The Effect of Military Expenditure on Economic Growth and Environmental Quality in Uganda

Anthony Ladis Komba[*]

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Abstract

This research aims to empirically investigate how military expenditure (ME) relates with economic growth (GDP) and environmental quality (CO_2) in Uganda from 1990-2022 using a flexible autoregressive distributed lag (ARDL) model and Toda-Yamamoto Granger causality test. The results showed that in the long run, ME is positively related to GDP but the result is insignificant. However, in the long run, the effect of ME on CO_2 is positive and statistically significant. Furthermore, the short run effect of ME on GDP is negative but insignificant while on CO_2, the effect of ME is positive and significant. Additionally, the causality test results revealed a unidirectional causality running from ME to GDP and ME to CO_2. Also, a bidirectional causality flows from population growth (PG) to GDP and CO_2 while a unidirectional causality flows from gross capital formation (GCF) to GDP and CO_2. From these results, Uganda policymakers should encourage military spending since it yields a positive effect on economic growth but should keep in mind of the environmental quality to align with Sustainable Development Goal 13. However, other sectors of the economy like education, agriculture should not be abandoned.

Keywords: Military expenditure; Economic growth; Environmental Quality: Toda-Yamamoto

JEL Classification: E01, E21

[*] Istanbul Ticaret University, *Post Graduate Student, aladis.komba@istanbulticaret.edu.tr, https://orcid.org/0009-0007-2007-6271*

1. Introduction

The effect of military expenditure on economic growth and environment has been widely studied by many scholars. Military expenditure and economic growth studies have been a debate with no general conclusion over the years. Several of these studies on the effect of military expenditure on economic growth have based on panel series which foregoes heterogeneity of each country. A dynamic panel studied by Hsin-Cheng et al., (2011) tried to create heterogeneity among the countries by grouping 91 countries into groups of high-, middle- and low-income countries. However, this would bring an aggregate result for each group rather than results from each country. For example, Uganda where the focus of this study lies is a low-income country but does not mean their results would be similar. Figure 1 shows the military expenditure in Uganda from 1990-2022. From the 1990s the amount spent on military reduced significantly following the end of pollical chaos and the emergency of new Museveni regime.

In recent years, the world has experienced military powers from the powerful economies invading the less powerful economies with Russia-Ukraine and Israel-Palestine. Meanwhile stability in Africa has been a question over the past decade. There have been several coups mostly in West and Central Africa followed by a number or rebel groups resurfacing. One famous rebel group Boko Haram in Nigeria terrorized the North of Nigeria for several years and are still in operation to this date. In Democratic Republic of Congo have had their share of terror from M23 a rebel group that was thought to have weakened but have re-emerged in recent years in Rwanda-DRC conflict (Ntanyoma, 2022). Political unstable African nations have been among the most underdeveloped on the continent showing stability is key to economy growth.

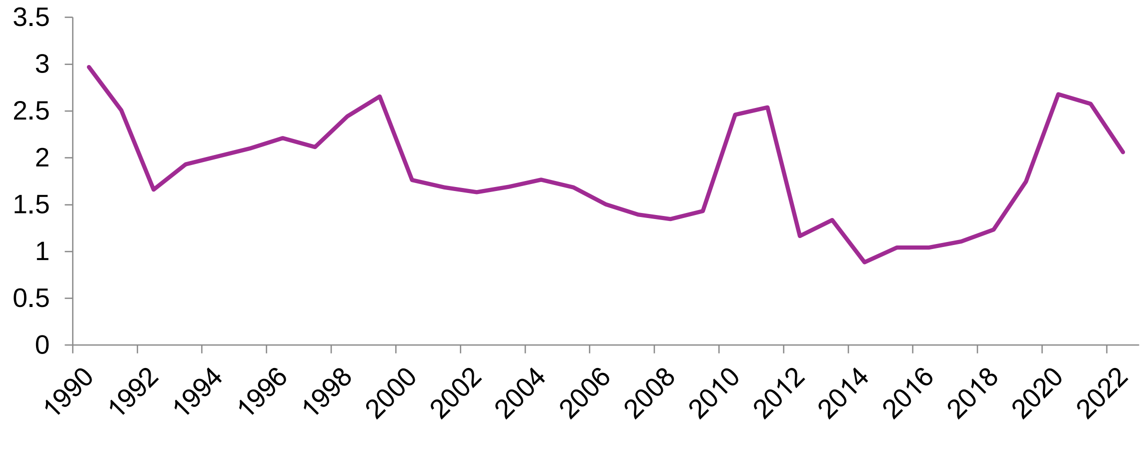

Figure 1: Military expenditure from 1990-2022. Source: WDI

East Africa has been a peaceful place to in Africa with less conflicts than other parts of Africa but there have had conflicts as well. Rwanda and Burundi battled each other during the tribal conflicts 1993-1994 where more than 800,000 civilians were killed (Meierhenrich, 2020). Uganda and Tanzania had conflict in famous Kagera war in 1977 where thousands of civilians were killed and displaced. The conflict was initiated by the Ugandan leader at the time, Iddi Amin Dada claiming part of Tanzania's territory under the famous Mwalimu Julius Nyerere. This war drained the economies of two nations and hindered growth of other sectors (Brown-Acheson, 2016). Meanwhile Kenya has had prolonged conflicts with Al Shaabab, a rebel group from Somalia. With such instability, investment activities shrink which eventually decreases economic growth. Military intervention is needed to restore and maintain stability to encourage investments and thereby growth.

Stockholm International Peace Research Institute SIPRI (2022) military expenditure database show that Africa countries had a total of $39.4 billion in 2022 a decrease of 5.3% from 2021. Algeria and Morocco were the biggest spenders on the continent occupying 74% of the total Africa military spending. Nigeria recorded a big drop in the military spending of 38% from the previous year but still faced several conflicts from farmer-herder and violent extremism. This could be because of their government redirecting funds to carter for damages left by floods in 2022 damaging property and displacing citizens. The biggest increase in military expenditure was however recorded by Ethiopia by 88% due to the renewed government offensive measures against Tigray People's Liberation Front located based in the north of Ethiopia. This paper focuses on Uganda that recorded $0.9 billion in military expenditure. East African countries allocated $3.1 billion in 2022 with Kenya having the biggest military spending of $1.1 billion, Tanzania 0.8 billion, Rwanda with $0.2 billion and Burundi with$ 0.1 billion (SIPRI 2022).

The causation from military to environmental quality could be explained with various ideas. One argument is that through military activities either in conflicts or during projects tend to pollute air and thereby harm the environment. In support of this argument, Saritas & Burmaoglu, (2016) explains a vital positive link between crude oil and military activities despite great progress in developing alternative technologies. Burning of crude oil depletes the environment. If military activities increase the dependence of crude oil which in turn increases air pollution hence military activities also deplete the environment. Lawrence et al., (2015) shows military expenditures increase CO_2 emissions due to the widespread use of oil fuels in national military departments The other argument is that through military research and development new environmentally safe technologies will be developed (Solarin, Al-Mulali, & Ozturk, 2018).

Hence this study focuses on specific low-income East African countries specifically Uganda and identify how military expenditure affects economic growth and environment. Uganda has had periods of peace and of war therefore would be a good suit for this study that aims to examine the effect of military expenditure in less war-torn countries. The section that follows explains the related literature in section 2. Section 3 describes the data used and methodology. Section 4 provides the econometric results and section 5 concludes and offers policy recommendations.

2. Literature Review

The literature pool has plenty of work on causation between military expenditure and growth but not so much on military expenditure and environment quality. Scholars like Abdu-Bader & Abu-Qarn, (2003); Dakurah et al. (2001); Dunne &Tian (2020), Heo, (1998); Kollias & Makrydakis (2000); Kusi, (1994) have contributed on military expenditure while Lawrence et al., (2015); Hooks & Smith (2005); Chen et al., (2023) have had their say on military expenditure and environment. Despite their efforts, a general causation results between military expenditure, growth, and environment have no general conclusion. These differences in empirical results could be since the theoretical methods employed, samples selected, and time chosen are different from study to study (Ram, 1995).

The causation has been found to be vary between unidirectional, bi-directional and no causation. A causation from military expenditure shows the economics demand more for military activities as well as spill-offs from research and development that lead to more utilization of capital stock and higher employment. Meanwhile, a causation to military expenditure shows the economies are trying to spend more on military activities for security purposes (Kollias & Paleologou, 2004).

2.1 Military Expenditure and Economic Growth

The direction of causality is crucial in determining policy implications whether to focus on economic growth or on military expenditure and shows endogeneity or exogeneity. Experts have found different results depending on the income level of a country and the methodology used. However, there is a broad political and academic debate about the direction of causality between the two variables in net arms exporting and importing countries and among countries with different levels of development. The positive relations have been evidenced more from developed economies than developing ones. The developed nations consider offensive military expenditure which leads to producing arms for commercial purposes. In doing so, employment opportunities are created and income through exports. (Alptekin & Levine , 2012) provide evidence that most developed countries have offensive military expenditure hence tending towards a positive relationship.

The works of Chen, Lee, & Chiu (2014) used a two-step Generalized Method of Moments (GMM) on 137 countries to analyse the causality between the two variables. They found short-run unidirectional, bidirectional and no causality in the 137 countries. A short-run causality from defence burden to real GDP in lower-middle income and high-income countries. Also found from real GDP to defence burden short-run causality. In Asia, Europe they found a bidirectional short-run causality. No causality was found in upper-middle income, European and central Asian and Sub-Saharan African countries. A study from Chang et al., (2011) found that increases in military spending led to decrease in economic growth in low-income countries of Africa, Eastern Europe, the Middle East, Asia Meridional, and the Pacific basin.

Ortiz et al., (2019) in their study covering 126 countries found a unidirectional causality from real output to military spending in high income countries and from military spending to real output in upper-middle and lower middle- income countries. They also found no causality relationship lower income countries. Muhammad (2020) uses the pairwise Dumitrescu Hurlin panel causality test results exhibit causality between military expenses and economic growth where he found bi-directional relationship.

Finally, in a study of Saba & Ngepah (2019) analysed military spending and economic growth for 35 African countries over 1990–15 and found four causality relationship; (a) no causal link in seven countries; (b) unidirectional causality from military spending to growth in two countries; (c) unidirectional causality from growth one-way in 14 countries; and (d) bidirectional causality in 12 countries. Although there are several academicians that found a causality relationship, study of Abdel-Khalek et al., (2019) failed to find any causal linkages between military spending and economic growth in India over 1980–16 where they used the Hendry General-to-Specific model.

2.2 Military Expenditure and Environmental Quality

Most arguments reveal a positive relationship between military expenditure and environment, but some studies show negative relationship. One argument is that through military activities either in conflicts or during projects tend to pollute air and thereby harm the environment. In support of this argument, Saritas & Burmaoglu (2016) explains a vital positive link between crude oil and military activities despite great progress in developing alternative technologies. Burning of crude oil depletes the environment, then if military activities increase the dependence of crude oil which in turn increases air pollution military activities also deplete the environment. Lawrence et al.,(2015) shows military expenditures increase CO_2 emissions due to the widespread use of oil fuels in national military departments. The other argument is that through military research and development new environmentally safe technologies will be developed.

In the studies of Hooks & Smith, (2005) developed the term "treadmill of destruction" describing militaries' destructive theory on environment. They argued that militarism damages the environment during times of war and peace. The results were supported by Solarin et al., (2018) who looked at the environmental impact of military expenditure in the United States from 1960 to 2015 and found military expenditure reduces ecological footprint. Another argument using ecological footprint for environment was by Ahmed, Zafar, & Mansoor, (2020) in Pakistan using a causality and cointegration tests finding military expenditure reduces ecological footprint and unidirectional causality from military expenditure.

Military expenditure increases with increases in geopolitical risks like wars, conflicts, rebellions Studies of Chen et al., (2023); Pata & Ertugrul (2023); Wang et al., (2023) show that in 2020s geopolitical risks have negative effects on the environment in both developing and advanced economies. Still on geopolitical risks, Bildirici & Gokmenoglu, (2020) show that terrorism increase CO_2 emissions using the panel Autoregressive Distributed Lag (ARDL) approach. Similar results were found by Bildirici (2021) that terrorism increases CO_2 emissions in China, India, Israel, and Türkiye. Recent studies of Saba (2023) on militarization, economic growth and CO_2 emissions in South Africa found no causal relationship between military spending and CO_2 emissions.

3. Data and Methodology

This article focuses on Uganda from the period of 1990-2022. The selection of these period was due to the availability of data and it the period Uganda gained peace after years of pollical unrests. Two models are employed to understand the long run and short run relationship between military expenditure, economic growth and environmental quality and the predictive power between these variables. For this case, ARDL bound testing technique to understand the long run and short run dynamics and Toda-Yamamoto Granger causality to understand the predictive powers. The table 1 shows the studied variables and their sources.

Table 1: Data used and their sources.

Symbol	Variable	Indicator	Variable Type	Measurement	Source
$\boldsymbol{ME}$	Military spending	Military expenditure	Independent	% of GDP	SPRI
$\boldsymbol{GDP}$	Economic growth	GDP per capita	Dependent	constant 2015 US$)	WDI
$\boldsymbol{CO_2}$	Environmental Quality	Per capita CO_2 emissions	Dependent	tons	OWD
$\boldsymbol{PG}$	Population growth	Population growth	Control	Annual growth (%)	WDI
$\boldsymbol{GCF}$	Investment	Gross Capital Formation	Control	% of GDP	WDI

The data is logged and tested for stationary with traditional Augmented Dickey Fuller (ADF) tests by Dickey & Fuller, (1997) and further analysed by Phillips-Perron (PP) by Phillips & Perron, (1988) to determine the number of integrations I (d) before the data is stationary. The tests are completed with ARDL and Toda and Yamamoto (1995) Granger Causality.

3.1 Autoregressive Distributed Lag Model

The long run and short run effects military expenditure (explanatory variable) on economic growth (dependent variable) will be examined with ARDL model with population growth and gross capital formulation as control variables. Equation 1 and 2 provide a simple understanding of the growth model.

$$GDP_t = f(ME_t, PG_t, GCF_t) \tag{1}$$

$$CO_{2_t} = f(ME_t, PG_t, GCF_t) \tag{2}$$

After the data is logged, this will eliminate heteroscedasticity issue and non-linear function forms. Two equations will help capture the effect of military expenditure on growth and environment separately. Equations 1 and 2 can be further expanded to form an ARDL equation with the long-run in the first part and the short-run in the second part as in equation 3 and 4.

Where L stands for variables' natural logarithm, μ_t and ε_t are error terms for equation 3 and 4 respectively. t denotes time period. The autoregressive distribute lag model as proposed by Pesaran et al. (2001) is used because of its superiority over other methods of linear regression. It has the ability to figure out between the values of dependent and independent variables in a sparse manner, this has made it to have an edge over the remarkable Johansen and Juselius (1990) model. The short-run effect is captured by error correction model (ECM) as in equation 5 and 6.

$$\Delta LGDP_t = \alpha_0 + \alpha_1 LGDP_{t-1} + \alpha_1 LME_t + \alpha_2 LPG_t + \alpha_3 LGCF_t + \sum_{j=1}^{p} \varphi_1 \Delta LGDP_{t-1} + \sum_{j=1}^{p_1} \sigma_{2,j} \Delta LME_{t-1} + \sum_{j=1}^{p_2} \sigma_{3,j} \Delta LPG_{t-1} + \sum_{j=1}^{p_3} \sigma_{4,j} LGCF_{t-1} + \mu_t \quad (3)$$

$$\Delta LCO_{2_t} = \beta_0 + \beta_1 LCO_{2_{t-1}} + \beta_2 LME_t + \beta_3 LPG_t + \beta_4 LGCF_t + \sum_{j=1}^{q} \lambda_1 \Delta LCO_{2_{t-1}} + \sum_{j=1}^{q_1} \lambda_{2j} \Delta LME_{t-1} + \sum_{j=1}^{q_2} \lambda_{3j} \Delta LPG_{t-1} + \sum_{j=1}^{q_1} \lambda_{4j} LGCF_{t-1} + \varepsilon_t \quad (4)$$

$$ECT_{t-1} = \Delta LGDP_t = \alpha_0 + \sum_{j=1}^{p} \varphi_1 \Delta LGDP_{t-1} + \sum_{j=1}^{p_1} \sigma_{2,j} \Delta LME_{t-1} + \sum_{j=1}^{p_2} \sigma_{3,j} \Delta LPG_{t-1} + \sum_{j=1}^{p_3} \sigma_{4,j} LGCF_{t-1} + \emptyset Z_{t-1} + \mu_t \quad (5)$$

$$ECT_{t-1} = \Delta LCO_{2_t} = \beta_0 + \sum_{j=1}^{q} \lambda_1 \Delta LCO_{2_{t-1}} + \sum_{j=1}^{q_1} \lambda_{2j} \Delta LME_{t-1} + \sum_{j=1}^{q_2} \lambda_{3j} \Delta LPG_{t-1} + \sum_{j=1}^{q_3} \lambda_{4,j} LGCF_{t-1} + \gamma Z_{t-1} + \varepsilon_t \quad (6)$$

Where q and p stand for the model's lag order. α_{1-3} and β_{1-3} represents the long-run parameters while φ_{1j} and λ_{1j} represent the short-run parameters. Δ denotes first differenced element and t is the time period. $\emptyset$ and γ measure the speed of adjustment to the long-run equilibrium.

According to Pesaran et al (2001), estimating the ARDL model requires to first do an F-test which will determine the combined significance of lagged variables then followed by determining the null hypothesis for the absence of a long-run relationship and comparing it with the alternative hypothesis, i.e. $H_0: \pi_{i1} = \pi_{i2} = \pi_{i3} = \pi_{i4} = 0$ against . $H_1: \pi_{ij} \neq 0, i = 1, \dots, 4$. In accordance with Pesaran et al (2001) the lower boundaries critical values are I(0) while the upper boundaries are I(1). When the F-statistic is greater than the upper boundary critical value the null hypothesis is rejected and if its lower than the lower boundary then the null hypothesis is not rejected.

3.2 Toda-Yamamoto Granger Causality

The main objective of this study is to understand the causal link between military expenditure, economic growth, and environment. The importance of causal analysis when it comes to creating policies which variables predicts the other and how strong is it. Since the variables are integrated of different orders, Toda and Yamamoto (1995) Granger Causality is the best over the traditional Granger Causality test. Equation 7 and 8 illustrates Toda-Yamamoto Granger Causality with the variables remain as previously defined.

$$\begin{bmatrix} LGDP_t \\ LME_t \\ LPG_t \\ LGCF_t \end{bmatrix} = \begin{bmatrix} e_1 \\ e_1 \\ e_1 \\ e_1 \end{bmatrix} + \sum_{i=1}^{p} \begin{bmatrix} \partial_{11i}\partial_{12i}\partial_{13i}\partial_{14i} \\ \partial_{21i}\partial_{22i}\partial_{23i}\partial_{24i} \\ \partial_{31i}\partial_{32i}\partial_{33i}\partial_{34i} \\ \partial_{41i}\partial_{42i}\partial_{43i}\partial_{44i} \end{bmatrix} \times \begin{bmatrix} LGDP_{t-i} \\ LME_{t-i} \\ LPG_{t-i} \\ LGCF_{t-i} \end{bmatrix} \times \begin{bmatrix} LGDP_{t-j} \\ LME_{t-j} \\ LPG_{t-j} \\ LGCF_{t-j} \end{bmatrix} + \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ \epsilon_{3t} \\ \epsilon_{4t} \end{bmatrix} \quad (7)$$

$$\begin{bmatrix} LCO_{2t} \\ LME_t \\ LPG_t \\ LGCF_t \end{bmatrix} = \begin{bmatrix} \theta \\ \sigma \\ \psi \\ \alpha \end{bmatrix} + \sum_{i=1}^{p} \begin{bmatrix} \partial_{11i}\partial_{12i}\partial_{13i}\partial_{14i} \\ \partial_{21i}\partial_{22i}\partial_{23i}\partial_{24i} \\ \partial_{31i}\partial_{32i}\partial_{33i}\partial_{34i} \\ \partial_{41i}\partial_{42i}\partial_{43i}\partial_{44i} \end{bmatrix} \times \begin{bmatrix} LCO_{2t-i} \\ LME_{t-i} \\ LPG_{t-i} \\ LGCF_{t-i} \end{bmatrix} \times \begin{bmatrix} LGDP_{t-j} \\ LME_{t-j} \\ LPG_{t-j} \\ LGCF_{t-j} \end{bmatrix} + \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ \epsilon_{3t} \\ \epsilon_{4t} \end{bmatrix} \quad (8)$$

Toda-Yamamoto Granger Causality makes use of Wald statistic distribution that VAR(p+dmax), with dmax denoting the maximum order of integration of the variables in the VAR system and p is the lag selected.

The null hypothesis is that the independent variable does not granger cause the dependent variable. Rejecting the null hypothesis shows that military expenditure granger causes economic growth. The same approach is repeated for CO_2.

4. Empirical Results

4.1 Preliminary Results

Table 2.0 shows yearly data of a logged series in Uganda. GDP is observed to have the highest mean on 6.4441 while CO_2 with the lowest of -2.5756. PG is seen to have the lowest volatility of 0.0701while CO_2 with the largest of 0.4446. Jarque-Bera show that the data is linear with the p values not being significant even at 10%.

Table 2: descriptive statistics of log data of GDP, CO_2, ME, PG, GCF for Uganda

	LGDP	LCO_2	LME	LPG	LGCF
Mean	6.4441	-2.5756	0.5570	1.1266	3.0452
Median	6.4781	-2.4909	0.5582	1.1134	3.0948
Maximum	6.8398	-2.0078	1.0880	1.2517	3.4649
Minimum	5.9121	-3.3470	-0.1219	0.9980	2.5186
Std. Dev.	0.3149	0.4446	0.3175	0.0701	0.2319
Skewness	-0.2670	-0.1259	-0.2704	0.1693	-0.6412
Kurtosis	1.6480	1.4667	2.1861	1.9488	2.6989
Jarque-Bera	2.9055	3.3194	1.3131	1.6769	2.3859
Probability	0.2339	0.1901	0.5186	0.4323	0.3033

From Table 2.1, military expenditure is observed to have a medium negative relationship with economic growth and environment that is significant at 1%. Population growth also has a weak relationship with growth (negative) and environment (positive) not significant even at 10% level of significance. Finally, gross capital formation has a very strong positive relationship on growth and environment.

Table 2.1: Correlation matrix

	LGDP	LCO_2	LME	LPG	LGCF
LGDP	1.0000				
LCO_2	0.9841	1.0000			
	[0.000*]				
LME	-0.4503	-0.432748	1.0000		
	[0.0085*]	[0.0119**]			
LPG	-0.0289	0.0276	-0.0093	1.0000	
	[0.8727]	[0.8787]	[0.9589]		
LGCF	0.8993	0.8726	-0.4758	-0.1431	1.0000
	[0.0000*]	[0.0000*]	[0.0051*]	[0.4268]	

Values in [] show probability value, * p value < 1%, ** p value< 5%

From Table 2.2 it is observed that, with ADF unit root test the data is stationary after first differencing except for GDP that is stationary at level. Table 2.2 proves these results by showing that the entire data in stationary after first differencing. Therefore, the data is integrated of order one, I (1).

Table 2.2: Augmented Dickey Fuller (ADF) unit root test results

Variable	Level		First Difference	
	C	C&T	C	C&T
LGDP	-1.9613	0.1474	-3.9505	-4.4465
	[0.0004*]	[0.9964]	[0.0049*]	[0.0068*]
LCO_2	-0.6277	-1.9667	-5.1541	-5.0712
	[0.8506]	[0.5966]	[0.0002*]	[0.0015*]
LME	-2.6981	-2.4980	-5.3517	-5.3340
	[0.0854]	[0.3269]	[0.0001*]	[0.0008*]
LPG	-3.1301	-3.1139	-4.0274	-3.9470
	[0.0346**]	[0.1208]	[0.0040*]	[0.0218*]
LGCF	-2.3809	-3.2147	-8.0068	-8.0408
	[0.1548]	[0.0996]	[0.0000]	[0.0000]

t-statistic and probability value [], * p value < 1%, ** p value< 5%

Table 2.3: Phillips-Perron (PP) unit root test results

Variable	Level		First Difference	
	C	C&T	C	C&T
LGDP	-1.7715	-0.1226	-3.9339	-4.4465
	[0.3872]	[0.9921]	[0.0051*]	[0.0068*]
LCO_2	-1.1058	-2.1025	-5.1354	-5.0500
	[0.7121]	[0.5249]	[0.0002*]	[0.0015*]
LME	-2.7761	-2.6284	-5.5730	-6.1663
	[0.0730]	[0.2711]	[0.0001*]	[0.0001*]
LPG	-2.3353	-2.1571	-3.7488	-3.6061
	[0.1676]	[0.4960]	[0.0081*]	[0.0457*]
LGCF	-2.3728	-3.2411	-9.3888	-13.9383
	[0.1570]	[0.0946]	[0.0000*]	[0.0000*]

t-statistic and probability value [], * p value < 1%, ** p value< 5%

In table 2.2 and table 2.3, C denotes with constant while C & T denotes with constant and trend.

4.2 Long-run ARDL Results

Two equations were developed to determine the effect of military expenditure on economic growth and environmental quality in Uganda. Table 3.1 shows the long-run dynamics with GDP as the dependent variable. It proved that a 1%-point change in military expenditure resulted to a 0.2615%-point increase in economic growth, but the results are not significant. These results contradict those made by Chang et al. (2011) in low-income countries where military expenditure decreased economic growth. This could imply Uganda is demanding more military services which will in turn lead to more employment of labour that will eventually result into increased output. A unit point change in population growth and gross capital formulation have very strong positive impact of 1.3815% and 1.5007% on economic growth with the results being statistically significant at 1% level. This confirms that the growing population of Uganda has a significant role on economic growth on the country. In Table 3.1.1 the F-statistic 7.8749 is greater than the upper boundary 4.84 at 1% hence rejecting the null hypothesis that there is no long-run relationship.

Table 3.1: Long run levels Equation with GDP as dependent variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LME	0.2615	0.2821	0.9271	0.3676
LPG	1.3815	0.5829	2.3699	0.0307**
LGCF	1.5007	0.1974	7.6010	0.0000*

* p value < 1%, ** p value< 5%; The maximum and optional lag order is 4.

Table 3.1.1: F-Bounds Test showing longrun relationship

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	7.8749	10%	2.01	3.1
K	3	5%	2.45	3.63
		2.5%	2.87	4.16
		1%	3.42	4.84

From table 3.3, a unit point change in military expenditure increases CO_2 emissions by 0.6889% in the long-run but the results are significant at 10%. This contradicts the long-run results that are positive. This implies that the military activities in Uganda contribute to a big percentage to the depletion of the environment and suitable policy measure should be considered. Results concluded by Lawrence et al. (2015) support those in this study, they observed military expenditure to increase CO_2 emissions due to the fact that military activities use plenty of oil fuels. In the long-run, population growth decreases environmental depletion by 7.1234% while gross capital formation increases the depletion of the environment by 1.7994%. The long-run relationship is proved by the F-bound test with the F-statistic 7.9108 being greater than the upper boundary 4.84 indication a long-run relationship.

Table 3.3: Long run levels Equation with CO_2 as dependent variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LME	0.6889	0.3725	1.8495	0.0818
LPG	-7.1234	1.1019	-6.4642	0.0000*
LGCF	1.7994	0.3799	4.7358	0.0002*

* p value < 1%, ** p value< 5% level of significance. The maximum and optional lag order is 4.

Table 3.3.1: F-Bounds Test showing long-run relationship

Test Statistic	Value	Significance.	I (0)	I (1)
F-statistic	7.9108	10%	2.01	3.1
K	3	5%	2.45	3.63
		2.5%	2.87	4.16
		1%	3.42	4.84

Note: I (0)= lower boundary; I(1)=upper boundary * denotes 1% level of significance

4.3 Short-run ARDL Results

Table 3.2 illustrates the short-run effect of military expenditure on economic growth. A positive error correction term was recorded indicating a positive adjustment towards the long-run equilibrium at a rate of 11.02%. A percentage point change in Population growth decrease economic growth by 0.3163% while a percentage point change in gross capital formation increased economic growth by 0.0375% in the short-run.

Table 3.2: ECM Regression with GDP as dependent variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LME)	-0.0177	0.0146	-1.2117	0.2432
D(LME(-1))	0.0124	0.0144	0.8579	0.4036
D(LME(-2))	-0.0246	0.0143	-1.7146	0.1057
D(LME(-3))	-0.0286	0.0161	-1.7773	0.0945
D(LPG)	-0.3163	0.0706	-4.4764	0.0004*
D(LGCF)	0.0375	0.0428	0.8756	0.3942
D(LGCF(-1))	0.1461	0.0362	4.0365	0.0010*
D(LGCF(-2))	0.1259	0.0347	3.6299	0.0023*
D(LGCF(-3))	0.1241	0.0314	3.9515	0.0011*
ECM(-1)*	0.1102	0.0180	6.1160	0.0000*
R-squared	0.5747			
Adjusted R-squared	0.3732			

* p value < 1%, ** p value< 5% level of significance

Table 3.4 provides the short-run effect of military expenditure on environment; the effect is seen to be positive and significant at 1%. A 1%-point change in military expenditure led to an increase in CO_2 emissions by 0.2305%. The results fall in line with those in the long-run hence both in the long-run and short-run military expenditure increases CO_2 emissions. A percentage point change in population growth reduced environmental depletion by 0.3172%. A similar effect is observed when there is a percentage point change in gross capital formation, CO_2 emissions reduced by 0.4775%. At a rate of 17.54% the short-run equilibrium is adjusted negatively to the long-run equilibrium.

Table 3.4: ECM Regression with CO_2 as dependent variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LME)	0.2305	0.0545	4.2256	0.0006*
D(LPG)	-0.3172	0.2626	-1.2078	0.2436
D(LPG(-1))	0.0157	0.3398	0.0463	0.9636
D(LPG(-2))	0.6886	0.3403	2.0234	0.0590
D(LGCF)	-0.4775	0.1651	-2.8907	0.0102*
D(LGCF(-1))	-0.6908	0.1892	-3.6506	0.0020*
D(LGCF(-2))	-0.7454	0.1829	-4.0742	0.0008*
D(LGCF(-3))	-0.5426	0.1309	-4.1434	0.0007*
ECM(-1)	-0.1754	0.0287	-6.1014	0.0000*
R-squared	0.6278			
Adjusted R-squared	0.4790			

* p value < 1%, ** p value< 5% level of significance

4.4 Toda-Yamamoto Granger Causality Results

Toda-Yamamoto Granger Causality test is used to determine the direction of the causal relationship between the selected variables in this study. Causality analysis is the main goal of this study and this model allow to achieve it. The results may serve as guidance to the Uganda policy makers in military expenditure, economic growth and environment. Table 4.1 provides the findings of Toda-Yamamoto Granger causality results. The variables in red are independent variables while those in black are dependent variables such that the null hypothesis is the independent variable does not granger cause the dependent variable.

It has been observed that. Military expenditure granger causes economic growth, but economic growth does not granger cause military expenditure forming a unidirectional causality from military expenditure to growth. This implies that, a change in the policies on military expenditure will predict growth of Uganda's economy. These results were also found by Ortiz et al. (2019) in low-income countries where the causality moved from military spending to real output. Both population growth and gross capital granger cause growth but growth only granger causes population growth but not gross capital formation. Hence a bidirectional causality between population growth and economic growth but a unidirectional causality from gross capital formation to growth. This prove that human resource has predictive power in the economic growth of Uganda.

Table 4.2 illustrates the causal linkage between environmental quality and the other variables with the exception of economic growth. For environment, which is indicated by CO_2 emission, military expenditure granger causes environment, but environment does not granger cause military expenditure. The unidirectional causality from military expenditure to economic growth was also observed by Ahmed, Zafar & Mansoor (2020) in Pakistan. This explains how policy changes on military expenditure have a strong predictive power on the environment. Bidirectional causality from environment to population growth while a unidirectional causality from gross capital formation to environment.

Table 4.1: Causality Results

Variables	LGDP	LME	LPG	LGCF
LGDP	….	2.4523	68.9134	1.0668
	….	[0.6532]	[0.0000*]	[0.8995]
LME	52.75512	….	66.0959	2.9596
	[0.0000*]	….	[0.0000*]	[0.5646]
LPG	132.2485	0.6775	….	2.9031
	[0.0000*]	[0.9541]	….	[0.5742]
LGCF	114.5928	4.9363	388.5587	….
	[0.0000*]	[0.2939]	[0.0000*]	….

Chi-sq values and p values []; * p value < 1%, ** p value< 5% level of significance

Table 4.2: Causality Results

Variables	LCO_2	LME	LPG	LGCF
LCO_2	….	1.4160	132.5271	2.5952
	….	[0.9541]	[0.0000*]	[0.6277]
LME	2387.8730	….	66.0959	2.9596
	[0.0000*]	….	[0.0000*]	[0.5646]
LPG	2208.4340	0.6775	….	2.9031
	[0.0000*]	[0.9541]	….	[0.5742]
LGCF	1139.8490	4.9363	388.5587	….
	[0.0000*]	[0.2939]	[0.0000*]	….

Chi-sq values and p values []; * p value < 1%, ** p value< 5% level of significance

5. Conclusion and Recommendation

The study's aim is to examine the causal relationship between military expenditure on economic growth and environmental quality in Uganda from 1990-2022. Uganda being a low-income country in East Africa provide a suitable case study for countries whose military expenditure is not influenced by war. Two models are employed to determine the causal linkage as well as the long-run and short-run dynamics using Toda-Yamamoto Granger causality and Autoregressive Distributed lag models respectively.

Military expenditure was observed to have a unidirectional causality to economic growth and environment. The results imply that, military expenditure has a predictive power over environment and economic growth. Policies directed towards military expenditure such that the amount spent is increased or decreased will have a significant impact on economic growth and environment. Linking the causal results with the ARDL results, military expenditure in Uganda has a positive effect in the long-run while a negative in the short-run. Since military expenditure has predictive power over economic growth, an increase in military expenditure such as through employment of more soldiers will positively affect economic growth but not in the short-run. Therefore, Uganda should further proceed with the demand of military activities but to a strict percentage of national budget to cater for other sectors of the economy like education.

Both in the short-run and long-run, military expenditure in Uganda increased CO_2 emissions. As explained by Hooks & Smith (2005) this could be due to release of radioactive elements and pollutants; movement of defence equipment with requires consumption of dirty fuels. Uganda should therefore reconsider their military activities to comply with Sustainable Development Goal 13 (SDG 13). The control variable population growth and gross capital formation in this study. A bidirectional causality was found from population growth to economic growth and environment implying that a change in policies on one could affect the other. In the long-run while keeping other factors constant, population growth affects economic growth positively and reduces the CO_2 emissions in Uganda. This could imply that the growing population is educated of the dangers of depleting the environment and is a resource to the government. In the short-run, a change in population growth reduced economic growth and CO_2 emissions. Gross capital formation granger causes economic growth and CO_2 emissions, but the dependent variables do not granger cause gross capital formation. The unidirectional causality shows that the past values of gross capital formation have a predictive power over economic growth and CO_2 emissions. In the long-run, gross capital formation increases both economic growth and environment but in the short-run it only increases growth and reduces CO_2 emissions. Increase in gross capital formation will increase employment which will lead to more output. But in doing so, physical capital like industries will further emit CO_2 into the atmosphere and the effect if realised in the long-run.

6. References

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