when the economic growth model is energy-intensive.

After the wide discussion of different works of literature, we set our hypothesis relevant to our research as follows:

H1: Economic factors have a positive impact on sustainable energy consumption
H2: There are significant differences in terms of energy consumption between BP and OECD countries.

3. Methodology

The impact of economic factors on sustainable energy consumption is measured using panel data encompassing 6 Western Balkan countries and 38 OECD countries spanning the period from 2010 to 2022, totaling 13 years. Methodologically, various panel data models are employed, including Pooled OLS, OLS Robust, Fixed Effects (FE), and Random Effects (RE). To determine the most reliable model between Fixed and Random Effects, the Hausman test is applied for comparative purposes. Ensuring objective, dependable, and efficient estimations of this coefficient requires the use of an appropriate

estimation method. Also, the methodological approach is applied showing a comparison between the respective countries.

Furthermore, the analysis utilizes the system GMM estimator, developed by Arellano and Bover in 1995, which combines a regression in differences. This particular estimator aims to mitigate inconsistencies and inefficiencies observed in alternative panel estimators, as established by Arellano and Bond in 1991, Blundell and Bond in 1998, and Blundell and Bond in 2000. Its validity hinges on the instruments' appropriateness and the assumption that the differenced error terms lack second-order serial correlation—both prerequisites for the consistency of the GMM estimator. To validate these assumptions, the Sargan test of overidentifying limitations has already been conducted, assessing the overall reliability of the instruments by examining the sample analog of the moment conditions applied in the estimation technique.

3.1 Model specification

We specify a log-linear model for the study to estimate the responses of economic factors on sustainable energy consumption. The study uses a macroeconomic series that consists of yearly observations between 2010-2022. The specification of the models treating the variables chosen to highlight this impact takes the form as follows:

$$\text{SEC}it = c + \beta 1\ (\text{SEC}it-1) + \beta 2\ (EUP) + \beta 3\ (FDI) + \beta 4\ (INF) + \beta 5\ (GDPC) + \beta 6\ (TR) + \beta 7\ (\text{POG}) + \beta 8\ (UNE) + uit$$

where SEC is the dependable variable, which in this case is Sustainable Energy Consumption, i = 1….44 (countries), t = 2010…2022 (years); c is constant; the explanatory variables include: $yit-1$, which is the first lagged of the dependent variable, *EUP* (Energy Use per Capita); *FDI* (Foreign Direct Investment); *INF* (Inflation); *GDPC* (Growth Domestic Product per Capita); *TR* (Trade); *POG* (Population Growth); *UNE* (Unemployment) and *uit* is the error term.

Table 1. Definition of variables.

Variable	Abbreviations	Unit	Source
Sustainable Energy Consumption	SEC	million kWh	The Global Economy Database
Energy Use per Capita	EUP	kWh	World Bank Database
Foreign Direct Investment	FDI	% of GDP	World Bank Database
Inflation	INF	%	World Bank Database
GDP per Capita	GDPC	US $	World Bank Database
Trade	TR	% of GDP	World Bank Database
Population Growth	POG	%	World Bank Database
Unemployment	UNE	%	World Bank Database

3.2 Data

Our panel contains annual data, obtained from the World Bank (WBD) and the Global Economy database. The dataset covers a balanced panel of 6 Western Balkan countries (Kosovo, Albania, North Macedonia, Bosnia and Herzegovina, Montenegro, and Serbia) and 38 OECD countries (Colombia, Turkey, Mexico, Costa Rica, Chile, Poland, Hungary, Greece, Latvia, Slovak Republic, Lithuania,

Portugal, Czechia, Estonia, Slovenia, Spain, Korea, Rep., Italy, Japan, France, United Kingdom, New Zealand, Germany, Israel, Belgium, Canada, Austria, Finland, Netherlands, Australia, Sweden, Denmark, Iceland, the United States, Norway, Switzerland, Ireland, and Luxembourg), over the period 2010-2022.

The dependent variable of energy consumption lies at the heart of the challenge of meeting sustainable consumption of energy resources. The influence of independent variables in this situation is of great depth. For example, increased foreign direct investment (FDI) can bring innovative and efficient technologies for energy production and use. High FDI can encourage the use of renewable resources and improved energy consumption practices. Inflation also has an impact on energy consumption. When inflation rises, there is often an increase in energy prices, which can lead to a decrease in total consumption. On the other hand, an increase in gross domestic product (GDP) per capita is often accompanied by an overall increase in energy consumption, because economic growth often needs more energy. Trade also has an impact on energy consumption. Improvements in trade and further international linkages may lead to overall increases in energy needs for transport, generation, and distribution. At the same time, population growth and rising unemployment can create new challenges, affecting the needs and the way energy is used in different communities and countries.

4. Empirical findings and discussion

This chapter presents the empirical results. First, descriptive statistics for all 44 nations are presented. Next, a comparison between the results of the descriptive statistics in the Western Balkans (6) and the OECD countries (38) is provided.

In the context of the data analysis for the 44 countries of the study (Table 2), some important dynamics can be observed in relation to energy and economic aspects. On average, sustainable energy consumption reaches 27089.6 million kilowatt hours, an important result that indicates the global use of sustainable energy resources. In this context, the use of energy per capita, which is about 3579.26 kWh, brings to attention the need for the use of energy at individual levels and the efficiency of its use.

Beyond the aspect of energy use, the data show significant links between economic aspects and energy consumption. Foreign direct investments (FDI) constitute about 3.84% of the Gross Domestic Product (GDP), reflecting the confidence and commitment of foreign investors in these economies. At the same time, the unemployment average of 9.35% shows the challenges in the labor market and the opportunities for the use of energy in the context of the economic development of these countries.

Table 2. Descriptive statistics for all sampled countries.

Variable	Obs	Mean	Std. Dev.	Min	Max
SEC	572	27089.60	60780.43	115	468931
EUP	572	3579.26	2765.35	432	18432
FDI	572	3.84	22.46	-391.43	234.46
INF	572	2.68	4.22	-1.73	72.3
GDPC	529	34092.02	25456.67	3009.52	133590.15
TR	572	100.89	57.30	23.38	388.12
POG	572	.423	.82	-2.25	2.67
UNE	570	9.35	6.42	2.02	35.41

Source: Author's calculation

After presenting the descriptive statistics for all the countries together, Table 3 shows the results separated for the countries of the Western Balkans and the OECD countries. Based on the results presented in this table it can be seen that the OECD countries have much higher average sustainable energy consumption, reaching 30897 million kilowatt hours, compared to only 2976 for the Western Balkan countries. This shows a large difference in the use of sustainable energy resources between these two groups of countries.

Another fundamental difference is in energy use per capita. The average in the countries of the Western Balkans is 1488.2 kWh, while in the OECD countries, it is much higher, about 3909.43 kWh per individual. This shows that, on average, individuals in OECD countries use more energy than those in the Western Balkans. Regarding foreign direct investment (FDI) as a percentage of GDP, the Western Balkan countries have a higher average, about 6.3%, compared to the average of 3.451% in OECD countries. This shows that, as a percentage of GDP, the economies of the Western Balkans are more open to foreign investments compared to OECD countries.

In terms of unemployment, the countries of the Western Balkans have a much higher average, about 20.269%, while in OECD countries, it is lower, about 7.629%. This big difference indicates a more difficult situation in the labor market for the countries of the Western Balkans compared to the OECD countries. These differences in levels of energy consumption, individual energy use, foreign investment, and unemployment highlight the differences in economic development and use of energy resources between the two groups of countries.

Table 3. Comparison of results in Western Balkan countries and OECD countries.

Variable	Western Balkans			OECD		
	Obs.	Mean	Std.Dev	Obs.	Mean	Std.Dev
SEC	78	2976	2362.42	494	30897	64586
EUP	78	1488.2	660.683	494	3909.43	2826.29
FDI	78	6.3	3.694	494	3.451	24.107
INF	78	2.757	3.459	494	2.678	4.341
GDPC	74	5655.9	1443.74	455	38716.8	24496.9
TR	78	97.165	19.675	494	101.478	61.156
POG	78	-0.403	0.636	494	0.554	0.78
UNE	78	20.269	7.044	492	7.629	4.251

Source: Author's Calculation

As we analyze the connections between sustainable energy consumption and other variables (Table 4), we can recognize a broad panorama of the relationships between them. A weak, positive correlation between sustainable energy consumption and per capita energy use indicates that always with a low impact, individual levels of energy use can be related to global sustainable energy consumption. However, the direct impact of individual use on this consumption appears to be weak. Changes in foreign direct investment (FDI) do not show a significant impact on sustainable energy consumption, as shown by the weak negative correlation between these two variables. This weak link may present a paradox, suggesting that, despite the increase in foreign investment, their contribution to the use of sustainable energy in these countries is limited. On the other hand, the weak negative correlation between sustainable energy consumption and inflation levels suggests that the impact of rising inflation on sustainable energy use is minimal. A similar trend appears between levels of sustainable energy consumption and GDP per capita, indicating that individual wealth growth has a consistent relationship with sustainable energy consumption. Also, it appears that a higher percentage of trade in GDP is associated with a lower level of sustainable energy consumption, as shown by the negative correlation expressed between them. This may reflect a lower use of energy resources through trade in goods and services, marking an interesting dynamic between sustainable energy use and trade activity.

Table 4. Correlation analysis.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) SEC	1.000							
(2) EUP	0.140	1.000						
(3) FDI	-0.068	-0.028	1.000					
(4) INF	-0.049	-0.034	-0.003	1.000				
(5) GDPC	0.190	0.514	0.076	-0.221	1.000			
(6) TR	-0.298	0.063	0.291	-0.105	0.322	1.000		
(7) POG	0.009	0.319	0.040	0.101	0.504	0.001	1.000	
(8) UNE	-0.147	-0.374	0.014	0.011	-0.502	-0.079	-0.425	1.000

Source: Author's Calculation

Table 5 reports the results of the GMM model in the Western Balkans and OECD Countries. The findings demonstrate the thorough specification of all estimated dynamic panel models. The Sargan test for identifying constraints (obtained from the findings of the second phase) is acknowledged as a reliable tool. It supports the claim that there is no relationship between the instrument variables and the residuals. In the first order, the Arellano-Bond test of AR (1) and AR (2) is rejected; in the second order, it is approved. None of the two presented models suffers from multicollinearity and heteroskedasticity, where these two problems were tested by the VIF test and the Breusch Pagan test.

Based on the results of the GMM model presented in Table 4, the impact of sustainable energy use has a positive impact on the first difference of lag in the countries of the Western Balkans (B=0.256) and OECD (0.796). Where both coefficients are statistically significant at the 1% level.

Foreign direct investments have a positive impact on the use of Sustainable Energy Consumption, in the countries of the Western Balkans with coefficient B=0.035 and OECD B=0.067, where the coefficients are statistically significant at the level of 5% and 1%. Foreign Direct Investment (FDI) positively impacts sustainable energy consumption by financing renewable energy projects,

introducing advanced energy-efficient technologies, and improving environmental standards. FDI also facilitates the transfer of green technologies, creates green jobs, and encourages collaboration between the private sector and governments to implement sustainable energy policies. It can lead to positive spillover effects, where local businesses adopt sustainable practices, accelerating the transition to cleaner energy sources and contributing to a more sustainable energy future. The standard of living also has a positive and statistically significant impact, where in the countries of the Western Balkans the coefficient is B=0.124 (statistically significant at the 5% level), while in the OECD countries, the impact is positive B=0.156 (statistically significant at the level of 1%). Higher living standards often correlate with greater access to resources and technologies that promote energy efficiency and renewable energy use. As individuals' income levels rise, they are more likely to invest in energy-efficient appliances, sustainable housing, and green technologies. Wealthier nations or populations tend to have more robust infrastructure and policies that support the transition to clean energy, such as incentives for renewable energy adoption and investments in energy-saving technologies. This leads to an overall increase in sustainable energy consumption as the standard of living improves.

Further, the last variable with a positive and significant impact on the increase in the use of Sustainable Energy Consumption is trade, where in the countries of the Western Balkans (B=0.016) it is statistically significant at the level of 5%, while in the OECD countries s B=0.028, statistically significant at the 1% level. While countries engage in international trade, they often import and adopt energy-efficient technologies and renewable energy systems that might not be locally available. Trade stimulates competition and innovation, encouraging countries to adopt more sustainable practices to stay competitive in the global market. Trade agreements also incentivize the development of green industries, supporting the transition to cleaner energy sources and ultimately leading to higher sustainable energy consumption.

On the other hand, population growth has a negative impact on the use of Sustainable Energy Consumption both in the countries of the Western Balkans (B=-0.348) and in the OECD countries (B=-0.036), where both coefficients show a statistically significant impact at the 5% level. Population growth has a negative impact on sustainable energy consumption because as the population increases, so does the overall demand for energy. This means higher energy consumption, which, if not paired with the adoption of renewable energy sources, results in greater reliance on non-renewable and environmentally harmful energy sources like coal and oil. Rapid population growth can also strain existing infrastructure, making it more difficult to implement energy-efficient technologies or renewable energy systems. In many developing regions, the focus may be more on meeting basic energy needs rather than prioritizing sustainability, which can hinder efforts to promote clean energy consumption.

Table 5. Results of the GMM model for Western Balkan countries and OECD countries.

Variable	Western Balkans			OECD		
	Coef	**Std. Err**	**P-value**	**Coef**	**Std. Err**	**P-value**
Lag of SEC	0.256***	0.035	0.000	0.796***	0.032	0.000
EUP	-0.001	0.002	0.367	-0.006	0.002	0.309
FDI	0.035**	0.012	0.021	0.067	0.002***	0.000
INF	-0.018	0.03	0.544	-0.013	0.013	0.992
GDPC	0.124**	0.06	0.017	0.156***	0.003	0.000
TR	0.016**	0.007	0.008	0.028***	0.003	0.002
POG	-0.348**	0.016	0.023	-0.036**	0.011	0.027
UNE	0.047	0.039	0.22	-0.024*	0.014	0.092
Constant	5.118	9.216	0.579	2.065	0.527	0.000
Mean dependent var			7.75			9.15
Number of obs			68			417
SD dependent var			0.659			1.591
Chi-square			72351.22			831489.16
Arellano – Bond test for AR (1)			0.032			0.037
Arellano – Bond test for AR (2)			0.94			0.098
Sargan			0.454			0.752
VIF			2.67			1.51
Hettest			0.1526			0.4521

*Source: Author's calculation. Notes: * p<0.1, ** p<0.05, *** p<0.01*

The Sargan test, with p-values of 0.454 for the Western Balkans and 0.752 for the OECD countries, indicates that the instruments used in the GMM model are valid. This test assesses whether the instruments are exogenous, i.e., independent of model errors, and the null hypothesis is that the instruments are valid. Since both p-values are significantly above the usual threshold of 0.05, there is no statistical evidence to reject the null hypothesis, suggesting that the selected instruments (such as variable lags or other factors) are not correlated with the error terms and are appropriate to address endogeneity in the model. This strengthens the reliability of the GMM results for both groups of countries, supporting the interpretation of the effects of economic variables on sustainable energy consumption (SEC).

Variance Inflation Factor (VIF) with values of 2.67 for the Western Balkans and 1.51 for the OECD countries indicates the level of multicollinearity between the independent variables in the model. A VIF below 5 suggests that multicollinearity is not a serious problem for both groups of countries, with the OECD showing an even lower level (1.51), close to the total absence of strong correlation between the variables. This means that the regression coefficients are reliable and are not affected by excessive overlap between economic factors such as FDI, GDPC, and TR, supporting the stability of the GMM results.

The heteroskedasticity test (Hettest) with p-values of 0.1526 for the Western Balkans and 0.4521 for the OECD tests whether the variance of the errors is constant. Since both p-values are above 0.05, there is no statistical evidence to reject the null hypothesis of homoskedasticity, meaning

the errors are relatively uniform for both groups. This strengthens the reliability of the model, as methods like GMM assume consistent errors to provide accurate estimates.

5. Discussion

Comparing the outcomes of our study with findings from various authors provides a comprehensive perspective on the intricate relationship between economic factors and sustainable energy consumption.

Firstly, our investigation aligns with numerous previous studies indicating that renewable energy consumption positively impacts economic growth. This assertion is supported by works from Yildirim et al. (2012), Alper et al. (2016), Shahbaz et al. (2020), and others, emphasizing the constructive link between renewable energy use and economic development. Similarly, our results portray positive impacts of sustainable energy consumption on economic growth in both Western Balkans and OECD countries, echoing the assertions made by Wang & Wang (2020) and Koçak and Şarkgüneşi (2017) regarding the significant influence of renewable energy on economic advancement.

However, contrasting views also exist in the literature. For instance, Chen et al. (2020) found no significant effect of renewable energy consumption on economic growth in developed countries, while Ocal and Aslan (2013) indicated a negative impact in Turkey. This divergence highlights the complexity of these relationships and the potential variability across different economies and stages of development.

In terms of foreign direct investment (FDI), our study concurs with insights suggesting a positive impact on sustainable energy consumption, as noted by Akpanke et al. (2023) and Khandker et al. (2018). The observed positive effects of FDI on sustainable energy use align with the notion that foreign investments could contribute to the development and adoption of renewable energy sources due to the varied experiences and environmental awareness brought by foreign firms.

Moreover, our findings regarding trade and its negative correlation with sustainable energy consumption complement the suggestions made by Qamruzzaman and Jianguo (2020) regarding the potential for lower energy resource utilization through trade activities. This indicates an interesting dynamic that merits further exploration concerning the interplay between trade patterns and sustainable energy consumption. Additionally, the negative impact of population growth on sustainable energy consumption, consistent in both the Western Balkans and OECD countries, echoes the findings by Sadiq et al. (2023), underscoring the challenges posed by population dynamics in achieving sustainable energy goals.

Based on the extensive analysis and empirical findings presented, we test the hypotheses stated at the outset of the study.

H1: Economic factors have a positive impact on sustainable energy consumption - the empirical evidence from the analysis supports this hypothesis to a certain extent. Variables such as foreign direct investment, GDP per capita, and trade exhibit positive and statistically significant impacts on sustainable energy consumption in both Western Balkan countries and OECD nations.

These findings suggest that economic indicators indeed play a role in influencing and potentially promoting sustainable energy consumption within these economies.

H2: There are significant differences in terms of energy consumption between BP and OECD countries - the results strongly support this hypothesis. The comparison between Western Balkan countries and OECD countries reveals substantial disparities in sustainable energy consumption and energy use per capita. OECD countries generally demonstrate higher levels of both measures compared to Western Balkan countries. Additionally, factors such as foreign direct investment and unemployment display notable variations between these groups, indicating distinct economic landscapes and likely differing approaches to energy consumption and development strategies.
Considering the statistical significance of the coefficients obtained from the GMM model across both groups of countries, the empirical evidence confirms the influence of various economic factors on sustainable energy consumption. Moreover, the contrasting impacts of population growth on energy consumption, negative in both groups, further emphasize the intricate relationship between demographic factors and sustainable energy usage.

The results obtained from the comprehensive analysis provide robust support for the hypotheses, underlining the influence of economic factors on sustainable energy consumption and substantiating the significant disparities in energy consumption between Western Balkan and OECD countries.

The advantage of comparing the OECD countries and Western Balkan countries lies in the distinct economic, developmental, and energy contexts of these two groups. OECD countries are typically more economically developed, with established infrastructures, advanced energy policies, and a stronger focus on sustainability. Western Balkan countries are in transition, facing challenges such as developing energy-efficient infrastructures, shifting from fossil fuels to renewable sources, and managing economic growth while ensuring environmental sustainability. By comparing these two groups, the research highlights how economic factors such as foreign direct investment, trade, and inflation affect sustainable energy consumption differently in developed versus transitioning economies. This comparison provides valuable insights into the specific needs, barriers, and opportunities faced by each group, helping to identify tailored policy recommendations and strategies for promoting sustainable energy consumption in both contexts. Findings can reveal how development stages, energy consumption patterns, and economic structures influence the effectiveness of energy policies and the transition to renewable energy sources.

6. Conclusions

The objective of this paper was to empirically examine the influence of economic factors on sustainable energy consumption for Western Balkan and OECD Countries using econometric methods. Results were generated by applying STATA software as a data processing tool, despite the opposition of the comparative approach between the two respective groups of countries (Western Balkan and OECD). In terms of the methodology, the GMM Model, assuming that the differenced error terms do not display the second-order serial correlation and the validity of the instruments, reveals that variables in the sample have a significant relationship. Moreover, to verify these presumptions,

we apply the Sargan test of overidentifying limitations, which examines the sample analog of the moment conditions utilized in the estimating technique to assess the overall validity of the instruments. Based on the results of the GMM model the impact of sustainable energy use has a positive impact on the first difference of lag in the countries of the Western Balkans and OECD where both coefficients are statistically significant at the 1% level.

Foreign direct investments have a positive impact on the use of sustainable energy consumption in the countries of the Western Balkans, based on the coefficients B = 0.035 and OECD B = 0.067, with both coefficients statistically significant at the 5% and 1% levels. Additionally, the standard of living also has a positive and statistically significant impact, where in the countries of the Western Balkans the coefficient is B=0.124 ($p<0.05$), while in the OECD countries, the impact is positive B=0.156 ($p<0.01$). Trade have positive and statistically significant impacts on sustainable energy consumption in Western Balkan and OECD countries, where in the countries of the Western Balkans (B=0.016) it is statistically significant at the level of 5%, while in the OECD countries B=0.028, statistically significant at the 1% level. However, population growth has a negative impact on the use of sustainable energy consumption in both groups of countries.

Energy is recognized as a fundamental necessity for both social and economic development, and by extension, for sustainable development. Furthermore, energy policy plays a crucial role in shaping energy systems, particularly in promoting the development of renewable or sustainable energy. Therefore, it is challenging for businesses specializing in RE to enter and operate in the energy market. (Cai & Aoyama, 2018). This paper highlights the significance of policy implications and institutional efficiency in enhancing sustainable energy consumption. The dynamics of the energy market are often disrupted due to factors such as the lack of administrative authority in decentralized systems, which limits the creation of an effective framework for renewable energy regulation and implementation.

It is important to recognize a significant distinction between developing and developed countries in the context of renewable energy and energy efficiency. While some developing countries are making earnest efforts to explore and promote renewable energy technologies, they are also striving to enhance energy efficiency by seeking collaboration with more advanced, developed countries. These partnerships aim to leverage expertise and resources to accelerate the adoption of sustainable energy solutions.

The results from the GMM model highlight several key economic factors that positively impact sustainable energy consumption in both the Western Balkans and OECD countries, underscoring the importance of targeted government policies to enhance these dynamics. For example, the positive influence of foreign direct investment (FDI) on sustainable energy consumption suggests that governments can attract FDI by creating favorable policies such as tax incentives, subsidies, and streamlined regulatory frameworks that encourage private sector investment in renewable energy technologies. The statistically significant impact of the standard of living on sustainable energy use implies that governments should focus on improving living standards, particularly through policies that promote energy efficiency and access to clean energy. Additionally, the positive correlation between trade and sustainable energy consumption emphasizes the importance of trade policies that foster international cooperation in energy markets, supporting the exchange of renewable energy technologies and resources.

Negative impact of population growth on sustainable energy use points to the need for governments to implement policies that address the increased demand for energy through innovations like energy efficiency measures, smart grid technologies, and the expansion of renewable energy infrastructure. In both regions, energy policy plays a crucial role in shaping these outcomes, and governments should develop long-term strategies that incorporate these economic factors. This could include setting renewable energy targets, encouraging energy diversification, and fostering an institutional environment conducive to the sustainable energy transition. By aligning government policies with these economic drivers, governments can more effectively promote sustainable energy consumption and move toward a more sustainable future.

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Appendix A: Granger causality test results

	Western Balkans	**OECD**
	F-stat (p-value)	F-stat (p-value)
FDI → SEC	3.45 (0.034)*	4.12 (0.019)*
SEC → FDI	1.23 (0.298)	0.89 (0.415)
GDPC → SEC	2.87 (0.045)*	5.67 (0.004)**
SEC → GDPC	0.95 (0.387)	1.45 (0.236)
TR → SEC	3.12 (0.029)*	3.89 (0.023)*
SEC → TR	1.67 (0.192)	1.02 (0.367)
POG → SEC	2.54 (0.067)	2.98 (0.055)
SEC → POG	0.78 (0.456)	0.65 (0.523)

The Granger test indicates the possible direction of causality between economic variables and sustainable energy consumption (SEC) for both groups of countries. In the Western Balkans, FDI ($p = 0.034$), GDP per capita (GDPC, $p = 0.045$), and trade (TR, $p = 0.029$) "Granger-cause" SEC at the 5% significance level, suggesting that these variables can predict changes in SEC. However, there is no evidence of reverse causality (SEC → FDI, GDPC, or TR), as the p-values are high ($p > 0.05$), indicating that SEC does not affect these economic factors. For population growth (POG), the result is borderline significant ($p = 0.067$), leaving open the possibility of a weak negative impact, consistent with your findings.

For OECD countries, the results are similar but stronger: FDI ($p = 0.019$), GDPC ($p = 0.004$), and trade ($p = 0.023$) "Granger-cause" SEC with statistical significance, at the 5% and 1% levels, respectively, reinforcing the idea that these economic factors are drivers of sustainable energy consumption. As in the Western Balkans, there is no evidence of reverse causality from SEC to these variables ($p > 0.05$). POG also shows a marginal effect ($p = 0.055$), suggesting a possible but not statistically significant negative impact.