Journal of Sustainable Development Issues, 2024, 2(2),
p. 67-75.
Journal homepage: https://journalsdi.com/index.php/jsdi/index; **ISSN: 3078-2546**

The effect of Carbon Emissions on Life Expectancy: Evidence from Azerbaijan

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ABSTRACT

Life expectancy (LEX) is an important indicator of the general health status and quality of life of a country. It is directly related to factors such as the effectiveness of a country's health policies and the level of social and economic welfare. Carbon dioxide (CO_2) emissions are one of the key causes of global climate change and have direct negative impacts on human health through air pollution. Many studies in the literature have revealed that high CO2 emissions have negative effects on health and reduce life expectancy. This study, probably the first of its kind in Azerbaijan, was analyzed using data for the period 1974-2022. The stationarity of the variables was tested with nonlinear unit root tests such as KSS, Sollis and Kruse and it was found that they were not stationary at the level. The existence of a cointegration relationship between the variables was determined through the A-ARDL method. Based on the results obtained from CCR and FMOLS method, a 1% increase in CO2 leads to a 0.15% decrease in LEX. In addition, the results of the FTY causality test revealed that there is unidirectional causality from CO2 to LEX.

Keywords: Life expectancy, Carbon emissions, A-ARDL, Causality

JEL Classification: C22, I18, Q53

DOI: 10.62433/josdi.v2i2.29

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Received: January, 2024 | 1st Revision: October, 2024 | Accepted: November, 2024

1. INTRODUCTION

Carbon emissions refer to the amount of carbon dioxide (CO2) released into the atmosphere. These gases absorb some of the energy from the sun, causing the temperature on the earth's surface to rise. This is known as the greenhouse effect and is one of the main causes of climate change. Climate change can affect temperature rise, melting of glaciers and sea level change. These emissions are mostly caused by the burning of fossil fuels such as coal, oil and natural gas. These are one of the main causes of global warming and climate change (Kartal and Pata, 2023). The economic impacts of climate change are far-reaching. Many studies show that climate change leads to reduced agricultural productivity, water scarcity and increased energy demand. This has serious implications for food security and economic stability, especially in developing countries (Stern, 2006). In addition, infrastructure damage and restoration costs resulting from extreme weather events also increase the economic burden. The main causes of carbon emissions are energy production, transport, industrial processes, agriculture, deforestation, etc. The impact of carbon emissions on human life in many aspects has been investigated at different times in different countries. In one of them, the effects of CO_2 emissions on life expectancy were investigated in 68 low- and middle-income countries of the world from 1990 to 2017. The results showed that emissions had a negative impact on life expectancy in developing countries, but emissions had a positive impact in developing countries. The study emphasizes the importance of policies such as reducing CO_2 emissions and transition to renewable energy. The limitations of the study include not including COVID-19 data and not using some advanced analysis methods. It is recommended that more modern techniques and a larger database be used in future studies(Mahalik, M, 2022). Another study examined the impact of carbon emissions on life expectancy in Nigeria from 1980 to 2016. The results show that carbon dioxide emissions reduce life expectancy and fossil fuel consumption also has a negative effect. The positive effect of electricity consumption was identified. The study emphasizes the need for sustainable energy use and increased health expenditure in Nigeria (Osabohien, R, 2021). It analyzed the long- and short-term relationships between healthcare expenditures, GDP, CO2 emissions and life expectancy in Malaysia between 1997 and 2021. The results show that in the long run the independent variables have no significant impact on life expectancy, but in the short run health care costs and CO2 emissions have a significant impact. For future research, it is recommended to make comparisons with other countries and to focus more on renewable energy technologies (Redzwan, N.et al. 2024). In these studies, we can see the effect of carbon emissions on life expectancy for different countries. But this impact has not been specifically investigated for Azerbaijan. In this paper, our main motivation is to investigate the effect of carbon emissions on life expectancy in Azerbaijan. Over the past two decades, Azerbaijan has experienced substantial economic growth, primarily driven by its extensive crude oil and natural gas exports, which have consistently comprised more than 92% of the country's total exports (Mikayilov et al. 2020). For this reason, Azerbaijan, as an oil-rich country, serves as a good case study for investigation. The following sections of our study continue as Literature Review, Methodology, Data and Model, Results, Conclusions and Political Recommendation.

2. LITERATURE REVIEW

In this section of the study, a summary of the studies analysing the effects of carbon emissions on life expectancy at birth in different countries is presented in Table 1.

Table 1: Relationships Between CO_2 and Life Expectancy

Authors	*Country(ies)*	*Period*	*Variables*	*Methods*	*Results*
Mahalik(2022) et al	68 developing and emerging economies	1990-2017	LE, INC, POP, CE, URB, IND, FD, GLOB, CCE, PCE	PCSE, FGLS	CO2↑ LEXP↑ in developing group, CO2↑ LEXP↓ in emerging group and whole country
Osabohien(2021) et al	Nigeria	1980-2017	LEXP, CO2, FFC, TEPC, EH	ARDL	CO2↑ LEXP↓
Redzwan(2024) et al	Malayasia	1997-2021	LEXP, CO2, HE, GDPPC	ARDL	CO2↑ LEXP↑
Matthew(2020) et al	West Africa	2000-2018	LEXP, CO2, AGQ	2SLS	CO2↑ LEXP↑
Rjoub(2021) et al	Turkiye	1960-2018	LEXP, CO2, GDP	FTY causality	CO2→LEXP
Hasnawati(2024) et al	Indonesia	1950-2020	LEXP, CO2, PG, GDPG	Granger causality	No causation
Rahman(2022) et al	31 world's most polluted countries	2000-2017	LEX,GDPPC, CO2,HEX, WAT, SAN	FGLS, Granger Causality	CO2↑ LEXP↓ CO2→LEXP

↑, ↓, → signs indicate increase, decrease and direction of causality, respectively.

3. METHODOLOGY

Based on the characteristics of the variables used in the study, the stationarity of the variables was analyzed with non-linear unit root tests such as KSS (2003), Sollis (2009) and Kruse (2011). Since the variables are I(1) series, Johansen (1988) method is used to search for the presence of cointegration between these variables, but this method is not preferred due to the observed break in the variables. Gregory-Hansen (1996) criticized Johansen (1988) for not taking into account the breaks in his study, while Hatemi-J (2008) criticized Gregory-Hansen (1996) for considering only one break and designed his study to search for the presence of cointegration in the presence of two breaks. Maki (2012) developed a test that allows the existence of cointegration under multiple breaks. Although these tests take breaks into account, they generally do not allow for the simultaneous analysis of short and long-run dynamics between variables. Pesaran (2001) proposed the ARDL method, which allows for the simultaneous analysis of both short- and long-run dynamics between variables, but does not allow for the existence of cointegration in the presence of a break in the variables. Meanwhile, Bootstraping ARDL method developed by McNown (2018) and A-ARDL method developed by Sam (2019) are cointegration tests that also examine short and long term dynamics between variables under the assumption that there is a single or multiple breaks in variables. By addressing this theoretical framework, A-ARDL method is preferred in order to obtain the short and long term dynamics along with the existence of cointegration relationship between the variables under the assumption that there is a break(s) in the analysis. The long run effects of CO2 on LEX were estimated by Fully-Modified Ordinary Least Squares(FMOLS) and Cointegrating Canonical Regression (CCR) method. The causality relationship between the variables is analysed with the Fourier-Toda-Yamamoto causality test developed by Nazlioğlu (2016). The main difference of this test from Granger (1969) and Toda-Yamamoto (1995) causality tests is its ability to take into account smooth and sharp breaks.

4. DATA AND MODEL

In this study, the data used cover the period 1974-2022 and the data were obtained from the official website of the World Bank. Descriptions of the variables and information about the unit of measurement are presented in Table 2.

Table 2: Description of Variables

Symbol	*Variables*	*Unit*	*Period*	*Source*
CO2	Carbon Emissions	Kilo ton(kt)	1974-2022	Our World in Data (2024)
LEXP	Life Expectation	Year		World Bank (2024)

Descriptive statistics of these variables are presented in Table 3 before conducting the econometric analysis. According to the information given in Table 3, the average amount of carbon emission per capita in the period analyzed is 5 kt, while the average life expectancy is 65.38 years. The minimum and maximum values of carbon emission and life expectancy are 2.98 and 7.58 kt, 60.2 and 73.48 years, respectively. Examining the skewness and kurtosis values of both variables, it is possible to say that the values of the variables have a right-skewed distribution since the skewness values are positive and a platykurtic distribution since the kurtosis values are less than 3. Analyzing the coefficients of variation, it is possible to state that the CO2 variable has undergone more variation in the period examined. Based on the Jarque-Bera test statistic and the related probability value, at the 5% significance level, the CO2 variable does not conform to the normal distribution, while the LEX variable conforms to the normal distribution. Another descriptive statistic calculated in order to learn the relationship direction and strength between the variables is the correlation coefficient.

Table 3: Descriptive Statistics

	CO_2	LEX
Mean	5.0013	65.384
Median	3.9393	63.561
Maximum	7.5785	73.488
Minimum	2.9824	60.228
Std. Dev.	1.6857	4.2406
Coef.Var	0.3371	0.0649
Skewness	0.3259	0.4664
Kurtosis	1.2354	1.7454
Jarque-Bera	7.2245	4.9897
Probability	0.0269	0.0825
Observations	49	49

Taking into account the 1% significance level, since both variables fit the normal distribution, the correlation coefficient between the variables was calculated by Pearson method and the results are presented in Table 4.

Table 4: Correlation matrix

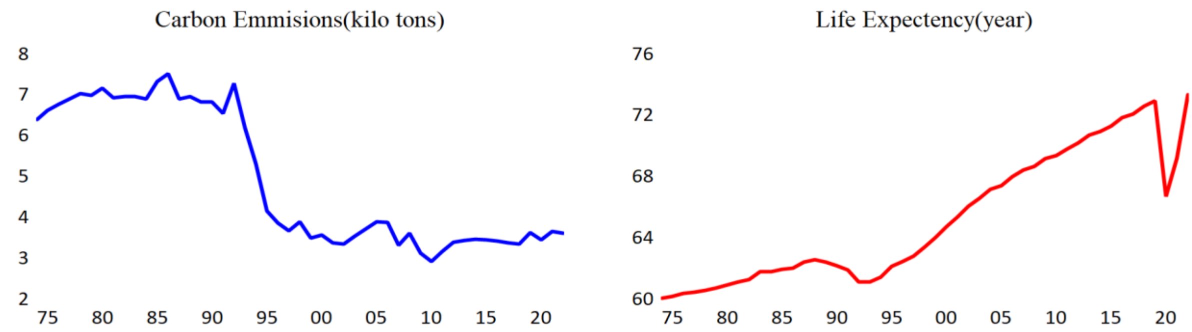
	CO_2	LIFEXP
CO_2	1	-0.8102
LIFEXP	-0.8102	1

From the information presented in Table 4, as expected, there is a negative and strong relationship between CO2 and LEX. In other words, as the amount of carbon emission increases, life expectancy decreases.

Although descriptive statistics contain general information about the variables, they are not very successful in reflecting the dynamics of the variables over time. In order to determine the dynamics of the variables over time, time graphs of the variables were plotted and presented in Figure 1.

There is a general upward trend in the CO2 graph from 1975 until the mid-1990s. After the mid-1990s, there was a sudden and significant decline and this downward trend continued until the mid-2000s. Afterwards, emission levels became relatively more stable and followed a horizontal course with small fluctuations. In general, the trend is not linear. It follows a positive linear trend between 1975-1990, while it shows a negative trend (decline) after 1990. Since this decline is sudden and sharp, it is more similar to an exponential downward trend. The graph of LEX shows a continuous upward trend since 1975. This increase seems to have accelerated especially after the 2000s.

Figure 1: Graphs of variables



However, due to the COVID19 pandemic in 2020, the increase in deaths at a very young age caused a sudden decline and then rapidly increased again. Thus, the upward trend in the LEX graph seems to be an exponential increase rather than a linear increase. It can be seen from the graphs that both variables have a trend. The fact that the variables have a trend allows us to suggest an idea about their non-stationarity. However, in time series analysis, analytical tests rather than graphs are preferred to decide on the stationarity level of variables. Since both variables contain an exponential trend as seen from the series graphs, KSS(2003), Sollis(2009) and Kruse(2011) tests, using exponential functions in the test equations, were preferred to determine the degree of stationarity of the series. The findings obtained as a result of the application of the tests are given in Table 5.

As presented in Table 5, both variables are non-stationary series in the equation with constant. Since the calculated test statistics for both variables are smaller than the critical values of the respective unit root tests, the null hypothesis stating that the series contain unit root cannot be rejected. In other words, according to the equation with constant, both variables are I(1) series. Considering the equation with constant and trend, the test statistics calculated according to the KSS (2003) and Kruse (2011) tests are not greater than the corresponding critical values.

However, the test statistic calculated according to the Sollis (2009) test is greater than the relevant critical value. Considering these results, it is possible to conclude that both variables are non-stationary at level. Finally, it is concluded that CO2 and LEX variables are non-stationary or I(1) series at level values for both the equation with constant and the equation with constant and trend.

Table 5: Unit Root Results

Variables	*KSS(2003)*		*Sollis(2009)*		*Kruse(2011)*		
	Constant						
	Test stat	*Lag*	*Test stat*	*Lag*	*Test stat*	*Lag*	*Results*
LnCO2	-1.8078	0	0.8942	0	1.7160	0	I(1)
LnLEXP	-1.2919	0	2.0635	0	3.5945	0	I(1)
	Constant&Trend						
LnCO2	-2.1243	0	2.2843	0	4.4652	0	I(1)
LnLEXP	-2.6996	0	6.0989*	0	9.6937	0	I(1)

* indicates that the null hypothesis is rejected at 10% significance level.

Based on the detailed theoretical framework given in the Methodology section, the existence of cointegration between the variables is analysed with the A-ARDL method. Thus, the A-ARDL method was used based on the following model.

$$LnLEX_t = f(LnCO_2) \tag{1}$$

As a result of the estimation of equation (1) with A-ARDL, we obtained the results given in Table 6.

Table 6: A-ARDL Cointegration Results

Model	ARDL order	Break Time	$F_{OVERALL}$	$t_{Dependent}$	$F_{INDEPENDENT}$	Results
Case III	3,4	2020	30.584***	-4.3867*	57.486***	Cointegration
Critical Values	Peseran et al. (2001)		Narayan (2005)		Sam et al. (2019)	
	Lower	Upper	Lower	Upper	Lower	Upper
1%	4.29	5.61	5.33	7.06	4.60	4.72
5%	3.23	4.35	3.71	5.02	2.96	5.14
10%	2.72	3.77	3.01	4.15	2.30	4.11

*** ,**,*indicates that the null hypothesis is rejected at 1%, 5% and 10% significance level, respectively

Table 6 illustrates that Case III, which includes the constant, is the preferred equation among the five that result from the ARDL method's inclusion of the constant and trend. The most appropriate model order for this equation was determined as ARDL(3,4). According to Figure 1, a break occurred in 2020 due to the COVID-19 pandemic. This break date was estimated by considering it as a dummy variable in the model. Because of the overall, dependent and independent test statistics obtained as a result of the estimation are greater than the relevant critical values in absolute value, the null hypothesis stating that there is no cointegration between the variables is rejected. That is, there is cointegration between the variables.

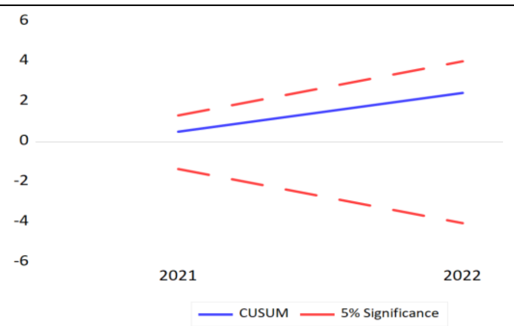
Subsequent to the estimation of the A-ARDL(3,4) model, the relevant diagnostic tests of the model were performed and the results are presented in Table 7. Analysing the results given in Table 7, it is seen that the errors are free of autocorrelation and heteroskedasticity and they are normal distributed. Based on the R-R test result, there is no problem in the model in terms of functional form. In addition, CUSUM and CUSUMSQ graphs show that there is no change in the parameters of the model over time.

Table 7: Diagnostics of A-ARDL

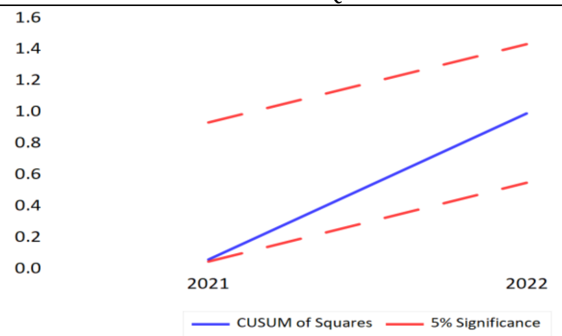
R^2	*F-statistics*	*JB*	*BG-LM*	*White*	*R-R*
0.997.	1639.8***	0.3132(0.8550)	1.3246(0.2835)	1.4347(0.2074)	0.2035(0.8400)

Parametres Stability Tests

CUSUM



CUSUM SQ



JB; Jarque-Bera normality test, BG-LM; Breusch Godfrey LM autocorrelation test, White-hetero-skedasticty test; R-R; Ramsey-Reset refers to specification testing.

The long run effects of CO2 on LEX are estimated by CCR and FMOLS method and the results are presented in Table 8.

Table 8: Long-run Estimates

Variabls	CCR	FMOLS
Constant	4.2430***	4.2443***
LCO2	-0.1577***	-0.1538***
COVID19	-0.1129*	-0.1108*
R^2	0.6275	0.6261
SER	0.0388	0.0389

Regarding the results given in Table 8, CCR and FMOLS results are quite similar. While CO2 increased by 1%, LEX decreased by 0.15% on average. Due to COVID, middle life expectancy in Azerbaijan decreased by 0.11 per cent on average. Taking into account that the model is a full logarithmic model, the average life expectancy calculated by using the constant coefficient is approximately 67.45 years ($e^{constant}=2.7^{4.24}=67.45$). Comparing with the average life expectancy of 65.38 in the descriptive statistics presented in Table 3, it is understood that the values obtained from the CCR and FMOLS method do not differ significantly.

The results of the causality analysis given in Table 9 indicate that CO2 is the cause of LEX variable. Nevertheless, LEX is not the cause of CO_2.

Tablo 9: Causality Test Results

Causality Direction	Test statistics	k	lag	Results
CO2→LEX	16.566***	1	2	H_0 Reject
LEX→CO2	3.5904	1	2	H_0 Don’t Reject

*** ,indicates that the null hypothesis is rejected at 1% significance level.

5. RESULTS

According to the results of the analyses conducted with the data covering the period 1974-2022 for Azerbaijan, CO2 and LEX variables are non-stationary or I(1) series at level values. The existence of a cointegration relationship between these variables was determined by the A-ARDL method. The long-run effects estimated by CCR and FMOLS methods show that a 1% increase in CO2 causes an average decrease of 0.15% in LEX. The causality test conducted with the FTY method shows that although CO2 is the cause of LEX, the vice versa is not valid.

6. CONCLUSION

In conclusion, this study analysed the relationship between carbon dioxide (CO2) emissions and life expectancy (LEX) in Azerbaijan in depth. The analysis using the A-ARDL method revealed that there is a long-run cointegration relationship between the variables. The long-run coefficients estimated by CCR and FMOLS methods showed that a 1% increase in CO2 emissions decreases life expectancy by 0.15%. This finding clearly demonstrates that environmental degradation has negative effects on public health. The causality analysis performed with the FTY method showed that CO2 emissions have a unidirectional causality on life expectancy, but life expectancy has no effect on CO2 emissions. The results obtained are consistent with other studies in the literature such as Mahalik (2022), Osabohien (2021), Rjoub (2021) and Rahman (2022). In this context, it is once again emphasised how important environmental policies are to improve the quality of life.

7. POLICY RECOMMENDATION

The results of the study suggest that policy makers should consider the following policy recommendations since the increase in carbon emissions reduces life expectancy.

In order to reduce carbon emissions, the amount of carbon emissions should be reduced by 10%, 25% within the scope of short (2025), medium (2030) and targets. In line with the long-term targets (2050), a carbon neutral economy should be established. To achieve these targets, in addition to providing financial support and subsidies for renewable energy sources such as solar, wind and hydroelectricity, the development of technologies to increase energy efficiency for industry and households should also be encouraged. In addition, in the transport and construction sectors, the construction of buildings with low carbon emissions should be promoted and the energy efficiency of existing buildings should be increased, with the development of public transport systems, the widespread use of electric vehicles and the increase of bicycle lanes as appropriate. There should also be additional taxes on sectors with high carbon emissions, while tax reductions should be provided to sectors with low carbon emissions. In high-carbon emission regions, healthcare centres and their quality should be improved in order to provide easier access to healthcare services for the population. In the case of realisation of these policy recommendations, since the amount of carbon emissions in Azerbaijan will decrease rapidly, the negative effects of carbon emissions on human health and life expectancy will be eliminated.

Author Contributions: All part of the this study conducted by Zuleykha Javanshirova.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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