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The Relationship Between Economic Growth and Pollution in Zambia

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Abstract

This study examines the effect of economic growth on emission levels in a country. It specifically examines this relationship in the context of Zambia. To analyze the data, the study adopts the ARDL model. The findings reveal no long-run relationship existed between GDP and greenhouse emissions. However, there was a positive short-run relationship present between them. The weakening of the relationship in the long run might suggest a progression towards a more sustainable economy, where environmental degradation is not an inevitable cost of economic growth. These findings may be a possible indication of alignment with the EKC hypothesis, which means that after a certain threshold of economic growth, Zambia is likely to experience a reverse effect in the relationship between economic growth and emissions. Therefore, the study suggests that policymakers should encourage investment in clean energy, sustainable economic shifting, and strengthen environmental regulations to promote long-term sustainable growth.

Keywords: GDP, Carbon Emissions, Air Pollution, EKC, Sustainability

1. Introduction

Economic growth, measured by GDP, refers to the increase in the size of a country's economy over time (RESERVE BANK OF AUSTRALIA | Education, 2023). This growth is directly related to how much goods and services the economy is putting out. From this, it becomes obvious that production is a necessity for economic growth.

However, the production process may come with some negative effects if not properly mitigated. For instance, activities like the burning of natural gases, fossil fuels, and coal are necessary in order to produce heat and electricity for industrial processes. These activities and many other economic activities, like combustion engine-powered transportation, cause pollution to the environment.

Pollution is when contaminants in the form of substances (either solids, liquids, or gases) or energy (like heat, radioactivity, light, sound, or heat), which can cause adverse effects, are introduced into the natural environment. The pollutants can either be from naturally occurring events or an anthropogenic source (Merriam-Webster, n.d.).

Pollution comes in different forms, namely; air pollution, water pollution, light pollution, land pollution, etc. However, the type which is of focus in this case is air pollution. Air pollution happens when particulates or chemicals are released into the atmosphere (World Health Organization: WHO, 2019). Particulates are tiny particles whose size ranges from $PM10$ to

$PM2.5$ micrometres (European Environmental Agency, 2024). However, some of the most common air pollutants are in the form of gaseous chemicals like sulphur dioxide, chlorofluorocarbons (CFCs), nitrogen dioxide, carbon dioxide, and carbon monoxide (Overview of Greenhouse Gases | US EPA, 2024).

Gases like carbon dioxide, methane, nitrous oxide, ozone and synthetic gases like chlorofluorocarbons are classified as greenhouse gases because of how they affect the earth's atmosphere. These gases trap heat in the atmosphere, which is essential to maintain hospitable temperatures on the planet. Nevertheless, because of human activities which produce these gases, their concentration in the atmosphere keeps increasing, leading to harmful effects on the environment and humans like global warming. In 2022, CO2 emissions accounted for about 80% of the greenhouse gases (Overview of Greenhouse Gases | US EPA, 2024).

Based on this, the study aims to explore the relationship between economic growth and air pollution in a developing country. The study will use data on Zambia, a developing country in southern Africa, to provide insight into sustainable economic growth. It aims to use a quantitative approach to examine this relationship. Furthermore, it also aims to provide policymakers and stakeholders in Zambia and other similar developing countries with useful insight into the impact of economic development activity on the environment.

The paper consists of five main sections. The first section is the introduction, then the literature review, followed by a methodology section, a discussion of the results, and finally the conclusion.

2. Literature Review

The interest in understanding the factors that cause an impact on the environment has become more pronounced, especially with the growing climate change concerns. There is a growing number of researchers who have examined how different economic factors are impacting the environment. This review comprises three sections: (1) the Economic Growth-Environment Nexus and the Environmental Kuznets Curve hypothesis, (2) the energy consumption-emissions nexus, and (3) the socioeconomic, political, and technological determinants of environmental quality.

Economic Growth-Environment Nexus and the EKC Hypothesis

Many researchers have explored the relationship between economic growth and environmental quality through the lens of the Environmental Kuznet Curve (EKC), which posits that emission levels rise initially with income and fall passed a certain threshold. Recent studies reveal mixed findings related to the hypothesis based on different factors.

Baydoun and Aga (2021), focus on how CO2 emissions in the Gulf Cooperation Council (GCC) countries are affected by energy consumption, economic growth, financial development, and globalization. Applying the cross-sectionally augmented autoregressive distributed lag test to analyze data from 1995 to 2018, they find that economic growth and energy consumption decrease environmental sustainability. And for the GCC economies studied, the findings also validated the environmental Kuznets curve (EKC) hypothesis. Another study that supports the EKC hypothesis is by Ben Amar (2021), which uses the dynamic correlation measure and bivariate cross-wavelet coherency to test the relationship between carbon dioxide (CO2) emissions and economic growth (real GDP per capita) in the United Kingdom using data from

1751 to 2016. The findings from the study reveal the existence of an Environmental Kuznets Curve (EKC) in the UK, with a turning point estimated around the mid-twentieth century. The turning point corresponds with the introduction of changes in environmental standards and policies, which reflects the regulatory efforts to limit pollution by reducing the discharge of grit into the atmosphere, as well as the decline in the use of coal as a source of energy. The findings align with Raihan and Tuspekova (2022) who use Dynamic Ordinary Least Squares (DOLS) to examine the effect of economic growth, renewable energy, and forested areas on carbon emission levels in Malaysia. This study finds a positive relationship between carbon emissions and economic growth in Malaysia. Furthermore, it found that renewable energy use and forested areas showed an inverse relationship with CO2 emissions. Furthermore, these findings are corroborated by Ahmad et al. (2023), who examine how renewable energy transition, abundance of natural resources, financial globalization, and economic growth affect the ecological footprint (EF) in G-11 countries under the Environmental Kuznets Curve (EKC) framework. The study uses the cross- sectional autoregressive distributed lags to carry out this objective. Their findings confirm the presence of the EKC hypothesis for the G-11 countries.

However, the findings from the study done by Cetin and Bakirtas (2020) do not align with the EKC hypothesis. Their study researched the long-term relationship between real GDP, financial development, fossil fuel consumption, and carbon dioxide emissions in 15 emerging markets. It used heterogeneous dynamic panel data techniques to analyze data from 1980 to 2014. Their findings showed that in the long run, emerging markets did not follow the environmental Kuznets curve hypothesis. They also found that financial development and CO2 emissions were directly proportional. Based on their findings, they recommended the promotion of environmentally friendly technologies to prevent pollution. Furthermore, Banday and Aneja (2019) also reach a similar conclusion where the findings do not fully align with the EKC hypothesis. Their study examined the nature of the relationship between economic growth, energy consumption, and CO2 emissions in G7 countries. They also examined if it was the consumption of renewable energy, non-renewable energy, or both that determined sustainable economic growth in G7 countries. Their study used pooled mean group ARDL to analyze the short-run and long-run relation between these variables for individual countries between the period 1971 and 2014. They also applied the Granger causality test to check for causal relationships between the variables. The results of the PMG ARDL approach indicated the presence of a long-run relationship among economic growth, CO2 emissions, and energy consumption. They also found a positive short-run relationship among the variables.

Energy Consumption and Transition Dynamics

Another factor that is mentioned in the economic growth-environment nexus is energy consumption - particularly renewable versus non-renewable sources. For instance, Mujtaba et. al (2022) used data from 1970 to 2016 to investigate the linear and non-linear impact of economic growth (EG), capital formation (CF), renewable and non-renewable energy (NRE) consumption on CO2 emissions, and the ecological footprint of seventeen OECD countries. Using the ARDL for symmetric analysis and NARDL for asymmetric analysis, they find that economic growth and gross capital formation dampen environmental quality in the OECD region. Their results indicate that conventional energy obtained from fossil fuels is observed to worsen environmental quality. However, they also find that renewable energy consumption enhances environmental quality. These findings align with the findings of Ahmad et al. (2023). Their study finds that natural resource rent positively impacts the ecological footprint, while renewable transition negatively affects it. Based on these findings, they recommend that the countries should adopt policies to enhance renewable energy transition. Further, the findings on renewable energy are collaborated by Ali et al. (2022) who employed the pooled mean group (PMG), mean group (MG), and dynamic fixed effects (DFE) estimators. The data they use is from South American countries between the period 1995 to 2020. Their study finds that while environmental pollution increases with increasing economic growth, it decreases with increasing renewable energy both in the short and long term. Furthermore, a bidirectional causality was found between economic growth and environmental pollution, with a unidirectional causality running from renewable, and non-renewable energy to environmental pollution.

However, Xue et al. (2021) have opposing findings in regard to renewable energy. Their research examines the impact of clean energy consumption on CO2 emissions using the ARDL model. The study uses data from France ranging from 1987 to 2019. Their research surprisingly finds that clean energy consumption does not contribute to the reduction of emissions in the short run. Furthermore, they conclude that economic growth leads to higher CO_2 emissions, while urbanization is conducive to environmental quality.

Socioeconomic, Political, and Technological Determinants

Other economic-related factors in the literature aside from growth and energy that affect the environment are urbanization, globalization, and technological innovation. Yang and Khan (2021) examine the relationship between economic growth, urbanization, and environmental sustainability in the presence of population growth and industry value-added in the thirty International Energy Agency (IEA) member countries using data from 1992 to 2016. They find that capital formation and biocapacity increase the ecological footprint in the short run. Furthermore, the long-run results indicate that industrial value added and capital formation improve environmental sustainability. On the other hand, economic growth, urbanization, biocapacity, and population growth deteriorate environmental sustainability in the long run. Ali et al. (2022) also reach a similar conclusion. Their study, also employing the ARDL model to analyze data from Pakistan, finds that natural resources reduce CO2 emissions while technological advancement, economic progress, energy use, and urbanization increase CO2 emissions.

In regards to globalization, Baydoun and Aga (2021) also analyze its effect on CO2 emissions in the Gulf Cooperation Council (GCC) countries. They conclude that financial globalization leads to improved sustainability. These findings are also corroborated by the findings of Ahmad et al. (2023). Their study also considers how financial globalization affects the ecological footprint (EF) in the G-11 countries. Furthermore, the study also explores the moderating role of financial globalization in the relationship between renewable energy transition and EF. They find that financial globalization negatively affects the ecological footprint. Based on these findings, they recommend that the countries should adopt policies to enhance financial globalization.

However, these findings are partially contradicted by the findings of Ali et al. (2022). Employing the pooled mean group (PMG), mean group (MG), and dynamic fixed effects (DFE) estimators, their study finds that economic globalization increases environmental pollution in the long term, while social globalization and the moderation effect between political globalization and renewable energy improve environmental quality in the long run.

Overall, the Environmental Kuznets curve hypothesis is supported mainly in economies that are regulated and have high incomes but rejected in most emerging markets. Regarding renewable energy, the consensus from the studies is that it enhances sustainability but this is dependent on enforcement of complementary policies. Furthermore, the majority of studies conclude that emissions worsen with urban expansion, however, this effect is offset by technological advancements.

3. Methodology

The objective of the study is to analyze the relationship between economic growth and greenhouse gas emissions in Zambia. Furthermore, it also analyses whether the relationship between economic growth and emissions follows the EKC hypothesis in Zambia. The study uses yearly data for GDP growth and greenhouse gas emissions sourced from the World Bank. The data used is 30 years in total, running from 1990 to 2020.

The methods used to analyze the data include the Augmented Dickey-Fuller test, the ARDL method. The first step in the analysis involves a look at the descriptive statistics of data, like the mean, median, standard deviation, and kurtosis. The Augmented Dickey-Fuller test is used to test for unit root in the two-time series variables. The ARDL method is used to test for the long-run equilibrium relationship and estimate the short- and long-run causalities. If there is no long-run equilibrium relationship present, only the short-run ARDL model is estimated.

To establish whether the long-run equilibrium relationship is present, cointegration analysis is used. Cointegration analysis can be done using a number of tests like Engle and Granger's (1987) and Johansen's (1988) methods. In this study, the ARDL bounds-testing framework is used.

The ARDL bounds-testing framework is chosen because it has several advantages over methods like Engle and Granger's (1987) and Johansen's (1988) methods. For instance, the ARDL method only uses a single reduced form of equations to estimate the long-run relationships, unlike the previously mentioned methods which use a system of equations (Pesaran and shin, 1999). Furthermore, the ARDL method is advantageous because it can handle data with a mix of I (0), I (1), or fractionally integrated variables (Pesaran et al., 2001). Given this, estimations with this method avoid non-stationary time series data issues. The ARDL model also allows for different variables to have different optimal lags, which is not possible with other methods. Furthermore, it can handle smaller samples of data and is considered robust for cointegration testing (Persaran et al., 2000).

4. Results Descriptive Statistics

This section presents the descriptive statistics of the time series variables used. From the table below, it can be seen that the mean for the log of greenhouse gas emissions is 10.25 and 22.91 for the log of GDP. The standard deviation for greenhouse gas emissions and GDP are 0.15 and 0.87 respectively. The data for both GDP and greenhouse emissions are platykurtic. Platykurtic means that the data points in the series are spread out, while Leptokurtic means more values concentrated about the mean. Both variables have nearly symmetric distributions since the values of their skewness is between -0.5 and 0.5.

Table 1. Descriptive statistics of Greenhouse Gas Emissions

	Percentiles	Smallest		
1%	10.03511	10.03511		
5%	10.03802	10.03802		
10%	10.06928	10.061	Obs	31
25%	10.13966	10.06928	Sum of Wgt.	31
50%	10.22052		Mean	10.24716
		Largest	Std. Dev.	.149942
75%	10.41769	10.45573		
90%	10.45573	10.48396	Variance	.0224826
95%	10.49426	10.49426	Skewness	.3771509
99%	10.50807	10.50807	Kurtosis	1.84078

Table 2. Descriptive statistics of GDP

	Percentiles	Smallest		
1%	21.88075	21.88075		
5%	21.90913	21.90913		
10%	21.9402	21.9127	Obs	31
25%	22.00438	21.9402	Sum of Wgt.	31
50%	22.84335		Mean	22.9098
		Largest	Std. Dev.	.8707679
75%	23.77968	23.97649		
90%	23.97649	23.99327	Variance	.7582367
95%	24.02431	24.02431	Skewness	.0601801
99%	24.0568	24.0568	Kurtosis	1.216111

Unit-root test results

Before testing for cointegration, the unit root test is applied to find out the stationarity of the data. The Dickey-Fuller test is used to perform the test. The null hypothesis of the test is that the unit root is present in the series or that the series is non-stationary. If the absolute value of the test statistic less than the absolute value of the critical value, then the series is non-stationary. If the absolute value of the test statistic is greater than the absolute value of the critical value then the series is stationary.

Table 3. GDP at level

Dickey-Fuller test for unit root   Number of obs = 30

		Interpolated Dickey-Fuller		
	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-0.825	-3.716	-2.986	-2.624

MacKinnon approximate p-value for Z(t) = 0.8117

Table 4. Total Green House Gas emissions at level

Dickey-Fuller test for unit root Number of obs = 30

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		Interpolated Dickey-Fuller		
Z(t)	-0.206	-3.716	-2.986	-2.624

MacKinnon approximate p-value for Z(t) = 0.9378

Table 5. GDP at first difference

Dickey-Fuller test for unit root Number of obs = 29

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		Interpolated Dickey-Fuller		
Z(t)	-3.667	-3.723	-2.989	-2.625

MacKinnon approximate p-value for Z(t) = 0.0046

Table 6. Total Green House Gas emissions at first difference

Dickey-Fuller test for unit root Number of obs = 29

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		Interpolated Dickey-Fuller		
Z(t)	-5.434	-3.723	-2.989	-2.625

MacKinnon approximate p-value for Z(t) = 0.0000

The results show that the absolute value of the test statistic for GDP is 0.825 at level, which is less than the absolute value of the critical value, which is 2.986 indicating that the series is non-stationary at level. The series becomes stationary after differencing it once as can be observed from the results of the differenced series which has a test statistic of – 3.667 and a 5% critical value of – 2.989. The test statistic for greenhouse emissions is -0.206 at level with a 5% critical value of – 2.986, indicating that it is non-stationary. However, differencing it once shows that it is integrated of order 1.

Lag Order Selection Criterion

Table 7. Lag order selection

Selection-order criteria
Sample: 1994 - 2020 Number of obs = 27

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-1.39951				.00441	.251815	.280358	.347803
1	56.021	114.84	4	0.000	.000084*	-3.70526*	-3.61963*	-3.4173*
2	57.0863	2.1306	4	0.712	.000106	-3.48787	-3.34516	-3.00794
3	57.9228	1.6731	4	0.796	.000136	-3.25354	-3.05375	-2.58163
4	64.319	12.792*	4	0.012	.000117	-3.43104	-3.17416	-2.56715

ARDL Bound test

In order to check if a long-run relationship is present between the variables during the specified period, the ARDL bound test is used. ARDL is suitable when variables have the same order of integration or different orders of integration and neither variable has to be differenced more than once to become stationary. Both variables in the data have been transformed using log transformation before checking for cointegration.

The null hypothesis for the bounds test is that there is no cointegration between the variables. Two hypothesis tests can used for the bound test, namely; the F-test and the t-test. If the F-statistic is greater than the critical value of the I (1) regressor, then the null hypothesis can be rejected, but if its less than the critical value of the I (0) regressor, the null hypothesis can't be rejected. If the F-value falls between these two critical values, then the results are inconclusive. For the t-test, the t-statistic has to be greater than the critical value of the I (0) regressor for the null hypothesis to be accepted and less than the critical value of the I (1) regressor for the alternative hypothesis to be accepted.

Table 8. Bound Test Results

```
ARDL(1,0) regression

Sample: 1991 - 2020                               Number of obs     =         30
                                                  R-squared         =     0.1472
                                                  Adj R-squared     =     0.0841
Log likelihood =  51.156585                       Root MSE          =     0.0464
```

D. lgTGHGEmissions	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ADJ						
lgTGHGEmissions L1.	-.2118874	.1099614	-1.93	0.065	-.4375096	.0137349
LR						
lgGDP	.1870162	.0525932	3.56	0.001	.0791038	.2949285
SR						
_cons	1.272013	.8025609	1.58	0.125	-.3747063	2.918732

```
Pesaran/Shin/Smith (2001) ARDL Bounds Test
H0: no levels relationship                F =  2.331
                                          t = -1.927

Critical Values (0.1-0.01), F-statistic, Case 3
```

	[I_0] L_1	[I_1] L_1	[I_0] L_05	[I_1] L_05	[I_0] L_025	[I_1] L_025	[I_0] L_01	[I_1] L_01
k_1	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84

```
accept if F < critical value for I(0) regressors
reject if F > critical value for I(1) regressors

Critical Values (0.1-0.01), t-statistic, Case 3
```

	[I_0] L_1	[I_1] L_1	[I_0] L_05	[I_1] L_05	[I_0] L_025	[I_1] L_025	[I_0] L_01	[I_1] L_01
k_1	-2.57	-2.91	-2.86	-3.22	-3.13	-3.50	-3.43	-3.82

```
accept if t > critical value for I(0) regressors
reject if t < critical value for I(1) regressors

k: # of non-deterministic regressors in long-run relationship
Critical values from Pesaran/Shin/Smith (2001)
```

The results show the F-test show that the F-value is 2.331 which is less than the 5% critical value of the I (0) regressor, meaning that the null hypothesis cannot be rejected. Furthermore, the t-statistic yielded from the t-test also concludes that there is no cointegration since its value of -1.927 is greater than the 5% critical value of the I (0) regressor.

ARDL short-run model

Since there is no presence of a long-run relationship between the variables, the ARDL model is specified to check for a short-run relationship between the variables.

Table 9. Short-run ARDL Model

```
ARDL(1,0) regression

Sample: 1991 - 2020                          Number of obs     =        30
                                             F(    2,     27)  =    140.92
                                             Prob > F          =    0.0000
                                             R-squared         =    0.9126
                                             Adj R-squared     =    0.9061
Log likelihood =  51.156585                  Root MSE          =    0.0464
```

lgTGHGEmissions	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lgTGHGEmissions						
L1.	.7881126	.1099614	7.17	0.000	.5624904	1.013735
lgGDP	.0396264	.0184489	2.15	0.041	.0017723	.0774804
_cons	1.272013	.8025609	1.58	0.125	-.3747063	2.918732

The results show that in the short run, a percentage increase in the first lag of greenhouse emissions causes a 0.78 percent increase in greenhouse emissions at the 5% statistical significance level. Furthermore, a percentage change in GDP also has a statistically significant impact on greenhouse emissions. A one percent increase in GDP leads to a 0.039 percentage increase in greenhouse emissions.

Model Diagnostics

Table 10. Short-run ARDL Model

```
Durbin-Watson d-statistic(  3,    30) =  1.983893
```

Table 11. Heteroskedasticity Test

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob > chi2
1	0.001	1	0.9811

H0: no serial correlation

Table 12. Breusch-Godfrey Test

```
White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(5)      =     6.37
         Prob > chi2  =   0.2715
```

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedasticity	6.37	5	0.2715
Skewness	1.92	2	0.3831
Kurtosis	0.10	1	0.7542
Total	8.39	8	0.3963

CUSUM and CUSUM of Squares

The CUSUM and CUSUM of squares charts are used to determine how stable the model is. If the recursive residual lies within the bounds of the critical region, it means that the estimated model is stable. Both figures of the recursive residual indicate that the model is stable. This indicates that for the period under consideration, the estimated parameters of the study are stable.

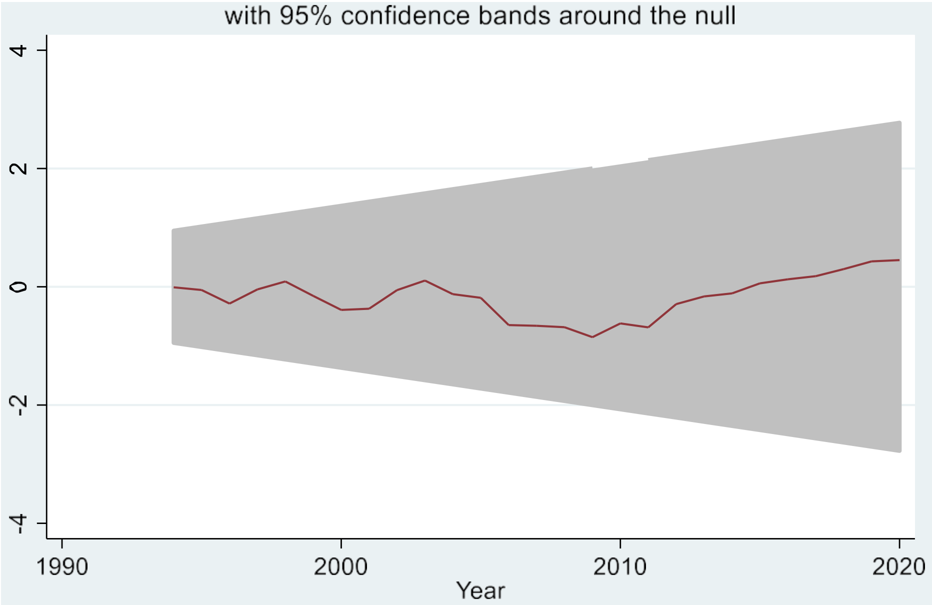

Fig. 1: CUSUM

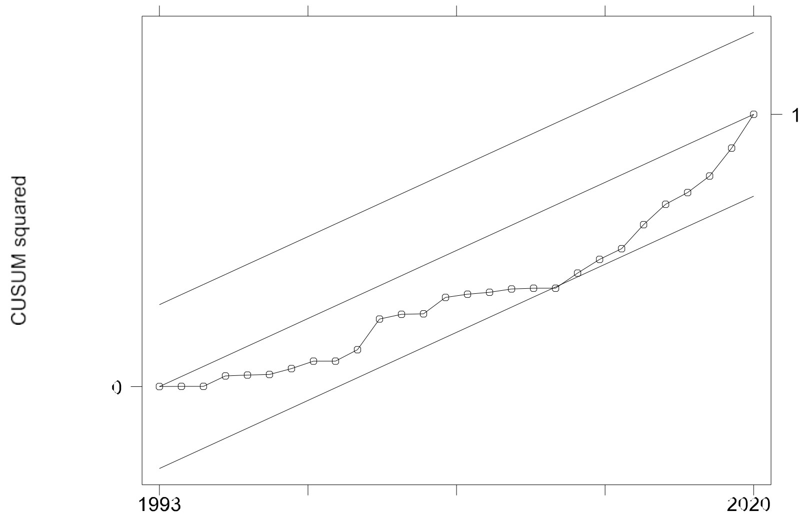

Fig. 2: CUSUM of Squares

5. Conclusion

This study aimed to examine the relationship between GDP and greenhouse gas emissions in Zambia using the ARDL model with a focus on whether the relationship aligns with the Environmental Kuznets Curve (EKC) hypothesis. The results showed that no long-run relationship existed between the two variables. However, there was a positive short-run relationship present between GDP and greenhouse emissions. In other words, a rise in GDP growth leads to an increase in greenhouse gas emissions in the immediate period.

However, the decoupling of the relationship between GDP and emissions in the long run might suggest a progression towards a more sustainable economy, where environmental degradation is not an inevitable cost of economic growth. These findings may be a possible indication of the EKC hypothesis, which means that passed a certain threshold of economic growth, Zambia is likely to experience a reverse effect in the nature of the relationship between economic growth and emissions. Therefore, policymakers should encourage investment in clean energy, sustainable economic shifting, and strengthen environmental regulations to promote long-term sustainable growth.

Future research studies can focus on examining industry-specific emission trends, evaluating the effect of technology innovation, and assessing whether the dynamics for the relationship between greenhouse emissions and economic growth in Zambia eventually reaches the EKC turning point. Furthermore, future researchers can also focus on examining this relationship with regional data from Southern African countries.

References

1) Aye, G. C., & Edoja, P. E. (2017). Effect of economic growth on CO2 emission in developing countries: Evidence from a dynamic panel threshold model. Cogent Economics & Finance, 5(1), 1379239.
2) Banday, U. J., & Aneja, R. (2019). Energy consumption, economic growth and CO2 emissions: evidence from G7 countries. World Journal of Science, Technology and Sustainable Development, 16(1), 22-39.
3) Cetin, M. A., & Bakirtas, I. (2020). The long-run environmental impacts of economic growth, financial development, and energy consumption: Evidence from emerging markets. Energy & environment, 31(4), 634-655.
4) European Environmental Agency. (2024, July 3). What is particulate matter and what are its effects on human health? European Environment Agency's Home Page. https://www.eea.europa.eu/en/about/contact-us/faqs/what-is-particulate-matter-and-what-are-its-effects-on-human health#:~:text=Particulate%20matter%20consists%20of%20a,2%2C5%20micrometers%20in%20diameter.
5) Heidari, H., Katircioğlu, S. T., & Saeidpour, L. (2015). Economic growth, CO2 emissions, and energy consumption in the five ASEAN countries. International Journal of Electrical Power & Energy Systems, 64, 785-791.
6) Hitam, M. B., & Borhan, H. B. (2012). FDI, growth and the environment: impact on quality of life in Malaysia. Procedia-Social and Behavioral Sciences, 50, 333-342.
7) Kais, S., & Ben Mbarek, M. (2017). Dynamic relationship between CO2 emissions, energy consumption and economic growth in three North African countries. International Journal of Sustainable Energy, 36(9), 840-854.
8) Kumar, V., & Chander, R. (2016). Foreign direct investment and air pollution: Granger causality analysis. IOSR Journal of Business and Management, 2(20), 12-17.
9) Merriam-Webster. (2024). pollution. In Merriam-Webster Dictionary. https://www.merriam-webster.com/dictionary/pollution
10) Overview of Greenhouse Gases | US EPA. (2024, April 11). US EPA. https://www.epa.gov/ghgemissions/overview-greenhouse-gases
11) Pesaran, M.H. and Smith, R. (1998). Structural analysis of cointegration VRS. Journal of Economic Surveys, 12: 471-505.
12) Pesaran, M.H., Shin, Y. and Smith, R. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16: 289-326.

13) Raihan, A., & Tuspekova, A. (2022). Toward a sustainable environment: Nexus between economic growth, renewable energy use, forested area, and carbon emissions in Malaysia. Resources, Conservation & Recycling Advances, 15, 200096.
14) Rana, R., & Sharma, M. (2019). Dynamic causality testing for EKC hypothesis, pollution haven hypothesis and international trade in India. The Journal of International Trade & Economic Development, 28(3), 348-364.
15) RESERVE BANK OF AUSTRALIA | Education. (2023, May 4). Economic Growth. Reserve Bank of Australia. Retrieved September 11, 2024, from https://www.rba.gov.au/education/resources/explainers/economic-growth.html
16) World Health Organization: WHO. (2019, July 30). Air pollution. https://www.who.int/health-topics/air-pollution#tab=tab_1