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Research Article

## FOSSIL FUEL SUBSIDIES AND CARBON INTENSITY OF WELL-BEING IN EMERGING AND DEVELOPING ECONOMIES

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### Abstract

The carbon intensity of well-being, which combines environmental well-being and human well-being outcomes into a single variable, represents the ratio of CO<sub>2</sub> emissions to life expectancy. This study seeks to determine the impact of factors affecting the level of pollution per unit of human well-being. To this end, the study examines the impact of fossil fuel subsidies, access to energy, health expenditures, and per capita income on carbon intensity of well-being in 33 emerging and developing economies. The findings reveal that fossil fuel subsidies and per capita income increase the pollution level per unit of human well-being, i.e., they increase carbon intensity of well-being. Furthermore, they show that access to energy and health expenditures reduce the pollution level per unit of human well-being, i.e., they decrease carbon intensity of well-being. Based on these findings, policy makers can help achieve the desired sustainability goals by gradually reducing fossil fuel subsidies, shifting to clean energy sources, and increasing access to energy.

**Keywords** : Carbon Intensity of Well-Being; Fossil Fuel Subsidies; Access to Energy; Health Expenditure.

**Jel Classification** : C23; Q56; Q58.

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# YÜKSELEN VE GELİŞMEKTE OLAN EKONOMİLERDE FOSİL YAKIT SÜBVANSİYONLARI VE REFAHIN KARBON YOĞUNLUĞU

## Öz

*Çevresel refah ve insan refahı sonuçlarını tek bir değişkende birleştiren refahın karbon yoğunluğu, CO2 emisyonunun beklenen yaşam süresine oranını ifade etmektedir. Bu çalışmada birim insan refahı başına düşen kirlilik seviyesine etki eden faktörler belirlenmeye çalışılmıştır. Bu amaç doğrultusunda 33 yükselen ve gelişmekte olan ekonomilerde, fosil yakıt sübvansiyonlarının, enerjiye erişimin, sağlık harcamalarının ve kişi başına gelirin refahın karbon yoğunluğu üzerindeki etkisi incelenmiştir. Bulgular, fosil yakıt sübvansiyonlarının ve kişi başına gelirin birim insan refahı başına düşen kirlilik seviyesini yani refahın karbon yoğunluğunu artırdığını ortaya koymaktadır. Ayrıca enerjiye erişimin ve sağlık harcamalarının birim insan refahı başına düşen kirlilik seviyesini yani refahın karbon yoğunluğunu azalttığını ortaya koymaktadır. Bu bulgulardan hareketle, politika yapımcıların fosil yakıt sübvansiyonlarının kademeli olarak azaltarak temiz enerji kaynaklarına yönlendirmesi ve enerjiye erişimi artırması sürdürülebilirlik açısından istenilen hedeflere ulaşmasında yardımcı olabileceği düşünülmektedir.*

**Anahtar Kelimeler** : Refahın Karbon Yoğunluğu; Fosil Yakıt Sübvansiyonları; Enerjiye Erişim; Sağlık Harcamaları.

**Jel Sınıflandırması** : C23; Q56; Q58.

## INTRODUCTION

Environmental well-being (EWB), which refers to achieving a balance between environmental and social well-being, is based on the idea that harm to the environment should be minimized while maximizing human well-being (Briscoe, Givens & Fitzgerald, 2025). The nexus between the environment and human well-being is expressed in terms of CIWB, ecological intensity of well-being (EIWB), and carbon intensity of subjective well-being (CISWB) (Jorgenson, 2014; Jorgenson & Dietz, 2015; Briscoe et al., 2025). At this point, the Sustainable Development Goals (SDGs), which are a call for urgent action, offer a common plan for well-being both today and in the future. These goals include combating climate change (SDG13) and health and well-being (SDG3). SDG3 and SDG13 jointly emphasize improving health outcomes while reducing environmental pressures. Achieving lower pollution per unit of human well-being is only possible with a lower CIWB, EIWB, or CISWB. Therefore, strategies that promote low carbon emissions and high human well-being are policies that increase sustainability by reducing environmental stress and achieving a lower CIWB value (Greiner & McGee, 2020).

One of the major obstacles to achieving a low CIWB value is the continued high use of fossil fuels. Fossil fuels have historically held, and still maintain, a leading position in the world's energy infrastructure (Ritchie & Rosado, 2017). However, they also have many negative effects. CO2 emissions resulting from fossil fuel combustion and industrial activities constitute nearly two-thirds of present-day greenhouse gas (GHG) outputs, representing the most significant driver of their overall rise. Between 2021 and 2022, global GHG emissions increased by 1.2%, hitting an unprecedented peak of 57.4 gigatons of CO2 equivalent (GtCO<sub>2e</sub>) (UN Environment Programme, 2023).

FFS, which encourage the use of fossil fuels, aim to protect consumers by keeping prices low, but they come at a significant cost because they lead to lower spending, hinder growth, and cause environmental degradation (IMF, 2023). Debate continues regarding the environmental impacts of FFS. One view on the relationship between FFS and the environment is that these subsidies worsen environmental degradation by lowering fossil fuel prices (Sovacool, 2017; Solarin, 2020). The second view is that subsidies reduce environmental degradation because they encourage economic actors to adopt more energy-efficient goods, services, and technologies (Solarin, 2020). In addition, FFS increase stress on the environment, causing more premature deaths through local air pollution (Coady, Parry, Sears & Shang, 2017).

In 2021, Saudi Arabia, Turkmenistan, Libya, and Algeria were the countries that provided the most subsidies, giving more than \$500 per person. Fossil fuel subsidies of less than \$100 per capita were provided in countries across Europe, North and South America, and East Asia, while subsidies of less

than \$20 were provided in those in Africa and South Asia (Ritchie, 2025). During the peak of the global energy crisis in 2022, FFS surged to record levels. Financial support for natural gas and electricity usage more than doubled, and subsidies for oil increased by around 85%. However, in 2023, the overall subsidy amounts decreased as certain government assistance programs were phased out (IEA, 2023). Despite this decline, FFS remain nearly three times higher than 2020 levels and well above historical averages (UN, 2025).

In addition to FFS and access to energy can also have important effects on EWB. Tracking SDG 7: The Energy Progress Report (IEA, IRENA, UNSD, World Bank, WHO, 2025) demonstrates that access to electricity and clean cooking technologies improved in 2023 relative to levels observed in 2015. With industrialization and urbanization, the need for access to energy and the problem of environmental pollution have increased (Kocak, Cobanoglu & Celik, 2023). According to the report, in 2023, 666 million people will lack access to electricity, and 2.1 billion people will lack access to clean cooking. Although some progress has been made towards achieving SDG 7 (affordable and clean energy), this progress is insufficient to meet the targets set out in the SDGs (WHO, 2024a). In many developing nations, people lacking access to modern energy sources frequently depend on outdated fuels like coal, wood, and kerosene for heating and lighting. These conventional energy sources tend to be inefficient and produce substantial GHG emissions, intensifying both climate change and air degradation (Xu, Khan, Zhang & Usman, 2023). Energy is linked not only to environmental impacts but also to human well-being. Limited access to electricity, reliance on unclean fuels, and inefficient energy consumption are fundamental aspects of energy poverty. These conditions reinforce the link between elevated levels of energy poverty and deteriorating health outcomes (Banerjee, Mishra & Maruta, 2021). Energy is a fundamental step in human development. The lack of modern energy, particularly electricity services, affects many aspects of human development at both the societal and household levels (Yahong, Cai, Khan & Chandio, 2023). Access to basic energy services such as lighting, transportation, heating, and cooling can lead to significant gains in LE. However, excessive energy consumption does not necessarily mean a longer life. In fact, energy use can be significantly reduced without jeopardizing LE (Cleveland, 2022).

Additionally, HEALTH plays a crucial role in shaping both environmental sustainability and social welfare. Investing in public health serves as a vital governmental strategy for delivering essential services and enhancing citizens perceived quality of life (Yang, Zhao & Cui, 2022). HEALTH is a crucial factor in achieving SDG3, which aims to enable individuals of all ages to live healthy lives and improve their well-being (Rahman, Dyuti, Tareque & Alnour, 2025). Thus, total HEALTH increases human well-being and reduces stress on the environment (Sweidan, 2018). In addition, the global health sector is responsible for up to 4.6% of total GHG emissions, including gases such as carbon dioxide, methane, and ozone (The Commonwealth Fund, 2022). In contrast, HEALTH can significantly contribute to lowering CO<sub>2</sub> emissions, either directly or indirectly. This is because increased healthcare spending contributes to increased CO<sub>2</sub> emission efficiency (Bilgili, Kuşkaya, Khan, Awan & Türker, 2021). Healthcare spending, which increased with COVID in 2019, fell to 9.9% of global GDP in 2022 (WHO, 2024b). Regionally, high-income countries spend a much larger share of their income (approximately twice as much) on health services than low-income countries. Furthermore, unlike high-income countries, the public share of health service financing is much lower in low- and middle-income countries (Ortiz-Ospina, Arriagada & Roser, 2017).

Developing nations face the greatest risks from climate change, which can intensify the challenges of poverty and accelerate the pressures of rapid urban growth. Uncontrolled environmental pollution has become a serious threat to public health and overall well-being in developing nations. As these countries experience swift industrial growth and urban expansion, the harmful effects of this pollution are becoming more evident (Omer, 2024). Developing countries face challenges in meeting their climate transition financing needs, and excluding China, developing countries are likely to face a total investment gap of over 10 trillion dollars by 2050 (OECD, 2025). For these reasons, this study attempts to determine the impact of factors affecting CIWB on the path to sustainable development using data from 33 EMDEs. In the literature, different variables such as CO<sub>2</sub> emissions, ecological footprint, and GHG are frequently used to represent environmental pollution. However, while studies on the CIWB or EIWB are present in the literature, they have not been examined as intensively as studies on the variables mentioned above. Therefore, this study aims to contribute to the literature by examining the relationship

between FFS, energy access, and health expenditures with CIWB. CO<sub>2</sub> emissions are considered a critical indicator of environmental degradation, focusing solely on the environmental dimension. CIWB, on the other hand, is a three-dimensional index that combines environmental, economic, and social factors to provide a comprehensive well-being indicator. Therefore, the CIWB is a more relevant indicator than CO<sub>2</sub> emissions.

One of the contributions of this study is that, compared to environmental economics studies, previous literature has paid less attention to how FFS, AE, and HEALTH are related to pollution, and no study has discussed the effect of these variables on the CIWB. By evaluating this effect, the aim is to contribute to the literature on sustainable development. The second contribution of the study is to expand the existing literature by examining the role of FFS, AE, and HEALTH in 33 EMDEs. The main innovation of the study is that it addresses the relationship between FFS, AE, and HEALTH and human and environmental outcomes through CIWB, which combines them into a single variable.

The remainder of this study is structured as follows. The second section reviews the literature on environmental well-being and develops hypotheses. The third section introduces the model and data. The fourth section explains the methodology. The fifth section presents the findings, and the sixth section provides conclusions and policy recommendations.

## **I. LITERATURE AND HYPOTHESES DEVELOPMENT**

Discussions on environmental sustainability are ongoing. Empirical studies on this topic have yielded very different conclusions regarding the achievement of environmental sustainability. The prevailing literature has focused on different variables representing environmental sustainability. Among these, GHG, CO<sub>2</sub> emissions, and ecological footprint are frequently used. In addition to these, there are studies that focus on the quantitative analysis of sustainability using criteria that combine human and environmental outcomes into a single variable. These studies have intensively examined the impact of factors that reduce or increase CIWB and EIWB.

### **I.I. Growth-CIWB**

Studies in the literature have generally focused on how economic development affects CIWB and EIWB. In addition, attempts have been made to determine how different control variables affect this process. York, Rosa & Dietz (2004) determined that an increase in GDP would result in a decrease in EIWB. They examined the nexus between economic growth and EIWB within the framework of the Environmental Kuznets Curve (EKC) hypothesis and confirmed the validity of the EKC. Jorgenson (2014) contended that although future economic expansion is expected to enhance global human well-being, it will also contribute to a rise in CO<sub>2</sub> emissions. Givens (2015) has demonstrated a direct relationship between increases in development and urbanization levels and CIWB. Examining the role of international trade, Givens (2018) documented that economic growth plays an increasing role in CIWB, while international trade has a decreasing effect. Feng & Yuan (2016) determined that technological innovation and diffusion may have a reducing effect on CIWB, while economic development positively affects CIWB. Jorgenson & Givens (2015) argue that economic development alone is not the only way to reduce CIWB. Jorgenson & Dietz (2015) found that the impact of development on EIWB increased over time in high-income countries but became increasingly unsustainable in less developed countries. Ergas, Greiner, McGee & Clement (2021) similarly revealed that economic growth increases CIWB. Li et al. (2019) determined that the nexus between CIWB and economic growth is not linear and that this relationship is inverted N-shaped. Greiner & McGee (2020) found that the relationship between GDP and CIWB is asymmetric in developed countries, but that this relationship is symmetric in less developed countries. Irshad, Hussain & Malik (2021) determined that economic growth increases EIWB. Briscoe et al. (2025) found that higher GDP in high-income countries is associated with higher CIWB and lower CISWB and CITWB. Studies examining how income inequality affects environmental well-being, such as Jorgenson (2015), have shown that reducing income inequality could lead to a decrease in CIWB. It has been found that per capita GDP has a positive effect on CIWB. Jorgenson, Dietz & Kelly (2018) discovered that CIWB rose in response to economic growth, a higher concentration of income among the affluent, and a growing share of the population living below the poverty line, whereas income inequality had a negligible impact on CIWB. Jorgenson et al. (2024) concluded that economic growth and increased income inequality raise CIWB scores. Silva, Li & Barbosa (2020) showed that income inequality has an increase effect on EIWB, but growth has a

negative effect. Findings from these studies indicate that per capita income can have either a reducing or increasing effect on CIWB (Ergas et al., 2021; Hai et al., 2023). Based on the above discussion, the following hypothesis is proposed:

*H1: Per capita income increases the CIWB score.*

## **I.II. Energy-CIWB**

In addition to economic growth, there are also studies that consider the impact of energy. Among studies examining the nexus between energy and EWB, Hai, Thuan & Nga (2023) showed that increases in economic growth and energy consumption lead to a decrease and increase in CIWB, respectively. Wang, Ren, Liang, Li & Wang (2022a) reported that economic development and energy consumption contribute to the deterioration of CIWB. Behjat & Tarazkar (2021) demonstrated that economic growth is positively associated with energy consumption, while its relationship with EIWB is negative. Khurshid, Egbe & Akram (2024), unlike other studies, considered infant mortality rates as an indicator of well-being. They demonstrated that energy consumption and geopolitical risks have harmful effects on EIWB and confirmed the validity of the EKC. Thombs (2022) showed that an increase in fossil fuel dependency is associated with an increase in CIWB. Wang et al. (2022) revealed that economic growth and energy intensity positively affect CIWB, while urbanization and renewable energy consumption negatively affect CIWB. Koçak, Ulucak, Dedeoğlu, & Ulucak (2019), as well as Koçak & Çelik (2022), found that access to electricity in sub-Saharan Africa increases CO2 emissions. However, Bilgili et al. (2022) found that access to electricity reduces CO2 emissions in Asian countries.

Energy access plays a vital role in enhancing environmental quality and alleviating energy poverty and poverty. This is because access to energy promotes economic growth, improves well-being, and reduces poverty (Koçak et al., 2019; Koçak & Çelik, 2022; Bilgili et al., 2022). Increased access to electricity, clean cooking fuels, and technologies have an improving effect on well-being (Byaro, Mmbaga & Mafwolo, 2024). Consequently, access to energy may have a reducing effect on CIWB. In light of the earlier discussion, the following hypotheses are proposed:

*H2: Access to energy decreases the CIWB score.*

## **I.III. Health-CIWB**

Debates continue regarding the impact of HEALTH on environmental quality. HEALTH can have either a detrimental (The Commonwealth Fund, 2022) or beneficial (Bilgili et al., 2021) effect on environmental quality. Conversely, a prevailing perspective in the literature suggests that health positively influences human well-being (Muradov, Aydin, Bozatli & Tuzcuoglu, 2024; Bétilla, 2025). Sweidan (2018) found that economic performance has an increase effect on CIWB; however, HEALTH has a negative effect. Bilgili et al. (2021) concluded that public and private health expenditures have an increasing effect on CO2 emissions. Based on these results, HEALTH may have a decreasing effect on the CIWB score. Based on the above discussion, the following hypothesis is proposed:

*H3: Health expenditure decreases the CIWB score.*

## **I.IV. FFS-CIWB**

One of the variables examined in this study is FFS. Since most subsidies aim to lower fossil fuel prices and exclude renewable energy subsidies, FFS are likely to worsen environmental quality (Solarin, 2020). Therefore, it is widely accepted that removing FFS could provide environmental benefits by discouraging fossil fuel use (Okorie & Wesseh Jr, 2024). On the other hand, energy subsidies increase social well-being by reducing the effects of energy poverty (Hosan et al., 2023). The FFS's amplifying effect on emissions generally far outweighs its limited beneficial effect on welfare (Sovacool, 2017; Coady, Parry, Sears, & Shang, 2017). Consequently, although the FFS provides a modest increase in welfare, it leads to a much larger increase in emissions, thereby raising the CIWB ratio. This shows that subsidies increase welfare in an unsustainable and environmentally inefficient way. Regarding environmental sustainability, Solarin (2020) and Solarin & Al-Mulali (2022) examined the effect of FFS on the ecological footprint and CO2 emissions, respectively, in EMDEs. The result revealed that FFS increases ecological footprint and CO2 emissions. Therefore, FFS is likely to have an enhancing effect on the CIWB value. Based on the above discussion, the subsequent hypothesis is put forward:

#### H4: Fossil fuel subsidies increase the CIWB score.

In addition to the above-listed literature, there are studies examining the effects of various factors on CIWB. Wang, Xie, Wu & Feng (2022b) found that urbanization increases CIWB in low- and middle-income countries, while it can decrease it in highly urbanized countries. Wang et al. (2023) examined the effect of international trade on CIWB according to income groups and showed that this effect is negative in high- and upper-middle-income countries and positive in low- and lower-middle-income countries. Song et al. (2022) showed that the digital economy plays a positive role in enhancing ecological well-being at the regional level. Fitzgerald, Givens & Briscoe (2024) found that reducing working hours can improve EWB. Briscoe (2025) revealed that transitions to democratic governance are associated with a decline in CIWB in the following year when GDP and natural gas production are controlled for.

Unlike the aforementioned studies, this research aims to identify the impact of FFS, AE, and HEALTH on CIWB in 33 EMDEs. Thus, this study aims to make progress in this field by assessing sustainability through a new composite variable that combines FFS, AE, and HEALTH, environmental health, and human well-being. Nevertheless, the joint role of fossil fuel subsidies, energy access, and health expenditure within a CIWB framework remains empirically unexplored.

## II. MODEL AND DATA

Based on the studies by York et al. (2004), Dietz, Rosa & York (2012), Givens (2015), and Givens (2018), the basic models used to estimate the direct impact of FFS, AE, and HEALTH on CIWB are as follows:

$$CIWB_{it} = \delta_0 + \delta_1 FFS_{it} + \delta_2 AE_{it} + \delta_3 HEALTH_{it} + \delta_4 GDP_{it} + \varepsilon_{it1} \quad (1)$$

where CIWB = carbon intensity of well-being, FFS= fossil fuel subsidies. AE= Access to energy, following Awan, Kocoglu, Subhan, & Shakib (2025), we consider an index that uses equally weighted measures of access to clean energy and access to electricity as indicators of energy access. HEALTH = health expenditure, GDP = per capita income, and  $\varepsilon$  = the error term. Health expenditures have not been converted to logarithmic form because they are a percentage of GDP. All other variables were converted to logarithmic form.

This study attempted to determine the impact of factors affecting CIWB in 33 EMDEs by creating a panel data set from 2010 to 2023. The list of countries is given in Appendix 1. Detailed explanations regarding the dataset are provided in Table 1. The data used in this study were obtained from the Our World in Data (OWD, 2025), United Nations Development Programme (UNDP, 2025), International Energy Agency (IEA, 2025), and World Bank (WB, 2025) databases.

**Table 1: Variable Information**

Variable	Symbol	Unit	Source
CO2 emissions	CO2	tons per person	OWD
Life expectancy	LE	total (years)	UNDP
Carbon intensity of well-being	CIWB	index	Author calculation
Fossil fuel subsidies	FFS	per capita million US\$	IEA
Access to clean energy	CLEAN	percentage of population	WB
Access to electricity	ELEC	percentage of population	WB
Access to energy	AE	equally weighted index	Author calculation
Health expenditure	HEALTH	percentage of GDP	WB
Per capita income	GDP	constant 2015 US\$	WB

*Dependent variable (CIWB):* This variable is calculated by dividing per capita CO2 emissions by life expectancy. Life expectancy is a measure of well-being that is widely used in demographic and public health studies, with broad global data coverage and methodological robustness (Jorgenson, 2015). CO2 emissions are used because they are directly linked to fossil fuel use and are consistent with the focus of our work (fossil fuel subsidies). However, such a calculation cannot be made by directly dividing CO2 emissions by life expectancy. This is because CO2 emissions per capita, measured in tons (numerator), are a much smaller number compared to life expectancy, measured in total years (denominator). Therefore, when the ratio of these two values is calculated, the result is largely dominated

by the denominator (life expectancy). Therefore, to resolve this dilemma, following Dietz et al. (2012), Givens (2015), and Briscoe (2025), a correction factor is calculated to ensure that the ratio is not overly influenced by either the numerator or the denominator. To calculate this figure, the following formula is used, where M denotes the average value, while S signifies the standard deviation:<sup>2</sup>

$$D = ((S_{CO2} \times M_{LE})/S_{LE}) - M_{CO2} \quad (2)$$

CIWB is calculated using the following formula, considering the correction factor calculated as 107.032:

$$CIWB = \left( \frac{CO2 + 107.032}{LE} \right) \times 100 \quad (3)$$

### III. METHODOLOGY

The current study applied the Driscoll-Kraay (D-K, 1998) estimator, a nonparametric regression approach that accounts for cross-sectional dependence, heteroscedasticity, and autocorrelation, to determine the effect of factors influencing CIWB. This approach provides more reliable and robust results compared to traditional estimation methods. Moreover, this estimation method effectively manages missing data and is well-suited for both balanced and unbalanced datasets (Haseeb, Xia, Saud, Usman & Quddoos, 2023; Sugiharti et al., 2025).

This research employs the D-K algorithm to perform Ordinary Least Squares (OLS) estimation, integrated within a linear model represented as follows (Baloch, Khan & Ulucak, 2020a; Baloch, Khan, Ulucak & Ahmad, 2020b):

$$y_{it} = x'_{it}\beta + \mu_{it} \quad i = 1, \dots, N, t = 1, \dots, T \quad (4)$$

Here,  $y_{it}$  represents the dependent variable (i.e., CIWB), while  $x_{it}$  represents the independent variables (i.e., FFS, AE, HEALTH, and GDP).

To address endogeneity stemming from reverse causality, we employ the instrumental variable estimator within the generalized method of moments (IV-GMM) framework. Reverse causality and omitted variable bias can distort results, and IV-GMM provides a robust approach for handling such issues. This method allows us to consistently estimate relationships in cases where one or more explanatory variables are correlated with the error term (Ma & Li, 2025; İşık et al., 2025)

Quantile regression (QR) offers a more resilient approach compared to conventional regression methods, which typically concentrate only on mean outcomes. QR was first introduced by Koenker & Bassett (1978). In contrast to traditional linear regression, which aims to estimate the conditional mean of the dependent variable, QR enables the assessment of the conditional median and other quantiles within the distribution of the dependent variable (Raghutla, Padmagirisan, Sakthivel, Chittedi & Mishra, 2022). Also, QR is more robust to outliers and non-normal data than standard OLS regression (Baum, 2013). Instead of the classical QR approach, we employ bootstrapped simultaneous quantile regression (BSQREG) to estimate multiple quantiles at once. This method provides robust standard errors, minimizes absolute residuals, and is unaffected by monotonic data transformations (Yahya & Lee, 2023). BSQREG adjusts the model using bootstrap-derived standard errors, preserving the assumption of independent errors and accounting for variability in their distributions (Baum, 2013).

Based on the work of Yahya and Lee (2023), the quantile regression model is specified as follows:

$$y_{it} = \gamma_{\vartheta} x'_{it} + \mu_{it}; \quad Quant_{\vartheta}(y_{it}|x_{it}) = \gamma_{\vartheta} x'_{it} \quad (5)$$

where  $y_{it}$  is the CIWB;  $x_{it}$  is a vector consisting of regressors (FFS, AE, HEALTH, and GDP);  $\mu$  represents residuals, and  $Quant_{\vartheta}(y_{it}|x_{it})$  denotes the  $\vartheta^{th}$  conditional quantile of CIWB given  $x$ .

BSQREG is a substitute method used to analyze confidence intervals and significance tests (Efron & Tibshirani, 1994). This estimator repeatedly resamples the data to calculate empirical confidence intervals and provides more efficient estimates under strong heteroscedasticity (Khan & Karim, 2026).

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<sup>2</sup> Prior to this calculation, the coefficient of variation (standard error/mean) for CO2 and LE was calculated as 1.138 and 0.081, respectively. Since the variation in CO2 in the denominator is greater than the variation in LE in the denominator, the variation in CO2 will affect the variation in LE.

Furthermore, BSQREG is an efficient and appropriate nonparametric methodology for panel data situations and provides robust data outputs (Yeboah et al., 2024).

#### IV. RESULT AND DISCUSSION

A summary of the descriptive statistics of the variables used in the model estimation is presented in Table 2. The average value of CIWB is 5.0683, with a range between 4.9387 and 5.3467. The mean of FFS is -8.8976, with a range between -5.5013 and -17.674. The mean of the AE is 4.4012, with a range between 3.2148 and 4.6051. The mean of HEALTH and GDP are 4.5662 and 8.7435, respectively. CIWB, HEALTH and GDP exhibit positive skewness, while FFS and AE display negative skewness. Moreover, the Jarque-Bera test rejects normality at the 1% level, showing the data isn't normally distributed. Hence, using BSQREG to estimate model coefficients is appropriate.

**Table 2: Descriptive Statistics**

	<b>CIWB</b>	<b>FFS</b>	<b>AE</b>	<b>HEALTH</b>	<b>GDP</b>
Mean	5.0683	-8.8976	4.4012	4.5662	8.7435
Median	5.0558	-8.5939	4.5705	4.2630	8.5821
Maximum	5.3467	-5.5013	4.6051	10.4503	11.3096
Minimum	4.9387	-17.674	3.2148	1.5999	6.8497
Std. Dev.	0.0798	2.0084	0.3248	1.8307	1.0134
Skewness	1.0650	-0.6818	-1.7075	0.9815	0.5406
Kurtosis	4.5627	3.8455	4.7485	3.7474	2.6068
Jarque-Bera	120.3990	44.4165	263.1379	76.1109	22.8328
Prob.	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
Observations	462	462	462	429	462

Note: \*\*\* denotes  $p < 0.01$ .

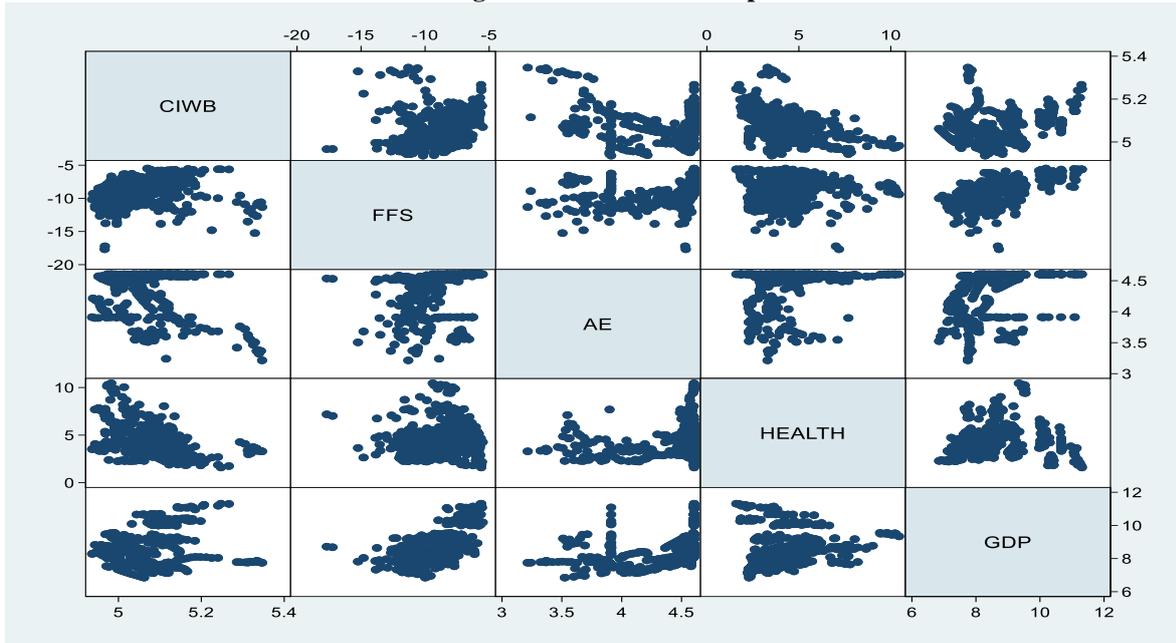
Table 3 and Figure 1 display the relationships among all study variables. CIWB exhibits a significant positive association with both FFS and GDP indicators. Nevertheless, CIWB demonstrates a robust negative relationship with the AE and HEALTH indicators.

**Table 3: Correlation Matrix**

	<b>CIWB</b>	<b>FFS</b>	<b>AE</b>	<b>HEALTH</b>	<b>GDP</b>
CIWB	1				
FFS	0.1579*** (0.0007)	1			
AE	-0.3149*** (0.0000)	0.3885*** (0.0000)	1		
HEALTH	-0.4557*** (0.0000)	0.0463 (0.3392)	0.2992*** (0.0000)	1	
GDP	0.1462*** (0.0016)	0.6132*** (0.0000)	0.4231*** (0.0000)	0.0562 (0.2457)	1

Note: \*\*\* denotes  $p < 0.01$ .

**Figure 1: Correlation Graph**



A potential issue for the validity of multiple regression results is collinearity among the regressors. A higher variance inflation factor (VIF) indicates a higher degree of multicollinearity among the independent variables. The results for the VIF applied to examine multicollinearity are presented in Table 4. The results obtained indicate that there is no multicollinearity problem in either model.

**Table 4: VIF Results**

Variable	VIF	1/VIF
FFS	1.71	0.5838
AE	1.53	0.6524
HEALTH	1.12	0.8968
GDP	1.77	0.5657
Mean VIF	1.53	

Table 5 presents the findings of D-K standard error method and IV-GMM results, in which CIWB serves as the dependent variable, while FFS, AE, HEALTH, and GDP are included as independent variables. Findings from the D-K standard error method results show that FFS and GDP increase the CIWB score, while AE and HEALTH decrease it. According to these results, FFS and GDP increase CO2 emissions per life expectancy. Therefore, an increase in the level of economic development leads to an increase in FFS by governments, which increases the CIWB score, resulting in an undesirable outcome in terms of sustainability. This finding supports the hypotheses that FFS and GDP increase the CIWB score (H1; H4). No studies examining the effect of FFS on CIWB have been found in the literature. However, Solarin (2020) found that FFS increases environmental stress. Thombs (2022) determined that fossil fuel dependency increases CIWB. Therefore, the results of this study are consistent with Solarin (2020) and Thombs (2022).

AE and HEALTH reduce CO2 emissions per life expectancy. Therefore, increased public access to energy and governments' health-improving policies reduce the CIWB score, resulting in a desirable outcome in terms of sustainability. This finding supports the hypotheses that AE and HEALTH reduce the CIWB score (H2; H3). No study examining the effect of energy access on CIWB has been found. However, the results of this study are consistent with Bilgili et al. (2022), who state that energy access contributes to improving environmental conditions, and Koçak et al. (2019), who concluded that energy access improves welfare by reducing poverty. Furthermore, consistent with Sweidan (2018), we found that total HEALTH have a negative effect on CIWB. In conclusion, FFS and GDP worsen environmental well-being, while AE and HEALTH improve it.

**Table 5: D-K Standard Error and IV-GMM Results**

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	IV-GMM
FFS	0.0062*** (0.0008)				0.0096*** (0.0012)	0.0093*** (0.0022)
AE		-0.0720*** (0.0020)			-0.1228*** (0.0075)	-0.1218*** (0.0215)
HEALTH			-0.0198*** (0.0020)		-0.0143*** (0.0010)	-0.0137*** (0.0014)
GDP				0.0115*** (0.0011)	0.0206*** (0.0020)	0.0208*** (0.0038)
Constant	5.1219*** (0.0099)	5.2644*** (0.0059)	5.1589*** (0.0097)	4.9651*** (0.0089)	5.5794*** (0.0505)	5.5669*** (0.0900)
Kleibergen-Paap rk LM statistic (p value)						163.312 (0.0000)
Kleibergen-Paap rk Wald F statistic						4.1e+04
Hansen J statistic (p value)						0.4653

Note: \*\*\* denotes  $p < 0.01$ . Standard errors in parentheses.

For the purpose of controlling for endogeneity, we considered the IV-GMM results, which document that FFS and GDP increase CIWB, while AE and HEALTH decrease it. These results corroborate the findings of the D-K standard error estimator. The results obtained from these tests show that the IVs are neither under-identified nor weak, and the instruments are not over-identified. Therefore, the results show that the results of the IV-GMM technique are reliable.

#### IV.I. Robustness Check

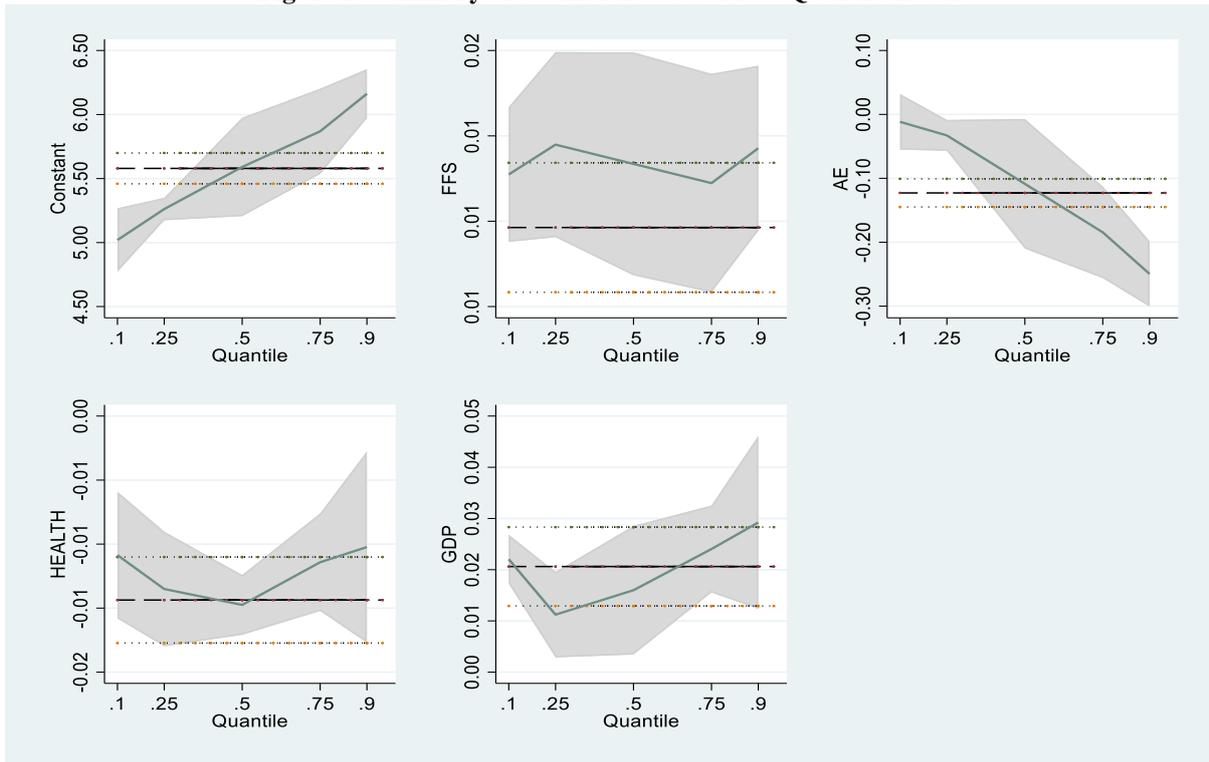
We use the BSQREG estimation technique to test the robustness of the estimation results we obtained with D-K. Table 6 presents the results obtained from the BSQREG method, and the summary of coefficients can be found in Figure 2. The results obtained from model show that an increase in FFS and GDP is associated with an increase in CIWB. AE has a negative relationship with CIWB, except for the 10th and 25th quantiles. An increase in HEALTH is associated with a decrease in CIWB. Therefore, in all estimates, we show that FFS and GDP worsen environmental well-being, i.e., lead to an increase in CIWB, which is an undesirable situation in terms of sustainability. However, we show that AE and HEALTH improve environmental well-being, i.e., lead to a decrease in CIWB, which is an expected and desirable situation in terms of sustainability. Thus, in all predictions, the regression results show strong robustness with consistent coefficient signs across all models. This stability confirms the reliability of the findings and supports their importance for policy decisions.

**Table 6: BSQREG Results (robustness)**

Variable	q10	q25	q50	q75	q90
FFS	0.0127*** (0.0022)	0.0144*** (0.0022)	0.0133*** (0.0028)	0.0122*** (0.0028)	0.0142*** (0.0026)
AE	-0.0116 (0.0190)	-0.0328 (0.0097)	-0.1085** (0.0448)	-0.1845*** (0.0307)	-0.2496*** (0.0231)
HEALTH	-0.0108*** (0.0024)	-0.0135*** (0.0021)	-0.0147*** (0.0014)	-0.0114*** (0.0023)	-0.0102*** (0.0034)
GDP	0.0220*** (0.0042)	0.0112*** (0.0039)	0.0159*** (0.0058)	0.0240*** (0.0040)	0.0292*** (0.0066)
Constant	5.0199*** (0.1220)	5.2615*** (0.0449)	5.5905*** (0.1845)	5.8687*** (0.1477)	6.1624*** (0.1111)

Note: \*\*\* denotes  $p < 0.01$ ; \*\* denotes  $p < 0.05$ . Bootstrapped standard errors (500 replications) are reported in parentheses.

**Figure 2: Summary of Coefficients at Various Quantile Levels**



## CONCLUSION AND POLICY IMPLICATIONS

This study examined the impact of FFS, access to energy, health expenditures, and per capita income on CIWB in 33 EMDEs for the period 2010-2023, with the aim of contributing to research on CIWB. The D-K standard error estimator and IV-GMM were applied for empirical analysis, and the BSQREG method was applied for robustness control. FFS can have different effects on different income groups in countries when policies related to energy access and health change. Quantile regression provides a flexible framework for modeling this. BSQREG is ideal for examining how the relationship between variables changes under different conditions by performing heterogeneity analysis.

The results obtained from both methods were consistent with each other. According to the results obtained, we showed that FFS and GDP lead to an increase in CO<sub>2</sub> emissions per life expectancy, causing an increase in the CIWB score and an undesirable outcome in terms of sustainability. However, we determined that AE and HEALTH cause a decrease in CO<sub>2</sub> emissions per life expectancy, leading to a decrease in the CIWB score and an expected outcome in terms of sustainability. FFS encourage fossil fuel consumption by lowering energy prices, which directly leads to increased CO<sub>2</sub> emissions. However, these subsidies can also contribute to increased social welfare by facilitating access to energy. However, when these two effects are considered together, it is seen that the increase in CO<sub>2</sub> emissions caused by FFS outweighs the increase in social welfare. Therefore, it is concluded that FFS have a net increasing effect on the CIWB.

The purpose of this study is to present policy implications on how we can reduce carbon intensity while preserving and perhaps even increasing well-being. This study clearly demonstrates that environmental and human well-being can be compatible and provides a clear roadmap for achieving long-term sustainable development. By implementing smart policies such as reducing dependence on fossil fuels, promoting renewable energy, ensuring access to energy, and prioritizing public health, countries can increase well-being while reducing carbon emissions.

For this reason, the following policy conclusions have been drawn: The phased removal and redirection of FFS can facilitate the expansion of clean energy and energy access. ii) Hospitals and healthcare centers should prioritize better energy efficiency, strengthen waste disposal systems, and encourage the use of environmentally friendly medical products and pharmaceuticals. iii) Economic development should focus on expanding the service industry, digital technologies, low-emission manufacturing, and

renewable energy, rather than investing in carbon-intensive sectors. iv) Financial support currently allocated to FFS can be rechanneled into clean energy initiatives, helping to provide the population with greater access to sustainable energy sources. v) EMDEs exhibit a heterogeneous structure in terms of FFS. For example, Saudi Arabia, Turkmenistan, Libya, and Algeria are among the EMDEs that provide the most FFS. The economies, budget revenues, and exports of these countries are heavily dependent on the oil and natural gas sector. Therefore, these countries can eliminate the rentier economy and accelerate the transition to renewable energy by implementing policies to gradually reduce FFS.

This study is limited to 33 EMDEs and annual data from 2010 to 2023. The dataset on FFS in EMDEs is provided by the IEA. Therefore, the short data range is due to the data provided by this database. Future studies may examine the impact of FFS on environmental well-being for different country groups. Furthermore, future research could investigate the threshold effect of FFS on the relationship between economic growth and CIWB. This study aimed to empirically examine the direct relationship between FFS and CIWB at the quantile level. However, testing indirect channels underlying this relationship, such as energy access, healthcare quality, or economic productivity, would be a valuable direction for future research. Such a mechanism analysis requires more complex mediation models and more detailed data sets. In addition, due to data availability, it was not possible to examine some important EMDEs subgroups in greater depth. Future studies could shed light on causal mechanisms using structural models or mediation analyses and examine differences between country groups with different development paths more sharply. Empirical studies can also be expanded to include different environmental and well-being indicators.

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<b>Ethics Statement</b>	<i>The author declares that all ethical principles and rules were strictly observed throughout every stage of the preparation of this study. In case of any violation, ÖHÜİBF Journal is under no responsibility, and all responsibility rests solely with the author.</i>
<b>Conflict of Interest</b>	<i>The author has no conflicts of interest to declare. The author also certifies that the submission is original work and is not under review at any other publication.</i>
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## Appendix 1.

### List of Countries

Countries		
Algeria	Ghana	Pakistan
Angola	India	Qatar
Argentina	Indonesia	Russia
Azerbaijan	Iraq	Saudi Arabia
Bahrain	Iran	Sri Lanka
Bangladesh	Kazakhstan	Thailand
Brunei	Kuwait	Turkmenistan
China	Libya	Ukraine
Colombia	Malaysia	UAE
Ecuador	Mexico	Uzbekistan
Egypt	Nigeria	Vietnam