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Research Article

The nexus economic growth and energy poverty: Evidence from D-8 countries

Ekonomik büyüme ve enerji yoksulluğu arasındaki ilişki: D-8 ülkelerinden bulgular

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Abstract

Energy is critical in production and daily activities in all economies today. Although energy is usually required for economic growth in developed economies, it is also fundamental to economic growth and growth in less developed and developing economies. In this context, this study aims to investigate the linkage between energy access and economic growth in D-8 nations. Inflation, health expenditures, and income were included in the model as control variables. The data set covers the period from 1990 to 2021 and is annual in frequency. The methodology employed includes PANIC and CIPS unit root and Durbin-Hausman co-integration tests. A co-integration relationship was found in the model, and AMG (Augmented Mean Group) was used to perform long-run coefficient estimates. After the coefficient estimation results, we found no statistically significant relationship between energy poverty and economic growth. The energy factor should be used more effectively in poverty reduction. In particular, expanding renewable energy sources will also contribute positively to sustainable growth.

Keywords: Energy Poverty, Economic Growth, Durbin -Hausman, Energy Access, D-8 Countries

Jel Codes: P18, O43, O11

Öz

Enerji, tüm ekonomilerde hem üretim hem de günlük faaliyetler açısından kritik bir rol oynamaktadır. Gelişmiş ekonomilerde genellikle ekonomik büyüme için enerjiye ihtiyaç duyulurken, daha az gelişmiş ve gelişmekte olan ekonomilerde de ekonomik büyüme ve kalkınma için enerji temel bir unsurdur. Bu bağlamda, bu çalışmanın amacı, D-8 ülkelerinde enerjiye erişim ile büyüme arasındaki bağlantıyı araştırmaktır. Enflasyon, sağlık harcamaları ve gelir kontrol değişken olarak modele dahil edilmiştir. Veri seti, 1990'dan 2021'e kadar olan dönemi kapsamaktadır ve yıllık frekanstadır. Kullanılan metodoloji, PANIC ve CIPS birim kök testleri ile Durbin-Hausman eşbütünleşme testlerini içermektedir. Modelde bir eşbütünleşme ilişkisi bulunmuş ve uzun dönem katsayı tahminlerini gerçekleştirmek için AMG (Augmented Mean Group) kullanılmıştır. Katsayı tahmin sonuçlarına göre, enerji yoksulluğu ile ekonomik büyüme arasında istatistiksel olarak anlamlı bir ilişki bulunamamıştır. Yoksullukla azaltmada enerji faktörü daha etkin kullanılmalıdır. Özellikle yenilenebilir enerji kaynaklarının yaygınlaştırılması sürdürülebilir büyümeye de pozitif katkı sağlayacaktır.

Anahtar Kelimeler: Enerji Yoksulluğu, Ekonomik Kalkınma, Durbin-Hausman, Enerji Erişimi, D-8 Ülkeleri

Jel Kodları: P18, O43, O11

Introduction

Energy, a fundamental pillar of macroeconomics, exerts considerable influence over various economic dimensions such as growth, poverty, unemployment, income distribution, etc. Access to energy is crucial for nations aiming for economic progress. The value of energy, a vital production input, significantly outweighs other factors in developed and developing countries (Acharya and Sadath, 2019). To promote global sustainable development, significant organizations such as the United Nations (UN), the World Bank (WB), and the International Monetary Fund (IMF) closely monitor energy trends (González-Eguino, 2015). However, several challenges hinder universal energy access. These include the non-renewable nature of fossil energy resources and their potential exhaustion, the limited share of renewable energy in total consumption, the relatively high costs associated with harnessing renewable sources, logistical challenges in distribution and ensuring supply security due to resource dispersion, geopolitical instability, and strategic concerns (Adusah-Poku and Takeuchi, 2019; Singh and Inglesi-Lotz, 2021).

Energy poverty, defined as the lack of access to adequate, affordable, high-quality, secure, and environmentally friendly energy services essential for human and economic development, poses significant challenges, particularly in underdeveloped and developing nations with high energy dependency (Reddy, 2015). The energy consumption disparities among countries underscore this issue's critical nature. Enhanced utilization of modern energy resources and increased accessibility foster economic growth and development and advance fundamental social development components such as education, higher wages, and overall quality of life (Barnes and Samad, 2018). The positive correlation between energy consumption and well-being highlights energy poverty as a critical driver of social exclusion, revealing its adverse ramifications for society and individuals during economic growth and development (Guzowski, Martina, and Zabaloy, 2021). Energy poverty inhibits individuals from meeting basic needs such as heating and lighting, impeding their participation in society. Moreover, it significantly reduces efficiency in environmental preservation, healthcare, and economic activities, thus stifling developmental potential (González-Eguino, 2015). Additionally, the impact of energy poverty on gender roles and educational opportunities is paramount (Sovacool, 2012).

When examining the role of energy in meeting societal needs, it is insufficient to focus solely on energy consumption or supply. The primary consideration should be how energy resources enable essential services such as heating, cooking, access to clean water, and transportation for individuals and society (Reddy, 2000). Energy poverty, a significant challenge requiring attention due to its potential to create a poverty trap and perpetuate cycles of impoverishment, stems from a combination of factors including low-income levels, a high proportion of income spent on energy expenses, suboptimal energy efficiency, and elevated energy prices (González-Eguino, 2015). Addressing energy poverty requires implementing comprehensive macroeconomic policies encompassing price regulations, energy conservation initiatives, tariff adjustments, tax incentives, and energy efficiency measures (Widuto, 2022). Mitigating energy poverty offers numerous benefits, including reduced healthcare costs, decreased air pollution, enhanced welfare, improved household financial stability, increased access to energy services, and consequently, fostering social development. These benefits strengthen economic growth and societal well-being (EU Commission Recommendation, 2020).

The determinants of energy poverty are intricately linked to locally specific socio-political and environmental contexts. Efforts to quantify energy poverty face considerable challenges due to its entrenchment within the private realm of households, its susceptibility to spatial and temporal dynamics, and its sensitivity to cultural configurations (Bouzarovski, 2014). Despite these complexities, the intersection of energy poverty with economic growth, social development, and societal infrastructure transformations within the sustainable development framework necessitates a multifaceted analysis employing diverse indicators (Pachauri and Spreng, 2011). The literature contains numerous studies investigating the hypothesized strong relationship between economic growth and energy consumption. However, research exploring the nexus between energy poverty and economic growth in emerging economies remains notably scarce.

The Developing Eight (D-8) Economic Cooperation Organization, established in 1997 and encompassing a population exceeding one billion, is a global entity transcending regional boundaries with its guiding principles and geographical scope. Over the past two decades, the D-8 has evolved into a formidable economic bloc, boasting a collective economic size surpassing 3.7 trillion dollars. The D-8 member countries collectively contribute approximately 4% to the world's export volume, amounting to $758.5 billion, and 4.4% to the global import volume, totalling $833.2 billion. Since its inception, the gross domestic product (GDP) per capita among member nations has risen from an average of $2,207 to $4,645 in 2016. With a combined population of approximately 1.1 billion, the D-8 countries hold roughly 15%

of the world's proven oil reserves, constituting around 10% of annual oil production and 6% of consumption globally. Furthermore, these nations possess approximately 23% of the world's natural gas reserves, accounting for 13% of natural gas production and 11% of consumption (Trade Map, 2020).

In studies investigating energy poverty, distinctions such as those between developed and developing nations and between affluent and impoverished countries, along with variations in climate zones, emerge as primary criteria for determining indicators (Schuessler, 2014). However, upon analysis of existing literature, a universally accepted indicator for energy poverty remains elusive due to its globally variable causes. Factors contributing to this complexity include the substitutability of energy services, the lack of consensus on which energy services are deemed essential, and the challenges in establishing poverty thresholds for each energy service, precluding a universally agreed-upon criterion for interpreting energy poverty (Culver, 2017). Nonetheless, in studies exploring the relationship between energy poverty and economic growth, the utilization of electrical energy emerges as a significant indicator directly impacting economic growth (Yang, 2000; Yoo, 2006; Ho and Siu, 2007; Stern, Burke, and Bruns, 2019). Notably, the consumption of electrical energy resources tends to escalate concomitant with economic growth and development, driven by technological innovations (Alter and Syed, 2011). Consequently, efforts are made to capture the interaction between electricity consumption and economic growth by emphasizing the accessibility and active utilization of electricity (Dagoumas and Kitsios, 2014; Morrissey, 2017). Thus, it can be asserted that facilitated by the infrastructure investments it engenders, electric energy can mitigate income inequality, employment, and poverty by fostering economic growth (Attigah and Mayer-Tasch, 2013).

Given the amassed data, it is evident that burgeoning economies will inevitably witness a concurrent surge in energy consumption. Consequently, a compelling imperative exists to scrutinize the issue of energy poverty within the context of Developing Eight (D-8) countries, which manifest a pronounced need for energy resources relative to their counterparts. Examining energy poverty within the framework of newly industrializing nations, exemplified by the D-8 consortium, is poised to yield novel insights for scholarly discourse. The primary objective of this study is to investigate the impact of energy poverty on economic growth in D-8 countries over the period spanning from 1990 to 2021. The indicator utilized to gauge energy poverty is access to electricity, and panel data analysis techniques are employed to explore this relationship. This study aims to contribute to the existing literature in two key aspects: (i) by analyzing the relationship between energy poverty and economic growth and development in the context of D-8 countries, and (ii) by examining the linkage between energy poverty and economic development through methods that consider heterogeneity and cross-sectional dependence.

In the first section of the study, the theoretical framework is summarized. In the second section, the results of the empirical analyses and findings of the study are interpreted. The study concludes with policy recommendations based on the findings.

Literature

In recent years, the number of studies investigating the correlation between energy poverty and economic growth has surged. This section highlights a selection of such studies employing various datasets and analytical methodologies. Onyeji (2010) examined the interplay between economic growth and energy poverty across 53 developing nations from 1985 to 2005, utilizing the Ordinary Least Squares (OLS) test. The findings revealed that economic growth enhances electricity accessibility, positively influencing economic growth. In a similar investigation, Rehman and Deyuan (2018) explored the relationship between the rate of electricity accessibility and economic growth in Pakistan, employing the Autoregressive Distributed Lag (ARDL) Bounds Test from 1990 to 2016. The study found a statistically significant positive effect of urban population electricity accessibility and energy utilization on long-term economic growth, contrasting with a negative impact in rural areas. Alam, Miah, Hammoudeh, and Tiwar (2018) examined the effects of electricity accessibility rates on various economic indicators, including Gross Domestic Product (GDP), foreign direct investments, financial development, and economic growth across 56 developing nations. They utilized the panel co-integration test from 1991 to 2013, and their findings revealed a sustained relationship between electricity accessibility and labour productivity and a positive correlation with economic growth. In another study, Manga (2020) analyzed data from seven less-developed countries from 1995 to 2016, utilizing the Kónya causality test. The findings indicated a bidirectional causality between energy poverty and economic growth in the Central African Republic and Madagascar. In contrast, Burkina Faso, Haiti, and Malawi observed a unidirectional causality relationship.

Singh and Inglesi-Lotz (2021) employed the Generalized Method of Moments (GMM) to analyze data from 14 Sub-Saharan African countries from 1990 to 2016. Their findings revealed a significant association between access to electricity and GDP. The research indicated that alleviating energy poverty can stimulate economic growth, with a 1% increase in access to electricity correlating with a 0.120% rise in annual growth. Ullah et al. (2021) conducted a time series analysis of data from 1990 to 2017 to explore the correlation between energy poverty and economic growth in Pakistan. Their analysis demonstrated a statistically significant relationship between energy poverty and short- and long-term economic growth. Similarly, Raghutla and Chittedi (2022) performed a panel data analysis examining the correlation between energy poverty and economic development in BRICS nations from 1990 to 2018. They used access to electricity as a variable, and the study uncovered a unidirectional causal relationship between economic development and access to electricity in the short term, indicating that access to electricity positively impacts the economic advancement of these countries. In a different regional context, Castro-Cárdenas and Ibarra-Yunez (2023) investigated the relationship between energy poverty and economic growth across seven Latin American countries from 1990 to 2018. Employing an ARDL model and panel data analysis, they examined both short- and long-term effects. Energy poverty was quantified as the percentage of the population with access to electricity relative to the total population, while GDP per capita served as an indicator of economic growth. The study results suggested an absence of a short-term correlation between energy poverty and GDP while identifying a negative relationship in the long term.

Conversely, no causality relationship was identified in Gambia and Mali. Amin, Liu, Chandio, Rasool, Luo and Zaman (2020) scrutinized data from seven selected South Asian countries between 1995 and 2017 using ARDL and Penalized Quantile Regression Tests. Their investigation, focusing on electricity access as a variable, concluded that energy poverty negatively affects economic development in both the short and long run across all countries. Similarly, Aigheyisi and Oligbi (2020) analyzed the Nigerian economy from 1990 to 2017 using the Robust Error Correction Model (ECT) test. Their study inferred that energy poverty imparts a detrimental effect on economic development, emphasizing the importance of enhancing access to electricity to foster positive developmental outcomes. Simultaneously, Acharya and Sadath (2019) quantitatively assessed the interconnection between energy poverty and economic development. Employing datasets from the Human Development Survey for the years 2004-2005 and 2011-2012, along with the Multidimensional Energy Poverty Index (MEPI) and development index specific to India, their investigation demonstrated a discernible correlation between energy poverty and the economic underdevelopment of the nation, underscoring a negative association between economic progression and energy poverty.

Previous studies generally affirm that energy poverty significantly affects economic growth. In this paper, we investigate the influence of energy poverty on economic growth in D-8 nations from 1990 to 2021. The metric to gauge energy poverty is based on access to electrical energy. Additionally, the model integrates inflation, income, and health expenditure as explanatory variables for economic growth. Health expenditure is pivotal for economic growth because it substantially contributes to human capital development and maintains a robust and healthy labour force.

Data and methodology

This study investigates the impact of energy poverty on economic development across D-8 countries from 1990 to 2021. The study period has been determined based on the most extended available data. The D-8 countries were selected for two reasons. First, they were chosen due to the lack of studies evaluating economic growth and energy poverty from their perspective. Second, unlike developed countries, access to energy has rapidly increased in developing countries over the past few decades. Therefore, this group of countries was selected to observe the effects of energy poverty on economic growth and development. Energy poverty is assessed using the indicator of access to electrical energy, following the definition by Raghutla and Chittedi (2022). The model incorporates inflation, income levels, and health expenditures as explanatory variables in exploring economic development. Health expenditures are crucial for economic growth, contributing significantly to human capital development and maintaining a healthy labour force. The dataset used in this study is sourced from the World Bank and is detailed in Table 1 below.

Table 1: Variables Definitions

Symbol	Variables	Definition
lnEG	Economic Growth	GDP per capita (constant)
EP	Energy Poverty	Access to electricity (% of population)
INF	Inflation	Inflation, consumer prices (annual %)
lnINC	Income	GNI per capita, PPP (current international $)
HEAL	Healthy Expenditure	Domestic general government health expenditure (% of GDP)

The functional relationship analyzed between the variables in the study is articulated as follows:

EG=f(EP,INF,INC,HEAL)

The empirical analysis in this study adopts second-generation panel data techniques, building upon the framework established by Raghutla and Chittedi (2022), who utilized first-generation panel data analysis. Our approach accounts for horizontal cross-sectional dependence and heterogeneity, which enhances the robustness and reliability of our results compared to earlier methods. The model employed in this study is formulated as Equation 1 below:

$$lnEG_{it} = \beta_0 + \beta_1 EP_{it} + \beta_2 INF_{it} + \beta_3 lnINC_{it} + \beta_4 HEAL_{it} + \mu_{it} \quad (1)$$

Where t denotes time dimension; i denotes units (countries); β denotes parameter coefficients; μ denotes error term.

This study uses panel data techniques to investigate the impact of energy poverty on economic development. The empirical analyses commenced by assessing whether the variables exhibit horizontal cross-sectional dependence. This consideration is crucial in selecting appropriate unit root tests to evaluate the stationarity levels of the variables. If horizontal cross-sectional dependence is present, second-generation tests are warranted, whereas first-generation tests are suitable if such dependence is absent. The bias-adjusted LM cross-sectional dependence test proposed by Pesaran, Ullah, and Yamagata (2008) was employed to ascertain horizontal cross-sectional dependence. Given that our study entails a panel with $T>N$ and T>N observations, indicating a larger time dimension compared to the cross-sectional dimension, the bias-adjusted LM test was deemed suitable.

Subsequently, unit root tests were conducted on the dataset to address horizontal cross-sectional dependence using second-generation techniques. Specifically, the PANIC test by Bia and Ng (2004) and the CIPS test by Pesaran (2007) were employed to assess the stationarity of the variables. After determining stationarity levels, co-integration analyses were performed using the Durbin-Hausman co-integration test developed by Westerlund (2008). This test accommodates horizontal cross-sectional dependence and provides both homogeneous and heterogeneous results. It allows independent variables to exhibit stationarity at the level or first difference, provided that the dependent variable is stationary at the first order. Pesaran and Yamagata (2008) and Swamy (1970) conducted homogeneity tests to determine whether to apply homogeneous or heterogeneous statistics. Finally, after establishing the co-integration relationship, long-run coefficient estimates of the model variables were computed using the Augmented Mean Group (AMG) estimator developed by Bond and Eberhardt (2009) and Eberhardt and Teal (2010). The AMG estimator is particularly suited for scenarios characterized by horizontal cross-sectional dependence and the model's non-uniform distribution of slope coefficients.

Empirical findings and discussion

Descriptive statistics

Table 2 presents the descriptive statistics of the panel dataset spanning from 2000 to 2021. In the D-8 countries, the energy poverty indicator ranges from a minimum of 32 to a maximum of 100. Similarly, the inflation data exhibits a minimum value of -1.138 and a maximum value of 54.915 during the specified period. Regarding health expenditure, the budget allocation ranges from a minimum of 0.423 to a maximum of 4.422. The economic growth variable demonstrates a minimum value of 4.027 and a maximum of 8.247. Additionally, the income variable ranges from a minimum of 3.209 to a maximum of 4.477.

Table 2: Descriptive Statistics

Variables	Mean	Std. Dev.	Min	Max
lnEG	5.563	1.382	4.027	8.247
EP	86.158	19.638	32	100
INF	10.002	8.904	-1.138	54.915
lnINC	3.906	0.321	3.209	4.477
HEAL	1.511	1.022	0.423	4.422

Correlation analysis

Table 3 displays the correlation matrix among economic growth, energy poverty, inflation, income, and health expenditures. It highlights a negative correlation between economic development and health expenditures. Meanwhile, energy poverty, inflation, and income show positive correlations. Additionally, energy poverty, inflation, and income exhibit positive correlations with all variables in the dataset.

Table 3: Correlation Analysis

	lnEG	EP	INF	INC	HEAL
lnEG	1.0000				
EP	0.1056	1.0000			
INF	0.1834	0.0644	1.0000		
lnINC	0.0868	0.8033	0.0676	1.0000	
HEAL	-0.0483	0.6018	0.2858	0.7410	1.0000

Dependency properties

Table 4 presents the results concerning horizontal cross-section dependence. According to the findings, all variables included in the model demonstrate significant horizontal cross-section dependence at a 1% statistical significance level. Horizontal cross-section dependence indicates that shocks affecting one country also affect others, reflecting globalization. Therefore, these results are consistent with the observed trend of globalization worldwide.

Table 4: Cross-Section Dependency Test Results

	Bias-Adjust CD Test (Pesaran, 2008) t-stat[Prob.]
lnEG	15.621[0.000] [a]
EP	24.310[0.000] [a]
INF	5.547[0.000] [a]
lnINC	20.419[0.000] [a]
HEAL	19.127[0.001] [a]

Note: a represents a 1% statistical significance level, respectively.

Stationarity properties

Upon confirming the presence of horizontal cross-sectional dependence in the variables, unit root analysis proceeded using second-generation tests. Specifically, the PANIC test by Bia and Ng (2004) and the CIPS test by Pesaran (2007) were employed. The unit root test results are summarized in Table 5. According to the PANIC and CIPS tests, all variables, except for inflation, are non-stationary at the level. Specifically, the natural logarithm of economic growth (lnEG), energy poverty (EP), the natural logarithm of income (lnINC), and health expenditures (HEAL) exhibit non-stationarity at the level. However, inflation data shows stationarity in the trended PANIC unit root test and both CIPS unit root test models. It is concluded that the variables exhibit stationarity at the first difference at various levels of statistical significance. A unit root at the level implies that shocks affecting these variables are permanent and do not dissipate in the short run.

Table 5: PANIC and CIPS Unit Root Tests Results

	Bia and Ng-PANIC		Pesaran-CIPS	
Level	With trend t-Statistics [Prob.]	Without trend t-Statistics [Prob.]	With trend t-Statistics [Prob.]	Without trend t-Statistics [Prob.]
lnEG	0.620[0.267]	-1.955[0.974]	-1.389[0.998]	-1.521[0.757]
EP	0.392[0.652]	-0.624[0.733]	-0.822[1.000]	-1.867[0.378]
INF	2.062[0.019][b]	0.149[0.440]	-3.056[0.012][b]	-2.662[0.004][a]
lnINC	-1.754[0.960]	-1.339[0.909]	-2.032[0.801]	-2.061[0.190]
HEAL	-0.812[0.791]	-0.504[0.693]	-2.402[0.390]	-1.765[0.494]
1 difference				
ΔlnEG	2.643[0.004] [a]	3.190[0.001] [a]	-5.680[0.000] [a]	-2.399[0.000] [a]
ΔEP	4.132[0.000] [a]	6.858[0.000] [a]	-3.072[0.010] [b]	-2.289[0.061] [c]
ΔINF	6.205[0.000] [a]	6.054[0.000] [a]	-3.401[0.000] [a]	-3.093[0.000] [a]
ΔlnINC	1.776[0.037] [b]	1.594[0.055] [c]	-3.602[0.000] [a]	-3.286[0.000] [a]
ΔHEAL	3.540[0.000] [a]	3.443[0.003] [a]	-4.391[0.000] [a]	-4.176[0.000] [a]

Note: [a], [b] and [c] represent 1%, 5% and 10% statistical significance levels, respectively.

Homogeneity and dependency

All variables show non-stationarity at the first difference, with the inflation variable (INF) being stationary at the level (I(0)). Conversely, variables lnEG, EP, lnINC, and HEAL are stationary at the first difference (I(1)). Subsequently, a co-integration relationship was examined using the Durbin-Hausman co-integration test developed by Westerlund (2008). This test is suitable for co-integration analysis when the dependent variable is I(1) while the other variables are either I(0) or I(1). The Durbin-Hausman test accounts for horizontal cross-section dependence and provides two sets of results: group and panel statistics. Panel statistics are used for homogeneous models, whereas group statistics are employed for heterogeneous models. The homogeneity tests such as the Delta test (Swamy, 1970), its adjusted version $Delta_{adj}$ (Pesaran and Yamagata, 2008), and the Bias-adjust test for horizontal cross-section dependence (Pesaran, 2008) were conducted on the model before the Durbin-Hausman co-integration test. The results of these homogeneity and cross-sectional dependence tests are summarized in Table 6. The homogeneity test assesses whether the countries in the panel exhibit specific characteristics consistent across the panel, mainly focusing on whether the slope coefficients have a homogeneous or heterogeneous distribution. At a statistical significance level of 1%, both the Delta and $Delta_{adj}$ statistics reject the null hypothesis, indicating heterogeneous slope coefficients. Therefore, the alternative hypothesis, which suggests heterogeneous slope coefficients, is accepted.

Tablo 6: Homogeneity and Cross-Section Dependency Tests Results

Homogenite Tests	t-Statistic[Prob.]
Delta	29.539[0.000] [a]
$Delta_{adj}$	31.511[0.000] [a]
CD test	
Bias-Adjust CD Test (Pesaran, 2008)	5.631[0.000] [a]

Note: a represents a 1% statistical significance level, respectively.

Panel co-integration and coefficient estimator test results

The Durbin-Hausman co-integration results, preferred for examining co-integration relationships based on unit root findings, are presented in Table 7. Considering group statistics due to heterogeneous slope coefficients, a co-integration relationship is identified at a 5% statistical significance level in both the trended and trendless models.

Tablo 7: Durbin-Hausman co-integration test results

Test statistics	**With trend t-Statistics [Prob.]**	**Without trend t-Statistics [Prob.]**
Durbin-H group statistic	-2.119[0.017] [b]	-1.525[0.064] [c]
Durbin-H panel statistics	-1.859[0.032] [b]	-1.792[0.037] [b]

Note: [b] and [c] represent 5% and 10% statistical significance, respectively.

After establishing a co-integration relationship in the model, the effects of the independent variables on the dependent variable were examined using the AMG (Augmented Mean Group) coefficient estimator. The results obtained are presented in Table 8. The effect of energy poverty(EP) on the entire panel's economic growth(EG) is statistically insignificant. However, according to the country-specific results, this relationship is statistically significant for Bangladesh, Indonesia, Malaysia, Pakistan, and Turkey.

The impact of energy poverty on economic growth is positive in the countries where statistically significant results were found, except for Turkey and Pakistan. These findings are consistent with the studies of Aigheyisi and Oligbi (2020), Amin et al. (2020), and Zhao, Mahendru, Ma, Rao, and Shang (2022). Zhao et al. (2022) emphasized that green energy production positively influences economic growth. Therefore, renewable energy sources are again highlighted instead of fossil fuel sources.

The effect of inflation (INF) on economic growth is statistically insignificant and harmful for the entire panel and all countries except Pakistan. For Pakistan, the impact of inflation on economic growth is statistically significant and negative. The findings of this study are consistent with those of Gillman, Harris, and Ma'tya (2004), Bawa and Abdullahi (2012), Mandeya and Ho (2021), and Thioune, Mignamissi, and Bikoula (2024). Inflation negatively affects many economic indicators, especially economic growth and income distribution. Khan and Hanif (2020) highlight that high inflation negatively influences economic growth by discouraging investment and directing investors toward interest-bearing investments.

The variable lnINC positively affects economic growth for the entire panel and all individual countries. This is because an increase in national income will also raise per capita income. Lastly, the effect of health expenditures (HEAL) on economic growth is statistically insignificant for the entire panel. However, it is statistically significant for Iran, Pakistan, and Turkey at the country level. The coefficients are negative for Turkey and positive for Iran and Pakistan. These results are similar to those of Narayan, Narayan, and Mishra (2010), Odisanwa (2014), and Yang (2020). Investments in human capital, including health expenditures, contribute positively to economic growth by enhancing productivity and efficiency through improvements in the quality of human capital.

Table 8: AMG Coefficient Estimate Results

	EP	INF	lnINC	HEAL
Countries	Coef. [Prob.]	Coef. [Prob.]	Coef. [Prob.]	Coef. [Prob.]
Bangladesh	0.001[0.009][a]	-0.001[0.509]	0.578[0.000] [a]	-0.027[0.317]
Egypt	-0.004[0.484]	0.001[0.301]	0.480[0.000] [a]	-0.037[0.117]
Indonesia	0.001[0.055] [c]	-0.001[0.717]	0.621[0.000] [a]	0.002[0.640]
Iran	-0.003[0.516]	-0.001[0.604]	0.618[0.000] [a]	0.018[0.007] [a]
Malaysia	0.019[0.006] [a]	0.001[0.168]	0.468[0.000] [a]	0.001[0.952]
Nigeria	0.001[0.724]	0.001[0.787]	0.643[0.000] [a]	0.004[0.726]
Pakistan	-0.002[0.000] [a]	-0.001[0.088] [c]	0.718[0.000] [a]	0.013[0.005] [a]
Turkiye	-0.065[0.018] [b]	-0.001[0.212]	0.524[0.000] [a]	-0.022[0.010] [b]
PANEL	-0.006[0.446]	0.001[0.716]	0.581[0.000] [a]	-0.005[0.413]

Note: [a], [b] and [c] represent 1%, 5% and 10% statistical significance levels, respectively.

Conclusion and recommendations

In this study, we examined the impact of energy poverty, inflation, income, and health expenditures on economic development using data from D-8 countries from 2000-2021. Our empirical analyses employed PANIC and CIPS unit root tests, the Durbin-Hausman co-integration test, and the AMG coefficient estimator. We found horizontal cross-section dependence among the variables. The unit root tests showed inflation data stationary at the level, while other variables exhibited unit roots. Given the dependent variable's I(1) nature, the Durbin-Hausman co-integration test confirmed a co-integration relationship in the model. Subsequently, we used the AMG estimator to estimate long-run coefficients.

Across the panel, only income demonstrated a statistically significant and positive impact on economic development, with no significant results observed for other variables. However, country-specific results highlighted the significant impact of energy access on economic development in Bangladesh, Indonesia, Malaysia, Pakistan, and Turkey. Specifically, this effect was positive for Bangladesh, Indonesia, and Malaysia. Inflation showed statistical significance on economic growth, albeit negatively. The effect of income on economic growth was positive and statistically significant across all countries. Additionally, the influence of the healthy expenditure variable on economic growth was positive for Iran and Pakistan, negative for Turkey, and statistically significant. The results are confirmed by Amin et al. (2020), Zhao et al. (2022), Mandeya and Ho (2021), Onisanwa (2014), and Yang (2020).

Based on the findings and results, several policy recommendations emerge. A crucial initial step involves addressing the challenge of access to energy resources. Secondly, energy infrastructure investments should be expanded to increase access to energy. This will improve the overall quality of life and help reduce production costs. Increased production will, in turn, contribute to improving living standards. Third, energy planners should prioritize meeting the population's energy needs, particularly in rural areas, where poverty is more prevalent than urban centres. Improving rural energy infrastructure is especially important for addressing this disparity. Fourth, promoting renewable energy sources in the energy supply will facilitate sustainable growth and development. Environmental policies are essential for sustainability and improving human welfare and health.

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