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Impact of Sustainable Energy Technologies, Government Governance and Environmental Taxes on Sustainable Energy Transition in E7 Countries: Fresh Evidence using CUP-FM CUP-BC Approach

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ABSTRACT

The current study examines the effectiveness of sustainable energy technologies, governance and environmental taxes on energy transition using E7 countries data for the period 2006-2020. The study used CUP-FM and CUP-BC estimation techniques to assess the relationship between variables. Findings of the study reveal the positive association between constructs, suggesting that expansion of clean energy resources including solar and hydroelectric energy helps economies to experience sustainable energy transition as it ensures energy security. The significant relationship of government governance also suggests that governance indicators are crucial for energy transition. Moreover, the effective imposition of environmental taxes facilitates industries to shift toward sustainability while discouraging the reliance on non-renewable resources. Interestingly, the positive influence of industrialization, inflation and population growth indicate that although industrialization and population growth amplify the demand of energy consumption, however, when driving demand is paired with sustainable policies, it may result in green energy transition. In addition, findings also suggest that economies have an opportunity to capitalize on inflation-led pricing trends to boost energy diversification and advance sustainable opportunities.

Keywords: Sustainable Energy Technologies, Solar and Hydroelectric Sources, Government Governance, Environmental Taxes, Sustainable Energy Transition

JEL Classifications: Q42, Q48, Q56, H23, Q58, O33

1. INTRODUCTION

The modern world is grappling with various challenges including surging population numbers, sustainability-related risks, socio-economic progress and resource scarcity, primarily fueled by globalization. However, the most considerable one is environmental degradation as it is manifested in diverse forms including resource exhaustion, climate shifts and critical health challenges. To address these deleterious repercussions of environmental destruction, switching to low-carbon energy resources and technologies particularly solar and hydroelectric power, stands out as the most viable approach. In this regard, limiting anthropogenic climate perturbation to 1.5°C while promoting holistic economic transformation are most daunting concerns globally. However, these two predicaments should not be looked as competing interests but interconnected goals and address simultaneously especially in the wake of post-pandemic disruptions. Given the scenario, a broad-scale migration toward clean energy is the definitive and superior approach. Since, the transition to renewable energy is driven by core pillars such as economic viability, budget prudence and energy independence. Thus, it may result in environmental sustainability and inclusive growth, especially in developing nations. It is because in emerging economies, there exists an untapped renewable energy potential that is indispensable for global energy transition (Murshed, 2021; Østergaard et al., 2021).

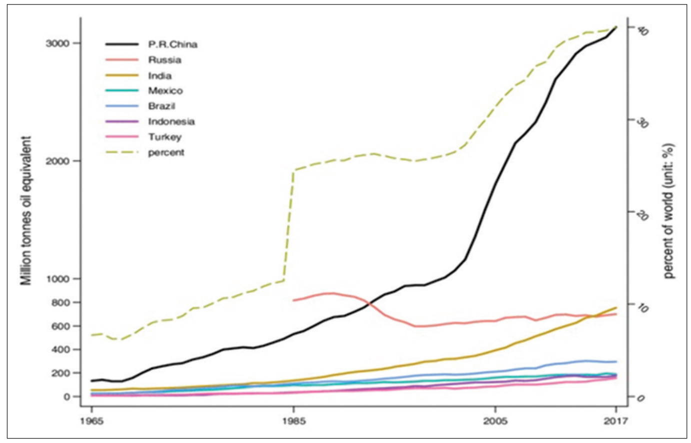
Since energy transition aimed at shifting away from non-renewable resources to renewable resources, therefore, the whole shift is propelled by essential drivers such as surge in power consumption, renewable energy adoption and development in energy retention methods (Murshed, 2021). It is argued that technological innovation and heightened societal polarization toward sustainability have rendered this shift more viable and necessary. However, factors such as pricing and deep rooted and persistent changes in energy supply are the heart of this transition. As a result, this transition help economies to get rid of harmful emissions through decarbonization methods (Davidson, 2019).

From statistical point of view, scholars expected to experience a 50% increase in renewable energy capacity between 2019 and 2024 (Joshi, 2021). As a reaction, energy companies are shifting to renewable resources to minimize their reliance on coal which is considered an energy production source. Moreover, the transition is also influenced by stakeholders which heightens the pressure on power providers to reduce their coal dependent assets and consider alternative yet friendly resources. Although, some experts deduce a slower growth in transition due to policy, economic and technological related challenges. However, the growing urgency of climate change compels major oil businesses to venture into new energy sectors and adapt new business models in order to identify sustainable energy solutions. While the federal incentives for renewable resources are gradually declining, renewable energy demand remains robust because of profound commitment coming from sizeable corporate buyers (Hoicka et al., 2021). Statistics reveal that corporate renewable capacity has been increasing three times- recorded before the year 2015 which is expected to grow more in future. Efforts in the form of RE100 coalition empower businesses to source 100% energy from clean resources, thus, helping them to cater long-term demand (Cantarero, 2020). In addition, it is also projected that electric vehicle penetration rate will experience a jump from 10% to 12.5% by 2025 (Ivanovski and Marinucci, 2021).

Echoing global trends, E7 countries are also experiencing substantial challenges in the form of resource scarcity and ecological balance due to reliance on traditional resources. From Figure 1, with the passing years energy consumption rate is increasing along with increasing demand of energy production. However, their renewable capacity especially in China, Brazil, India and Russia is not up to the mark to fulfill the increasing demand. To overcome this shortfall, it is crucial for E7 economies to adopt sustainable energy technologies with a smooth energy shift. Because the shift is necessary for fulfilling energy needs and sustaining environmental quality.

In the light of the above argument, the study addresses various gaps to expand the contribution on sustainable energy transition

Figure 1: Energy consumption in E7 countries



specifically in the context of E7 economies. As globalization has necessitated the need for swift technological progress, all of these are fundamentally associated with energy availability. This high demand would push economies to increase their reliance on conventional energy resources, leading to environmental deterioration. From this point of view, renewable resources as a fundamental energy source have been explored many times in passing years, however, the multidimensional view is yet to be explored particularly from emerging economies' perspective (Bazilian et al., 2020; Cantarero, 2020; Huang et al., 2018; Saheb et al., 2018; Wang and Wang, 2020). Since studies overlooked its dimensions along with other crucial factors, the present study considers these factors by analyzing the role of governance, environmental taxes, energy transition and sustainable renewable technologies (solar and hydroelectric) within E7 framework. Thus, the study contributes to literature by considering the multi-dimensional view along with other outlined factors that are unexplored in a collective manner.

The remaining portion of the study is organized into four sections. The literature review section captures the highlights of prior literature to explain the variables and their interrelated relationships within different contexts. The methodology section outlines the procedure of data collection and data techniques. Whereas the data analysis section highlights the outcomes of the study. Finally, the last section of the study is concluded with study's key findings, implications and future research agenda.

2. LITERATURE REVIEW

The escalating energy needs, propelled by globalization, often leave economies with no choice but to increase their reliance on traditional resources, particularly in the scenario of emerging nations. However, huge reliance leads to disturbing environmental quality, suggesting the abrupt need for sustainable energy solutions. Although there are multiple alternatives, solar and hydroelectric energy are considered viable substitutes to fulfill energy demand and discourage environmental harm at the same time. In this context, Khan et al. (2022) explored energy transition, consumption and sustainable technologies within OECD framework and revealed that although these factors improve environmental quality, however, they hinder economic development. The study also outlined that in some OECD nations the use of non-renewable resources improves economic growth but damage environmental quality. Under these findings, the study suggested prioritizing structural adjustment in energy industry, identifying and removing non-market barriers to sustainability, fostering sustainable trade and green technology adoption and show support for resilient urbanization. Similarly, study of Dong et al. (2022) confirmed the sustainable energy technologies discourage carbon emissions and endorse sustainable energy transition within 23 emerging economies. Further, Ivanovski and Marinucci (2021) reviewed the promising relation of sustainable energy technologies with energy security and established a strong and positive relationship, thus, claiming that renewable energy plays essential role in long-term energy security. Collectively these studies signify the need for sustainable energy technologies in robust energy transition and carbon neutrality.

Institutions use a diverse range of taxation methods to raise revenue and fund their expenditures. Among these measures, taxation is viewed as a widely used source, impersonating in various forms such as environmental taxes, sales taxes, income taxes etc. Environmental taxes play a crucial role in implementing sustainable policies. It is argued that the dominant form of environmental taxation emphasizes energy production and consumption, affecting both environmental and economic outcomes. Nevertheless, governments prioritize these taxes when they intend to develop policies and implement projects related to natural resources because any occurrence has a profound impact on these initiatives' outcomes. In this regard, energy transition is important to highlight as environmental taxation laws greatly affect such policies. Prior literature emphasizes the significant role of environmental taxation in a country's energy transition process. In this context, Freire-González and Puig-Ventosa (2019) proclaimed that variations in environmental taxation policies may cause subtle changes in energy transition process. Thus, suggesting a strong bond between environmental taxation and sustainable energy transition. Similarly, study of Breetz et al. (2018) scrutinized energy transition from political point of view while questioning the role of institutional policies in natural resource management and environmental quality. Based on the findings, the study revealed that when robust political support is paired with effective governance, it may have a profound impact on energy transition process and environmental sustainability. Since the increased energy consumption doubles the production demand, thus, relying on traditional resources, environmental consequences are inevitable. Hence, a structured and planned shift toward sustainable energy is mandatory to suppress these harmful effects. Furthermore, study of Bashir et al. (2021) confirmed that sustainable efforts can be of success if overall consumption of energy is reduced while focusing on energy transition process. These studies highlight that environmental taxation is viewed as a key policy tool that creates a strong bond between energy transition and sustainable environment. However, policy stability and government intervention should be coupled with such taxation methods as together they ensure a greener future.

As literature argues that success rate of national level projects mainly depends on how effectively governance has been implemented by institutions. This is particularly crucial for energy transition efforts as such efforts are generally infused into national level policies (Sadiq et al., 2025). Strong and effective governance ensures that well-structured roadmaps have been development and practical SOPs are established to streamline the transition process. Good governance not only minimizes uncertainty level but also makes sure that the policies and infrastructure are well-occupied to ensure smooth transition from fossil fuel-based resource to eco-friendly resources.

In this context, Dowling et al. (2018) argued that if energy related policies, regulatory systems and socio-technological framework do not follow sustainability principles then they might not be help for sustainable energy transition. The study further argued that if energy market and grid infrastructure continue to promote non-renewable production and show rigidness, it might create challenges for economies to shift toward renewable resources. However, if energy systems are perceived dynamic in nature, the likelihood of successful energy transition increases. The study also emphasized that how government actions have bigger consequences, thus, should be taken carefully. On the other hand, study of Hoppe and Miedema (2020) evaluated how governance approach at regional level is helpful in energy transition. Based on the findings, it is revealed that effective governance intensifies energy transition efforts at national and regional level. Similarly, Huang et al. (2018) looked into the role of urban governance and reveal that energy transitional governance is an effective and long-term strategy that may responsible for broader shift toward renewable energy. Building on the argument, study of Watari et al. (2021) outlined the significance of well-crafted governance structure in energy transition and low carbon emissions. The study indicated that strong governance may lead to long-term sustainability through effective natural resource management. In essence, governance, either at regional or urban level or national level, plays a significant role in energy transition efforts. It is due to policy coherence, systemic resilience that provides clear road maps for renewable transition while reducing the negative effect of institutional barriers.

Renewable energy transition benefits economies in a way that promotes a carbon conscious environment which further helps them to deal with climate change. Literature proclaims that renewable energy adoption ensures environmental sustainability while simultaneously improving economic and social structures. In this context, Deka and Dube (2021) highlighted a bidirectional yet long-term association of inflation and exchange rates with renewable energy usage. The study proclaimed that the use of renewable energy significantly affects inflation and exchange rates, however, exchange rates and inflation do not affect renewable consumption. In the light of the study, the study suggested that the higher the rate of renewable adoption, the higher the chances of currency appreciation and economic and environmental benefits. Similarly, study of Talha et al. (2021) highlight the role of strategic oil management and energy consumption within inflation context. The study suggested that with effective oil price management, economies gain a chance to diminish inflationary pressures. Further, Khan et al. (2022) countered the suggestion by highlighting a negative association between energy resources and inflation. All in all, these studies outline a complex relationship between inflation and renewable energy, suggesting that its dual role in economic and environmental stability cannot be overlooked.

Since, global economy, fueled by globalization, is progressing at an unparalleled velocity, the need for essential goods has also been accelerating. This speedy growth causes disparity between demand and supply, which is further aggravated by technological progress that necessitates the need for leading edge products. In order to fulfill the demands, economies have invested their efforts to production capacity because with increased capacity, they are able to maintain economic growth and improve revenue growth. However, one shouldn't neglect the consequences of industrial expansion that may lead to higher energy consumption and severe environmental degradation (Hanlin et al., 2021). Thus, renewable energy shift has become a necessary step to address this environmental harm. In this context, Hanlin et al. (2021) offered an empirical insight by reviewing the relationship of industrialization with environmental pollution. The study indicated that industrial activities are responsible for pollution and environmental degradation. Thus, renewable transition is needed to suppress these harmful effects (Mehmood et al., 2025). Since the ability of nation is dependent on energy access, low-cost and resilient energy access are necessary to achieve sustainability goals. Since economic expansion is possible with rapid industrialization, however, it comes with environmental costs, including higher emissions and ecological damage. Building on this, study of Fernandes (2020) argued industrialization results in higher emissions and consumption, thus, increasing environmental risks. Therefore, it is suggested in the literature that to restrict environmental risk while sustaining industrial growth, the country has to experience sustainable energy transition.

In addition, population growth is another pressing global challenge that gives birth to various other challenges such as job scarcity, resource inefficiency, carbon pollution and ecological damage. In this context, Dong et al. (2018) examined the association between population growth and environmental quality as the relationship significantly affect energy transition. The study indicated that population growth leads to higher emissions. However, it also pressures economies to shift toward renewable energy production. It implies that population growth indirectly leads to renewable energy shift. Since population growth is a central force of environmental collapse, hence pressures economies to move toward renewable solutions. It is because more non-renewable consumption, leading to environmental damage. Thus, in order to fulfill the gap renewable adoption not becomes a choice but a necessity (Hussain and Rehman, 2021; Namahoro et al., 2021).

3. RESEARCH METHODOLOGY

The study investigates the association among governance, and environmental taxes and sustainable energy transition in the context of E7 economies. The study used secondary data which has been gathered from multiple resources including WDI and Natural resources governance institutions, covering the period from 2006 to 2020 (Table 1).

The current article has run descriptive statistics that show the details of the variables. Moreover, the current article also has also run the year-wise and country-wise descriptive statistics that show the details of the variable according to countries and years. In addition, the current article has also run the correlation matrix to investigate the correlation among variables. Moreover, the current article has also run the P-CD test developed by Pesaran and BP-LM test developed by Breusch and Pagan. The equation for the LM test developed by Pesaran is given below:

$$LM_2 = \sqrt{\frac{1}{N(N-1)}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\left(T_{ij}\hat{\rho}_{ij}^2 - 1\right)} \rightarrow N(0,1) \quad (1)$$

While CD test developed by the Pesaran equation is given as below:

$$CD = \sqrt{\frac{2}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}T_{ij}\hat{\rho}_{ij}^2 \rightarrow N(0,1) \quad (2)$$

In contrast, the equation for the BP-LM test developed by Breusch and Pagan is given as under:

$$LM_1 = \sum_{i=1}^{N-1}\sum_{j=i+1}^{N}T_{ij}\hat{\rho}_{ij}^2 \rightarrow X^2\,\frac{N(N-1)}{2} \quad (3)$$

The stationarity of the variables has also been examined by the study with the help of the cross-sectional Augmented Dickey-Fuller (CADF) test. The CADF for the panel data equation is mentioned below:

$$X_{it} = \alpha_i + b_i X_{it-1} + c_i\bar{X}_{it-1} + d_i\Delta\bar{X}_t + e_{it} \quad (4)$$

Moreover, the study has checked the Cross-Sectionally dependence (CSD) issue with the help of Cross-Sectionally Augmented IPS (CIPS) developed by Pesaran (Sarkodie and Strezov, 2019). This approach provides knowledge related to

Table 1: Measurements of variables

Variable Code	Variable Names	Measurement	Sources
SET	Sustainable Energy Transition	"REO (percentage of total energy output)"	WDI
		"Electricity production from solar source (percentage of total)"	WDI
		"Electricity production from hydroelectric sources (percentage of total)"	WDI
GG	Government governance	"Energy governance Index"	Natural Resources Governance Institutions
ENT	Environmental Taxes	"Environmental taxes (% of total revenue)"	WDI
IND	Industrialization	"Industry value added (% of GDP)"	WDI
INF	Inflation	"Consumer price (annual percentage)"	
PG	Population Growth	"Population growth (annual percentage)"	WDI

whether or not CSD issues exist (Chang et al., 2017). The CIPS equation is mentioned below:

$$\Delta W_{i,t} = \varnothing_i + \varnothing_i Y_{i,t-1} + \varnothing_i \bar{Y}_{t-1} + \sum_{l=0}^{p} \varnothing_{il} \Delta \bar{W}_{t-1} + \sum_{l=0}^{p} \varnothing_{il} \Delta W_{i,t-1} + \mu_{it} \quad (5)$$

In the above equation, $\bar{W}$ shows the average cross-section represented below:

$$W^{i,t} = \varnothing^1 \overline{EPSS}^{i,t} + \varnothing^2 \overline{EPHS}^{i,t} + \varnothing^3 \overline{GG}^{i,t} + \varnothing^4 \overline{ENT}^{i,t} + \varnothing^5 \overline{IND}^{i,t} + \varnothing^6 \overline{INF}^{i,t} + \varnothing^7 \overline{PG}^{i,t} \quad (6)$$

Moreover, the statistics related to the CIPS test are given as under:

$$\widehat{CIPS} = N^{-1} \sum_{i=1}^{n} CADF_i \quad (7)$$

The current article has examined the co-integration with the help of (Westerlund and Edgerton, 2008) approach. The null hypothesis of the approach is that there is no co-integration exists. Thus, the equation for this approach is given below:

$$\mathrm{LM}_{\varphi}(i) = T\hat{\varphi}_i (\hat{r}_i / \hat{\alpha}_i) \quad (8)$$

$$\mathrm{LM}_{\tau}(i) = \hat{\varphi}_i / SE(\hat{\varphi}_i) \quad (9)$$

Where, $\hat{\varphi}_i$ shows the approximation against standard error $\hat{\alpha}_i$, $\hat{r}_i^2$ shows its long-run assessed variance, $\varphi i\ (L) = 1 - \sum \varphi_{ij} L^j$ shows a scalar polynomial and, the ρ_i shows the factor loading parameters vector.

Finally, the current article has checked the linkage among the constructs with the help of CUP-FM and CUP-BC established by (Bai et al., 2009). The basic feature of these estimation techniques is that they provide robust estimation. Moreover, the CUP-FM technique produces continuous parameters, covariance matrix estimation and factor loadings until convergence is attained. The equation for the techniques is given below:

$$\beta_{cup} = \left[\sum_{i=1}^{N} \left(\sum_{t=1}^{T} \hat{y}_{it} + \hat{\beta}_{cup} \right) \left(x_{it} - \bar{X}_i \right)' - T \begin{pmatrix} \lambda'_i \left(\hat{\beta}_{CUP} \right) \hat{\Delta}_{F\varepsilon i} \left(\hat{\beta}_{CUP} \right) \\ + \hat{\Delta}_{u\varepsilon i} \left(\hat{\beta}_{CUP} \right) \end{pmatrix} \right] \times \left[\sum_{i=1}^{N} \sum_{t=1}^{T} \left(x_{it} - \bar{X}_i \right) \left(x_{it} - \bar{X}_i \right)' \right] \quad (10)$$

Where, $\hat{\Delta}_{F\varepsilon i}$ *and* $\hat{\Delta}_{u\varepsilon i}$ are one-sided estimated covariance.

4. RESEARCH FINDINGS AND DISCUSSION

Table 2 presents a descriptives the study to develop an understanding of data variation and central tendency of selected variables. Since, standard deviation value of SET is 21.959, suggesting a significant spread in the data. This highlights a wide variation in SET levels. Meanwhile max and min values also indicate a major divergence, highlighting some economies have weak energy transition while others have advanced transitioning. The mean value of EPSS suggests that countries are generating lower amount electricity from solar sources. In addition, the minimum and maximum values suggest that production of solar based electricity has not developed fully across all economies. However, values of EPHS are more prevalent when we compare it to solar based electricity. Meanwhile, the standard deviation value of EPHS highlights that although some nations have high reliance on hydroelectric power, other nations do not have a capacity to produce enough electricity from hydroelectric power. Moreover, governance quality across all economies seems to be moderate as the mean value suggests. Standard deviation value of GG also highlights a consistency across economies. In case of environmental taxation, values suggest that there exists a substantial variation in such taxation rates. However, some economies tend to impose high tax rates. Overall, the descriptives of the study indicate a significant variation in case of all variables. However, narrow ranges of government governance and inflation suggest more consistency across data.

Table 2: Descriptive statistics

Variable	Obs	Mean	Standard Deviation	Min	Max
SET	105	26.722	21.959	10.651	88.996
EPSS	105	4.351	3.230	0.046	14.968
EPHS	105	22.152	20.508	5.856	84.021
GG	105	0.621	0.061	0.510	0.766
ENT	105	30.859	10.347	16.355	63.375
IND	105	32.064	8.009	17.702	48.061
INF	105	6.023	3.321	−0.728	16.332
PG	105	0.955	0.501	−0.327	1.703

Table 3 of the study offers a deeper insight into correlation among variables. It indicates how strongly variables are linked to each other. EPSS value indicates a moderate yet positive correlation with SET, suggesting that higher EPSS leads to a higher level of SET. However, EPHS value suggests a higher correlation compared to EPSS, suggesting a strong reliance of economies on hydroelectric power. In addition, weak correlation can be observed in the case of government governance, suggesting that it is less influential compared to industrialization and renewable capacity. Similarly, environmental taxation also has a weak correlation with SET, suggesting that ENT helps economies to foster green energy. The positive and moderate correlation between IND and SET suggests that expansion in industrial activities may push economies to invest in clean technologies. Moreover, a weaker correlation of inflation and population growth with SET indicates that the impact of INF and PG is almost negligible. It implies that sustainability initiatives are not affected by inflation.

Table 4 provides a detailed outcome of CSD tests that have been utilized to identify the degree of interdependence among “cross-sectional units”. It is necessary to evaluate because in panel data, there are chances that economic changes in one economy may bring change in others. From Table 4, it is apparent that all the constructs are statistically significant, suggesting that these constructs are highly correlated. It implies that policy change in one unit affects other economies as well. Moreover, all the values of EPSS highlight a strong cross-sectional dependency, indicating that EPSS related policies are interlinked across all countries.

Table 3: Matrix of correlations

Variables	SET	EPSS	EPHS	GG	ENT	IND	INF	PG
SET	1.000							
EPSS	0.548	1.000						
EPHS	0.989	0.429	1.000					
GG	0.274	0.292	−0.361	1.000				
ENT	0.284	−0.135	−0.289	0.393	1.000			
IND	0.589	−0.352	−0.585	0.406	0.513	1.000		
INF	0.030	−0.085	−0.008	−0.454	−0.240	−0.250	1.000	
PG	0.024	0.308	−0.077	−0.103	0.111	−0.045	0.124	1.000

Table 4: CSD test results

Variables	Breusch-Pagan LM	Pesaran Scaled LM	Pesaran CD
SET	216.553***	21.922***	9.102***
EPSS	277.292***	24.376***	13.920***
EPHS	123.992***	23.764***	4.118***
GG	219.009***	21.645***	8.443***
ENT	103.938***	25.463***	19.746***
IND	323.887***	33.255***	34.777***
INF	102.093***	21.435***	22.664***
PG	102.002***	37.298***	23.253***

Table 5: CADF and CIPS unit root tests result

Variables	CIPS		CADF	
	Level	1st difference	Level	1st difference
SET	----	−4.773***	----	−4.219***
EPSS	−2.092***	----	−2.991***	----
EPHS	−2.187***	----	−3.129***	----
GG	−2.955***	----	−3.228***	----
ENT	----	−5.782***	----	−5.132***
IND	----	−4.209***	----	−5.662***
INF	−3.029***	----	−2.128***	
PG	----	−5.191***	----	−4.291***

However, in case of EPHS, CSD is moderate, suggesting that energy reliance is not consistent, however, a certain degree of mutual dependency persists. Moreover, values of GG, PG, INF, ENT and IND show strong interdependence, suggesting a strong link across economies.

Table 5 of the study highlights that two methods were used to analyze unit root tests as these tests help researchers to identify where properties of study constructs remain consistent or change overtime. From Table 5, it is apparent that SET, IND, ENT, INF and PG are stationary at 1st difference only. On the other hand, EPSS, EPHS and GG values suggest that these variables are stationarity at level. Variables which are stationary at level suggest that they possess stable properties over the passage of time. Meanwhile, variables stationary at 1st difference highlights that at initial level they need to be different to achieve stationarity.

Table 6 presents the results of co-integration by using three model specifications. These models highlight a structural change that may influence the association between variables in the long run. From Table 6, it can be deduced that there is a strong presence of co-integration, especially when structural shifts are taken into account. In addition, regime shift also highlights a strong presence of co-integration, indicating that the relationship between variables is long-term and robust.

Table 7 of the study presents the results of CUP-BC and CUP-FM as these methods are widely utilized to assess a long-run association between variables. The values derived from both tests confirm that there exists a significant association between variables. Since, the estimates of CUP-FM are lower than CUP-BC, suggesting that SUP-FM may underestimate the actual values due to presence of small bias. However, CUP-BC offers more accuracy in estimated relationships, hence, correcting the bias. EPSS' value of CUP-FM and CUP-BC suggests a reliable and significant relationship due to higher t-values. However, the CUP-FM's effect size in case of EPHS is lower compared to CUP-BC value. Similarly, government governance shows a strong effect, but the effect size is larger in CUP-BC. Values of ENT show that environmental taxation tends to have a strongest and most positive impact on SET. In case of IND and INF, the effect size is moderate, whereas, in case of population growth, the relationship is highly significant.

The results showed that electricity production from solar sources has a positive association with sustainable energy transition. These results are supported by the past study of Neofytou et al. (2020), which indicates that the countries where electricity is preferred to be produced from solar sources, the supply of clean and recyclable energy increases within the economy. In this situation, when the firms can avail the clean, cheap, easy to access, and easy-to-use energy in the form of electricity from solar sources, they overcome the use of fossil fuels and can easily adopt sustainable energy transition. So, this previously conducted study states that electricity production from solar sources enhances the sustainable energy transition. These results are also in line with the study of Adewuyi and Awodumi (2021), which examines the role of electricity production from solar sources in the sustainable energy transition. The study claims that usually, in the economy, fossil fuels like coal, oil, gas, and more are utilized to meet energy needs, but these sources of energy are environment-affecting, health-damaging, expensive, and cannot be recycled. The firms considering these disadvantages prefer sustainable energy transition. The increase in electricity production from solar sources assists in adopting sustainable energy transition.

The results showed that electricity production from hydroelectric sources has a positive association with sustainable energy transition. These results are supported by the past study of Höfer and Madlener (2020), which shows that in the countries where electricity is produced from hydroelectric sources, clean, low-cost, and recyclable energy is available within the economy. When firms

Table 6: Co-integration test results

Model	No Shift		Mean Shift		Regime Shift	
	Test Stat	P-value	Test Stat	P-value	Test Stat	P-value
LM_τ	−3.102	0.000	−4.153	0.000	−5.493	0.000
LM_φ	−3.287	0.000	−4.439	0.000	−5.192	0.000

Table 7: CUP-BC and CUP-FM test results

Variables	CUP-FM		CUP-BC	
	Coefficient	t-stat	Coefficient	t-stat
EPSS	0.631***	4.124	0.753***	7.532
EPHS	1.092***	3.011	0.662***	4.192
GG	0.619***	5.091	2.198***	3.930
ENT	3.281***	3.721	2.773***	3.001
IND	2.720**	1.991	3.291***	2.018
INF	1.649**	2.029	2.651***	1.920
PG	0.619***	5.963	0.553***	4.090

can easily access clean, low-cost, and recyclable energy in the form of electricity from hydroelectric sources, they can reduce the use of fossil fuels can be reduced and transit to sustainable energy. So, this confirms that electricity production from hydroelectric sources enhances the sustainable energy transition. These results are also in line with the study of Vainio et al. (2019), which shows that tend the production of electricity from hydroelectric sources enhances the amount of energy available to be used for performing economic activities. When electricity produced from hydroelectric sources is enough to meet the energy need without creating any environmental, cost, or production issues, it becomes easy to apply sustainable energy transition.

The results showed that government governance has a positive association with sustainable energy transition. These results are supported by the past study of Sueyoshi et al. (2021). It posits that the countries where the government is attentive to the environmental conditions and considers the impacts of economic activities on the environmental quality, fossil fuels which are harmful to the natural environment and concerned resources, are discouraged from being overcome. In this situation, the government designs its economic policies to prevent the economic entities from utilizing fossil fuels and motivate them to sustainable energy consumption. Hence, government governance enhances sustainable energy transition. These results are also in line with the study of Dominković et al. (2018), which shows that government plays a significant role in shaping the economic structure and saving the country's environment as well as its inhabitants from the negative impacts of economic practices. When government regulates the economy and encourages renewable energy production, it promotes renewable energy consumption. Thus, government governance enhances sustainable energy transition.

The results showed that environmental taxes have a positive association with sustainable energy transition. These results are supported by the past study of Dominković et al. (2018), which posits that government levies environmental taxes on economic enterprises in order to prevent them from economic undertakings which have negative environmental impacts. As a result, the firm struggles to overcome the use of technologies and resources in business processes that require non-renewable energy. And they try to employ alternatives that are based on sustainable energy. This encourages sustainable energy transition in the economy. These results are also in line with the study of Jung et al. (2020), which shows that if in an economy, the environmental taxes are enforceable and the economy is regulated through these taxes, the business firms try to stop the use of energy resources which may cause harm to the environment. In this situation, fossil fuel consumption is tried to be overcome by utilizing sustainable energy like wind power, biomass, solar power, hydroelectricity, etc. Thus, environmental taxes enforcement supports sustainable energy transition. These results also match with Oudes and Stremke (2018), which highlights that when the environmental taxes are enforceable on the firms or individuals who are involved in the use of resources harmful to environment, they try to overcome the use of non-renewable energy by replacing it with sustainable energy. Hence, the sustainable energy transition increases within the country.

The results indicated that industrialization has a positive association with sustainable energy transition. These results are supported by the past study of Hasan et al. (2020), which claims that most industrial activities require energy in huge amounts. When industrial activities tend to increase within the country, the requirement for total energy increases within the country. When business firms find it difficult to fulfill energy requirements and consider that just reliance on traditional energy sources disturbs future energy, they tend to utilize sustainable energy. Therefore, the increase in industrialization enhances the sustainable energy transition. These results are also in line with the study of Franco et al. (2022), which proclaims that with the increase in industrialization, technological advancements and innovation start within the country. The increasing use of innovative energy-efficient technologies forces firms to increase renewable energy consumption. This drives sustainable energy transition.

The results showed that inflation has a positive association with sustainable energy transition. These results are supported by the past study of Podbregar et al. (2020), which throws light on the role of inflation in the sustainable energy transition. The study demonstrates that when inflation rises within the country, the government and individual business firms perform actively. They pay attention to environmental quality besides the economic well-being of the country. In this situation, there is motivation to replace the consumption of non-renewable energy with sustainable energy in the economy to reduce environmental pollution. This leads to an increase in sustainable energy transition. These results also match with the study of Hidayatno et al. (2019), which shows that the start of the inflationary period brings financial and technical development to the country. In a country making development, the use of renewable energy is preferred and needs to be utilized. So, inflation increases sustainable energy transition.

The results revealed that population growth has a positive association with sustainable energy transition. These results are supported by the past study of Taghizadeh-Hesary et al. (2021), which indicates that with the increase in the population of a country, both the social and economic activities increase. In many of these activities, energy is required. When in the market there is a higher energy demand, the producers pay attention to renewable energy production and introduce these sources of energy. Consequently, sustainable energy transition increases within the country. These results are also in line with the study of Sadiq et al. (2022), which explores the influences of population growth on sustainable energy transition. The countries with a larger population increase the basic needs like food, residence, cloth, and the requirement of life facilities. In order to meet these requirements, the interlinked economic activities increase. Consequently, demand for energy increases, and its major portion is met with renewable energy. So, increasing population growth begins a sustainable energy transition within the economy.

5. CONCLUSION

Academics may find much to learn from this study because it makes a significant contribution to literature. The study explores the influences of electricity production from solar and hydroelectric sources, government governance, and environmental taxes, along with inflation, industrialization, and population growth on sustainable energy transition. In many previous studies, the impacts of electricity production from solar and hydroelectric sources, government governance, environmental taxes, inflation, industrialization, and population growth on sustainable energy transition have been analyzed. But these research studies have discussed the role of these factors in the sustainable energy transition. The current study, which examines the impacts of all these variables on sustainable energy transition, collectively adds to the literature. In previous studies, environmental taxes have been merged into the variable: government governance while analyzing sustainable energy transition. The current study, which analyzes the role of government governance and environmental taxes in sustainable energy transition individually with equal significance, extends the literature. Moreover, this article makes a distinction in literature by initiating to analyze of electricity production from solar and hydroelectric sources, government governance, environmental taxes, inflation, industrialization, and population growth on sustainable energy transition for E7 economies.

The present study has great importance in emerging countries as it addresses sustainable energy transition, the major concern of the day in order to attain sustainable development. It serves as a set of guidelines for government, environmental regulators, and economists of a country on how they must deal with policy to encourage sustainable energy transition. The study guides that they must form policies to encourage electricity production from solar sources to motivate individuals and firms for the sustainable energy transition. Similarly, hydroelectric sources must also be employed for electricity production to enhance sustainable energy transition in the economy. The study also guides that government governance for environmental protection, economic growth, and resource management must be encouraged to enhance sustainable energy transition. The study conveys that government, along with regulators, must enforce environmental taxes on individuals and firms to force them to a sustainable energy transition. The study suggests that inflation and industrialization should be preferred for sustainable energy transition. The article has provided guidelines to the policy establishing authorities that they should develop the policies related increase the sustainable energy transition.

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