ESAM EKONOMİK VE SOSYAL ARAŞTIRMALAR DERGİSİ
Cilt/Volume: 5 Sayı/Issue: 1, Yıl/Year: 2024, 111-134.

ANALYZING THE RELATIONSHIP BETWEEN HEALTH EXPENDITURE, RENEWABLE ENERGY AND LIFE EXPECTANCY: EVIDENCE FROM ASIAN COUNTRIES

Iraima DORBONOVA[*]
ORCID: 0009-0003-0222-848X

İbrahim Halil SUGÖZÜ[**]
ORCID: 0000-0002-1861-3118

Abstract: This study investigates the relationship between health expenditures, renewable energy and life expectancy in Asian countries within a model covering the period 2000-2020. GDP data are also included in the model. In the study, after applying cross-sectional dependence test and Cross-sectional Augmented Dickey-Fuller unit root tests, panel cointegration test is employed to show whether there is a long-run mutual relationship between health expenditures and other variables, and then Dumitrescu-Hurlin (2012) panel causality analysis method is used to test the causality between the relevant variables in Asian countries. According to the empirical findings, while causality is found between health expenditures and renewable energy in most of the Asian countries, there is also a high level of causality between life expectancy and health expenditures. Moreover, the cointegration test between health expenditures and other variables confirms that there is a long-run relationship between the variables. It is concluded that policy makers in Asian economies should develop policy frameworks that provide opportunities for renewable energy consumption and support investment in

---

[*] PhD. Candidate, Department of Economics, Kyrgyz-Turkish Manas University, 1850D03001@manas.edu.kg

[**] Prof. Dr., Department of Economics, Kyrgyz-Turkish Manas University, ihsugozu@manas.edu.kg

DOI: https://doi.org/10.53662/esamdergisi.1459607

Araştırma Makalesi
Research Article

Geliş Tarihi: 27/03/2024
Kabul Tarihi: 24/04/2024

Atıf / Cite as: Dorbonova, I. - Sugözü, İ. H. (2024). Analyzing the Relationships between Health Expenditure, Renewable Energy and Life Expectancy: Evidence from Asian Countries, *ESAM Ekonomik ve Sosyal Araştırmalar Dergisi*, 5 (1), 111-134.

renewable energy projects to promote the use of clean technologies. Thus, an increase in renewable energy consumption can lead to economic prosperity by not only improving quality of life but also increasing productivity.

Keywords: Asian Countries, Economic Growth, Health Expenditure, Life Expectancy, Renewable Energy.

SAĞLIK HARCAMALARI, YENİLENEBİLİR ENERJİ VE YAŞAM BEKLENTİSİ ARASINDAKİ İLİŞKİLERİN ANALİZİ: ASYA ÜLKELERİNDEN ÖRNEKLER

Öz: Bu çalışma, Asya ülkelerinde sağlık harcamaları, yenilenebilir enerji ve ortalama yaşam süresi arasındaki ilişkiyi 2000-2020 dönemini kapsayan bir model çerçevesinde araştırmaktadır. GSYH verileri de modele dahil edilmiştir. Çalışmada yatay kesit bağımlılık testi ve yatay kesit Augmented Dickey-Fuller birim kök testleri uygulandıktan sonra, sağlık harcamaları ile diğer değişkenler arasında uzun dönemli karşılıklı bir ilişki olup olmadığını göstermek için panel eşbütünleşme testi ve ardından Asya ülkelerinde ilgili değişkenler arasındaki nedenselliği test etmek için Dumitrescu-Hurlin (2012) panel nedensellik analizi yöntemi kullanılmıştır. Ampirik bulgulara göre, Asya ülkelerinin çoğunda sağlık harcamaları ile yenilenebilir enerji arasında nedensellik ilişkisi bulunurken, yaşam beklentisi ile sağlık harcamaları arasında da yüksek düzeyde nedensellik ilişkisi tespit edilmiştir. Ayrıca, sağlık harcamaları ve diğer değişkenler arasındaki eşbütünleşme testi, değişkenler arasında uzun dönemli bir ilişki olduğunu doğrulamaktadır. Asya ekonomilerindeki politika yapıcıların, yenilenebilir enerji tüketimi için fırsatlar sağlayan politika çerçeveleri geliştirmeleri ve temiz teknolojilerin kullanımını teşvik etmek için yenilenebilir enerji projelerine yatırımı desteklemeleri gerektiği sonucuna varılmıştır. Böylece, yenilenebilir enerji tüketimindeki artış sadece yaşam kalitesini iyileştirmekle kalmayıp aynı zamanda verimliliği de artırarak ekonomik refaha yol açabilir.

Anahtar Kelimeler: Asya Ülkeleri, Ekonomik Büyüme, Sağlık Harcamaları, Yaşam Beklentisi, Yenilenebilir Enerji.

INTRODUCTION

In recent years, the consumption of fossil fuels has increased dramatically with the spread of industrialization and the rapid increase in the world population. The ever-increasing consumption of fossil fuels is not only depleting fossil reserves, but also threatening global climate change and increasing health risks (Farhad et al., 2008). Today, fossil fuels represent the most important energy source all over the world. While the need for energy is constantly increasing, countries are in search of new energy sources. In addition, 80% of greenhouse gas emissions are caused by the combustion of fossil fuels. In this context, renewable energy sources are needed both to slow down the depletion of fossil fuels and to slow down atmospheric pollution. Increasing infrastructure investments in renewable energy sources and shifting from fossil fuel use to alternative energy sources are among the primary objectives of all countries (Cosmi et al., 2003). Excessive carbon dioxide and other gases released into the atmosphere because of the use of solid fuels cause global climate change, air pollution and create environmental concerns on a global scale. However, energy obtained from renewable energies such as solar, wind and geothermal sources are environmentally friendly energy sources that do not cause any carbon dioxide emissions into the atmosphere (Bull, 2001). Many countries in the world are dependent on fossil fuel energy sources. Rising energy prices, diminishing world reserves, increasing energy imports, environmental and health problems caused by air pollution have led countries to search for new energy sources. Therefore, economies around the world are developing renewable energy policies to reduce dependence on fossil fuels and increase domestic renewable energy production. While fossil fuel resource reserves are limited and exhaustible, renewable energy resources are inherent in nature, have unlimited production capacity and are suitable for use in industry, housing and transportation (Popp et al., 2011).

Fossil fuel use releases a wide range of harmful pollutants into the air, including particulate matter, ozone, nitrogen dioxide, sulfur dioxide, mercury and other hazardous air pollutants. Inhalation of polluted air leads to impaired lung function, asthma, cardiovascular diseases, premature births and increased mortality in premature children. Children are particularly susceptible to asthma and lung dysfunction. Air pollution from fossil fuel use has shortened life expectancy worldwide by about 3 years. It shows that a 1% increase in carbon dioxide (CO_2) and PM_{10} will lead to about 1.1% - 2.5% decrease in life expectancy at birth and 5.4% increase in infant mortality (Lelieveld et al., 2019; Fotourehchi and Caliskan, 2018). Many epidemiological studies around the world have identified a negative link between air pollution and population health. Air pollution can cause cerebrovascular diseases, trigger or exacerbate ischemic heart diseases. Air pollution also negatively affects the nervous, digestive and urinary systems. Long-term exposure to air pollution has been reported to increase all-cause mortality. Furthermore, air pollution is a cause and aggravating factor for many respiratory diseases such as chronic obstructive pulmonary disease (COPD), asthma and lung cancer (Jiang et al., 2016). For example, outdoor air pollutants such as PM, NO_2 and SO_2 have been found to increase mortality rates; long-term exposure to PM increases the risk of cardiovascular disease and O_3 increases the risk of appendicitis (Kaplan et al., 2013, Carey et al., 2013, Gill et al., 2011, Peters et al., 2001).

Within this framework the use of renewable energy results in fewer emissions of greenhouse gases, CO_2, S_2O, NO_X, and particulate matter and is therefore harmless to health. Renewable energy consumption improves the quality of the air we breathe and leads to a reduction in premature death, heart attacks, asthma and cardiovascular diseases (Buonocore et al., 2016). Meeting the energy demand of countries from alternative energy sources such as solar, wind and geothermal energy is an important alternative in minimizing the health problems caused using traditional energy sources (Aldakhil et al., 2018; Treyer et al., 2014). In this context, the use of renewable energy will help reduce health expenditures by creating a positive impact on human health (Aldakhil et al., 2018; Treyer et al., 2014). Therefore, renewable energy sources contribute to the reduction of greenhouse gas emissions and fossil fuel use, prevent air pollution, and help reduce adverse impacts on the environment and health (Owusu et al., 2016). Moreover, in the long run, the use of renewable energy has positive effects on global temperature.

In the literature, the associations between health expenditure and environment pollution, renewable energy and economic growth have been deeply explored; however, less attention has been given to the health expenditure, renewable energy and life expectancy relationship. Thereby, this study aims to fill this gap and provide a contribution to the existing literature.

The use of renewable energy carries considerable significance for both the environment and human health (Ullah et al. 2020). Renewable energy provides clean energy and a clean environment, which could improve human health and life expectancy. Consequently, renewable energy consumption could prolong the life expectancy and reduce health spending. Taking this information into account, the objective of this research is to examine and discuss the long-term effects of renewable energy consumption on healthcare expenditure in Asian nations from 2000 to 2020, employing dynamic panel data methodologies. Asian countries are preferred as a panel sample in this study because being the globe's fastest expanding region, Asia necessitates escalating energy provisions to support its rapid economic growth (Raturi 2019). Besides, the extensive geographical scope of Asia coupled with their diversity and varied institutional capabilities, presents vast opportunities in the renewable energy market. Additionally, renewable energy provides a chance for the region to attain a prominent global standing in renewable energy markets and lead the transition towards clean energy.

Asia region holds significant global importance due to its expansive landmass and substantial share of the world's population and population growth. Its economic transformation, coupled with a shift towards cleaner energy sources, is crucial for advancing global sustainability goals and reducing carbon emissions. The area has established significant renewable energy capability across various technologies, such as solar photovoltaic, wind power, hydropower, bioenergy, and geothermal sources. The Asia region is taking a prominent position in advancing the global transition to renewable energy, although the adoption of renewable energy sources is growing, it is is occurring at a slower rate than that of traditional fossil fuels like natural gas and coal (Raturi 2019).

The structure of the study is as follows: The first section provides an overview of the relevant literature. The second section details the data and methodology used. The third section presents empirical outcomes of analysis. Finally, the conclusion section offers concluding remarks and potential policy recommendations.

1. LITERATURE REVIEW

A substantial study in the literature focuses on investigating renewable energy consumption and its relationships with other significant variables such as pollution, non-renewable energy consumption, international trade, and gross domestic product. Our study is connected to the branch of literature that examines healthcare expenditure and its relationship with renewable energy consumption and other proposed variables.

Ullah et al. (2020) have examined the linkage between trade, CO_2 emissions, renewable energy, and health expenditure in the case of Pakistan. They have utilized time series data spanning from 1998 to 2017 and employed the simultaneous equation approach for empirical analysis. The results from simultaneous equation reveal that an increase in trade volume positively contributes to the amount of CO_2 emissions and, as a result, CO_2 increases health expenditures. On the other hand, renewable energy is linked to reduced CO_2 emissions, and it lowers the health expenditures. This highlights the significance of renewable energy in improving environmental quality and decreasing health expenditures. Similarly, Sasmaz et al. (2021) evaluated the relationship between renewable energy use and health expenditures for 27 European Union member countries. In the research, the causality analysis is conducted separately for the two groups of EU member countries, labeled as pre-2000 and post-2000. The analysis shows that the relationship is unidirectional for countries that became EU members before 2000 and bidirectional for those that joined after the year 2000. Likewise, Çetin (2018) investigated the long-term correlation between healthcare spending and renewable energy consumption across BRICS-T nations from 2000 to 2015, utilizing the panel auto-regressive distributed lags (ARDL) approach. The analysis reveals that income per capita and emissions per capita have a positive impact on health expenditure per capita in the long run.

Triki et al. (2023) examined the impact of renewable energy, green finance, and public health expenditure on environmental quality in the Kingdom of Saudi Arabia using data from 1980 to 2020. To investigate both long- and short-term effects, they have employed linear autoregressive distribution (ARDL) and nonlinear autoregressive distribution (NARDL) models. The practical findings indicated that, in the process of estimating the ARDL model, every variable has a significant effect on the long-term condition of the environment, leading to its enhancement. Moreover, the NARDL model confirms the presence of significant positive or negative shocks that support an asymmetric relationship with the fluctuation of variables in both the short and long run. Piran et al. (2023) evaluates the effect of global warming, education, and renewable energy on healthcare spending. To assess the effect of renewable energy on healthcare expenditure, this study integrated renewable energy with gross domestic product (GDP). According to the results obtained from Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) estimators, there is an inverse relationship between GDP, renewable energy, education, and healthcare expenditure over the long term.

Xie et al. (2023) have examined the economic-environmental-health co-benefits of renewable energy development in China. The findings indicate that by developing renewable energy, it is possible to prevent 0.6 million premature deaths, 151 million illnesses, and 111 million days of work loss in 2050. On the other hand, Khan (2019) investigated the relationship between renewable energy, public health expenditure, logistics performance indices, and economic and environmental sustainability across ASEAN member countries, by analyzing panel data spanning from 2007 to 2017. The research applied the SEM (Structural Equation Modeling) model to test the hypotheses. The findings indicate that integrating renewable energy into logistical operations would improve both environmental and economic performance by reducing carbon emissions and greenhouse gas emissions. Based on the results, it was confirmed a negative correlation between public health expenditure and environmental performance, affirming that enhanced environmental sustainability characterized by lower carbon emissions and greenhouse gases leads to improved human health and economic growth. Shahzad et al. (2020) investigated the dynamic linkages among healthcare spending, economic growth, CO_2 emissions, information and communication technology, and renewable energy consumption within the context of Pakistan over the period of 1995-2017. The findings concluded that economic growth and CO_2 emissions positively affect healthcare spending, whereas information and communication technology and renewable energy consumption have a negative impact on healthcare expenditure. Furthermore, bidirectional Granger causality was verified between healthcare expenditure, economic growth, carbon dioxide emissions, and information and communication technology. Unidirectional causality originates from renewable energy consumption towards healthcare spending, economic growth, CO_2 emissions, and information and communication technology. In the short term, causality is running from renewable energy consumption to healthcare expenditure and economic growth. Additionally, in the short term, causality is running from information and communication technology to economic growth. Likewise, Apergis et al. (2018) utilizes panel methodological techniques to investigate the relationship between per capita CO_2 emissions, per capita real gross domestic product, renewable energy consumption, and health expenditures as a health indicator across a panel of 42 sub-Saharan African countries, covering the timeframe from 1995 to 2011. The empirical findings confirm a long-term correlation among the variables. In the short term, Granger causality demonstrates the existence of unidirectional causalities from real GDP to CO_2 emissions, renewable energy consumption, and health expenditures, as well as bidirectional causality between renewable energy consumption and CO_2 emissions. In the long run, there exists a unidirectional causality leading from renewable energy consumption to health expenditures, and bidirectional causality between health expenditures and CO_2 emissions. The long-term elasticity indicates that both renewable energy consumption and health expenditures cause the reduction of carbon emissions, whereas real GDP results in an increase in emissions.

Ben et al. (2019) investigated the relationships between renewable energy consumption, tourist arrivals, trade openness ratio, economic growth, foreign direct investment, and CO_2 emissions for 22 Central and South American countries using annual panel data from 1995 to 2010. The empirical results indicate that the variables exhibit cointegration. Short-term Granger causality tests reveal unidirectional causalities from: (i) renewable energy to CO_2 emissions and trade; (ii) tourism to trade and foreign direct investment; and (iii) economic growth to renewable energy and tourism. In the long term, there is bidirectional causality between renewable energy, tourism, foreign direct investment, trade, and emissions. Additionally, long-term evaluations for both the whole panel and the three income panel groups analyzed (Lower Middle, Upper Middle, High) emphasize that tourism, renewable energy, and foreign direct investment cause reduction in emissions, whereas trade and economic growth result in increased carbon emissions. On the other hand, Taghizadeh ve Taghizadeh (2020) utilizes the panel vector error correction model (VECM) and panel generalized method of moments (GMM) with data spanning from 2000 to 2016 for ten Southeast Asian countries to investigate the potential link between emissions, lung cancer, and the economy. The findings confirm that carbon dioxide and $PM_{2.5}$ are significant risk factors for lung cancer in the area. Moreover, the rising adoption of renewable energy and higher per capita healthcare expenditure are associated with a reduction in the prevalence of lung cancer. Nawab et al. (2021) investigated the relationship between economic development and environmental deterioration, considering health expenditure and renewable energy, across six selected ASEAN nations from 2000 to 2018. GMM and Granger causality test was employed to determine the relationship between the variables. The findings suggest a bidirectional relationship between energy consumption and carbon emissions. There is a unidirectional causality between economic development, healthcare expenditure, and environmental degradation. The GMM findings show that investment in the healthcare sector and utilization of renewable energy reduces environmental degradation level. Conversely, economic growth increases carbon emissions in ASEAN nations. Moreover, Omri et al. (2023) study provides an overview of the impacts of environmental health changes and explores ways to mitigate these effects by increasing healthcare expenditures. They have analyzed whether both public and private healthcare expenditures play a role in moderating the impacts of environmental degradation on health outcomes in Saudi Arabia, specifically focusing on disability-adjusted life years and infant mortality. The empirical findings indicated that: (i) carbon dioxide emissions unconditionally have a positive effect on increasing disability-adjusted life years and infant mortality; (ii) in all estimated models, there are consistent negative impact of public health expenditures on disability-adjusted life years and infant mortality, while global and private expenditures contribute to reducing infant mortality. (iii) Allocating funds to public health is more efficient than directing resources to private health sectors in reducing infant mortality. (iv) The interactions between health expenditures and CO_2 emissions have a significant negative effect on disability-adjusted life years and infant mortality only for the specifications relating to public health expenditures.

Karimi et al. (2023) examined the influence of renewable energy, CO_2 emissions, healthcare spending, and urbanization on life expectancy in G-7 nations from 2000 to 2019. The study has implemented an innovative Method of Moments Quantile Regression (MMQR). Additionally, to ensure the robustness of MMQR, alternative estimators such as fully modified ordinary least squares, dynamic ordinary least squares, and fixed-effect ordinary least squares have been employed. The findings suggested that consumption of renewable energy, healthcare spending, and urbanization contribute to a rise in life expectancy, while CO_2 emissions decrease life expectancy at birth. Yang et al. (2022) examined the nexus between population aging, healthcare spending, renewable energy budgets, and CO_2 emissions in G7 countries using annual panel data from 1985 to 2019. Second-generation estimation, Dumitrescu and Hurlin causality and Cross-Sectional Autoregressive Distributed Lag (CS-ARDL) methods were employed. The results from the CS-ARDL analysis show that population aging and increased renewable energy budgets improve the environmental quality of G7 countries by reducing CO_2 emissions. On the contrary, healthcare spending and economic growth weaken environmental sustainability. This conclusion drawn from the CS-ARDL analysis is also supported by the Augmented Mean Group (AMG) approach. The results of the Dumitrescu and Hurlin causality test reveal a unidirectional causality from population aging and renewable energy to CO_2 emissions. Another finding is that as the population ages, it results in increased healthcare spending, which in turn influences renewable energy budgets. Furthermore, this study also uncovers bidirectional causality between healthcare spending and renewable energy budgets.

In conclusion, numerous studies mentioned above have confirmed the bidirectional and unidirectional causality between trade, CO_2 emissions, population aging, urbanization, foreign direct investment, information and communication technology, life expectancy, renewable energy, and health expenditure in considered countries. Many researchers have identified positive causality among these variables, although some have either not observed such causality or have reported only weak relationships at most. These significant disparities may arise from differences in sample selection, methodologies, and analytical techniques employed in the studies. Additionally, country-specific characteristics related to economic, politic, technological, infrastructural, and institutional advancements play a vital role in evaluating empirical relationships.

2. DATASET, EXPLANATORY VARIABLES, MODEL AND METHODOLOGY

2. 1. Methodology

The study examines the nexus between renewable energy, health expenditure, gross domestic product and life expectancy at birth in Asian economies. Annual data are obtained from the Word Bank online database for a panel of 35 Asian economies (United Arab Emirates – Armenia - Azerbaijan – Bangladesh - Bhutan - China - Georgia – Indonesia - India - Iran, Islamic Rep. – Israel – Jordan – Japan – Kazakhstan - Kyrgyz Republic - Cambodia - Korea, Rep. - Lebanon - Sri Lanka - Maldives – Myanmar - Mongolia - Malaysia - Nepal - Pakistan - Philippines - Qatar – Russian Federation -

Singapore - Thailand - Tajikistan - Turkmenistan - Turkey – Uzbekistan - Vietnam), spanning the period 2000-2020. In the countries concerned, the latest up-to-date data were available up to 2020. Table 1 presents detailed information about the variables we selected, along with their descriptive statistics. The variables used for the empirical study are health expenditures (HEX) measured as a share of total GDP, gross domestic product (GDP) measured in constant 2005 prices, renewable energy consumption (REN) measured as a share of total final energy consumption, and life expectancy at birth, total years (LEX). Based on the availability of data, our empirical analysis includes the highest possible number of observations. In this study the panel cointegration test has been applied, which shows that whether there is a long-term interrelationship between health expenditure and renewable energy, which we focus on, and then the Dumitrescu–Hurlin (2012) panel causality method was employed to test causality between HEX, REN, GDP and LEX in Asian countries. The reason for using causality tests is to reach country-based results with the Dumitrescu–Hurlin (2012) panel bootstrap causality method. Before proceeding with these estimations, the first step is to check cross-sectional dependency and confirm the stationarity of all variables in the series. For the cointegration test, the econometric methodology requires that all variables included in the model exhibit integration at order I (1).

The following steps are followed: First, cross-sectional dependency relationship between the series was tested, and then the homogeneity of the series was checked. Thus, the CADF (Cross-Sectionally Augmented Dickey-Fuller) unit root test developed by Pesaran (2007) is employed to assess the degree of integration of the modeled variables, which is one of the second-generation unit root tests used in the case of cross-section dependency. Furthermore, Westerlund (2007) ECM Panel Cointegration analysis was conducted to test the existence of a long-term relationship between variables. Ultimately, panel causality analyses were conducted to examine the causal relationship between variables.

The general form of the empirical model illustrates the interrelationship between health expenditure, renewable energy, gross domestic product and life expectancy at birth and is demonstrated as follows:

$$HEX_{it} = f(REN_{it}, GDP_{it}, LEX_{it}) \quad (1)$$

We transformed the suggested variables into natural logarithms:

$$\mathrm{HEX}_{it} = \beta_0 + \beta_1 \mathrm{REN}_{it} + \beta_2 \mathrm{GDP}_{it} + \beta_3 \mathrm{LEX}_{it} + \mu_{it} \quad (2)$$

where $\beta_0$the constant is term of the model; β_1 to β_3 are the coefficient values of all the explanatory indicators in the model; μ_t is the error white noise term, and t is the time period.

Variables	**Description**	**Measurement**	**Source**
HEX	Health Expenditure	Current health expenditure (% of GDP)	World Bank-World Development Indicators
REN	Renewable energy consumption	% of total final energy consumption	
GDP	Gross Domestic Product	Constant 2015, Log., US$	
LEX	Life expectancy at birth	Life expectancy at birth, total (years)	
Asian Countries	United Arab Emirates, Armenia, Azerbaijan, Bangladesh, Bhutan, China, Georgia, Indonesia, India, Iran, Islamic Rep., Israel, Jordan, Japan, Kazakhstan, Kyrgyz Republic, Cambodia, Korea, Rep., Lebanon, Sri Lanka, Maldives, Myanmar, Mongolia, Malaysia, Nepal, Pakistan, Philippines, Qatar, Russian Federation, Singapore, Thailand, Tajikistan, Turkmenistan, Turkey, Uzbekistan, Vietnam		

Table 1: Summary of Variables

2. 1. 1. Cross-Section Dependence Test

One of the initial steps of the econometric estimation is to examine the cross-section dependence of the considered variables. First-generation panel unit root tests may lead to incorrect outcomes (due to size distortions) if substantial levels of positive residual cross-sectional dependence are present but ignored. The ignorance of cross-sectional dependency could result in unreliable findings because macroeconomic variables tend to impact various regions and may give rise to notable common shocks over time (Sabir and Gorus, 2019). Therefore, it's recommended to use second-generation panel unit root tests when it's confirmed that the panel exhibits considerable residual cross-sectional dependence. If cross-sectional dependence is not sufficiently high, there is a risk of losing statistical power when employing second-generation panel unit root tests that account for cross-sectional dependence. Therefore, it's crucial to present some evidence of the extent of residual cross-sectional dependence before choosing the suitable panel unit root test.

The Breusch and Pagan (1980) LM test is utilized to assess cross-sectional dependency if the time dimension is greater than cross-section size. The CD_{LM} test is utilized if the time dimension is less than the cross-section size, while the CD_{LM2} test is employed if the time dimension is equal to the cross-section size (Pesaran, 2004). The null hypothesis of this test indicates no cross-sectional dependency. The null hypothesis is rejected based on p-values, indicating the presence of cross-sectional dependence among the model variables. In the case of presence cross-sectional dependence, the second-generation unit root test is employed to assess the stationarity of variables. The econometric method for computing cross-section dependency is outlined in equation (3), where significant p-values indicate the rejection of the absence of interdependence when the time is sufficiently large and the sample approaches infinity.

$$CSD = \frac{\sqrt{2T}}{N(N-1)}\left(\sum_{i=1}^{N-1}\sum\nolimits_{q=l+1}^{N} p_{iq}\right) \tag{3}$$

2. 1. 2. Test of Homogeneity

The Pesaran and Yamagata (2008) homogeneity test was employed to assess whether the slope coefficients of the variables are homogenous or heterogeneous. The panel data model with FE and heterogeneous slopes can be written as follows:

$$y_{it} = \alpha_i + \beta_i' x_{it} + \varepsilon_{it}, \quad i = 1,\ldots,N, \quad t = 1,\ldots T, \tag{4}$$

where α_i is bounded on a compact set, x_{it} is a $k \times 1$ vector of strictly exogenous regressor, β_i is a $k \times 1$ vector of unidentified slope coefficients, such that $\left\|\beta_i\right\| < K$. Combining the time series observations for *i* yields

$$y_i = \alpha_i \tau_T + X_i \beta_i + \varepsilon_{it}, i = 1,\ldots,N, \tag{5}$$

where $y_i = \left(y_{i1},\ldots,y_{iT}\right)', \tau_T$ is a $T \times 1$ vector of ones, $X_i = \left(x_{i1},\ldots,x_{iT}\right)'$, and $\varepsilon_i = \left(\varepsilon_{i1},\ldots,\varepsilon_{iT}\right)'$.

The null hypothesis of interest is:

$H_0\!:\!\beta_i = \beta$ for all *i* (slope coefficients are homogenous)

Against the alternatives:

$H_1\!:\!\beta_i \neq \beta_j$ for all *i* for a non-zero fraction of pairwise slopes for $i \neq j$.

2. 1. 3. CADF (Cross-Sectionally Augmented Dickey-Fuller) Unit Root Test

In case of cross-section dependency, it's crucial to employ the second-generation unit root test, which considers this condition for a robust and reliable empirical estimations and policy suggestions. Several second-generation unit root tests are available for panel data analysis, including the Fisher-type test introduced by Maddala and Wu (1999) and the CADF (Cross-Sectionally Augmented Dickey-Fuller) unit root test developed by Pesaran (2007). CADF unit root test can be conducted for each cross-section (each country) as well as for the whole panel. Pesaran (2007) CADF regression equation in a panel with T time and N cross-sectional units, T > N and N > T, the simple dynamic linear heterogeneous panel data model is as follows:

$$y_{it} = \left(1-\varphi_i\right)\mu_i + \varphi_i y_{i,t-1} + u_{it} \qquad i = 1,\ldots,N\, and \;\; t = 1,\ldots,T \tag{6}$$

$$u_{it} = y_i f_t + \varepsilon_{it} \tag{7}$$

In which y_{it} is the observation on the ith cross-section unit at time,f_t is the unobserved common effect, and ε_{it} is the individual-specific error.

The equation (6) and (7) we can rewrite as:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \gamma_i \tag{8}$$

where $\alpha_i = \left(1-\varphi_i\right)\mu_i, \;\; \beta_i = -\left(1-\varphi_i\right) \; and \, \Delta y_{it} = y_{it} - y_{i,t-1}$

The unit root null and alternative hypotheses can be expressed as:

$H_0 : \beta_i = 0$ for all i

$H_1 : \beta_i < 0, \;\; i = 1,2,\ldots,N, \qquad\qquad i = N_1 + 1, N_1 + 2,\ldots,N$

A statistical CIPS (Cross-Sectionally Augmented IPS) method involves supplementary information into the regression analysis. This method incorporates the average values of lagged levels and first differences of each individual series within the panel (Pesaran, 2007). This modification improves the reliability of the regression outcomes by considering the cross-sectional interdependencies between observations in panel data. The CIPS value (Eq. 9) obtained from the CADF unit root test is derived by averaging the t value calculated for each cross-section.

$$CIPS(N,T) = t - bar = N^{-1}\sum_{i=1}^{N} t_i(N,T) \tag{9}$$

where $\mathrm{t_i(N,T)}$ is the CADF statistic for the ith cross-section unit given the t-ratio of the coefficient of $\mathrm{y_{i,t-1}}$ in the CADF regression.

The stationarity test for each individual variable is performed using Pesaran's approach. It assesses the null hypothesis of non-stationarity against the alternative hypothesis of stationarity within panel series and across different cross-sections. If the computed t-bar statistic exceeds the critical values at significance levels of $p < 0.01$, $p < 0.05$, and $p < 0.10$, we reject the null hypothesis, suggesting that the series is stationary. On the other hand, if it does not exceed these critical values, we do not reject the null hypothesis, indicating that the series is non-stationary. If the selected series shows stationarity at the same level, the Cointegration test will be used to identify the long-term relationship among the proposed variables.

2. 1. 4. Westerlund and Edgerton LM Bootstrap Cointegration Test

Empirical research has shown a growing interest in utilizing panel cointegration techniques to explore long-term cointegration relationships among integrated variables, taking into account both cross-sectional and time dimensions. The Lagrange Multiplier (LM) Bootstrap panel cointegration test, proposed by Westerlund and Edgerton (2007) assesses the presence of cointegration in the models. This test accounts for cross-sectional dependence within and between individual cross-sectional units.

The first two tests (Ga and Gt) are designed to assess the alternative hypothesis that at least one unit within the paneled countries is cointegrated, while the other two (Pa and Pt) evaluate the alternative hypothesis that the entire panel of countries is cointegrated. This is given in equation (10).

$$\Delta y_{it} = C_i + a_{0i}\left(y_{i,t-1} - b_i' x_{it-1}\right) + \sum_{j=1}^{k_{i1}} a_{11j}\,\Delta y_{i,t-j} + \sum_{j=-k_{2i}}^{k_{3i}} a_{2ij}\,\Delta x_{it-j} + \mu_{it} \qquad (10)$$

where a_{0i} is the speed of adjustment term (error term).

2. 1. 5. Dumitrescu-Hurlin Causality Test

This paper utilizes a causality method developed by Dumitrescu and Hurlin (2012), which is the extension of the Granger (1969) causality test. The panel causality test offers several benefits, including its effectiveness in analyzing unbalanced panel datasets, can be applied both in short panel (N>T) and long panel (N < T), and it allows cross sectional dependency among the countries included in the panel. In the implementation of the procedure, it's essential for the series used in the test to be stationary.

The underlying regression can be written as follow:

$$y_{i,t} = \eta_i + \textstyle\sum_{k=1}^{K} \pi_{ik} y_{i,t-1} + \sum_{k=1}^{K} \lambda_{ik} x_{i,t-k} + u_{i,t} \quad with \quad i = 1, \dots, N \; and \; t = 1, \dots, T \qquad (11)$$

where $y_{i,t}$ and $x_{i,t}$ are the stationary and cointegrated variables, t represents the time period (T), while i denotes the cross-section dimension (N), and k signifies lag order. Coefficients are allowed to vary among individuals but are presumed to remain constant over time. The null hypotheses of the Dumitrescu and Hurlin (2012) causality test are defined as:

$$H_0\colon \lambda_{i1} = \dots = \lambda_{iK} = 0, \qquad \forall_i = 1, \dots N$$

which indicates the absence of causality for all individuals in the panel. The alternative hypothesis of Dumitrescu and Hurlin (2012) assumes that there can be causality for certain individuals, but not necessarily for all;

$$H_1 : \lambda_{i1} = \ldots = \lambda_{iK} = 0, \qquad \forall_i = 1, \ldots N$$

$$\lambda_{i1} \neq 0 \;\; or \ldots or\, \lambda_{iK} \neq 0, \qquad \forall_i = N_1 + 1, \ldots N$$

where $N_1 \in [0, N-1]$ is unknown. If $N_1 = 0$, there is causality for all individuals in the panel. N_1 must be strictly smaller than N; otherwise, there is no causality for all individuals, and H_1 reduces to H_0 (Lopez and Weber, 2017).

3. EMPIRICAL OUTCOMES

3. 1. Cross-Section Dependence Test Results

According to the test outcomes in Table2, it was determined that there exists cross-sectional dependence among the series across the panel in Asian countries. As cross-sectional dependency was confirmed, test techniques that consider the presence of cross-section dependence were employed in the analysis.

Variables		Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
HEX	Stat.	3472.308	82.394	81.519	16.913
	Prob	0.000	0.000	0.000	0.000
GDP	Stat.	11653.96	319.569	318.694	107.875
	Prob	0.000	0.000	0.000	0.000
REN	Stat.	4437.238	110.366	109.491	12.954
	Prob	0.000	0.000	0.000	0.000
LEX	Stat.	10757.52	293.582	292.707	103.461
	Prob	0.000	0.000	0.000	0.000
Model	Stat.	2986.53	68.312	67.437	6.606
	Prob	0.000	0.000	0.000	0.000

Table 2: Results of Cross- Section Dependence Test

3. 2. CADF Unit Root Test Results

In this study, we utilized the Augmented Dickey-Fuller (ADF) test introduced by Dickey and Fuller (1979) to assess the stationarity and determine the integration order of all variables in the model. Table3 presents the results of the unit root estimation. As cross-section dependency was detected in the tests conducted, we move forward by conducting a second-generation test, the Cross-sectional Augmented Dickey-Fuller (CADF) unit root test developed by Pesaran (2007).

According to the empirical findings, all variables exhibit non-stationarity in their level form. However, the test statistics and their respective p-values indicate that all series become stationary at the first difference at the 1% significance level. Therefore, we reject the null hypothesis of non-stationarity at the 1% significance level and conclude that all series within the panel of Asian countries are integrated of order I (1).

<table>
<tr><th rowspan="2">Variable</th><th colspan="4">At Level</th><th colspan="3">1st Difference</th></tr>
<tr><th>Lag</th><th colspan="2">Intercept/ Trend</th><th>CIPS statistics</th><th>Lag</th><th>Intercept/ Trend</th><th>CIPS statistics</th></tr>
<tr><td>HEX</td><td>3</td><td colspan="2">0</td><td>-1.8557</td><td>3</td><td>0</td><td>-2.4206***</td></tr>
<tr><td>GDP</td><td>3</td><td colspan="2">0</td><td>-1.9031</td><td>3</td><td>0</td><td>-3.1713***</td></tr>
<tr><td>REN</td><td>3</td><td colspan="2">0</td><td>-1.7441</td><td>3</td><td>0</td><td>-3.0387***</td></tr>
<tr><td>LEX</td><td>3</td><td colspan="2">1</td><td>-2.2797</td><td>3</td><td>1</td><td>-5.0548***</td></tr>
<tr><td colspan="8"><i>Critical values of the individual cross-sectional extended Dickey–Fuller distribution averages:</i></td></tr>
<tr><td>Intercept (0)</td><td>%1</td><td>%5</td><td>%10</td><td>Trend (1)</td><td>%1</td><td>%5</td><td>%10</td></tr>
<tr><td>N:35 T:21</td><td>-2.32</td><td>-2.15</td><td>-2.07</td><td>N:35 T:21</td><td>-2.83</td><td>-2.67</td><td>-2.58</td></tr>
</table>

Statistical values have been determined according to the Akaike Information Criterion.
The symbols ***, **, * show that the statistical values are significant at 1%, 5% and 10% respectively

Table 3: CADF Unit Root Test Results for Fixed Effects Model

3. 3. Homogeneity Test Results

Based on the findings from the homogeneity test presented in Table 4, the null hypothesis (H_0) is rejected, which indicates the slope coefficients are homogenous. Therefore, it is inferred that the constant term and slope coefficients are not homogeneous across Asian countries.

Test	Test Statistic	Probability Value
Delta_tilda	22.323	0.000
Delta_tilda_adj	25.574	0.000

Table 4: Homogeneity Test Results

3. 4. Westerlund and Edgerton LM Bootstrap Cointegration Test Results

In the case of cross-dependency, it is essential to consider the results of bootstrap p-values in the cointegration test. The G_t and G_a tests examine cointegration for individual country groups, whereas the P_a and P_t tests assess cointegration for the whole panel. According to the test results, we reject the null hypothesis H_0, which suggests the absence of a cointegration relationship. The results presented in Table 5 indicate strong and significant evidence supporting the presence of cointegration in the model. These results provide further evidence of a significant long-term relationship, implying that they move together towards a long-run equilibrium. Thus, we can conclude that, in the long run, health expenditure will be affected by any changes in renewable energy consumption, gross domestic product and life expectancy at birth in Asian countries.

	Statistics	**asym p-val**	**bootstrap p-val**
g_tau	0.606	0.728	0.031
g_alpha	6.211	1.000	0.469
p_tau	1.472	0.930	0.038
p_alpha	2.803	0.997	0.009

Bootstrap probability values are obtained from 1000 iterations.
Lag and premise levels are taken as 2 and 1.

Table 5: Results of Westerlund and Edgerton (2007)
LM Bootstrap Cointegration Method

3. 5. Dumitrescu-Hurlin Causality Test Results

Dumitrescu-Hurlin panel causality analysis is applied to assess country-specific causality between health expenditures, renewable energy, life expectancy and GDP based on heterogeneity analysis. The results in Table 6 reveal the existence of causality from renewable energy to health expenditures in India, Israel, Kyrgyz Republic. There is a causality from health expenditures to renewable energy in Indonesia, Kazakhstan, Cambodia, Sri Lanka, Mongolia, Philippines, Turkey and Vietnam. For China, Singapore and Nepal, there is a bilateral causality between health expenditures and renewable energy.

According to another result of the analysis, there is a causality from health expenditures to life expectancy in Bhutan, Indonesia, Islamic Republic of Iran, Japan, Sri Lanka, Myanmar, Malaysia, Pakistan, Philippines and Thailand. Bidirectional causality was found in China, India, Republic of Korea and Qatar. In the United Arab Emirates, Azerbaijan, Kyrgyz Republic, Cambodia, Lebanon, Maldives, Nepal, Singapore, United Arab Emirates, Azerbaijan, Kyrgyz Republic, Cambodia, Lebanon, Maldives, Nepal, Singapore and the Central Asian countries of Turkmenistan, Uzbekistan and Tajikistan, a unidirectional causality from life expectancy to health expenditures was found.

There is a causal relationship from renewable energy to life expectancy in the United Arab Emirates, Bangladesh, India, Jordan and Turkey. While a bidirectional causality relationship was found in Maldives and Singapore, a causal relationship from life expectancy to renewable energy was found for China, Kazakhstan, Mongolia and Turkmenistan.

Finally, according to the causality analysis, there is a causality from GDP to health expenditures in Azerbaijan, Bangladesh, Indonesia, India, Jordan, Mongolia and Pakistan, and from health expenditures to GDP in the United Arab Emirates, Armenia, China, Georgia, Maldives, Nepal, Philippines, Qatar, Turkmenistan and Turkey. A bidirectional causality is found for Israel and Malaysia.

Country	**HEX>REN**	**REN>HEX**	**HEX>LEX**	**LEX>HEX**	**REN>LEX**	**LEX>REN**	**GDP>HEX**	**HEX>GDP**
	11	7	14	15	7	6	9	13
Un. Arab Emirates	1.694	0.755	2.137	5.206**	13.976***	1.517	1.991	3.605*
Armenia	0.615	1.146	0.548	0.007	0.152	0.486	0.054	2.758*
Azerbaijan	0.290	0.042	1.438	4.250**	0.012	0.356	7.889***	0.546
Bangladesh	2.185	0.261	1.616	1.178	4.080**	0.543	4.083**	2.645
Bhutan	0.289	0.123	9.208***	1.674	0.338	0.109	0.219	0.689
China	10.184***	6.955***	8.218***	3.530*	1.117	5.564**	0.022	5.582**
Georgia	1.207	0.357	0.346	9.788	0.599	0.215	0.586	9.058***
Indonesia	5.408**	1.627	6.803***	1.382	1.988	0.154	4.515**	1.452
India	0.172	18.357***	4.288**	15.491***	18.708***	0.03	3.730*	0.024
Iran, Islamic Rep.	0.224	1.217	4.320**	0.247	0.788	0.045	0.162	1.129
Israel	0.061	3.464*	1.016	14.877	0.026	0.001	2.937*	13.216***
Jordan	2.072	0.002	0.418	1.112	6.379**	2.625	4.492**	0.592
Japan	0.130	0.202	6.791***	0.198	1.611	0.96	0.833	0.001
Kazakhstan	5.850**	0.001	0.017	0.184	2.309	9.236***	2.285	0.701
Kyrgyz Republic	1.921	5.363**	0.866	3.682*	2.711	1.508	2.530	0.050
Cambodia	7.326**	0.067	2.306	4.501**	0.113	1.989	1.758	0.002
Korea, Rep.	0.055	0.475	12.207***	3.707*	1.973	0.112	0.546	0.926
Lebanon	1.109	0.314	3.410	3.094*	0.468	0.313	1.841	0.045
Sri Lanka	4.180**	2.386	10.043***	0.237	0.436	0.794	0.421	2.414
Maldives	0.968	0.513	0.008	9.892***	9.512***	15.398***	0.002	2.728*
Myanmar	0.156	3.066*	6.396**	0.038	0.026	1.181	1.584	0.227

Mongolia	8.172***	1.014	1.168	0.142	0.649	7.685***	13.141***	0.461
Malaysia	0.043	1.775	5.399**	1.570	0.837	0.294	2.975*	3.370*
Nepal	3.135*	7.876***	1.755	11.652***	1.064	1.818	1.046	13.29***
Pakistan	0.060	2.374	7.323***	0.229	0.370	0.012	3.148*	1.427
Philippines	4.441**	1.130	8.512***	0.006	2.325	1.031	0.106	7.903***
Qatar	0.538	0.408	6.168**	10.699***	0.038	0.643	1.469	5.796**
Russian Federation	0.000	0.623	1.832	0.033	0.260	0.416	0.287	0.378
Singapore	9.461***	4.542**	0.156	19.656***	5.072**	9.635***	0.046	1.699
Thailand	0.000	1.893	5.100**	0.219	0.016	0.461	1.248	0.481
Tajikistan	2.351	0.389	0.023	6.917***	1.472	0.891	0.758	2.151
Turkmenistan	0.735	1.214	0.163	8.380***	0.038	5.607**	0.824	2.818*
Turkiye	4.783**	0.093	0.796	3.464	13.242***	2.231	0.016	4.275**
Uzbekistan	0.017	0.762	0.134	19.544***	0.022	0.025	2.241	0.878
Vietnam	7.331***	1.413	0.184	0.335	1.630	0.000	2.128	0.824

Note: H_0: HEX does not cause REN when HEX>REN, etc.
The symbols ***, **, * show that the statistical values are significant at 1%, 5% and 10% respectively

Table 6: Dumitrescu-Hurlin Causality Test Results

CONCLUSION

The relationship between health expenditures, environmental pollution, economic growth and other variables has been the subject of numerous studies. However, it is difficult to say that sufficient studies have been conducted on the impact of renewable energy on health expenditures. Therefore, this study aims to investigate the dynamic causal linkages between renewable energy, health expenditures, gross domestic product and life expectancy in 35 Asian countries for the period 2000-2020 for which complete data are available. To achieve this objective, the study employs panel cointegration and panel causality analysis techniques. The empirical findings suggest that the long-run relationship between health expenditures and the independent variables renewable energy, life expectancy and GDP is strongly supported and that they move together towards a long-run equilibrium. Therefore, we can conclude that in the long run, health expenditures will be affected by any changes in renewable energy consumption, gross domestic product and life expectancy at birth in Asian countries.

The findings of the panel causality analysis provide evidence that all variables may have a causal relationship between each other across countries. To summarize, there is causality from health expenditures to renewable energy in 11 countries, from renewable energy to health expenditures in 7 countries, from health expenditures to life expectancy in 14 countries, from life expectancy to health expenditures in 15 countries, from renewable energy to life expectancy in 7 countries, from life expectancy to renewable energy in 6 countries, from GDP to health expenditures in 9 countries, and from GDP to health expenditures in 13 countries. Accordingly, while there is a strong relationship between life expectancy and health expenditures, there are different degrees of relationships in other variables across countries. For each variable, bidirectional relationships were also found in 2 or 3 countries. These findings suggest that the consumption of renewable energy sources not only contributes to sustainable development, but also reduces health expenditures and increases the welfare of the population, leading to an increase in life expectancy. Thus, our results support previous research by Shahzad et al (2020), Apergis et al (2018), Sasmaz et al (2021), Nawab et al (2021) and Yang et al (2022).

This study offers important policy implications. Policymakers in Asian economies should develop policy frameworks that provide opportunities for renewable energy consumption and support investment in renewable energy projects. To support investment in the renewable energy sector or attract FDI, countries need to improve infrastructure, ensure security and political stability. In addition, considering that an increase in GDP significantly affects health expenditures and a change in health expenditures significantly affects life expectancy, implementing policies that prioritize economic growth will increase the quality of life along with the level of welfare. Thus, total sustainability will be realized with a clean and green environment and a higher quality of life.

Hakem Değerlendirmesi
Dış bağımsız
Yazarların Katkısı
Yazarlar çalışmaya eşit oranda katkı sağlamıştır.
Çıkar Çatışması
Yazarlar çıkar çatışması bildirmemiştir.
Finansal Destek
Yazarlar bu çalışma için finansal destek almadığını beyan etmiştir.

REFERENCES

Aldakhil, A. M., Nassani, A. A., Awan, U., Abro, M. M. Q., & Zaman, K. (2018). Determinants of green logistics in BRICS countries: An integrated supply chain model for green business. *Journal of Cleaner Production*, 195, 861-868.

Apergis, N., Jebli, M. B., & Youssef, S. B. (2018). Does renewable energy consumption and health expenditures decrease carbon dioxide emissions? Evidence for sub-Saharan Africa countries. *Renewable energy*, 127, 1011-1016.

Ben Jebli, M., Ben Youssef, S., & Apergis, N. (2019). The dynamic linkage between renewable energy, tourism, CO2 emissions, economic growth, foreign direct investment, and trade. *Latin American Economic Review*, 28 (1), 1-19.

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange multiplier test and its applications to model specification in econometrics. *The review of economic studies*, 47 (1), 239-253.

Bull, S. R. (2001). Renewable energy today and tomorrow. *Proceedings of the IEEE*, 89 (8), 1216-1226.

Buonocore, J. J., Luckow, P., Norris, G., Spengler, J. D., Biewald, B., Fisher, J., & Levy, J. I. (2016). Health and climate benefits of different energy-efficiency and renewable energy choices. *Nature Climate Change*, 6 (1), 100-105.

Carey, I. M., Atkinson, R. W., Kent, A. J., Van Staa, T., Cook, D. G., & Anderson, H. R. (2013). Mortality associations with long-term exposure to outdoor air pollution in a national English cohort. *American journal of respiratory and critical care medicine*, 187 (11), 1226-1233.

Çetin, M. A. (2018). The Long Run Relationship between Health Expenditure and Renewable Energy Consumption in BRICS-T Countries: Panel ARDL Evidence. ICPESS 2018 Proceedings Volume 2: Economic Studies, 359-370.

Cosmi, C., Macchiato, M., Mangiamele, L., Marmo, G., Pietrapertosa, F., & Salvia, M. (2003). Environmental and economic effects of renewable energy sources use on a local case study. *Energy Policy*, 31 (5), 443-457.

Dickey, D.A. and Fuller, W.A. (1979) Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, 47, 427-431.

Dumitrescu, E. I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. *Economic modelling*, 29 (4), 1450-1460.

Farhad, S., Saffar-Avval, M., & Younessi-Sinaki, M. (2008). Efficient design of feedwater heaters network in steam power plants using pinch technology and exergy analysis. *International journal of energy research*, 32 (1), 1-11.

Fotourehchi, Z., & Çalışkan, Z. (2018). Is it possible to describe a Kuznets curve for health outcomes? An empirical investigation. *Panoeconomicus*, 65 (2), 227-238.

Gill, E. A., Curl, C. L., Adar, S. D., Allen, R. W., Auchincloss, A. H., O'Neill, M. S., ... & Kaufman, J. D. (2011). Air pollution and cardiovascular disease in the Multi-Ethnic Study of Atherosclerosis. *Progress in cardiovascular diseases*, 53 (5), 353-360.

Granger, C. W. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica: journal of the Econometric Society*, 424-438.

Jiang, X. Q., Mei, X. D., & Feng, D. (2016). Air pollution and chronic airway diseases: what should people know and do? *Journal of thoracic disease*, 8 (1), E31.

Kaplan, G. G., Tanyingoh, D., Dixon, E., Johnson, M., Wheeler, A. J., Myers, R. P., ... & Villeneuve, P. J. (2013). Ambient ozone concentrations and the risk of perforated and nonperforated appendicitis: a multicity case-crossover study. *Environmental health perspectives*, 121 (8), 939-943.

Karimi Alavijeh, N., Ahmadi Shadmehri, M.T., Dehdar, F., Zangoei, S. and Nazeer, N. (2023), "The role of renewable energy on life expectancy: evidence from method of moments quantile regression based on G-7 countries data", *International Journal of Energy Sector Management*, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/IJESM-11-2022-0001

Khan, S.A.R. The Role of Renewable Energy, Public Health Expenditure, Logistics and Environmental Performance in Economic Growth: An Evidence from Structural Equation Modelling. Preprints 2019, 2019010102. https://doi.org/10.20944/preprints201901.0102.v1

Lelieveld, J., Klingmüller, K., Pozzer, A., Burnett, R. T., Haines, A., & Ramanathan, V. (2019). Effects of fossil fuel and total anthropogenic emission removal on public health and climate. *Proceedings of the National Academy of Sciences*, 116 (15), 7192-7197.

Lopez, L., & Weber, S. (2017). Testing for Granger causality in panel data. *The Stata Journal*, 17 (4), 972-984.

Maddala, G. S., & Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test. Oxford Bulletin of Economics and statistics, 61 (SI), 631-652.

Nawab, T., Muneza, C., & Afghan, M. (2021). Impact of renewable energy consumption and health expenditure on air pollutants: Implications for sustainable development in ASEAN countries. *iRASD Journal of Energy & Environment*, 2 (2), 78-89.

Omri, A., Kahouli, B., & Kahia, M. (2023). Impacts of health expenditures and environmental degradation on health status—Disability-adjusted life years and infant mortality. *Frontiers in public health*, 11, 1118501.

Owusu, P. A., & Asumadu-Sarkodie, S. (2016). A review of renewable energy sources, sustainability issues and climate change mitigation. *Cogent Engineering*, 3 (1), 1167990.

Pesaran, M. H. (2004). General diagnostic tests for cross section dependence in panels. Cambridge Working Papers. Economics, 1240 (1), 1.

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, 22 (2), 265–312.

Pesaran, M. H., & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of econometrics*, 142 (1), 50-93.

Peters, A., Dockery, D. W., Muller, J. E., & Mittleman, M. A. (2001). Increased particulate air pollution and the triggering of myocardial infarction. *Circulation*, 103 (23), 2810-2815.

Piran, M., Sharifi, A., & Safari, M. M. (2023). Exploring the Roles of Education, Renewable Energy, and Global Warming on Health Expenditures. *Sustainabilit*y, 15 (19), 14352.

Popp, D., Hascic, I., & Medhi, N. (2011). Technology and the diffusion of renewable energy. *Energy Economics*, 33 (4), 648-662.

Raturi, A. K. (2019). REN21, 2019: Asia and the Pacific Renewable Energy Status Report.

Sabir, S., & Gorus, M. S. (2019). The impact of globalization on ecological footprint: empirical evidence from the South Asian countries. Environmental Science and Pollution Research, 26, 33387-33398.

Sasmaz, M. U., Karamıklı, A., & Akkucuk, U. (2021). The relationship between renewable energy use and health expenditures in EU countries. *The European Journal of Health Economics*, 22(7), 1129-1139.

Shahzad, K., Jianqiu, Z., Hashim, M., Nazam, M., & Wang, L. (2020). Impact of using information and communication technology and renewable energy on health expenditure: a case study from Pakistan. *Energy*, 204, 117956.

Taghizadeh-Hesary, F., & Taghizadeh-Hesary, F. (2020). The impacts of air pollution on health and economy in Southeast Asia. Energies, 13 (7), 1812.

Treyer, K., Bauer, C., & Simons, A. (2014). Human health impacts in the life cycle of future European electricity generation. *Energy Policy*, 74, S31-S44.

Triki, R., Kahouli, B., Tissaoui, K., & Tlili, H. (2023). Assessing the link between environmental quality, green finance, health expenditure, renewable energy, and technology innovation. *Sustainabilit*y, 15 (5), 4286.

Ullah, I., Rehman, A., Khan, F. U., Shah, M. H., & Khan, F. (2020). Nexus between trade, CO2 emissions, renewable energy, and health expenditure in Pakistan. *The International journal of health planning and management*, 35 (4), 818-831.

Westerlund, J., & Edgerton, D. L. (2007). A panel bootstrap cointegration test. Economics Letters, 97 (3), 185–190.

Xie, Y., Xu, M., Pu, J., Pan, Y., Liu, X., Zhang, Y., & Xu, S. (2023). Large-scale renewable energy brings regionally disproportional air quality and health co-benefits in China. Iscience, 26 (8).

Yang, X., Li, N., Mu, H., Ahmad, M., & Meng, X. (2022). Population aging, renewable energy budgets and environmental sustainability: does health expenditures matter? Gondwana Research, 106, 303-314.