



**T.C
ISTANBUL TICARET UNIVERSITY
INSTITUTE OF GRADUATE SCHOOL
DEPARTMENT OF ECONOMICS
MASTER OF ECONOMICS PROGRAMME**

**EXAMINING THE ROLE OF MILITARY EXPENDITURE ON
ECONOMIC GROWTH AND ENVIRONMENT IN FIVE EAST
AFRICAN COUNTRIES: A QUANTILE-ON-QUANTILE
GRANGER CAUSALITY ANALYSIS.**

MSc Thesis

Anthony Ladis KOMBA

January, 2025



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DEDICATION

I dedicate all the required information in this title ‘Examining the Role of Military Expenditure on Economic Growth and Environment In Five East African Countries: A Quantile-On-Quantile Granger Causality Analysis’ has been written per the academic manners and ethical commitment. I would clarify that all the materials, sources, data and all extra inputs have been benefited well throughout the writing procedure of this thesis. All matters contained in this thesis are my opinion and do not reflect the official view of Istanbul Ticaret University.

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ABSTRACT

The research aims to empirically analyse the causal relationship between militarization, economic growth and environment in Tanzania, Kenya, Uganda, Rwanda and Burundi. Data is collected for the five East African countries from 1990Q1 to 2022Q4 from World Development Indicators and Stockholm International Peace and Research Institute. A novel Quantile-on Quantile Granger causality is the main approach to investigate the predictive content of militarization for economic growth and the environment. A traditional Granger Causality is also employed. It was observed that traditional Granger causality failed to identify any causal effect of militarization on Granger cause growth and environment in the five countries. However, Quantile-on-Quantile Granger causality found the predictive content of militarization to flow from its lower and upper quantiles to the lower and upper quantiles of growth and environment. This suggests that militarization has a stronger influence on high and low military expenditure. Therefore, governments and policymakers should prioritize to balance between militarization and other government expenses to ensure peace, stability and stimulate growth. Similarly, environment friendly military equipment should be employed to coup with environment and comply with SDG 13.

Keywords: *Militarization; Economic growth; Environment; East African Countries; Quantile-on-Quantile-Granger Causality*

ÖZET

Bu araştırma, Tanzanya, Kenya, Uganda, Ruanda ve Burundi'de militarizasyon, ekonomik büyüme ve çevre arasındaki nedensel ilişkiyi ampirik olarak analiz etmeyi amaçlamaktadır. Veriler, 1990Q1'den 2022Q4'e kadar bu beş Doğu Afrika ülkesi için Dünya Kalkınma Göstergeleri ve Stockholm Uluslararası Barış Araştırmaları Enstitüsü'nden toplanmıştır. Militarizasyonun ekonomik büyüme ve çevre üzerindeki tahmin edici içeriğini incelemek için ana yaklaşım olarak yeni bir Kuantilden Kuantile Granger nedenselliği kullanılmıştır. Ayrıca, geleneksel Granger Nedenselliği de uygulanmıştır. Geleneksel Granger nedenselliğinin, militarizasyonun büyüme ve çevre üzerinde herhangi bir nedensel etkiyi belirleyemediği gözlemlenmiştir. Ancak, Kuantilden Kuantile Granger nedenselliği, militarizasyonun tahmin edici içeriğinin, militarizasyonun alt ve üst kuantillerinden büyüme ve çevrenin alt ve üst kuantillerine doğru aktığı tespit edilmiştir. Bu, militarizasyonun yüksek ve düşük askeri harcamalar üzerinde daha güçlü bir etkisi olduğunu göstermektedir. Bu nedenle, hükümetler ve politika yapıcılar, barışı, istikrarı sağlamak ve büyümeyi teşvik etmek için militarizasyon ile diğer hükümet harcamaları arasında bir denge kurmayı önceliklendirmelidir. Benzer şekilde, çevre dostu askeri ekipmanlar kullanılarak SDG 13'e uyum sağlanmalı ve çevreye zarar verilmemelidir.

Anahtar Kelimeler: Militarizasyon; Ekonomik büyüme; Çevre; Doğu Afrika Ülkeleri; Kantil-on-Kantil-Granger Nedenselliği .

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LIST OF ABBREVIATIONS

- SIPRI: Stockholm International Peace Research Institute
M23: March 23
OECD: Organization for Economic Co-operation and Development
QQ-GC: Quantile-on-Quantile Granger Causality
LGC: Linear Granger Causality
WDI: World Development Indicators
OWD: Our World in Data



CHAPTER ONE

1. Introduction

One nation fighting another has become a common global topic recently. On 1st October 2024, Iran launched 200 ballistic missiles at Israel following their recent hostile political ties (Schneider, 2024). Wars between Yemen, Lebanon, Palestine, and Israel. The 2020 Azerbaijani-Armenia war over the Nagorno-Karabakh enclave, Ethiopia's northern region Tigray conflict was prompted by Myanmar's army power grab (International Crisis Group, 2024). Furthermore, it has been 2 years since Russia invaded Ukraine, and despite Ukraine's extensive support from the West, the war does not look like ending soon. Unlike the Middle East, West and Central African countries have had civil wars rising from overthrowing the existing governments. Rebel and terrorist groups have germinated and strengthened in the claim of fighting against a corrupt government, however, at the expense of innocent lives. Sudan, Central Africa Republic, Chad, and Burkina Faso have experienced conflicts in recent years. A well-known rebel group in the Democratic Republic of Congo-M23, have re-emerged recently amid the Rwanda-DRC conflict (Ntanyoma, 2022). The quest for more resources, and power could be the reason behind all these wars or just the arrogance of the leaders, but what is known is the fact that there must be a financial facilitation. When the government facilitates its army on any military activity is what is called military expenditure. Records from the Stockholm International Peace Research Institute (SIPRI) (2023) show that the United States, China, Russia, India, and Saudi Arabia have the world's largest expenditure on military.

The focus of this study is on Burundi, Kenya, Rwanda, Tanzania, and Uganda in the years 1990Q1-2022Q4. These five countries form the core of the East African community. But also, the remaining East African countries like Ethiopia, were not included due to missing data. Initially, the community comprised three countries that is Tanzania, Kenya, and Uganda in 1967 but collapsed in 1977 after a conflict broke out between the states. Brown-Acheson, (2016) narrates Uganda's invasion of Tanzania what was commonly known as the Kagera War, was the nail in the coffin for this community after the economic depression. Twenty-three years later, with each member having new heads of state, the community was revived with two new members, Rwanda, and Burundi. Before joining, Rwanda and Burundi engaged in intense tribal wars in the years 1993-1994 which had more than 800,000 civilians killed (Meierhenrich, 2020). Hence the East African

Community was their hope to lift their economies out of recession caused by the wars. Thereafter, East Africa has been a peaceful place in Africa with fewer conflicts than other parts of Africa. However, chaos from terrorist groups has tortured the region as well. Al Shaabab originating from Somalia, brought chaos in the lives of Kenyan and Ugandan civilians and has had prolonged conflicts with Al Shaabab, a rebel group from Somalia. The economic literature has identified militarization as a public good that is, it cannot be excluded and does not exclude others from using it. Civilians enjoy the benefits of a defence system simultaneously without excluding others. Smith (1776) in his book *Wealth of Nations*, identified national security as a primary role for the government to equip the military and enhance its capability in defending the country. Protecting the economy from all threats provides a strong belief from investors within a country and abroad. This will eventually increase the level of output and economic growth will increase. From this view, spending on the military to ensure national security is a crucial factor in development. However, the technologies employed in militarization often do not protect the environment.

This research focuses on a causality analysis between militarization (ME), growth (GDP) and Environment (CO₂). The literature has presented four results of causality among the variables. First, no causality among variables, second; uni-directional causality from ME to GDP and CO₂, third; uni-directional causality from GDP and CO₂ to ME, and fourth; a bi-directional causality between three variables. The results help in suggesting to governments and policymakers in policy making where to put more strengths. As suggested by Saba and Ngepah, (2019), in no causal relationship situation it implies whatever policy changes are made on ME will neither affect GDP nor CO₂ and hence in such a situation independent goal can be achieved. A uni-directional causality from ME to GDP and CO₂ is taken more seriously since a change in policy in ME can affect GDP and CO₂. In the reverse scenario, a uni-directional causal relationship between GDP and CO₂ to ME will imply that ME will only affected when policies growth and environment are changed. In bi-directional causality, a policy change in ME can affect GDP and CO₂ and vice versa is true. Hence, in such situations, the economy must consider achieving the policy goals together.

To support the four causal results discussed. Studies on militarization and economic growth, existing studies employing the frequently used causality techniques of Granger causality and quantile Granger causality. Chen et al., 2014 found the causal relationship

to be unidirectional, bidirectional and no causality at all was also found. Another study by Ortiz et al., (2019) found only two causality relationships. They found no causality relationship in lower-income countries and unidirectional causality in other-income countries. Muhammad, (2020) in his study on non-OECD countries, also examines the predictive content between the studied where he finds a bi-directional causality between militarization and growth. Militarization and the environment have mostly been found to be unidirectional from military expenditure to the environment. Saritax and Burmaoglu (2016) and Ahmed et al., (2020) found comparable results with militarization having predictive power for the environment. Conversely, the study of Saba (2023) contradicts this finding by displaying a result showing no causality between ME and CO₂.

One may think that militarization only affects growth and environment in the times of war. However, Hooks and Smith (2005) observed militarization to have an effect in both times of peace and of war which implies policymakers should be keen on the influence an alteration of expenditure on military could have on the environment and growth. The effects of militarization on growth and the environment are both positive and negative. A study by Noubissi et al., (2022) examined the impact of military expenditures on air quality and carbon dioxide emissions for different countries and periods and found defence spending had positive effects on air quality in 54 countries from 1980 to 2016. Suggesting that an increase in militarization improved the environmental quality. In contrast, an increase in militarization could also negatively impact the environment as observed by Kwakwa, (2022) that public and military expenditures increased CO₂ emissions in Ghana (1971-2018). On economic growth, the positive impact of militarization on growth was observed by Desli et al., (2017) and Gokmenoglu et al., (2015) while the negative impact by Qiong and Junhua (2015) and Chang et al., (2011). Thus, this research hopes to further contribute to the existing causality literature pool by examining the causal relationship militarization has on economic growth and environment in Tanzania, Kenya, Uganda, Burundi, and Rwanda. The new Quantile-on-Quantile Granger causality model (QQ-GC) developed by Adebayo and Ozkan, (2024) will investigate the causal linkage. A sample period of 1990-2022 is selected due to data existing on those years in the five East African countries.

1.1 Problem Statement

Defence is a crucial need for humanity and a vital task for the government. Spending on defence by the government is economically termed as defence spending (Tuncay, 2017). The aim is to examine the causal effect of militarization to growth and the environment in Tanzania, Kenya, Uganda, Burundi and Rwanda. The five East African countries are selected because of their similarities; all are in East Africa; All are developing countries; and most importantly all are less affected by conflicts and wars. East African countries left out had missing data in several years. Furthermore, the absence of wars and conflicts would mean less militarization, but does that mean less impact on growth and the environment? Hooks and Smith (2005) suggest whether, in times of peace or war, expenditure on the military always has an effect, therefore the study will look to examine this with a causal analysis and provide suitable policy recommendations.

1.2 Objective of the study

The thesis aims to examine the predictive content of militarization on economic growth and environment in the five East African countries. The objectives are listed below.

- To examine the causal effect from militarization on economic growth and on environment.
- To examine the heterogeneous causal effect of militarization across the conditional quantiles of economic growth and environment.

1.3 Scope of the Study

The thesis analyses causality relationship with Quantile-on-Quantile Granger Causality (QQ-GC) as introduced by Adebayo and Ozkan, (2024). The analysis is centred in Tanzania, Kenya, Uganda, Burundi and Rwanda from 1990Q1 to 2022Q4. The countries selected do not only share borders, but culture and history. Traditional Granger causality by Granger (1969) is also used in support of the main causality approach of this study. In this study, the independent variable is militarization while the dependent variables are economic growth and environment. Hence, the null hypothesis is that militarization does not Granger cause growth or environment which is expected to be rejected.

1.4 Structure of Study

The thesis study is made into 5 chapters one of which has just been covered. Following this chapter, is Chapter Two. In chapter two, an overview of militarization in the world and in East Africa, a theoretical framework on how militarization could affect the economy and environmental quality and closed by other studies that have discussed a similar study. Chapter three will then follow. Which will discuss the data used in the thesis, and the methodologies used to analyse it. Since the study is a causality one, three causal methodologies are employed. Chapter four will cover the results from methodologies in Chapter Three and discuss them, offering an insight into what they imply. Finally, the thesis is closed by chapter five. A general conclusion and policy recommendations are discussed.

CHAPTER TWO

2.0 Overview of Military Expenditure

Militarization refers to the number of resources allocated by an economy to the military (Das, 2018). Expenses on personnel and equipment, research and development form militarization (SIPRI, 2022). Globally, militarization increased by 3.7% in 2022 to a record of \$2240 billion according to SIPRI (2023). This was driven by the Russian invasion of Ukraine in February 2022 which was followed by many European countries increasing their budget towards military expenditure. The military expenditures of all those involved rose significantly in this period. Russia's military spending is estimated to have risen by 9.2% moving to the top 3 spenders after the United States and China (SIPRI, 2022). Meanwhile, Ukraine had a record 640% increase in her military expenditure and ranked 11th in 2022 and 34 times higher than the previous year. United States have the biggest share of the world military spending at 39% (SIPRI, 2022). This could constitute military research and development, funding Ukraine, setting up military US military bases in various parts of the world, and recently funding Israel. According to SIPRI, the financial military aid given to beneficiary countries is accounted for as the donor's military spending. It is estimated that in 2022, the United States military aid to Ukraine was just 2.3 % of the total US military spending. China's military spending has increased for 28 consecutive years to a staggering \$292 billion in 2022 (SIPRI, 2022). Their focus for the next years is to promote emerging military technologies and Artificial Intelligence and boost the arms industry.

In Africa military spending has totalled up to \$39.4 billion in 2022 however this is a decrease of 5.3% from the previous year. The biggest spenders are northern African countries, Algeria and Morocco who staggeringly occupy 74% of African total military expenditure. In West Africa, Nigeria's spending on military dropped by 38% despite several conflicts their army has had to deal with including farmer-herder and violent extremism. However, in 2022 the country faced massive floods that prompted the government to divert funds from the military to handle the damages. Among the African countries, Ethiopia recorded the biggest increase in militarization. An 88% increase can be attributed to renewed government offensive measures against the Tigray People's Liberation Front. Moving to the focus of this study, East African countries recorded a total of \$3.1 billion in 2022. Kenya led the race with \$1.1 billion, Uganda with \$0.9

billion, Tanzania with \$0.8 billion, Rwanda with \$0.2 billion and Burundi with \$0.1 billion (SIPRI, 2022). Figure 1 shows the military spending in 2022 at constant 2021 of twenty countries in the world.

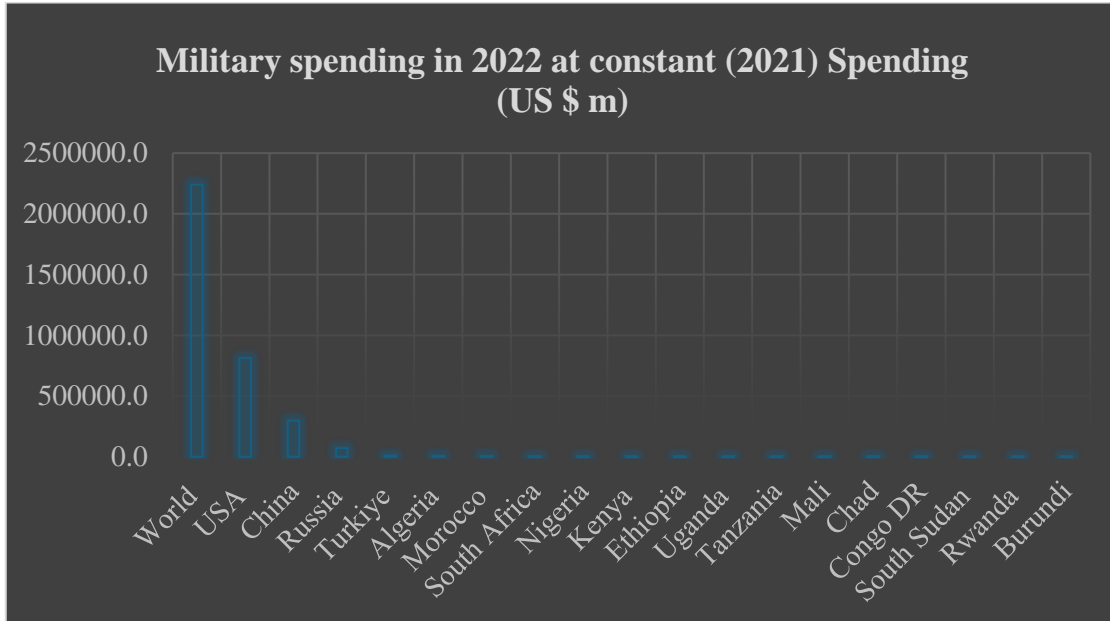


Figure 1; Military expenditure comparison. Source by SIPRI

The military ranking of these five developing countries shows which government spends more on military expenditure. Furthermore, military ranking shows the extent of military expenditure in the economy. The Global Firepower uses over 60 factors to determine a given nation's Power Index score (PwrIndx). The GFP shows that Egypt has the best military power followed by Algeria and South Africa. This data is in conjunction with SIPRI data on military expenditure spending with these same countries topping the African continent. The focus region, East Africa has Kenya as the highest ranked in the region. The figure below compares East Africa's military ranking with other countries. Spending on the defence sector does not guarantee safety to the citizens but increases the chances of security by far. For instance, having militarized vehicles alongside roads will intimidate criminals trying to cause threats. This also applies to the use of ICT and drones to detect potential threats before they occur.

2.1 Theoretical Literature Review

Militarization's effect on economic growth has been widely studied with some finding its effect to be positive while others negative. The two main channels that explain these

outcomes are the Neo-classical approach for negative impact and the Keynesian approach for positive impact. On the environment, several theories will be discussed.

2.1.1 Militarization and Economic Growth

Keynesian argued that militarization results in to increase in the use of capital stock, which increases investment employment and output and eventually leading to a positive impact to economic growth. With the economy growing, positive externalities will be experienced as well. Externalities like infrastructure, innovative technologies from military research and development as well as stability and discipline. Inventions in communications, transportation and electronics were mostly intended for military purposes but were absorbed for public use (Giray, 2004).

The second most common approach is the Neo-classical approach. Military expenditure negatively affects growth by creating a crowding-out effect on investments. Furthermore, inflation and divergence of resources from other sectors like agriculture possibly more productive areas of the economy (Lipow and Antinori, 1995). They assume that military expenditure to arise during times of vital need such that, it becomes difficult to allocate funds to other sectors (Alptekin, 2012). Therefore, the scarce resources will be diverted from crucial sectors to meet the vital needs in the military sector.

2.1.2 Militarization and Environment.

The literature has several empirical studies have investigated the impact of military expenditure on carbon emissions (Bildirici 2017; Erdogan et al. 2022; Qayyum et al. 2021). Militarization activities involve the use of fossil fuels which are major sources of greenhouse gas emissions (Bargaoui and Nouri 2017). Activities like military exercises and training, transportation all increase energy consumptions which therefore increase carbon emissions into the environment. Ahmed et al., (2021) showed military programs increase carbon emissions and deplete the environment through; Resource depletion; Flora and fauna extinction; release of radioactive elements and pollutants; transportation of military equipment and personnel; and testing of nuclear bombs. This could explain why most studies find a negative relationship between a one-way causality from militarization to environment.

2.2 Empirical Literature Review of Related Studies

There are several studies on militarization on growth and the environment, unfortunately, a consensus has not been made. Scholars like Abdu-Bader and Abu-Qarn, (2003); Dakurah et al., (2001); Heo, (1998); Kollias and Makrydakis, (2000); and Kusi (1994) have contributed to the literature on this topic. The difference in results could be explained by the sample period, the methodology and the countries selected (Kollias et al., 2004). They range from positive effects in some studies, negative effects in others, unidirectional causality and bidirectional causality in others.

2.2.1 Military Expenditure and Economic Growth

The causality analysis of militarization and growth has several empirical works such as Abu- (Abdu-Bader and Abu-Qarn, 2003), Dakurah et al. (2001), Chen Heo, 1998, Kollias and Makrydakis, (2000), Kusi, (1994). However, due to the difference in results from scholars one general result cannot be concluded. The results vary from the direction (unidirectional or bidirectional) and the nature (positive, negative, neutral) of causality between the two variables (Ortiz et al., 2019).

They depend on the level of socio-economic development, the sample period involved as well as the methodology used (Kollias et al., 2004). It can be differences in per capita income or the orientation of military expenditure. It is argued that developed economies with military supremacy obtain a positive impact from military expenditure. They focus more on research and development leading to modern weapons and export to less developed countries. Hence creating more employment and eventually increasing output. Military superior economies can also conquer new territories and obtain economic resources thereby strengthening their economic powers (Agnew and Crobridge, 2002).

Keynesian perspective sees military expenditure as any other government expenditure with no special merits diminishing the applicability of his arguments over time (Arrow, 1995). Several prior studies have drawn findings that support the Keynesian military view of the positive influence of military expenditure on national output (Benoit, 1978). Works from growth Dunne & Tian, (2013); Dunne & Tian, (2015); Dunne & Tian, (2016) provide evidence that military expenditure can have negative effects on economic growth. Benoit, (1973) has made a significant contribution to the literature in this topic. From his view, investment in military expenditure will eventually increase economic growth.

Investments in the arms industry will increase research and development of modern technologies increasing employment and output. The existing literature has positive and negative impacts of military expenditure on economic growth. Gerace, (2002) and Manamperi, (2016) found no relationship between the two variables.

Beginning with a positive relationship, the works of Wang et al., (2012); Cavicchioli and Pistori, (2016) and Gokmenoglu et al., (2015) found that military expenditure positively influences economic growth in Asia, Europe and Oceania agreeing with the Keynesian perspective. Desli et al., (2017) find a positive relationship between military expenditure and economic growth in developing countries. There have been arguments on the positive results and Gangopadhyay and Elkanj (2009) suggest that such results should be considered with caution since military expenditure data tends to be treated as classified information. 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 and Levine, (2012) provide evidence that most developed countries have offensive military expenditure hence tending towards a positive relationship.

Military expenditure has been found to hurt economic growth in various perspectives. In developed countries where increase in military expenditure increases interest rates and reduces private investments which also increases unemployment. For example, a study of military expenditure and GDP in China found that military expenditure increased the unemployment rate and negative impact on GDP (Qiong and Junhua, 2015). The other perspective is from low-income countries that must import arms leading to spending more than they generate from military activities. A study by Chang et al., (2011) found militarization retarded growth in low-income countries. Another perspective in conflict-torn countries like Syria, military expenditure has also been found to harm growth (Abdu-Bader and Abu-Qarn, 2003).

Furthermore, Faini et al., (1984) found a greater military burden is related to slow growth for 69 countries during 1952–70, they also found that a rise of 10% in military spending leads to a fall of 0.13% of annual economic growth. Klein (2004) reveal that overall, militarization had a negative influence on the growth rate of Peru over 1970–96. In support of this argument, a negative relationship resulted in low-income countries a study by Chang et al. (2011) during 1992-2006 covering 90 countries. D'Agostino et al.(2017)

observed a significantly negative effect of military spending on growth in 83 countries OECD over the period 1970–2014. Manamperi, (2016) found that military spending has a negative effect on both in short- and long-term growth in Turkey. Another study of Hou and Chen (2014) covering 21 OECD countries from 1960-2009 found a military spending has harmed growth. A significant and negative effect of military spending on economic growth was found by D’Agostino et al. (2017) in the context of OECD countries. A recent study of Muhammad, (2020) in his article looking at non-OECD countries also found a negative impact of military spending on economic growth.

The existing literature has plenty of works on the causality relationship between economic growth and military expenditure but employ the traditional causality techniques. The direction of causality is crucial in determining policy implications whether to focus on economic growth or military expenditure and shows endogeneity or exogeneity. Experts have found different results depending on the income level of a country and the methodology used. The works of Chen et al., (2014) 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 and Europe, they found a bidirectional short-run causality. No causality was found in upper-middle income, European Central Asian and Sub-Saharan African countries. 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 to exhibit causality between military expenses and economic growth where he found a 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 several academicians found a causality relationship, a study by 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.

2.2.2 Military Expenditure and Environment

The existing literature has plenty of studies on military expenditure and the environment. Most arguments reveal a positive relationship between the two variables, but some studies show a negative relationship. One argument is that military activities either in conflicts or during projects tend to pollute the air and thereby harm the environment. In support of this argument, Saritas and Burmaoglu, (2016) explain 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 on crude oil which in turn increases air pollution hence military activities also deplete the environment. Lawrence et al.,(2015) show military expenditures increase CO₂ 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 et al, 2018).

Studies by Hooks and 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 the environment by Ahmed et al., (2020) in Pakistan using 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, and rebellions Studies by Chen et al.,(2023), Pata and Ertugrul (2023), and Wang et al.,(2023) show that in the 2020s geopolitical risks have negative effects on the environment in both developing and advanced economies. Still on geopolitical risks, Bildirici and Gokmenoglu, (2020) show that terrorism increases CO₂ emissions using the panel Autoregressive Distributed Lag (ARDL) approach. Equivalent results were found by Bildirici, (2021) that terrorism increases CO₂ emissions in China, India, Israel, and Türkiye. In conclusion, a study of Saba (2023) on militarization, economic growth and CO₂ emissions in South Africa found no causal relationship between military spending and CO₂ emissions.

CHAPTER THREE

3.0 Data and Methodology

3.1 The Data

This paper examines the heterogeneous causal impact of ME, GDP and CO₂ in Burundi, Kenya, Rwanda, Tanzania and Uganda using time series data from 1990Q1-2022Q4. These five countries have also been selected due to the availability of data from 1990Q1-2022Q4. Military expenditure as a percentage of GDP represents military expenditure and was obtained from World Development Indicators (WDI). GDP per capita (constant 2015 US\$) obtained from World Development Indicators (WDI) (Bank, 2023) is used to represent Economic Growth while per capita CO₂ emissions collected from (OWD, 2023) represent the Environment. The results will be analysed in two forms, one with non-quantile approaches and the other with a quantile methodology. In both cases, the data is transformed into logarithmic form to handle small samples and deal with heteroscedasticity. Furthermore, with the quadratic match-sum method by Fareed et al. (2012), the data is converted into quarterly frequencies. For the quantile approach, the data is then first differenced (Δ). Table 1, presents the tabular form of the data, how is measured and where it was collected.

Table 1; Data and its source

Symbol	Variable	Measurement	Source
ME	Military expenditure	% of GDP	WDI
GDP	GDP per capita	constant 2015 US\$)	WDI
CO ₂	Per capita CO ₂ emissions	tons	OWD

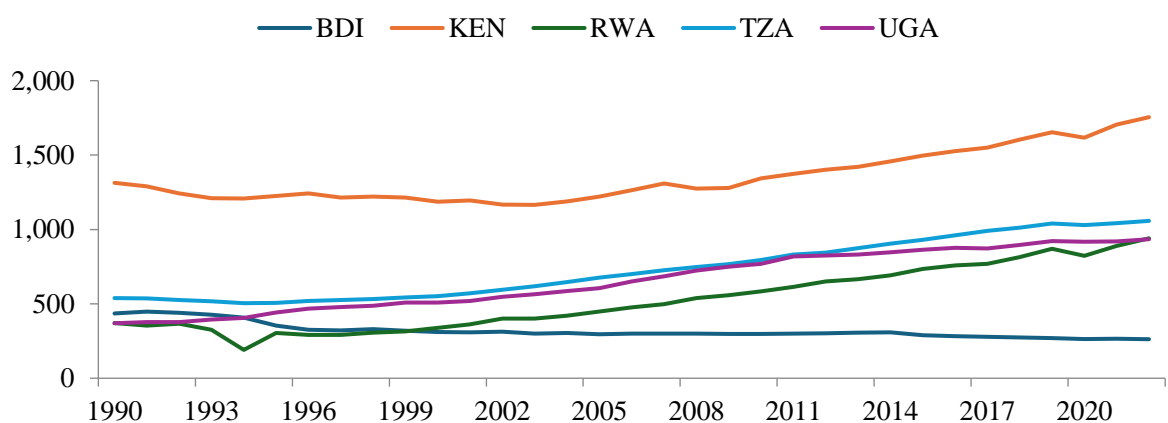
3.2 Graphical Series Representation

As suggested by Balcilar et al. (2019), the graphical representation in Figure 2 provides a prior understanding of trend, drift, structural breaks and seasonality. From panel 1, Kenya is observed to have a much bigger economy than her counterparts while Burundi with the smallest. In East Africa's leading economy, GDP is observed to gently rise from the early 2000s with slight drops in 2008 following the Al Shabab attacks. GDP fall in Burundi could be attributed to poor governance; prolonged term limits, and political

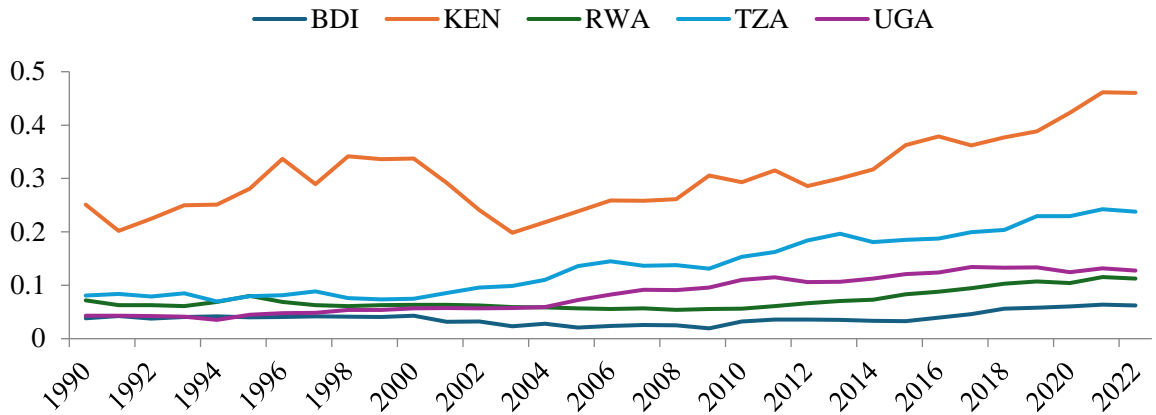
instabilities exacerbated by tribalism from early 1990 to 2020. It is the only series to be falling throughout the sample period. GDP in Rwanda was the lowest at the beginning of the series but grew at a higher rate than the others from 1996 to 2022. In the years 1993-1995, there was a sharp drop in GDP that can be linked to the Rwanda Genocide, a Hutu and Tusi war that had more than 100,000 dead (Meierhenrich, 2020). There is a quite close similarity between the GDPs of Tanzania and Uganda. Their economies have steadily been growing from the 1990s to 2022, but Tanzania was slightly ahead. Among the five countries, a fall in GDP can be noticed around 2021 with Tanzania having the lowest drop. COVID-19 had taken the globe by surprise affecting many economies including East African ones. However, Tanzania's GDP drop was lesser than the others because the government opted against a lockdown.

Panel 2 provides CO₂ emissions. The results are directly proportionate to Panel 1 implying that an increase in GDP increases CO₂. Therefore, Kenya with the highest emissions in the region and Burundi with the lowest. A better economy possesses more industries which leads to more output. The industries in turn emit greenhouse gasses into the environment thereby explaining an increase in GDP will lead to an increase in CO₂. To conclude, figure 2 panel 3 shows the trend of ME in East Africa. ME is observed to fluctuate vigorously from 1990 to the early 2000s and steadily falls thereafter. Around 1995-1997, the sharp rise in militarization in Rwanda was due to the genocide (Meierhenrich, 2020). Kenya's military has been the best since 1996 but in recent years, Uganda is observed to have more percentage of their GDP to militarization. Tanzania is the most peaceful country in the region, the low percentage could imply less military activities.

Panel (1): GDP



Panel (2): CO₂



Panel (3): ME

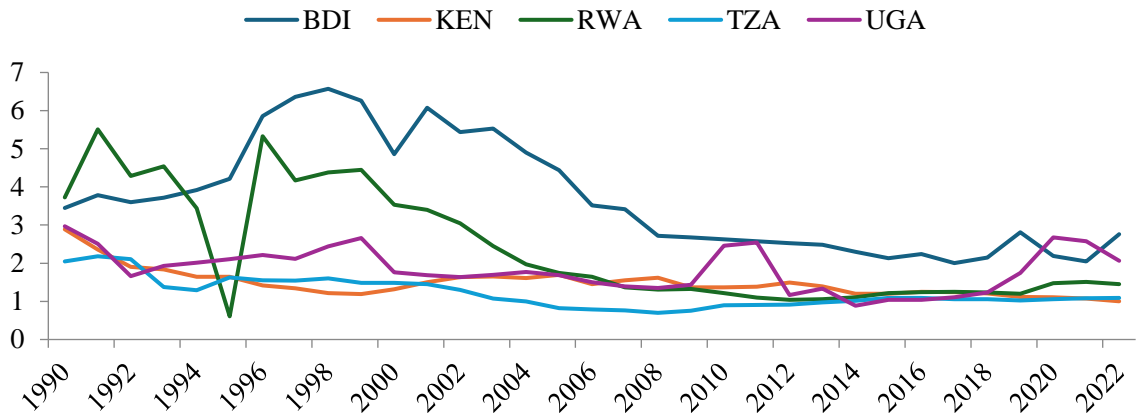


Figure 2: The annual GDP, CO₂, and ME values from 1990 -2022

3.3 Approach to Data Analysis

Following the analysis of graphs, a preliminary analysis is conducted to examine data eligibility for the proposed QQ-GC. The same data is prepared for non-quantile methodology and quantile methodology. Descriptive statistics are obtained by observing mean, standard deviation, Skewness, Kurtosis and Jarque Berra. In stationarity tests, the traditional ADF and PP tests and quantile ADF and PP unit root tests are carried out and followed by a non-linearity BDS test. In causality tests, LGC and novel QQ-GC are finally conducted.

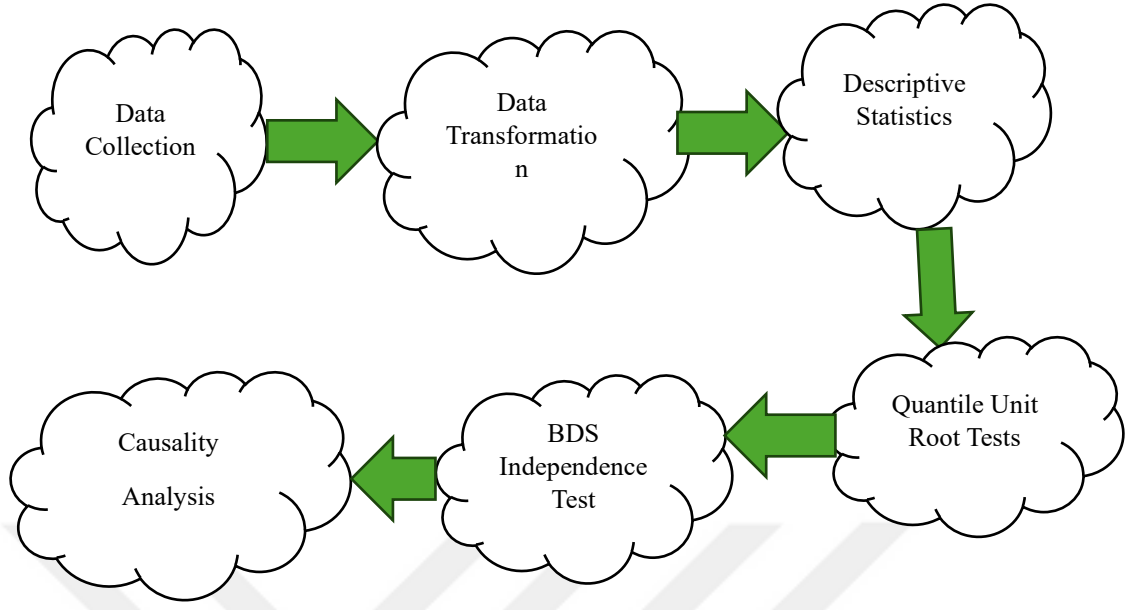


Figure 3; Steps to the analysis

3.4 Linear Granger Causality (LGC)

To begin our analysis, the traditional Granger Causality (LGC) developed by Granger (1969) is employed. This is necessary to compare the results with the main causality approach of this thesis. For this approach to work effectively, the series must be stationary. The null hypothesis is that X does not Granger Cause Y . For this paper, ME is tested if it Granger causes GDP and CO₂.

$$X_t = \alpha_o + \sum_{i=1}^P \alpha_i X_{t-i} + \sum_{i=1}^P \beta_i Y_{t-i} + u_t \quad (1)$$

α_o represents the constant term while u_t is the error term. P shows the lag order, t is time, α_i represents coefficients of the lagged values of Y , Y_{t-i} shows the lagged value of Y at periods t_1, t_2, \dots, t_p . β_i is the coefficient of lagged values of X , X_{t-i} shows the lagged values of X at periods t_1, t_2, \dots, t_p .

3.5 QQ-GC Methodology

Finally, the main purpose of this paper is the Quantile-on-Quantile Granger Causality (QQ-GC) method brought by (Adebayo and Ozkan 2024). The results of the preceding causality tests will then be compared to those of the studied methodology. QQ-GC is very suitable in non-normal and non-linear series as well as reducing the effect of outliers and extreme values in estimations and does not require distributional assumptions.

Consequently, the model allows us to analyse extreme market conditions in the lower quantile, mid quantile and upper quantile. In that case, QQ-GC can identify causal effects in specific parts of the quantile distribution. Last but not least, the QQ-GC uses indeed variables X and Y thereby producing more reliable outcomes. These reasons make the QQ-GC a better causality method than LGC and T-YGC.

QQ-GC begins with the traditional GC from equation 1, which specifies the traditional Granger Causality (LGC) from Y to X as proposed by Granger (1969).

We aim to observe the quarterly predictive power from ME to GDP and CO₂ emissions. The traditional causality tests cannot be employed here but a quantile Granger Causality (QGC) as used by Troster (2018) can be employed to some extent. However, the approach only covers the conditional distribution of the dependent variable while QQ-GC by Adebayo & Ozkan 2024 covers conditional distribution of both the dependent variable and independent variable. Hence the QQ-GC model provides a better analysis.

Following the work of Adebayo and Ozkan (2024), we let, QX_θ denotes θ th conditional X quantile QY_ϕ be ϕ th conditional quantile of Y . $QY_\phi(X)$ represents the ϕ th conditional Y quantile on X , and $QX_\theta(Y)$ as θ -th conditional X quantile on Y . Moreover, $QY_\phi(X)$ is not of course dependent of X and $QX_\theta(Y)$ not equally dependent of Y , i.e., $QY_\phi(X) = QY_\phi$ and $QX_\theta(Y) = QX_\theta$ with probability 1, if and only if $X, Y, I(Y - QY_\phi > 0)$, and $I(X - QX_\theta > 0)$. The indicator function is invariably denoted by $I(\bullet)$. Thus, QQ-GC is illustrated in Eq. (3);

$$QX_{\phi,t} = \alpha_{\phi,\theta,0} + \sum_{i=1}^p \alpha_i QX_{\phi,t-i} + \sum_{i=1}^p \beta_i QY_{\theta,t-i} + u_{\phi,\theta,t} \quad (3)$$

where $0 < \Phi$ and $\theta < 1$, $\alpha_{\phi,\theta,0}$ is the intercept, α_i denotes the values of the lags parameters for the ϕ th conditional quantile of X being estimated; X_{t-i} represents the values of the lags parameters for ϕ th conditional quantile of X at divers times or periods $(t_1, t_2, \dots t_p)$; β_i shows the values of the lag parameters for θ th conditional quantile of Y ; Y_{t-i} shows the values of the lag parameters for θ th conditional quantile of Y at diverse times or periods $(t_1, t_2, \dots t_p)$; and $\varepsilon_{\phi,\theta,t}$ denotes the residual at time t , quantile ϕ and θ

The quantiles specification is defined based on the works of Li et al. (2015) as: $\phi_t = \{QX_\phi, 0.05 \text{ to } 0.95\}$ and $\{QY_\theta, 0.05 \text{ to } 0.95\}$, where QX_ϕ denotes the θ -th conditional quantiles of the ME while QY_θ represents the quantiles of GDP and CO₂ emissions. The QQGC model is then estimated. Furthermore, to estimate this model, we follow the Granger test function as demonstrated in the ‘‘lmtest’’ R-studio software of Hothorn et al.

(2015) and the length for the estimations is determined by the Akaike Information Criteria (AIC) which provided an optimal lag length of 1.



CHAPTER FOUR

4. Empirical Results and Discussion

This chapter covers the results of this study from preliminary tests to the novel Granger causality test employed. The results will be from the traditional methods to quantile-based methods to show how better quantile-based methodologies are compared to the common approaches to data analysis. Chapter four is divided into two sections, first covering the non-quantile methods in preliminary tests and causality then section two is quantile-based tests.

4.1 A Non-Quantile Approach Results and Discussion

First, tables 2.1-2.5 provide the descriptive statistics of ME, GDP and CO₂. The data is logged and quarterly. Logging data reduces the chances of heteroscedasticity and approximates the data to normality. Table 3.1-3.5 provides the correlation matrix, illustrating the relationship between the variables in the study in the countries selected. Tables 4.1-4.3 provide results on the Augmented Dickey and Fuller (ADF) test by (Dickey and Fuller, 1979) and tables 5.1-5.3 represent the Phillips-Perron (PP) test results by (Phillips and Perron, 1988). These cover the preliminary tests.

Consequently, in this first part of the result section, the predictive power of ME on GDP and CO₂ are discussed in tables 6 and 8 while tables 7.1-7.5 provide the lag criterion to be used in the Toda-Yamamoto Granger Causality test.

4.1.1 Descriptive statistics

In Table 2.1, CO₂ is the only variable to have a negative mean while GDP has the biggest. GDP was shown to have the lowest volatility while ME was shown to fluctuate more about the mean than the others. ME and GDP are skewed to the right but CO₂ to the left while only GDP possess a Kurtosis > 3. Jarque-Bera shows data is not normally distributed for ME and GDP, but CO₂ is normally distributed hence the series is likely to be non-linear.

Table 2.1; Descriptive statistics for BDI

	ME	GDP	CO ₂
Mean	0.3090	1.4385	-0.8253
Median	0.3104	1.4274	-0.8183
Maximum	0.4716	1.5266	-0.6871
Minimum	0.1705	1.3908	-0.9963
Std. Dev.	0.0953	0.0372	0.0755
Skewness	0.2490	1.2268	-0.1696
Kurtosis	1.7428	3.5625	2.6441
Jarque-Bera	10.0576	34.8513	1.3293
Probability	0.0065*	0.0000*	0.5145

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

From Table 2.1, the results are quite similar to those in table 2.1 except CO₂ has the highest volatility here and all variables are positively Skewed. ME shows the greatest Kurtosis of >3 while GDP and CO₂ are all less than 3. The series still shows to likely be non-linear one.

Table 2.2; Descriptive statistics for KEN

	ME	GDP	CO ₂
Mean	0.0916	1.8000	-0.3021
Median	0.0842	1.7887	-0.3039
Maximum	0.2838	1.8687	-0.1901
Minimum	-0.0781	1.7643	-0.4082
Std. Dev.	0.0551	0.0301	0.0553
Skewness	1.0460	0.7924	0.0942
Kurtosis	4.6734	2.3443	2.3413
Jarque-Bera	39.4742	16.1792	2.5814
Probability	0.0000*	0.0003*	0.2751

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

Table 2.3 shows GDP to have the highest mean while CO₂ to have the lowest and a negative mean. CO₂ has the lowest volatility while ME has the highest hence it changes more about the mean. Unlike Table 2.1 and Table 2.2, GDP in Table 2.3 Skews to the left

while ME and CO₂ are to the right. All the variables have a Kurtosis of less than 3 and just like the previous, the series is likely to exhibit non-linearity.

Table 2.3; Descriptive statistics for RWA

	ME	GDP	CO ₂
Mean	0.1709	1.5463	-0.6638
Median	0.1039	1.5414	-0.6890
Maximum	0.4897	1.7154	-0.5374
Minimum	-0.1618	1.3033	-0.7309
Std. Dev.	0.1514	0.1022	0.0564
Skewness	0.3060	-0.1073	0.9514
Kurtosis	1.8906	2.0653	2.6033
Jarque-Bera	8.8293	5.0581	20.7792
Probability	0.0121**	0.0797	0.0000*

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

From Table 2.4, GDP has the greatest mean and median while CO₂ with the smallest mean and median. GDP fluctuates the smallest about the mean while CO₂ has the biggest volatility. The series is all positively Skewed and with a Kurtosis of < 3. JB results show the series to be non-linear.

Table 2.4; Descriptive statistics for TZA

	ME	GDP	CO ₂
Mean	0.0381	1.6404	-0.5170
Median	0.0201	1.6377	-0.5001
Maximum	0.2047	1.7425	-0.3531
Minimum	-0.0912	1.5551	-0.6695
Std. Dev.	0.0746	0.0657	0.1040
Skewness	0.4044	0.1657	0.0753
Kurtosis	2.4420	1.4941	1.4965
Jarque-Bera	5.3102	13.0760	12.5572
Probability	0.0703	0.0014*	0.0019*

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

The last table in descriptive statistics is not much different from the predecessors. Table 2.5 shows CO₂ to have the lowest mean and median while GDP with the greatest mean

and median. CO₂ has the highest volatility while GDP has the lowest. Unlike the previous results, the series is negatively Skewed with Kurtosis less than 3. The variables are shown to be non-linear at 10% (ME) and 1% (GDP and CO₂)

Table 2.5; Descriptive statistics for UGA

	ME	GDP	CO ₂
Mean	0.1393	1.6110	-0.6439
Median	0.1363	1.6197	-0.6224
Maximum	0.2754	1.7120	-0.4993
Minimum	-0.0388	1.4748	-0.8412
Std. Dev.	0.0795	0.0779	0.1099
Skewness	-0.2458	-0.2676	-0.1267
Kurtosis	2.2166	1.6494	1.4700
Jarque-Bera	4.7041	11.6089	13.2276
Probability	0.0952	0.0030*	0.0013*

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

The JB test by Jarque and Bera, (1980) values show that the series is not normally distributed. The null hypothesis that the series is normally distributed is rejected in most scenarios. This shows that analysing with non-quantile approaches may result in spurious results.

4.1.2 Correlation Matrix

In Table 3.1, ME is observed to have a positive weak relationship with GDP with results being significant at 1%. This implies that an increase in militarization in Burundi will increase the economic growth. However, ME and CO₂ have a weak negative relationship and significant even at 1%. Hence an increase in ME reduces harm to the environment. GDP and CO₂ have a very weak negative relationship, but the results are not significant even at 10|%.

Table 3.1; Correlation Matrix BDI

	ME	GDP	CO ₂
ME	1.0000		
GDP	0.3641	1.0000	

	[0.0000*]		
CO ₂	-0.2349	-0.0640	1.0000
	[0.0067*]	[0.4657]	

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

From Table 3.2, ME has a negative relationship with both GDP and CO₂ however, the effect is stronger with the latter. This briefly implies that in Kenya, militarization decreases economic growth but saves the environment. Meanwhile, GDP worsens the environment with a strong positive relationship that is significant at 1%.

Table 3.2; Correlation Matrix KEN

	ME	GDP	CO ₂
ME	1.0000		
GDP	-0.5837	1.0000	
CO ₂	-0.8178	0.7710	1.0000
	[0.0000*]	[0.0000*]	

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

In Table 3.3, ME links positively and very strongly with GDP and CO₂ with the results being significant at 1%. Implying that militarization improves the economy while damaging the environment. GDP and CO₂ have a very strong positive relationship showing the more the economy grows the more susceptible the environment is.

Table 3.3; Correlation Matrix RWA

	ME	GDP	CO ₂
ME	1.0000		
GDP	0.993248	1.0000	
CO ₂	0.953254	0.927967	1.0000
	[0.0000*]	[0.0000*]	

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

In Table 3.4, ME has a strong negative effect on GDP and CO₂ with both results being significant at 1%. Hence, in Tanzania, the economic growth lowers with an increase in military expenditure. While an increase in ME reduces the damage to the environment.

Table 3.4; Correlation Matrix TZA

	ME	GDP	CO ₂
ME	1.0000		
GDP	-0.6313 [0.0000*]	1.0000	
CO ₂	-0.6581 [0.0000*]	0.9837 [0.0000*]	1.0000

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

From Table 3.5, ME has a similar correlation as in Table 3.4 but with a lesser stronger effect. Hence just like in Tanzania, militarization will reduce economic growth and reduce carbon emissions into the environment.

Table 3.5; Correlation Matrix UGA

	ME	GDP	CO ₂
ME	1.0000		
GDP	-0.4443 [0.0000*]	1.0000	
CO ₂	-0.4256 [0.0000*]	0.9836 [0.0000*]	1.0000

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

To conclude, Kenya, Tanzania and Uganda possess comparable results which differ in magnitude. Tanzania with the strongest then Kenya and finally Uganda. In Burundi and Rwanda, the similarity is in the correlation between ME and GDP but differs between ME and CO₂.

4.1.3 Unit Root tests

The unit root test results are provided by (Dickey and Fuller, 1979) test and (Phillips and Perron, 1988) test. The results provide an insight into an integration order (I) which is

crucial in determining what lag to use in Toda-Yamamoto Granger Causality. The null hypothesis from both tests is that there is a unit root.

In Table 4.1, ADF results show that ME is not stationary at level and first difference for Tanzania only. ME in Rwanda and Uganda is stationary at first difference with the results being significant at a 5% level of significance. In Kenya and Burundi, ME is stationary at first difference only with constant but the null hypothesis cannot be rejected with constant and trend. GDP unit root results are recorded in Table 4.2. We fail to reject the null hypothesis that there is a unit root for all the countries. The series shows not be in I (1) and a unit root test at the second difference would make the series stationary. In Table 4.3; CO₂ in Kenya is stationary after first differencing at a 1% level of significance. The same case is with Tanzania but in Burundi and Rwanda is not stationary even after the first difference. In Uganda CO₂ is stationary after the first difference at a 1% level of significance but with a constant and not constant and trend.

To confirm ADF results, the PP unit root test is also carried out to help come up with a general conclusion on the stationarity of the series. In Table 5.1, ME is only stationary after first differencing at a 1% level of significance in all countries. Hence ME is I (1) in all the countries. Tables 5.2 and 5.3 show GDP and CO₂ to be only stationary after the first differencing and the results are significant at a 1% level of significance. For this case, PP results show the series to be integrated of order 1; I(1). Meanwhile, ADF results can be generally concluded to be I(1) because some variables were non-stationary even after the first differencing which could indicate they exhibit stationarity after the second differencing I(2).

Table 4.1; ME ADF unit root test results

Country	Level		First Difference	
	<u>C</u>	<u>C&T</u>	<u>C</u>	<u>C&T</u>
BDI	-1.3882 [0.5862]	-1.5667 [0.8006]	-3.2668 [0.0186**]	-3.1159 [0.1072]
KEN	-1.1058 [0.7121]	-2.0999 [0.5403]	-3.4490 [0.0111**]	-3.2599 [0.0780]
RWA	-1.9834 [0.2938]	-2.5050 [0.3253]	-3.5280 [0.0088*]	-3.6256 [0.0318**]
TZA	-2.5407 [0.1085]	-1.9364 [0.6294]	-2.8125 [0.0595]	-5.184517 [0.0796]
UGA	-2.5517	-3.1971	-3.4918	-3.3865

[0.1060] [0.0899] [0.0098*] [0.0479**]

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

Table 4. 2; GDP ADF unit root test results

Country	Level		First Difference	
	<u>C</u>	<u>C&T</u>	<u>C</u>	<u>C&T</u>
BDI	-2.8191 [0.0584]	-3.0847 [0.1145]	-2.2598 [0.1868]	-2.6415 [0.2631]
KEN	0.7698 [0.9932]	-1.8853 [0.6561]	-2.6130 [0.0931]	-3.4042 [0.0555]
RWA	0.1637 [0.9692]	-8.7512 [0.0000*]	-2.7228 [0.0732]	-2.6856 [0.2445]
TZA	-1.1755 [0.6835]	-2.9082 [0.1637]	-2.0896 [0.2493]	-1.5847 [0.7936]
UGA	-2.2872 [0.1777]	-0.9143 [0.9503]	-2.3479 [0.1589]	-3.1525 [0.0992]

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

Table 4.3; CO₂ ADF unit root test results

Country	Level		First Difference	
	<u>C</u>	<u>C&T</u>	<u>C</u>	<u>C&T</u>
BDI	-1.0908 [0.7180]	-1.2442 [0.8963]	-2.1761 [0.2161]	-2.4802 [0.3374]
KEN	-1.8101 [0.3742]	-2.2571 [0.4538]	-4.5447 [0.0003*]	-4.4400 [0.0027*]
RWA	-0.8467 [0.8018]	-1.3721 [0.8643]	-2.8808 [0.0506]	-2.7751 [0.2094]
TZA	-0.4002 [0.9046]	-3.1851 [0.0922]	-3.6759 [0.0056*]	-3.6817 [0.0272**]
UGA	-1.1673 [0.6870]	-1.6215 [0.7789]	-3.0138 [0.0364**]	-3.0520 [0.1228]

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

Table 5.1; ME PP unit root test results

Country	Level		First Difference	
	<u>C</u>	<u>C&T</u>	<u>C</u>	<u>C&T</u>
BDI	-1.1678 [0.6870]	-1.9101 [0.6436]	-5.0389 [0.0000*]	-5.0091 [0.0004*]
KEN	-3.1941 [0.0225**]	-3.3535 [0.0624]	-5.1936 [0.0000*]	-5.2230 [0.0002*]
RWA	-1.7719 [0.3930]	-2.8128 [0.1954]	-11.1945 [0.0000*]	-12.0318 [0.0000*]
TZA	-1.8022 [0.3781]	-1.3632 [0.8672]	-5.3300 [0.0000*]	-5.2363 [0.0002*]
UGA	-2.5748 [0.1008]	-2.4938 [0.3308]	-5.2764 [0.0000*]	-5.1509 [0.0002*]

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

Table 5.2; GDP PP unit root test results

Country	Level		First Difference	
	<u>C</u>	<u>C&T</u>	<u>C</u>	<u>C&T</u>
BDI	-1.5830 [0.4884]	-1.6600 [0.7633]	-4.9398 [0.0001*]	-4.8563 [0.0006*]
KEN	1.7516 [0.9997]	-1.8861 [0.6561]	-5.1035 [0.0000*]	-5.3314 [0.0001*]
RWA	0.1444 [0.9679]	-3.1470 [0.1000]	-6.3345 [0.0000*]	-6.5235 [0.0000*]
TZA	0.9196 [0.9955]	-3.2782 [0.0745]	-3.4592 [0.0107**]	-3.7308 [0.0237**]
UGA	-1.8598 [0.3504]	-0.0538 [0.9952]	-5.3336 [0.0000*]	-5.3291 [0.0001*]

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

Table 5.3; CO₂ PP unit root test results

Country	Level		First Difference	
	<u>C</u>	<u>C&T</u>	<u>C</u>	<u>C&T</u>
BDI	-0.8940	-1.0876	-6.2578	-8.0987
	[0.7875]	[0.9265]	[0.0000*]	[0.0000*]
KEN	-0.9402	-2.2907	-5.6701	-5.5504
	[0.7726]	[0.4357]	[0.0000*]	[0.0000*]
RWA	-0.1322	-1.6887	-4.8766	-4.7907
	[0.9426]	[0.7510]	[0.0001*]	[0.0008*]
TZA	-0.2458	-2.2902	-5.6878	-5.6202
	[0.9284]	[0.4359]	[0.0000*]	[0.0000*]
UGA	-0.7300	-1.8255	-5.3655	-5.3272
	[0.8345]	[0.6868]	[0.0000*]	[0.0001*]

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

4.1. LGC Results and Discussion

The LGC test developed by Granger (1969) shows that ME does not granger cause neither GDP nor CO₂. The results in Table 6.1 provide an implication that policy changes in ME will not predict changes in GDP or CO₂. To support these results, a causal study by Saba and Ngepah (2019) countries revealed no causal relationship between ME and GDP in 7 of the 35 countries studied. However, the descriptive statistics in Tables 2.1-2.5 and stationarity results in Tables 4.1-5.3 show that the results may not be genuine. LGC is suitable for a stationary and normal series while the preliminary results say otherwise. Hence for the series used in this paper, the LGC may not be suitable.

Table 6.1; Linear Granger Causality

	<i>F</i> -statistic	<i>p</i> -value	<i>P</i>
<i>Causing variable: ME of BDI</i>			
GDP	0.0002	0.9891	1
CO ₂	1.5619	0.2021	3
<i>Causing variable: ME of KEN</i>			

GDP	1.2180	0.2993	2
CO ₂	1.3002	0.2775	3
<i>Causing variable: ME of RWA</i>			
GDP	0.5359	0.5865	2
CO ₂	1.9174	0.1303	3
<i>Causing variable: ME of TZA</i>			
GDP	2.3754	0.0559	4
CO ₂	1.5911	0.1950	3
<i>Causing variable: ME of UGA</i>			
GDP	0.5831	0.4465	1
CO ₂	1.9079	0.1696	1

* p-value < 1%, ** p-value < 5%

4.2 A Quantile Approach Results and Discussions

In this section, the novel QQ-GC approach developed by Adebayo and Özkan (2024) is utilized and the results discussed. The quarterly first differenced log series first undergoes through pre-estimation tests before the main causal test on this study. Descriptive statistics start, then unit root test and finally the BDS independence test. Normally, traditional unit root tests like Augmented Dickey and Fuller (ADF) Dickey & Fuller, (1979) and, Phillips-Perron (PP) Phillips & Perron, (1988) are employed. However, this paper uses a different approach to analyse the stationarity in the entire conditional distribution of the studies variables which the traditional tests do not consider. After these stages, the quantile-on-quantile granger causality is then employed.

4.2.1 Descriptive statistics

From Table 8.1, the mean of ME is negative in all the countries apart from Burundi. ME in Kenya shows the smallest mean. The smallest deviation from the mean is in Kenya while the largest is in Rwanda. ME data Skews negatively in Kenya, Tanzania and Uganda while in Burundi and Rwanda, it Skews positively, and the Kurtosis value is >3. JB results by Jarque and Bera (1980) confirm the series is not normally distributed. Moreover, GDP, the mean is largest in Uganda and smallest in Kenya but the mean deviates more in Rwanda and least in Tanzania. The data is Skewed to the left in all countries except Uganda but in all countries, the Kurtosis value is >3. JB results confirm the series to exhibit non-linearity. Finally, CO₂ has the largest mean in Tanzania and the smallest in

Rwanda while it has the highest volatility in Burundi and the lowest in Rwanda and Uganda. In Skewness, CO₂ is negatively Skewed in Kenya, Rwanda and Tanzania but positively in Burundi and Uganda with a Kurtosis value is >3. JB results show the series to be non-normal. The kurtosis value is >3 in all variables implying the series is leptokurtic.

Table 8.1; Descriptive Statistics of ME, GDP and CO₂

Panel A) GDP					
	Mean	Std. Dev.	Skewness	Kurtosis	JB
BDI	0.0007	0.003	-0.879	4.187	24.542*
KEN	0.0006	0.002	-0.363	5.805	45.812*
RWA	0.0017	0.013	-0.578	39.694	7356.620*
TZA	0.0013	0.001	-0.863	3.619	18.371*
UGA	0.0018	0.002	0.603	4.804	25.692*
Panel B) CO ₂					
BDI	0.0011	0.015	0.122	12.586	501.902*
KEN	0.0008	0.009	-0.613	5.743	49.277*
RWA	0.0006	0.006	-0.122	6.444	65.051*
TZA	0.0021	0.008	-0.762	8.598	183.718*
UGA	0.0020	0.006	0.563	12.649	515.129*
Panel C) ME					
BDI	0.0001	0.013	0.458	6.946	89.572*
KEN	-0.0022	0.007	-0.544	4.364	16.622*
RWA	-0.0013	0.049	1.561	42.534	8584.278*
TZA	-0.0011	0.009	-1.527	15.627	921.094*
UGA	-0.0010	0.021	-1.088	11.543	424.208*

Note: *** p < 0.01 and ** p < 0.05

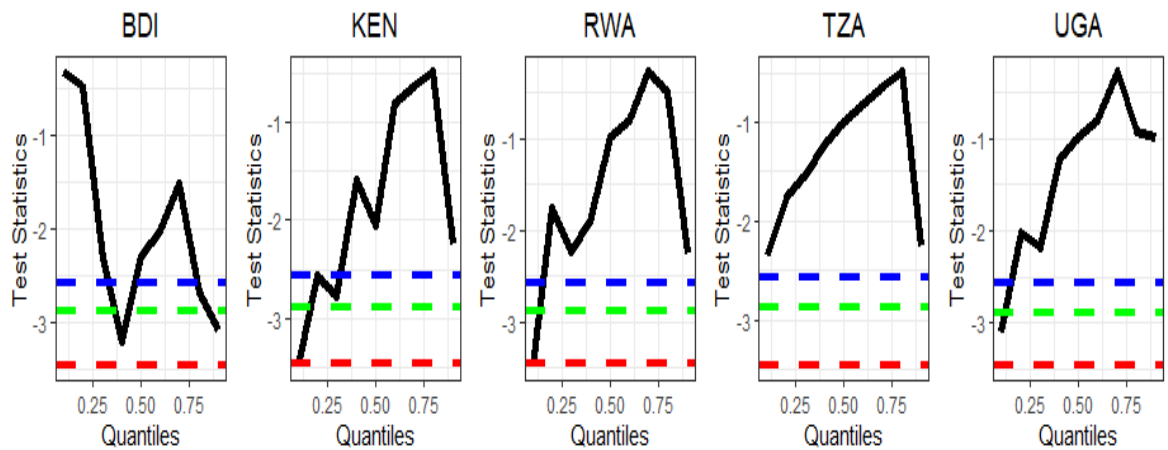
4.2.2 Unit Root Tests

Before the main analysis of this study, the QQ-GC approach the stationarity properties of the variables are first examined. Adebayo and Ozkan (2024) proposed quantile-ADF unit root test and quantile-PP unit root test which is utilized in this chapter. Figures 4.1-4.2 show the quantile unit root tests of ADF and PP at level. In Figure 4.1 Panels 1, 2 and 3 show GDP, CO₂ and ME to exhibit a non-stationary level even at a 10% level of significance respectively. Hence GDP, CO₂, and ME are all non-stationary at levels with

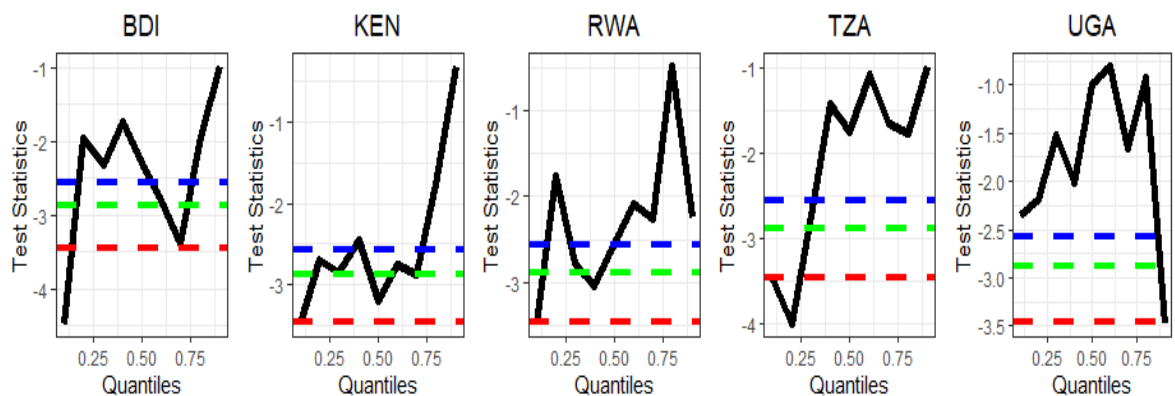
the quantile-ADF test. Similarly, for confirmation, figure 4.2 shows 3 panels with the results of the Quantile-PP unit root test at level. The results are similar to quantile-ADF, meaning that the variables are non-stationary even at 10% in their level forms. Therefore, the series is non-stationary at level.

Figures 4.3 and 4.4 provide the quantile stationarity results after first differencing. All variables become stationary even at a 1% level of significance with both in the quantile-ADF and quantile-PP unit root tests. Therefore, we conclude that the variables for this study are all integrated in the same order, that is, $I(1)$. The results match with those of non-quantile-based PP unit root tests in tables 5.1-5.3 but not entirely with non-quantile ADF results in Tables 4.1-4.3.

Panel (1): GDP



Panel (2): CO₂ emissions



Panel (3): ME

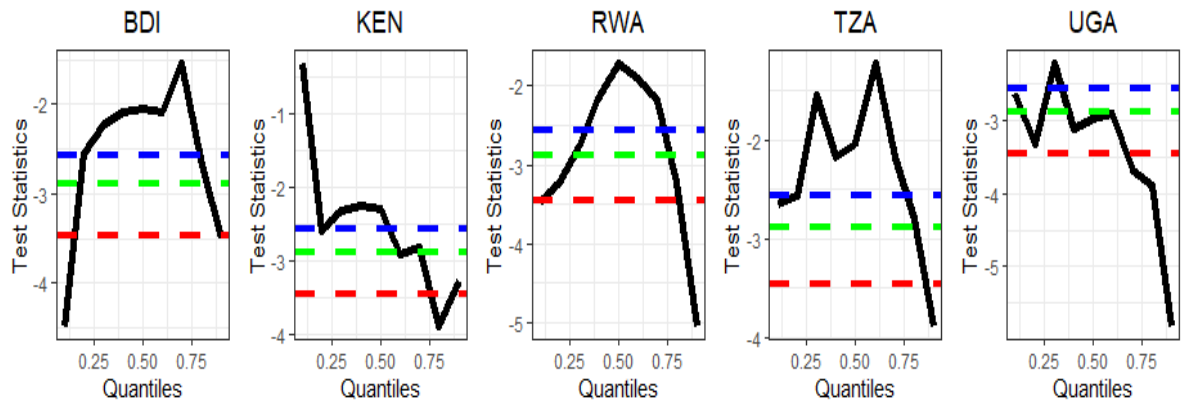
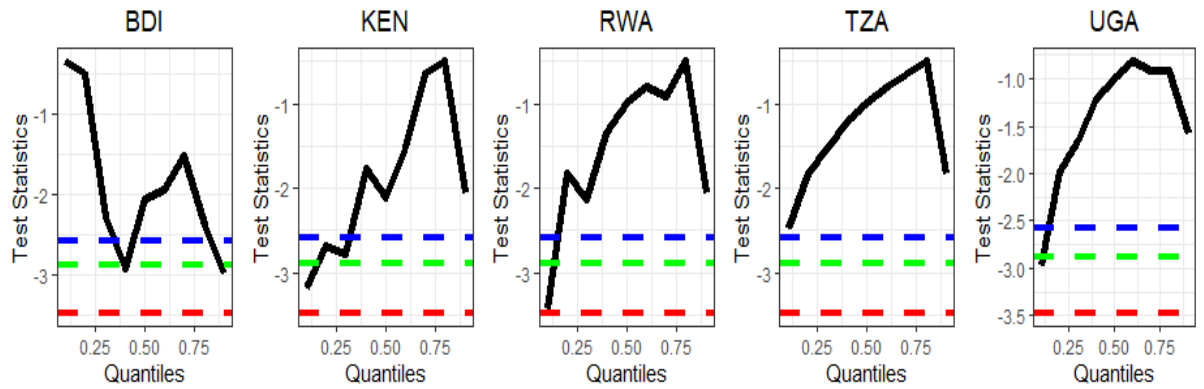
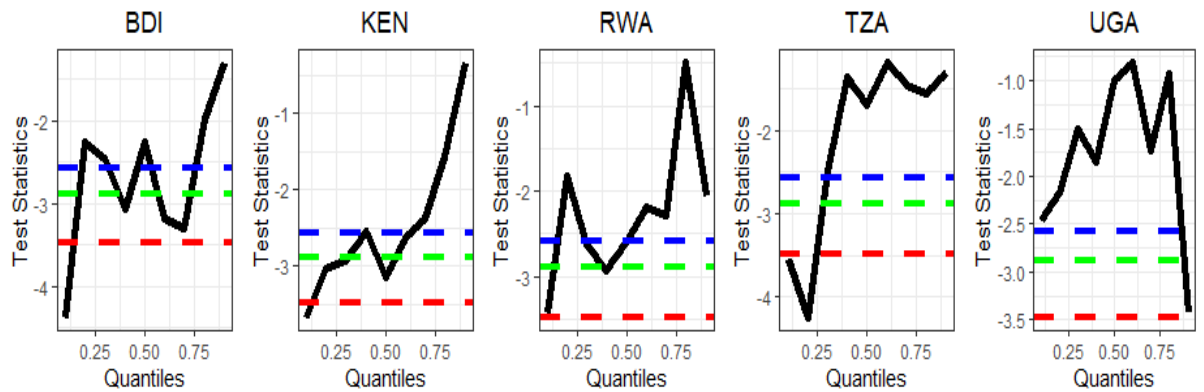


Figure 4.1; Quantile-ADF unit root test for the quarterly log-series at levels.
 Note: Blue, green, and red dotted lines represent 10%, 5%, and 1% significance levels.

Panel (1): GDP



Panel (2): CO₂ emissions



Panel (3) ME

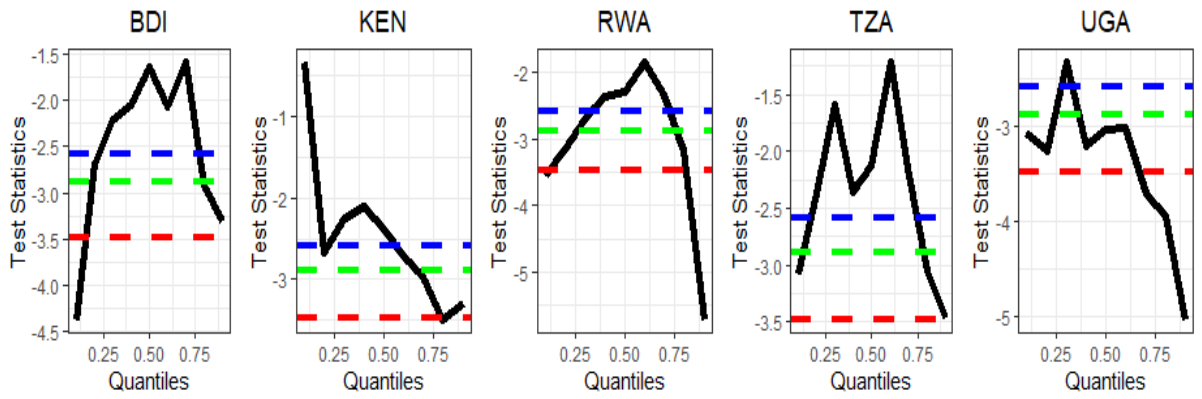
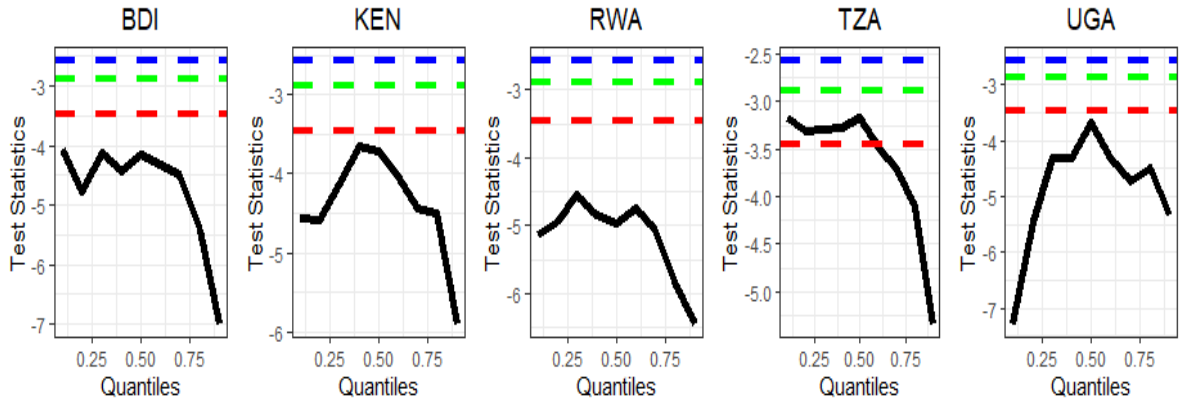
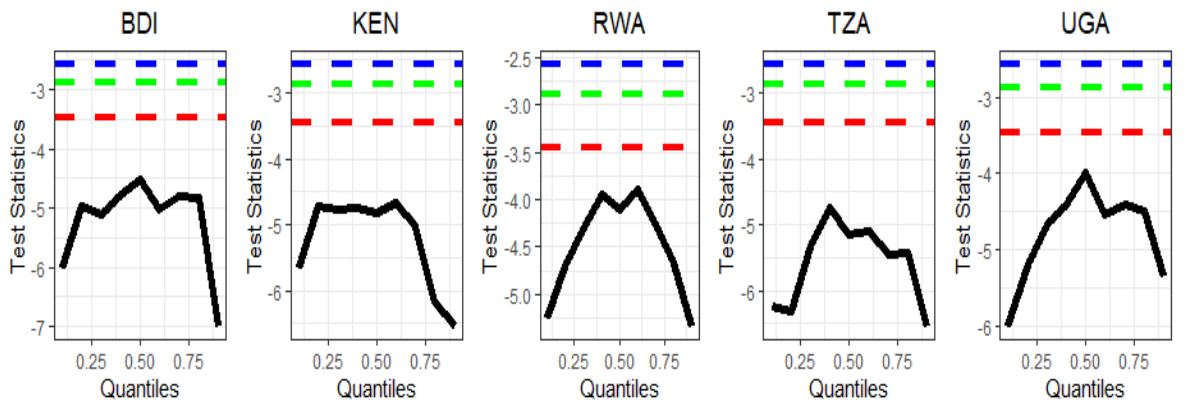


Figure 4.2; Quantile-PP unit root test for the quarterly log-series.
 Note: Blue, green, and red dotted lines represent 10%, 5%, and 1% significance levels.

Panel (1): GDP



Panel (2): CO₂ emissions



Panel (3): ME

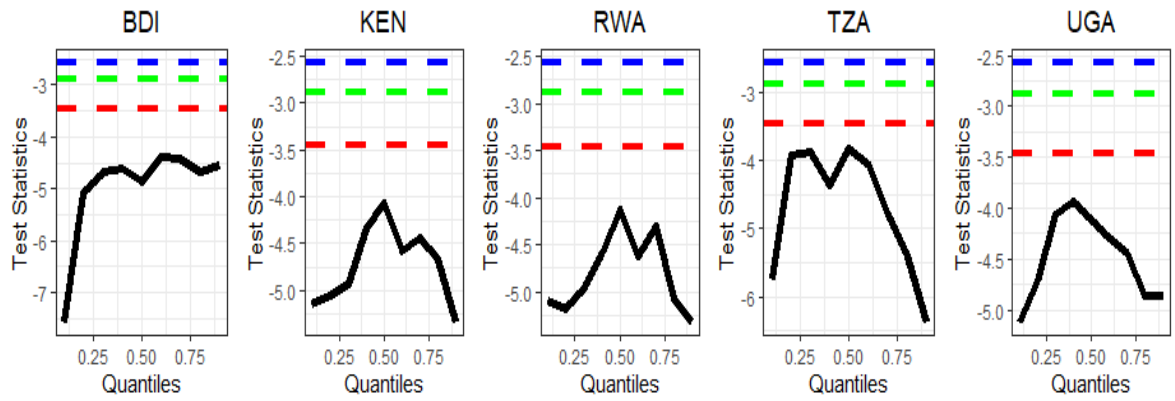
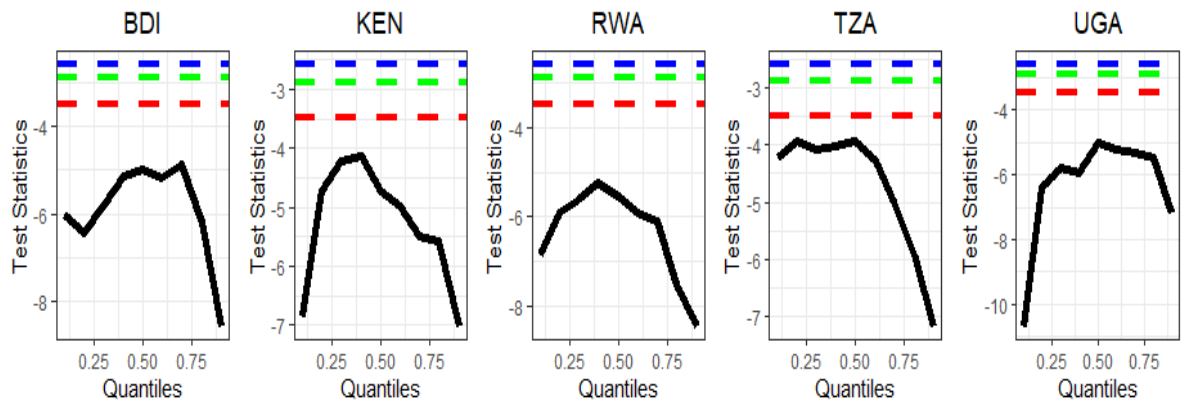
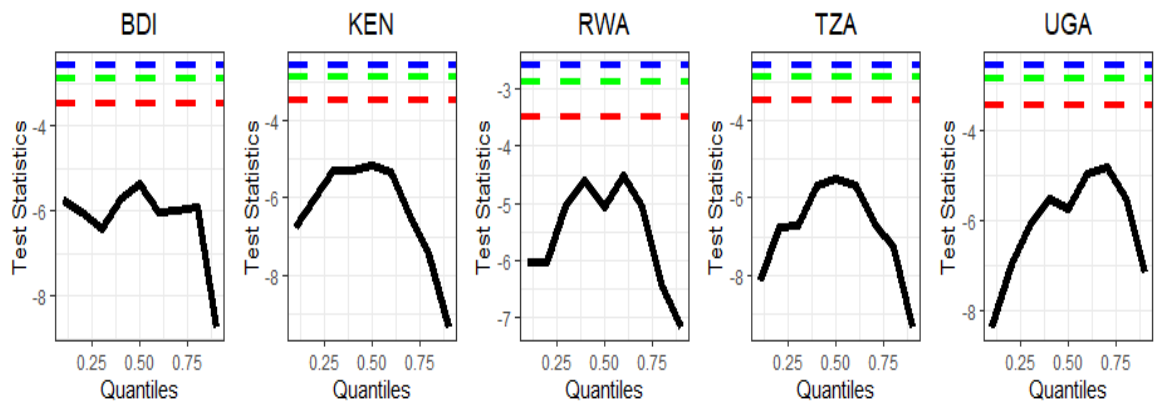


Figure 4.3; Quantile-ADF unit root test after first differencing
 Note: Blue, green, and red dotted lines represent 10%, 5%, and 1% significance levels

Panel (1): GDP



Panel (2): CO₂ emissions



Panel (3): ME

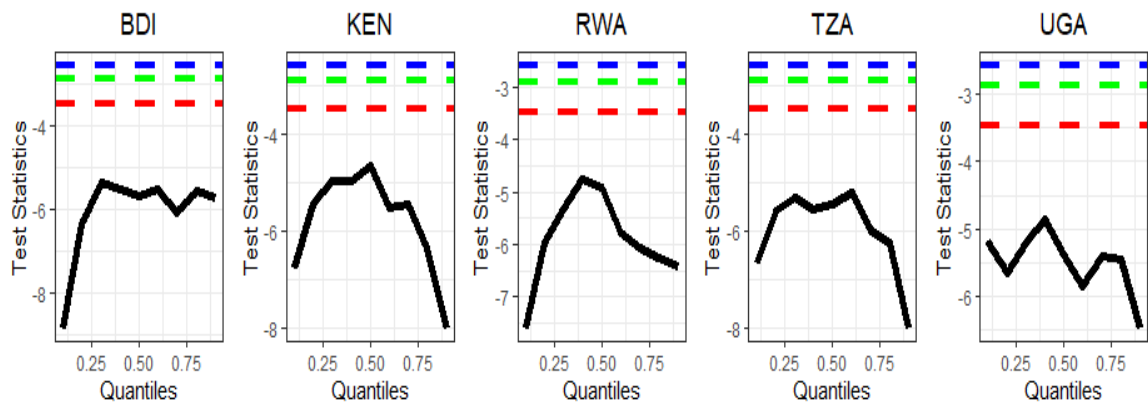


Figure 4.4; Quantile-PP unit root test results after first differencing.
 Note: Blue, green, and red dotted lines represent 10%, 5%, and 1% significance levels.

4.2.3 BDS Test

The Broock-Dechert-Scheinkman (BDS) test introduced by Broock et al. (1996) to analyse the (non)linearity status of the data series follows the stationarity tests. Here non-linearity is investigated in the first differenced log-series as seen in the works of Usman et al., (2024). The estimated z-statistics of the BDS independence test in Table 9, show that the stationary series exhibits non-linearity in the sample period. Following the Descriptive statistics and BDS test, the results are appropriate to use QQ-GC to analyse the analysis in the sample period.

Table 8.2; Nonlinearity Tests

Panel (A): GDP					
	Dmn:2	Dmn:3	Dmn:4	Dmn:5	Dmn:6
BDI	7.280*	6.526*	5.658*	6.458*	6.902*
KEN	9.650*	8.722*	7.936*	8.442*	8.527*
RWA	6.993*	7.770*	8.091*	9.152*	10.191*
TZA	17.505*	17.678*	17.688*	18.829*	20.155*
UGA	6.625*	5.291*	3.936*	4.247*	3.973**
Panel (B): CO ₂					
BDI	5.603*	4.710*	4.878*	5.987*	6.616*
KEN	6.527*	5.493*	4.593*	5.641*	6.170*
RWA	10.309*	9.336*	8.486*	9.285*	9.894*
TZA	6.441*	4.189*	2.681**	3.237*	3.719*
UGA	7.456*	6.228*	5.381*	5.406*	5.142*

Panel (C): ME					
BDI	5.519*	3.925*	2.589**	3.010*	3.394*
KEN	7.181*	6.031*	4.988*	6.020*	6.469*
RWA	8.764*	8.978*	8.917*	9.886*	10.850*
TZA	10.285*	9.828*	9.380*	9.449*	9.556*
UGA	7.322*	6.612*	6.260*	7.227*	8.003*

Note: * p-value < 0.01 and ** p-value < 0.05

4.2.4 QQ-GC Results and Discussion

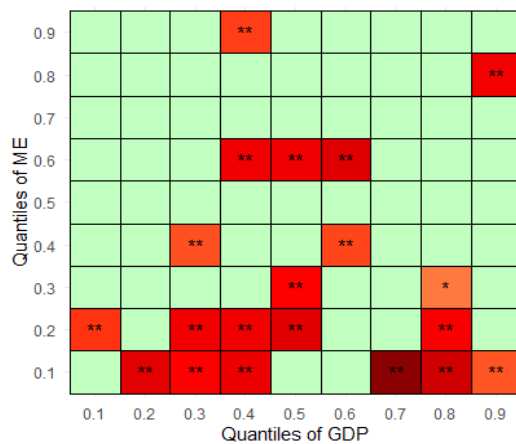
Figures 5.1 and 5.2 illustrate the predictive power of ME for GDP and CO₂ in Burundi, Kenya, Rwanda, Tanzania and Uganda. From Figure 5.1, In Burundi, there is strong causality between ME and GDP, that flows from the lower quantiles of ME (0.1 to 0.2) to the lower quantiles (0.2 to 0.4) and higher quantiles (0.7 to 0.9) of GDP. In Kenya, the predictive content of ME over GDP is observed to be weaker in the middle quantiles (0.4 to 0.6) but stronger in the upper quantiles (0.7 to 0.9) and lower quantiles (0.1 to 0.4) across ME and GDP quantiles. The causality flows from the lower quantiles of ME to the upper quantiles of GDP. Meanwhile, in Rwanda, the causality flows from the lower quantiles of ME to the middle and upper quantiles of GDP. Precisely, there is weak causality in the lower quantiles (0.2 to 0.4) but is stronger in the middle quantiles (0.4 to 0.6) and upper quantiles (0.7 to 0.9). In Tanzania, ME has a strong predictive power over GDP. The causality flows from the lower quantiles of ME (0.2 to 0.3) and upper quantiles (0.7 to 0.9) to the middle quantiles (0.3 to 0.6). Finally in Uganda, the causality is observed to be strong in the lower, middle and upper quantiles. It flows from the upper quantiles of ME (0.6 to 0.9) to the lower (0.2 to 0.4) and middle quantiles of GDP (0.4 to 0.6).

The predictive power of ME for GDP varies across the quantiles but is stronger in the lower and higher quantiles in Kenya, Burundi, and Uganda. The lower and upper quantiles represent periods of low and high expenditures, hence in these countries, ME has a stronger predictive capability for GDP. However, In Rwanda and Tanzania the strong predictive content of ME for GDP is observed in the middle and upper quantiles suggesting that ME's predictive power is stronger when militarization is normal and higher. The evidence of dependency structures from ME to GDP are consistent with the results of Saba and Ngepah (2019). Their results showed that in thirty-five African

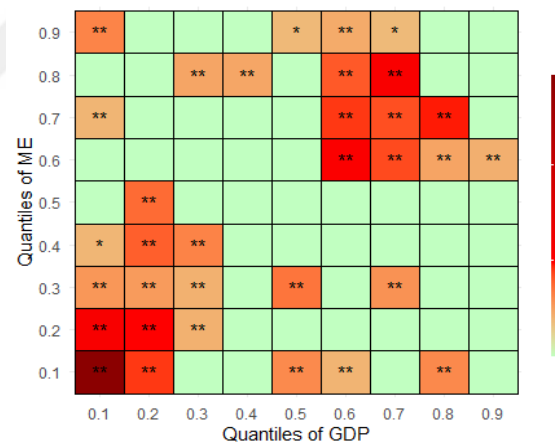
countries in only two, ME Granger caused growth. Consistently, Gbadebo et al. (2024) found comparable results of the causal relationship between defence expenditure to growth. They used Toda-Yamamoto and Hatemi-J causality tests examining the symmetric and asymmetric causal relationship between defence expenditure and GDP in Nigeria. However, a study covering 126 countries by Ortiz et al. (2019) found militarization to have predictive power over real output in middle-income countries but not in low-income countries.

In a nutshell, the predictive power of ME for GDP is strongest in Tanzania, Uganda and Burundi meaning militarization policies have a strong influence on GDP in these economies than in Kenya and Uganda where it was weaker. From Table 7.6, T-YGC results showed ME to have predictive power over GDP only in Rwanda and Tanzania at 1% level of significance while in Figure 5.1 QQ-GC results show ME to have predictive power for GDP in the countries. This shows that QQ-GC is a better approach to a causality analysis.

(a) BDI

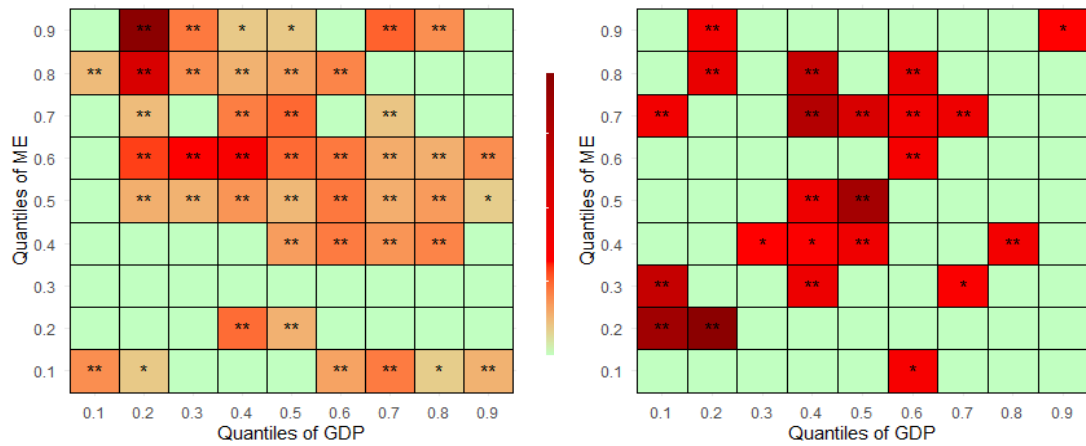


(b) KEN



(c) RWA

(d) TZA



(e) UGA

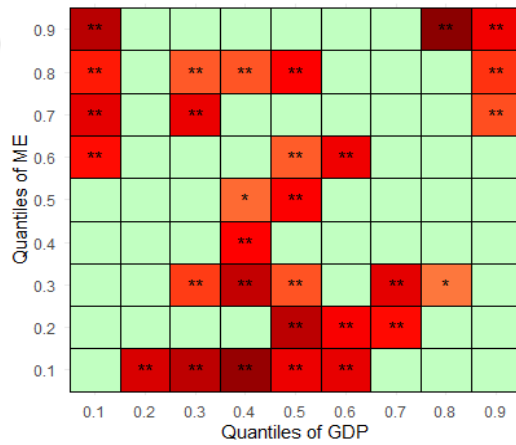


Figure 5.1; QQ-GC estimates between ME and GDP

Notes: ** denotes $p < 0.05$ and * denotes $p < 0.1$

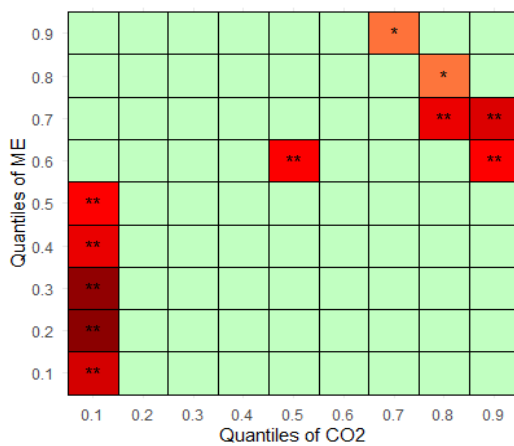
Moving to the causal linkage from ME to CO_2 , figure 5.2 shows the dependency structure between ME to CO_2 across their quantiles. Starting with Burundi, a strong causal linkage is observed from the lower to middle quantiles (0.1 to 0.5) and upper quantiles (0.6 to 0.9) of ME to the upper quantiles of CO_2 (0.6 to 0.9). In Kenya, the causality flows from the upper quantiles of ME (0.6 to 0.9) to the middle (0.4 to 0.5) to the upper (0.7 to 0.9) quantiles of CO_2 . Meanwhile, in Rwanda, the causal linkage flows from the lower (0.1 to 0.3) to the upper (0.8 to 0.9) quantiles of ME to the middle (0.6 to 0.7) quantiles of CO_2 . In Tanzania, the predictive power of ME flows from the lower (0.3 to 0.4) and upper (0.7 to 0.9) quantiles to the upper quantiles of CO_2 . Strong causal linkage is observed in the upper quantiles while no causal linkage in the lower quantiles. Finally, the case of Uganda indicates that ME has a predictive power for CO_2 in the lower quantiles (0.3 to 0.4) and

the higher quantiles of CO₂ emissions. This causal effect is stronger in the middle quantiles of ME.

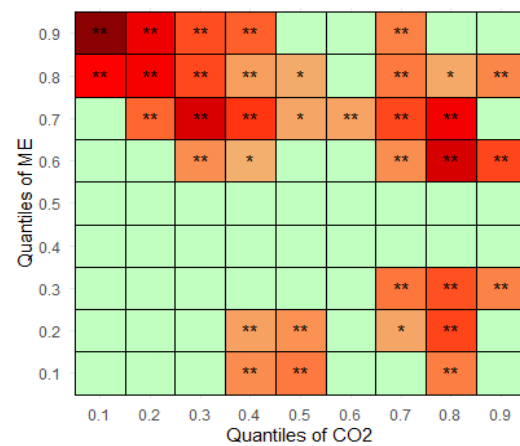
It can be summed up that, the dependency structure of ME over CO₂ in middle quantiles in Rwanda and Uganda. Stronger in the upper and lower quantiles in Burundi and Kenya while in Tanzania it is strongest in the upper quantiles. This suggests that, in Rwanda and Uganda ME has a strong influence on CO₂ when the expenditure in military is normal. In Kenya and Burundi, ME's influence is stronger in the extremes, in low and high military expenditure while in Tanzania in the periods of high military expenditure. In support of our results, Saritax and Burmaoglu (2016) as well as Ahmed et al., (2020) found a causal relationship flowing from militarization to the environment. Furthermore, Erdogan et al., (2022) with a similar study in Mediterranean nations, suggested that expenditure on defence harms the environment. On the contrary, Saba (2023) did not find any causal linkage between ME and CO₂.

To conclude, the dependency structure of ME over CO₂ is stronger and more spread across the quantiles in Kenya, Uganda and Rwanda. Therefore, policy changes on militarization in these countries will have more influence on CO₂ than in Tanzania and Burundi. The results in Table 7.6, ME Granges cause CO₂ in Burundi, Rwanda and Tanzania only yet with QQ-GC the causal linkage is observed in all countries selected.

(a) BDI

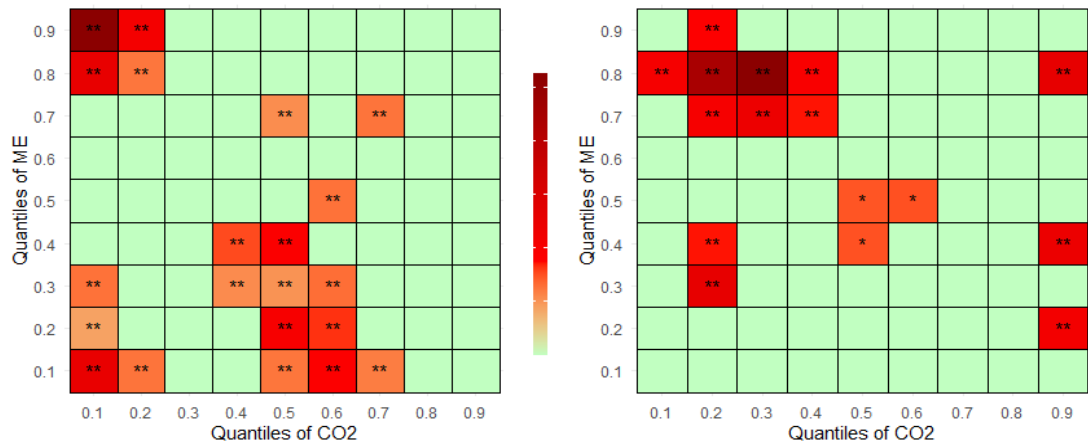


(b) KEN



(c) RWA

(d) TZA



(e) UGA

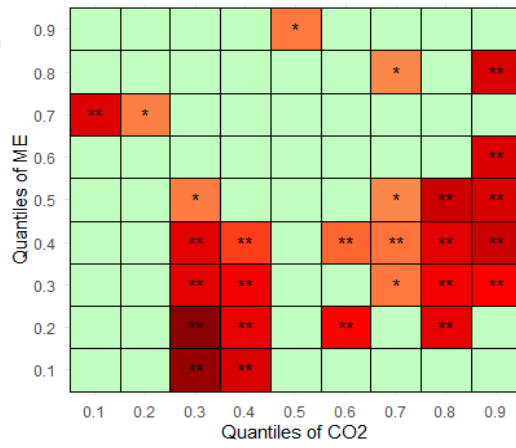


Figure 5.2; QQ-GC estimates of the causal effect between ME and CO₂

Notes: ** denotes $p < 0.05$ and * denotes $p < 0.1$

CHAPTER FIVE

5.0 Summary

5.1 Conclusion of the Study

With the high need for national security from conflicts, the level of militarization has increased in Africa. The thesis looks to explain the causal linkage of militarization on growth and environment in Burundi, Kenya, Rwanda, Tanzania and Uganda from 1990-2022. To clearly understand the causal relationship, the novel quantile-on-quantile Granger causality by Adebayo and Ozkan (2024). The results were then compared to linear Granger causality by Granger (1969). The empirical results prove that the main causality approach of the study is superior in handling the selected series. QQ-GC approach was able to identify causal linkages from ME to GDP and CO₂ in all countries while LGC did not find any causal linkages from ME to GDP and CO₂ in all countries. However, pre-estimation results showed the series to show non-linearity and non-normality, hence confirming their insignificance in this study.

QQ-GC results show evidence of ME predictive content over GDP and CO₂ in all countries selected. The results are heterogeneous across the quantiles of independent variables and dependent variables. In Kenya, Burundi and Uganda, ME's predictive power over GDP was stronger in lower and higher quantiles but weak in middle quantiles, hence a symmetrical relationship. Therefore, policies on militarization have more influence on GDP when expenditures on the military are high and low. Expenditure on the military through research and security should not create excuses for environmental degradation. The results show evidence of the heterogeneous predictive power of ME on CO₂ in all countries. ME causal linkage to CO₂ is stronger in the middle quantiles when the spending on military activities is normal in Uganda, Tanzania and Rwanda with low or no causality in the lower and upper quantiles. The causal linkage is only symmetrical in Kenya where it is stronger in the upper and lower quantiles while for other countries it is asymmetrical.

5.2 Policy Recommendation

The study focuses on militarization predictive content on growth and environment hence policy recommendations to the governments and policy makers of these countries should consider growing the economy as well as reserving the environment. From the results,

militarization Granger causes economic growth implying that an increase in military expenditure is likely to hinder or promote economic growth. In the case of hindering, the increase in ME will decrease consumption, investments and eventually economic growth. Therefore, the government should implement policies that will minimize spending on the military and focus on stimulating consumption, investment and economic growth. However, the spending should be minimized to a certain level to deal with unplanned internal and external conflicts which could still hinder the economy. In this case, the government can devote to peaceful conflict resolution techniques to maintain peace in their country and region. Militarization also Granger causes CO₂ as observed in Figure 5.2. Increasing the spending on militarization by deploying military equipment in ensuring peace in the country would likely have an adverse effect on the environment. Hence, we recommend the government deploy green energy-based military equipment instead of dirty energy-based equipment that uses vast amounts of energy. By doing so, the government will be complying with environmental sustainability goals as well as net-zero emissions targets.

5.3 Limitations of the Study

Although the study may look extensive covering three causality methodologies, it ignores other important aspects, hence it has some limitations. First, a regression would show the magnitude or direction of the effect of ME on GDP and CO₂. In that case, only three variables are used with no control variables. The causal results only show how ME would influence GDP and CO₂ but not the actual impact. Hence the results show ME to influence GDP and CO₂ but not the effect of ME whether it hinders growth and environment or promotes growth and environment. Studies by Alptekin and Levine (2012); Gokmenoglu et al., (2015); Ortiz et al., (2019) show results of both causality and regression. Second, the causal linkage analysed in this study is only one-sided; a uni-directional causal linkage from ME to GDP and CO₂. Of the four cases of causality, only two cases are described in the study, no causality and unilateral causality from militarization. The other cases of a uni-directional causality from GDP and CO₂ to ME and a bi-directional causality are all not captured unlike most studies in the literature like those of Gbadebo et al. (2024); Saba and Ngepah (2019); Erdogan et al. (2022). Third, the data of this thesis is based on only 5 developing countries in East Africa which therefore implies the suggestions in this study may not apply to other countries especially those more developed than those in our study.

Therefore, future studies will look to expand to more countries to provide a wider comprehensive understanding of this topic but also include an approach that will provide the size and magnitude of the effect of militarization on growth and the environment.



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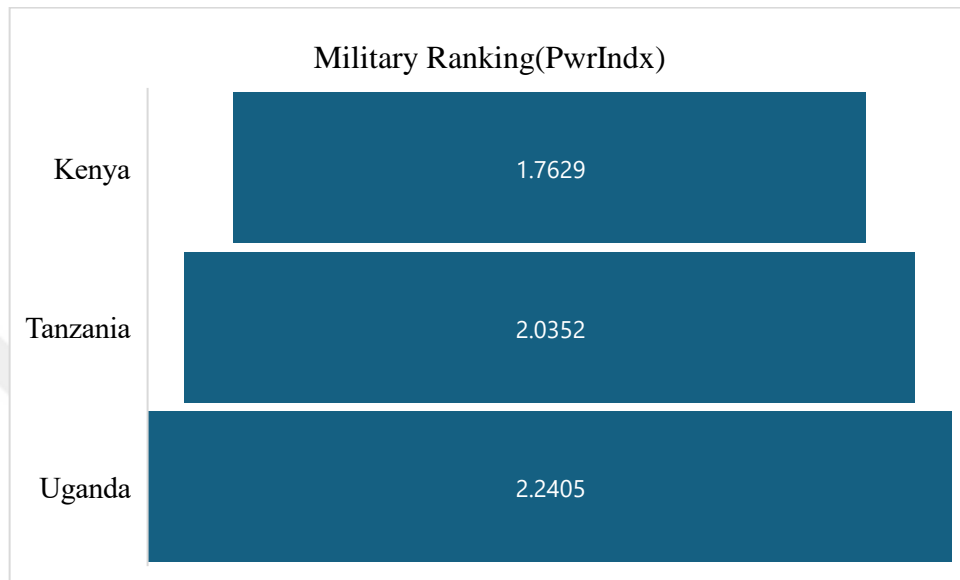
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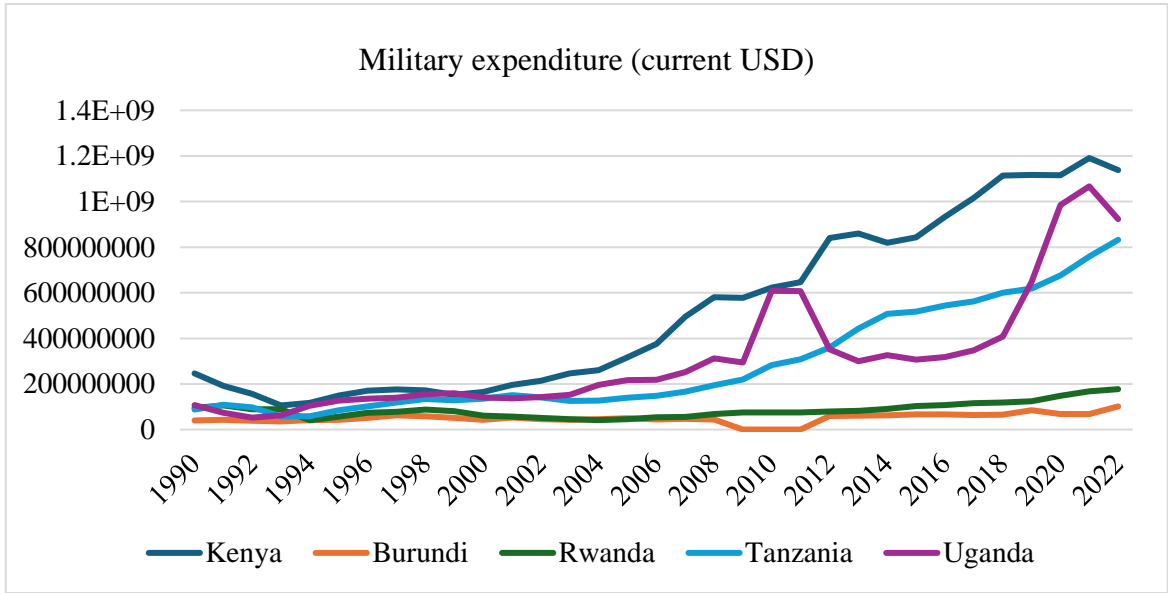
APPENDICES

APPENDIX 1.



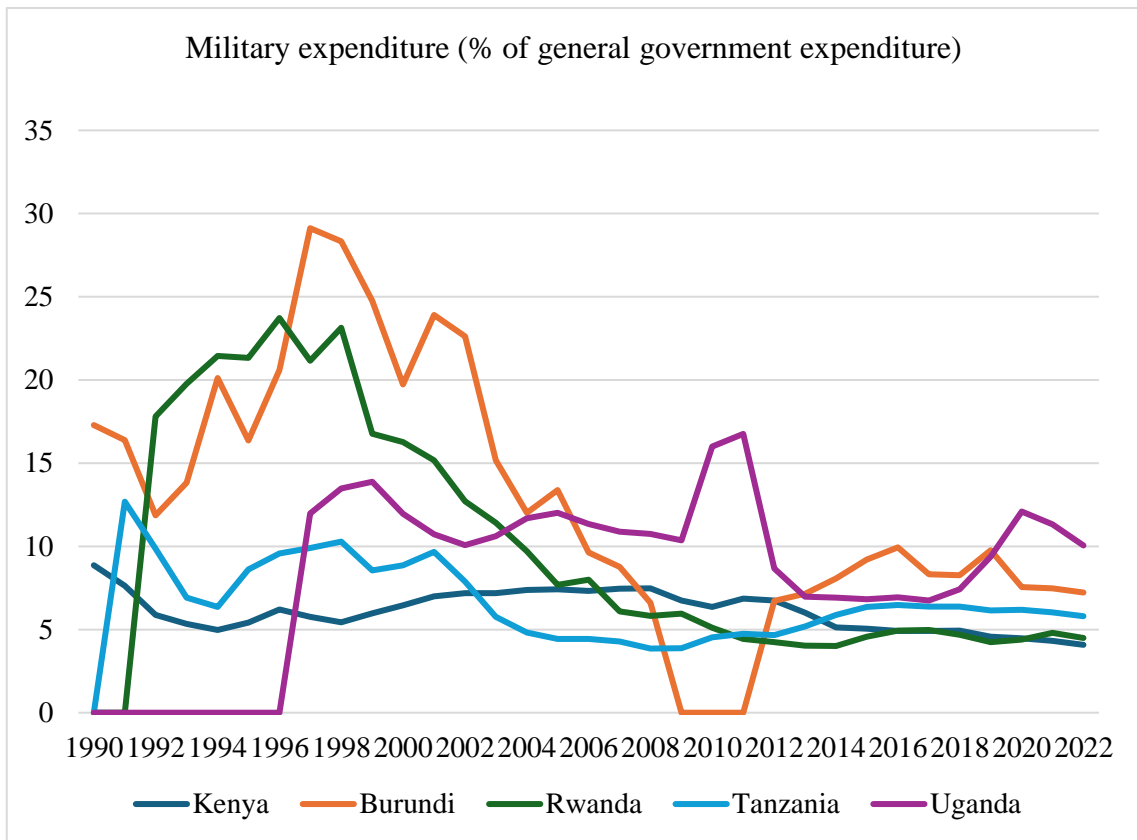
Source: SIPRI 2023

APPENDIX 2.



Source: SIPRI, 2023

APPENDIX 3.



Source: SIPRI, 2023