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FACULTY OF COMMERCE

DEPARTMENT OF ECONOMICS

IMPACT OF ECONOMIC GROWTH ON ENVIRONMENTAL QUALITY IN ZIMBABWE 1985-2015

BY

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A dissertation submitted to the Department of Economics in partial fulfillment of the Bachelor of Commerce Economics Honours Degree requirements.

SUPERVISOR Ms MANZOTE

YEAR 2017

DECLARATION

I, Mudzingwa Grace hereby declare that this research is a reflection of my own work towards the Bachelor of Commerce Economics Honours Degree.

Student's Signature…………………………. Date………………………..

SUPERVISOR'S APPROVAL FORM

The undersigned certify that they have supervised the student, Grace Mudzingwa (R141619C), dissertation entitled: The impact of economic growth on environmental quality in Zimbabwe. 1985-2015, submitted in partial fulfillment of the requirements of Bachelor of Commerce Economics Honours Degree at Midlands State University.

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APPROVAL FORM

The undersigned certify that they have supervised, read and recommend to the Midlands State University for acceptance of the research project entitled: The impact of economic growth on environmental quality in Zimbabwe. 1985-2015 submitted by Grace Mudzingwa (R141619C), in partial fulfillment of the requirements for Bachelor of Commerce Honours Degree in Economics.

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DEDICATIONS

I dedicate this piece of work to my parents.

ABSTRACT

This research was mainly aimed at investigating the environmental impact of economic growth in Zimbabwe for the period 1985-2015. Various authors have expressed their views with regards to the determinants of environmental degradation with economic growth as the major player. CO_2 *was used as a proxy for environmental quality. Using the Ordinary Least Squares model, the researcher obtained that in the early stages of development, growth accelerates the rate of environmental quality loss up to a certain level of income which would then later on help in improving environmental quality. The researcher then recommends on improving economic growth in Zimbabwe as way to improve environmental quality in Zimbabwe since increasing the level of national income increases the willingness to pay for a cleaner environment.*

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LIST OF ACRONYMS

CO	Carbon Monoxide
CO_2	Carbon Dioxide
EKC	Environmental Kuznets Curve
FEH	Factor Endowment Hypothesis
GDP	Gross Domestic Product
IPAT	Impact of Population, Affluence and Technology
LDC	Less Developed Countries
NO_2	Nitrogen Dioxide
PHH	Pollution Haven Hypothesis
STERP	Short-term Emergency Recovery Program
WDI	World Development Index

CHAPTER ONE

INTRODUCTION

1.0 Introduction

According to OECD (2000), environmental quality refers to the state of environmental conditions expressed in terms of indicators such as green-house gasses which include Carbon Dioxide (CO_2). According to Grossman and Krueger (1995), it constitutes the quality of the air, water and land. It also incorporates biodiversity. The higher the quantity of pollutants either in the air or water, the lower the environmental quality, therefore it can be measured using pollutants.

The Environmental Kuznets Curve (EKC) Hypothesis postulates that the relationship between economic growth and environmental quality is an inverted U-shaped that is to say economic growth increases the rate of environmental degradation in the short-run but will in the long-run improves environmental quality. According to Dasgupta *et al* (2002), environmental quality falls faster than per capita income in the early stage of development since greater priority will be given increased output, income and more jobs rather than to a clean and safer environment. Economic development leads to an increased use of the natural resources thereby increased emission of pollutants. In the early stages of development, people will be poor to pay for the environment but as their income increases the willingness to pay for quality environment increases thereby degradation falls. The emergency and effectiveness of the regulatory authorities such as EMA also contributes to an increase in environmental quality.

1.1 Background of the Study

Growing economic activities that are production and consumption, which are inevitable require the use of energy and materials. These economic activities generate large amounts of by-products. Ajide (2010) argued that environmental degradation can also put economic growth at risk itself. One of the major objectives of every economy is economic growth but this objective has a direct bearing on environmental quality. According to Kuznets (1955), environmental quality is hypothesized to vary with the level of economic development.

Economic growth can be defined as an increase in a nation's income according to Mishkin *et al* (2000). The real GDP growth for Zimbabwe for the period 1980-1992 was 2.4% on average. In the decade to 2010, the country's economic performance contracted by an average of 40,5% according to the Trade Policy (2012). This was due to high external debt, hyperinflation and an unstable macroeconomic environment among other things. In 2009, the government embraced a Short-term Emergency Recovery Program (STERP). This has shown greater economic recovery with growth rates of 6.7% in 2009, 13.18% in 2010 and 13.9% in 2011 according to the World Bank (2016). This program boosted the agricultural and the mining sectors which have proved to be the backbone of the Zimbabwean economy. From 2012, Zimbabwe encountered a drastic decline in the GDP which entails that the economy was definitely facing some challenges.

According to Blanco *et al* (2014) quality environment is regarded as a luxury good. The researcher argued that as the level of income increases, the willingness to pay for quality environment also increases. The researcher is therefore interested in ascertaining the impact of economic growth on environmental quality in Zimbabwe.

Since environmental quality is determined by the amount of pollutants as postulated by OECD (2000) therefore, for the purpose of this study, the researcher will use CO_2 as an environmental indicator. It is the major stock pollutant causing global warming. Global warming is a clear indication of climate change which is resulting from environmental degradation. In periods where there are high levels of carbon emissions recorded, it means the level of environmental degradation is high and in years with low carbon emission recorded, degradation would be low as well.

Fig. 1.1 depicts the trends of carbon-dioxide emission rate and economic growth rate for the period 1980 to 2014. The rate at which carbon emission is increasing is higher than the economic growth rate. With the low rate of economic growth, the Zimbabwean environment is at stake as shown by the higher rates of carbon emission.

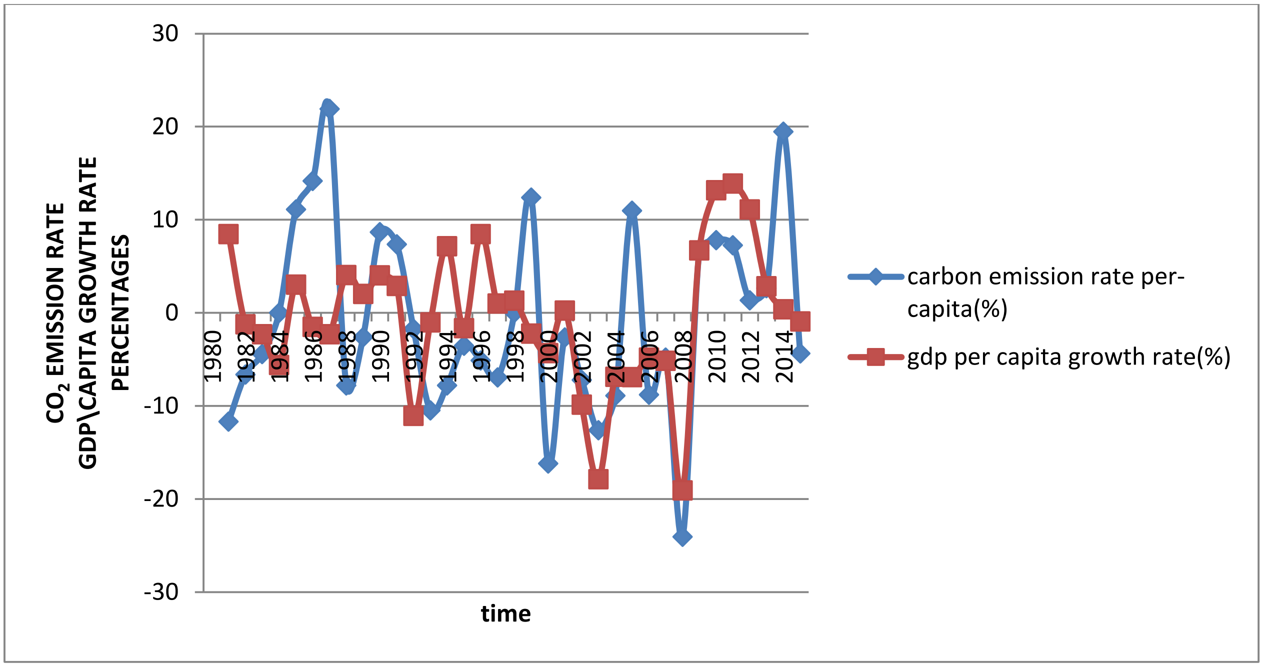

Fig. 1.1: Carbon dioxide emission rate and economic growth rate for Zimbabwe. (2006-2014)

Source: own calculation from data from The World Data Bank (2016).

The rate of carbon emission per-capita is surpassing the GDP per-capita growth rate in the Zimbabwean case in most years as shown in Fig.1.1In some years when economic growth rate was declining, the carbon emission rate was rather increasing. Referring to Fig.1.1, in 2004 economic growth was in the negative yet the carbon emission rate was as high as 10%. In the period, 2012-2014, economic growth was declining yet the carbon emission rate was increasing.

According to Kuznets (1955), both carbon emission and economic growth move in the same direction during the early stages of development, that is to say, as economic growth increases, carbon emission should increase as well. However, in the later stages of development, carbon emission falls as the level of economic growth increases. Since Zimbabwe is a less developed country, carbon emission should be increasing with economic growth assuming that quality environment is a luxury good of which only developed countries can consume. Therefore, the researcher seeks to ascertain the environmental impact of economic activities in the Zimbabwean scenario.

1.2 Problem statement

It is hypothesized that as the level of economic activities increase, the environment is negatively affected by increased pollution levels according to Kuznets (1955), up-to a certain level of income at which environmental quality will fall with economic growth. From the Zimbabwean scenario, it is not a clear cut issue as to the impact of economic growth on environmental quality. This is shown by the higher levels of carbon emission rates even if the level of economic growth was decreasing as shown in Fig.1.1. This research then seeks to explain and determine if economic growth affects environmental quality in Zimbabwe, to shed some light on the capabilities of mitigating carbon emission as well as improve or raise the level of economic growth as a way to improve the societal wellbeing of the Zimbabwean citizens. Of course increased national income is an indicator of increased societal well-being, but at the same time there is also need to consider the environmental cost of economic growth as it may also affect the nations' standards of living. There is need to mitigate the current environmental issues and advocate for a clean and safe environment, since environmental deterioration has the potential to worsen the economic growth of Zimbabwe if left unchecked. If increasing economic activities is the solution a clean environment in the long-run, as hypothesized by the EKC hypothesis, relevant policy recommendations may be drawn, basing on the results from this research.

1.3 Objectives of the study

The general objective is to determine the impact of economic growth on carbon emission in Zimbabwe where carbon emission is the environmental indicator.

The specific objectives are

- To determine the extent to which economic growth affects environmental quality.
- To come up with a quantitative analysis on the environmental impact of economic growth.
- Based on the findings of the study, to come up with relevant policy recommendations.

1.4 Hypothesis of the Study

H_0: Economic growth has no significant impact on environmental quality.

H_1: Economic growth has a significant impact on environmental quality.

1.5Significance of the Study

According to Tietenberg and Lewis (2012), the environment is regarded as an important asset in the long run, which the environmentalists are interested in ascertaining its value. This is done to ensure that firms and consumers consider the cost of lost quality environment when making their business and consumption decisions respectively. The accelerated level of pollution has increased the rate of environmental degradation. There is need to consider the opportunity cost of economic growth that is the loss in environmental quality. If in the long-run, economic growth has the potential to improve or solve the environmental issues that it would have posed in the short-run, then there is need to manipulate the growth of the economy so as to attain improved quality environment in the long-run. The EKC theory postulates that increased income levels can result in improvement in the quality of the environment, since the willingness to pay for environmental degradation would have increased, therefore this study seeks to determine whether economic growth can be a solution to the current environmental consequences currently faced by the nation.

Rahman and Porna (2001) and Ziramba (2015) among others employed panel data in the analysis of the impact of economic growth on environmental quality. Since panel data best suits with homogeneity among the selected groups, emissions may vary among nations due to several factors for example the stages of development therefore in assessing the environmental impact of growth may require country specific data. These studies also have been done in developed countries where economic growth rates are increasing with carbon emission. This research therefore seeks to fill the gap of the environmental consequences of economic activities in developing nations focusing on Zimbabwe in particular.

1.6 Organisation of the Rest of the Study

The rest of the study is structured as follows in the following chapters. In chapter Two the researcher reviews the existing literature on the subject matter. It constitutes both theoretical and empirical literature review. Chapter Three constitutes the methodology to be used in the study. In this chapter, the researcher will indicate the adopted model from the literature. The relevant tests carried out will also be outlined in this chapter. Chapter Four will then put the methodology outlined in chapter three into practice. The results from the study will be presented as well as analyzed in chapter four. Chapter Five will outline the recommendations and conclusions drawn.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviews all relevant literature, both empirical and theoretical. In the first section of this chapter the researcher will dwell on the theoretical literature of the environmental impact of economic growth. The theoretical literature review will include theories that analyze the environmental impact of economic growth with the Environmental Kuznets Curve (EKC) Hypothesis amongst them. The other section of this study will consist of the empirical studies on the impact of economic growth on the environmental quality by other scholars.

2.1Theoretical Literature Review

There are a few theories that have been put forward in explaining the impact of economic growth on environmental quality. The major theory in this respect is known to be the Environmental Kuznets Curve (EKC) Hypothesis with other theories coming after it. These include the Pollution Haven Hypothesis (PHH), Factor Endowment Hypothesis (FEH) and the Impact of Population Affluence and Technology (IPAT) model. All these theories are explored in this section to shed more light on the impact of economic growth on the environment.

2.1.1 The Environmental Kuznets Curve Hypothesis (EKC)

The EKC hypothesis is the underlying theory in explaining the effect of economic growth on environmental quality. This theory was propounded by Kuznets (1955). It postulates that there are three different channels in which economic growth affects the quality of the environment and these are the scale effect, the composition and the technique effect.

The scale effect is the rate at which pollution increases as the income level increases. It is present in the initial stages of development. The increased environmental degradation is a result of the extraction of the natural raw materials which are used in production. The composition effect refers to the structural changes in the economy which may result in long-run environmental pressure. Increased growth results in the structural changes in the economy and the economy would then engage in less polluting activities. The technique effect refers to the level of an economy's government regulations and the techniques employed by the firms. Economic growth brings about technological progress. This helps to counter-act the scale effects and reduces the demand for natural resources to fuel in economic growth.

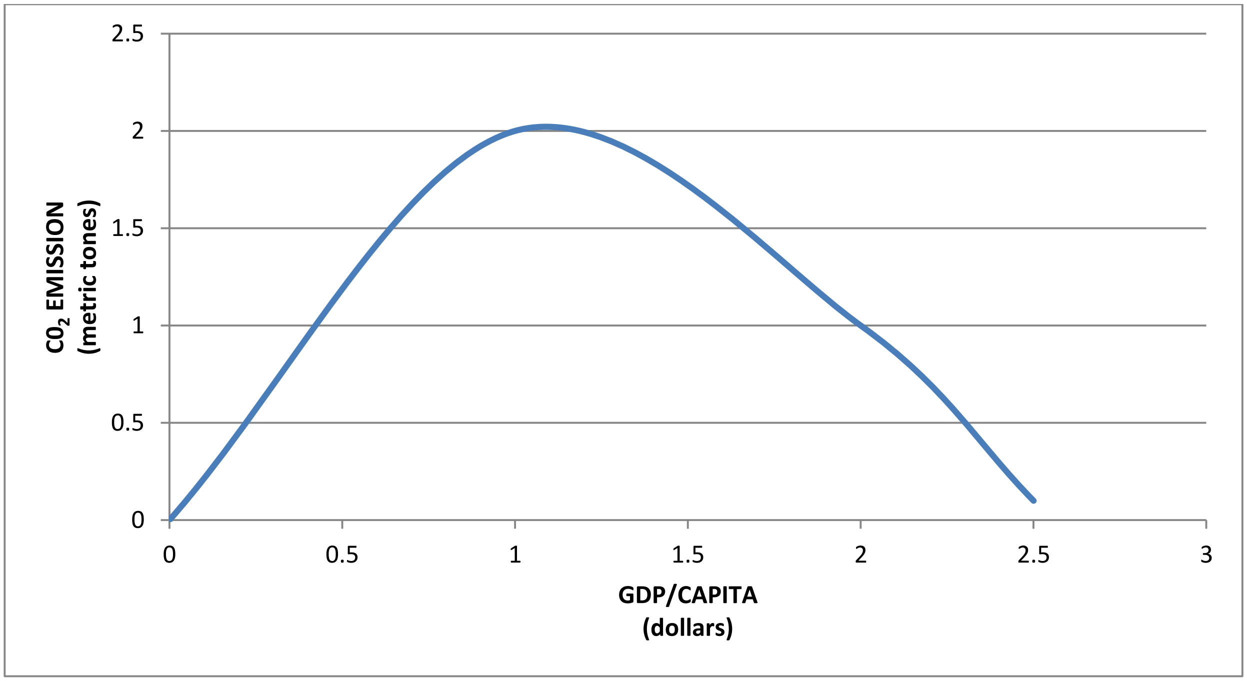

Fig. 2.1: The Environmental Kuznets Curve (EKC)

Source: Kuznets (1955)

The EKC postulates that as the level of a nation's income increases, environmental degradation increases with it, but then will begin to fall with increases in income. This results in an inverted-U shaped curve as shown on Fig. 2.1. It assumes that as income increases, the income elasticity for a cleaner environment also increases. In other words, this theory considers a clean environment to be a luxury good which only the rich economies can manage to consume according to Blanco *et al* (2014). Increases in economic development increases environmental damage due to several reasons argued Dinda (2005). It may be due to greater use of the available natural resources, more emission of pollutants for example carbon dioxide, dirty technologies employed, prioritization of increased income and less regard for the environmental consequences of economic growth. After a certain level or threshold of income, the economy's resources will then be channeled towards environmental protection, thus the U-shaped curve.

From the above explanation, it can be noted that this theory does quite well in explaining the environmental impact of economic growth. The inverted-U shaped curve shows that in the early stages of development, economic growth has a negative effect on environmental quality. This is shown by the increase in carbon emission with less GDP per capita. In the long-run however, with continuous economic growth, economic growth denotes a positive relationship on environmental quality which is shown by a fall in the carbon emission. However, the EKC does not denote the level of national income that a nation should attain in-order to begin having the benefits of quality environment. It just generalizes the turning point of which it may differ with the type of pollutant or with the country's stage of development.

2.1.2 The Pollution Haven Hypothesis (PHH)

Another theory that explains environmental degradation is the Pollution Haven Hypothesis (PHH). The theory was formulated by McGuire (1982). This hypothesis assumes that the level of strictness of the environmental regulations determines environmental quality. It further assumes globalization and free trade.

Developed countries are assumed to have strict regulations towards environmental protection therefore polluting firms relocate to developing countries where the regulations are assumed to be lax. Just like the EKC, this theory argues that in developing countries much priority is given to increased income and job creation and less attention is given to the environment. Rather, the cost of implementing and monitoring the environmental regulations is high, thus, resulting in relaxed regulations. This will then result in developing countries being pollution havens. According to Copeland (2013), the level of environmental quality is determined by the pollution intensity of an economic activity. The developing countries will then have comparative advantages in the production of the intensive polluting or dirty goods after the relocation by the MNC's.

Since the strict regulations lead to increased cost to the firms, they find it rationale to relocate. Their relocation increases the pace of environmental degradation, through the production of pollution intensive goods, in the developing countries increasing economic activities at the same time. Temurshoev (2009) argued that as the MNC's move to the developing countries, jobs are created and the social well-being is improved but then environmental degradation is accelerated.

This theory thereby concludes that developed countries benefit from quality environment at the expense of the developing countries.

Form the PHH perspective, economic growth resulting from MNC's activities in developing nations has a negative impact on environmental quality. Environmental degradation is accelerated with the increased level of economic activities in the developing nations since the increased economic growth results from the production of 'dirty' goods. This thereby means that in developing nations like Zimbabwe, economic growth has a negative effect on environmental quality that is to say environmental quality is lost as the level of economic activity increases.

2.1.3 The Factor Endowment Hypothesis (FEH)

The Factor Endowment Hypothesis (FEH) as propounded by Heckscher and Ohlin (1977) also explains environmental degradation in some way. It says that international trade is governed by comparative advantage. This comparative advantage also results from factor abundance. Countries with abundant factors that are used in polluting industries will on average have a higher rate of deterioration. Developed countries are assumed to be capital abundant, of which most industries, in which the capital is employed, emit more pollutants resulting in higher levels of environmental degradation in developed countries as compared to developing countries which are labour abundant.

Capital intensity is assumed to be positively correlated to pollution intensity. The capital abundant nations have comparative advantage in the production of 'dirty' goods which they will end up exporting to the labour abundant nations which produce the less polluting goods. This therefore means that the capital abundant nations increase their productivity by increasing the production of the pollution intensive goods which accelerate environmental degradation.

In reference to the FEH, developing nations like Zimbabwe which have abundant labour, can have an increase in economic growth facing less environmental consequences as compared to developed nations which have a comparative advantage in the production of capital intensive goods which intensifies the pollution levels. This therefore means that, according to the FEH, for developing nations like Zimbabwe, economic growth has no significant impact on environmental quality since their growth is facilitated by the use of a non-emitting factor of production that is labour.

2.1.4 The Impact of Population Affluence and Technology (IPAT) Model

This model was postulated by Ehrlich and Holdren (1972). The model explained the determinants of environmental impact. The major determinants in this model were population size, per-capita income and the level of technology that is available to cater for the level of consumption. The model depicts a non-linear and multiplicative relationship amongst the variables. The variables were rather dependent of each other since their product was determined as the degree of environmental impact.

Dietz and Rosa (1994) modified the model from IPAT to STIRPAT. The new model accounted for the impact of the error term, and made it possible for the estimation of parameters. The modified model was then used in economic analysis of the variables that is population, per-capita income and the level of technology.

Based on this model the level of economic growth accelerates environmental degradation. In other words, the environmental impact of economic growth is hypothesized to be positive that is to say they move in the same direction. If growth slows down, environmental impact should also fall. Based on this model, developed nations that have greater scale of production are hypothesized to have the greatest environmental impact than the developing nations since the high levels of economic growth leads to higher levels of pollutant emission. For developing nations like Zimbabwe where economic activity is low, the environmental impact of economic activities is assumed to be low as well.

2.2 Empirical Literature Review

Shafik and Bandopadhyay (1992) managed to estimate a relationship between economic growth and several indicators of environmental quality. The researchers argued that the environment is both an input and a consumable good. The researchers also argued that the types and forms of environmental degradation depend on the composition of output. This research was based on the panel data of one hundred and forty-nine countries, both developed and developing. The findings from this study gave a consistently significant relationship between environmental stress and national income. As the level of national income increases from low to high, the amount of pollutants into the air increased and then started to decrease as the economy reached a certain level of income, thus the turning point. The researchers also concluded that there was hope of coming out of the environmental problems in the long-run that is if the economy evolved from being poor to rich.

According to Grossman and Krueger (1995), the relationship between the level of pollution and economic growth has been estimated using equations that relate the level of pollutant emission to a flexible function of per capita income and to other covariates using the OLS model. The researchers assessed the relationship between the scale of economic activity and environmental quality indicators. The researchers argued that there are several environmental quality indicators and each indicator responds to economic growth differently. This study considered the quality of air as well as water quality. The study was based on the panel data of forty-six nations. Their model of estimation was in a form of polynomial and the researchers argued that the reason of using squared and cubed per-capita income was to consider the long-run environmental impact of per-capita income. The results from this study were in support of the EKC even though each environmental quality indicator had a different turning point.

Another research was carried out by Rahman and Porna (2001) who also assessed the long-run relationship between economic growth and environmental quality. The researchers argued that the resources for production are extracted from the environment and the by-products of production are also emitted on to the environment therefore collectively this has led to environmental degradation. The researchers used the panel co-integration technique for six countries in Asia to test the relationship between environmental qualities in these countries. The results depicted a positive relationship between per capita income and environmental degradation that is to say, environmental depletion increased with the level of economic growth.

For Hung and Shaw (2006) the approach was different. The researchers also conducted a research on the relationship between environmental quality and economic growth but the researchers' argument was that both variables were endogenously determined. Since regression of one linear equation where both variables determine each other yields biased results, the research was conducted using the simultaneous equation and used the 2-Stage-Least-Squares model for estimation. As proxies for environmental quality, the researchers used carbon monoxide (CO) and nitrogen dioxide (NO_2) and confirmed the existence of the EKC for those pollutants in Taiwan. However, the results showed that CO and NO_2 emission did not have any significant impact on economic growth.

In assessing the relationship between economic growth and international trade on environmental quality for developing and developed countries, Abdulai and Ramcke (2009) employed the Vector Error Correction Model (VECM).The scope of this study was 1980-2003. The results showed that both trade and growth affected environmental quality. The researchers then concluded that environmental quality was a thing for the developed nations since only economies with higher income levels could consume it, but then developing countries were associated with environmental degradation. The researchers suggested that for a clean and safe environment in developing nations, developed nations had to assist the developing countries to pull other their economic growth levels as well as in the structuring of environmental protection policies.

In the same manner, Yang *et al* (2010) employed the Johansen co-integration test as well as the Granger causality between environmental depletion and per-capita income. The researchers used time-series data from 1981-2006 for China. The researchers used three proxies for environmental quality and these are industrial waste water, industrial solid waste and waste gas. The results showed a negative long-run co-integration relationship between the two variables that is to say environmental depletion did not affect economic growth but rather economic growth significantly caused environmental depletion.

In Asia, Choi *et al* (2010) assessed the impact of trade openness and economic growth on the environment for three countries namely China, Japan and Korea for the period 1971-2006. This research analyzed the dynamic relationship of the variables using Vector Error Correction model. Both trade openness and growth had impacts on environmental quality even though the patterns differed with nations. The researchers then argued that the differences in the patterns of the relationship of the variables differed due to different levels of development.

Moreover, Wilson (2010) used time series data for the period 1981-2010. The researcher assessed the role or impact of other macro-economic variables on carbon dioxide emission in India. The variables included in the model were wholesale-price index of fossil fuels (WPI), energy consumption per capita, per capita income and energy reforms and the researcher adopted the IPAT model and estimated the co-efficients of the variables using OLS. This research also intended to assess the validity of the EKC in India. The results showed that per capita energy consumption and the WPI of fossil fuels had the greatest explanatory power. The researcher also concluded that if the EKC exist, India has not yet reached its turning point income.

In assessing the impact of economic growth and environmental quality, Phimphanthavong (2012) used time series data covering a period of 1980-2010. This research was done in Laos, Italy. To avoid spurious regressions associated with time series data, the researcher first did unit root tests for the variables and then estimated the results using OLS. The findings from this study confirmed with the EKC. The researcher then suggested that there is need for strong environmental protection so as to attain the sustainable development goals in Laos.

Alege and Ogundipe (2013) also assessed the relationship between environmental quality and economic growth in Nigeria for the period 1970-2011. The researchers used trade openness, population density, foreign direct investment and institutional quality as control variables. The results from this study showed that trade openness and weak institutions increased the rate of environmental degradation due to dumping. Population density increased the environmental abatement measures and the demand for a cleaner environment. Foreign direct investment negatively affected environmental quality. The results also showed the non-existence of the EKC since they failed to come up with the turning point income for Nigeria.

A research done by Kinda (2015) in eighty-five countries showed that economic growth and education positively affect environmental quality both in developed and developing nations. On the other hand, trade openness and democracy had a negative effect on the environment. The researcher argued that women education improved the environmental quality through population growth thus reducing pressure on the environment. Education also helps in molding up technocrats who would formulate effective policies that protect the environment. On the other hand, democracy led to environmental exploitation due to lack of property rights. Estimation was done using the Generalised Method of Moment.

Another research on the determinants of carbon dioxide emission in Africa was done by Ziramba (2015). The researcher used panel data for six Southern-Africa countries with Zimbabwe included. The researcher used the Auto Regressive Distributed Lag (ARDL) model in his research. The major determinant of carbon dioxide emission in these countries turned out to be the level of per capita income. However, the results failed to justify the existence of the EKC in these countries.

In the same manner, Sunday (2016)also investigated the validity of the EKC in Sub-Saharan African countries. The researcher used panel data for the countries ranging from 1980 to 2016 using the Ordinary Least Squares model. The researcher used different pollutants as proxies for environmental quality. The findings from this research showed that the EKC vas valid for certain pollutants and rejected it for other pollutants like carbon dioxide. The researcher then concluded that the, "pollute the environment today and it will clear up itself later" hypothesis do not hold for some pollutants such as carbon dioxide since they are stock pollutants. The emission of such pollutants accumulates in the long-run leading to increased stocks of such pollutants. The researcher also concluded that the EKC only hold for flow pollutants which do not have a long-run environmental impact.

2.3 Conclusion

The researcher managed to give a critical evaluation of the available literature on the impact of economic growth on environmental quality. The researcher also managed to give an outline of theories that have anchored this research. The results from the empirics outlined in this chapter differed across nations. In the following chapter the researcher will present the model adopted from the above outlined empirics in the analysis of the environmental impact of economic growth.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter presents the model used in the study, data collection methods and their sources among other things. The diagnostic tests done by the researcher are also presented in this chapter. This chapter is a pre-cursor for the following chapter for the results obtained from the undergone tests in this chapter will be presented in chapter four.

3.1 Model Specification

The study follows an empirical framework of Alege and Ogundipe (2013)and Phimphanthavong (2012)where the researchers specified a linear relationship between the environmental indicators and national income. The researchers emphasized on the quadratic function of GDP to determine its short-run and long-run impacts on environmental quality. Therefore, the model employed in this research is as follows:

$$CO_2 = \alpha_0 + \alpha_1 GDP_t + \alpha_2 GDP_t^2 + \alpha_3 GOV_t + \alpha_4 TO_t + \alpha_5 FDI_t + \alpha_6 EDU_t + \varepsilon_t \quad (1)$$

Where: CO_2 is carbon dioxide emission per capita and is the proxy for environmental quality. It is measured in metric tons per capita.

GDP is GDP per capita and is the proxy for economic growth in current US Dollars.

GOV is government expenditure on education. It is the government share as a percentage of national income.

TO is the degree of trade openness. It is measured using the trade openness ratio calculated as the GDP share of exports and imports.

FDI is Foreign Direct Investment measured as net inflows as a percentage of GDP.

EDU is a proxy of the literacy rate of the populace measured as primary school enrollment as a percentage of gross.

ε is the error term.

$\alpha_0 - \alpha_6$are the coefficients of the variables as well as the estimation parameters.

3.2 Justification of Variables

3.2.1 Gross Domestic Product (GDP)

This variable is the proxy for economic growth. The realGDP per capita was used in this study. Real GDP is the national income adjusted for inflation for the relative period according to Mishkin*et al* (2004).It is expected to have a positive relationship with carbon emission according to Kuznets (1955). This is due to the fact at the early stages of development, environmental quality would be negatively affected. It is measured as GDP (Current US Dollars) and data is obtained from the World Data Bank (2016).

3.2.2 Gross Domestic Product squared (GDP^2)

The squared GDP is added to determine the long run impact of economic growth on the environment. According to Selden (1994), the environmental challenges that the economy is currently facing may be as a result of the past economic activities. This variable will also help in determining the turning point of the EKC if it exists in the case of Zimbabwe. If the turning point exists in Zimbabwe, it is expected to have a negative relationship with carbon emission according to Kuznets (1955). This means as the per-capita income continuously increase, carbon emission will fall and environmental quality would eventually improve.

3.3.3 Government Expenditure (GOV)

This variable is added to control for the impact of government expenditure towards investments for example education on the environment. According to Hall and Charles (1999) the expected sign of government expenditure on environmental quality is indefinite. According to Bernauer and Koubi (2006) an increase government spending is accompanied by an increase in environmental degradation. On the other hand, Hallegatte*et al* (2012) argues that government expenditure reduces pollution due to the scale, composition and the technique effect which would then result in the demand for a quality environment. For the sake of this study, the researcher used government expenditure on education since it is a form of government investment on human capital. Gylfason (2001) argues that poor resource management is a result of neglected human capital. It is measured as a percentage of total GDP according to the World Development Index (2016).

3.3.4 Trade Openness (TO)

There is also need to determine the impact of the level of trade openness so as to determine and control the level of dumping according to Choi *et al* (2010). It can be calculated as the sum of imports and exports all divided by GDP according to the World Development Index (2016). It is assumed to be positively related to carbon emission.

3.3.5 Foreign Direct Investment (FDI)

This variable is added to the model to control for the impact of foreign investment on the environment. Since lax environmental regulations in the developing countries result in them being pollution havens as postulated by Kellenberg (2009). A-priori this variable is expected to bear a positive relationship with carbon emission to developing countries. It is measured as the net inflows as a percentage of GDP according to the World Development Index (2016).

3.3.6 Education (EDU)

According to the UNDP (2014) education is determined as an important aspect in as far as environmental quality is concerned. Kinda (2015) postulates that education attainment and carbon emission are negatively related since the increase in the literacy rate leads to the formulation of pollutant abatement measures thereby improving environmental quality. Bimonte (2002) argues that an increase in the literacy rate is accompanied by higher levels of environmental protection. It is measured as the primary school enrolment as a percentage of gross according to the World Development Index (2016).

3.3.7 Carbon-dioxide emission (CO_2)

This is the endogenous variable in the model and is the proxy for environmental quality. According to Rahman and Porna (2001), carbon dioxide is the major pollutant causing global warming; therefore, it requires instant attention so as to craft the relevant abatement measures and policies. The researcher uses CO_2 metric tonnes per capita, data obtained from World Development Index (2016). Periods with high levels of CO_2 emission represent low quality environment.

3.3 Data Sources

This research was undertaken using secondary data. The data used for the purpose of this research was found on the World Data Bank (2016). The researcher used time series data covering a period from 1985-2015.

3.4 Diagnostic Tests

Several diagnostic tests pertaining time series data have been done and these include stationarity tests, co-integration and autocorrelation tests among others.

3.4.1 Unit Root Test for Stationarity

Since all the variables in the outlined model are time series, they are prone to have a unit root problem. According to Engle and Granger (1987), regressing a time series variable on another may yield a high R^2 which shows goodness of fit of the model yet the variables may not actually have a meaningful relationship. These results are therefore deemed spurious. Therefore, the researcher used the Augmented-Dickey-Fuller (ADF) method to test for stationarity of the variables so as to avoid dubious regressions since the researcher used time series data.

H_0: unit root problem.

H_1: no unit root problem.

Decision Rule: Reject H_0 if the ADF statistic is greater than the critical values at 1%, 5% and 10% levels of significance, otherwise do not reject.

3.4.2 Co-integration Tests

If time series variables share the same common trend in the long-run, they are said to be co-integrated according to Gujarati (2009). A test for co-integration is a pre-test to counter spurious regression noted Granger (1986). There are two common methods for testing for co-integration and these are the Engle-Granger approach and the Johansen test. The Engle-Granger approach is appropriate in testing the co-integration in bi-variate models yet the Johansen test can be applied to multiple variable linear equations. For the sake of this study, the researcher used the Johansen method since the model estimated includes many variables.

H_0: there are no co-integrating equations.

H_1: there is at least one co-integrating equation.

Decision Rule: reject H_0 if Trace statistic or Max-Eigen value is greater than the critical value, otherwise do not reject.

3.4.3 Auto-correlation Tests

Autocorrelation can be defined as a situation in which the error terms of two different time periods exerts a relationship argued Gujarati (2009). The Classical Linear Regression Model (CLRM) assumes that the error term in one period do not have an impact on the error term of the other period. Regressions done where the error terms are auto-correlated may yield biased results of the parameters therefore, to test for the relationship between the error terms the researcher used the Breusch-Godfrey Serial LM test.

H_0: no autocorrelation.

H_1: autocorrelation present.

Decision rule: Reject H_0 if p-value Chi-Square is greater than p-value F, otherwise do not reject.

3.4.4 Heteroscedasticity Test

One key assumption of the classical linear regression model is that the variances of the error terms have equal spread that is they are homoscedastic. Heteroscedasticity refers to a scenario where the error terms have unequal spread. Estimations in the presence of heteroscedasticity may result in biased results. There are several methods of testing for heteroscedasticity in a model but for the purpose of this research, the researcher employed the Bruesh-Pagan-Godfrey test.

H_0: no heteroscedasticity.

H_1: heteroscedasticity present.

Decision rule: Reject H_0 if p-value Chi-Square is greater than p-value F, otherwise do not reject.

3.4.5 Multicollinearity tests

Multicollinearity is a case when two or more explanatory variables exert a linear relationship. Multicollinearity violates no regression assumptions argues Gujarati (2009). The results will still be best, linear and unbiased estimators (BLUE). Since time series data exert linear relationships among themselves and multicollinearity is inevitable. The researcher tested for multicollinearity to determine the pair-wise relationship among the variables.

3.4.6Model Specification Test

In adapting the model from the empirics, the researcher is thereby not certainly sure that the model is the true model for estimation. The researcher then tested if the adapted model is a fair representation of reality in estimating the impact of economic growth on environmental quality in Zimbabwe. In determining the model adequacy, the researcher used the Ramsey RESET method for model specification.

H_0: model incorrectly specified.

H_1: model correctly specified.

Decision rule: reject H_0 if the p-value is greater than 0.05, otherwise do not reject.

3.5Conclusion

In this chapter, the researcher dwelt much on model specification and diagnostic tests carried out in this research. The results from the estimation equation and the diagnostic checks outlined in this chapter will be presented in the following chapter.

CHAPTER FOUR

RESULTS PRESENTATION AND ANALYSIS

4.0 Introduction

In this chapter, the researcher presented the results obtained from the aforementioned tests in the previous chapter. The results presented in this chapter were estimated using E-Views package version 9.5 in ascertaining the impact of economic growth on environmental quality in Zimbabwe.

4.1 Diagnostic Check Results

Under the diagnostic test results, the researcher presents the preliminary diagnostic tests done by the researcher before the estimation of results. These include unit root test results, co-integration results and autocorrelation results among others.

4.1.1 Unit Root Test

The unit root tests were done to ascertain the level of stationarity of the variables. None stationary variables were differenced to make them stationary for regression purposes.

The table below shows the variables and their respective orders of integration.

Table 4.1: Unit Root Test Results (1990-2015).

Variable	Adf stat	Critical value	p-value	trend	drift	Order of integration
Co_2	-4.799249^{*}	-2.647120	0.0000	No	No	I(1)
Gdp	-4.031182^{*}	-2.647120	0.0002	No	No	I(1)
Gdp^2	-3.477329^{*}	-2.647120	0.0011	No	No	I(1)
Gov	-5.075128^{*}	-2.647120	0.0000	No	No	I(1)
To	-7.650930^{*}	-2.647120	0.0000	No	No	I(1)
Fdi	-2.433745^{**}	-1.952473	0.000168	No	No	I(0)
Edu	-5.095955^{*}	-2.647120	0.0000	No	No	I(1)

NB: *and **represents that the variable is stationary at 1% and 5%.

From table 4.1, all variables were stationary at first difference except FDI which is stationary at level. This means that of the seven variables in the model, six are difference stationary. The null hypothesis of non-stationarity is rejected when the ADF- statistic is greater than the critical value thereby concluding that there is no unit root problem.

4.1.2 Co-integration Test

According to Gujarati (2009), regressions involving non-stationary variables may yield spurious regressions. Since the variables had different levels of integration, the researcher proceeded to test the co-integration of the variables and determine if they have a long run relationship. The researcher used the Johansen Co-integration method and the results are presented in the table below.

Table 4.2: The Johansen Co-integration test results

Hypothesis	Decision Rule	Max-Eigen Stat	Critical Value	Decision
H_0: r = 0	Reject H_0 if Max-Eigen statistic > critical value.	58.42083	47.07897	Reject H_0.
H_0: r ≤ 1	Reject H_0 if Max-Eigen statistic is > critical value	41.49449	40.95680	Reject H_0
H_0: r ≤ 2	Reject H_0 if Max-Eigen statistic is > critical value	20.24580	34.80587	Do not reject H_0

The results in table 4.2 shows that the model has at most 2 co-integrating equations since the researcher failed to reject the null hypothesis at the region of at most 2 since Max-Eigen is less than the critical value. This means even though the variables in the model are stationary at different levels of integration, they have a long-run relationship therefore OLS estimation can be done with precision.

4.1.3 Autocorrelation Test

Under autocorrelation test results, the researcher presented the results from the Breusch-Godfrey Serial-Correlation-LM Test for autocorrelation. The results obtained were presented in the table below.

Table 4.3: Autocorrelation test results

Hypothesis	**Decision Rule**	**P-Value** (χ^2)	**P-Value (F)**
H_0: no autocorrelation	Reject H_0 if χ^2 -p-value > F-p-value.	0.2709	0.3424

From table 4.3 it can be denoted that the error terms are not correlated since the researcher failed to reject the null hypothesis since p-value chai-square is less than p-value-F. This therefore means that the CLRM assumption of no autocorrelation is satisfied.

4.1.4 Heteroscedasticity Test

To test for heteroscedasticity the researcher used the Breusch-Pagan-Godfrey test and the results were presented in the table below.

Table 4.4: Heteroscedasticity results

Hypothesis	**Decision Rule**	**P-Value** (χ^2)	**P-Value (F)**
H_0: homoscedastic error terms	Reject H_0 if χ^2 -p-value >F-p-value	0.1548	0.1575

As shown in Table 4.4, the researcher failed to reject the null hypothesis that the error terms are homoscedastic since p-value chai-square is less than p-value F, thereby concluding the absence of heteroscedasticity.

4.1.5 Multicollinearity Test

Table 4.5: multicollinearity test results

To determine the pair-wise relationship among the variables, the researcher tested for multicollinearity and the results are presented in table 4.5.

	Edu	**Fdi**	**Gdp**	**Gdp^2**	**Gov**	**To**
Edu	1.0000					
Fdi	-0.088909	1.0000				
Gdp	0.554012	0.166322	1.00000			
Gdp^2	0.466381	0.207911	0.989400	1.0000		
Gov	0.252946	-0.152275	0.126825	0.077776	1.0000	
To	-0.536723	0.603465	-0.107184	-0.040769	0.208829	1.0000

From table 4.5, it can be noted that severe multicollinearity is present only between GDP and GDP^2. Since the two variables are more or less the same, one would definitely expect the presence of multicollinearity. However, the researcher used the "do nothing" approach since both variables are equally important to the model.

4.1.6 Model Specification

Table 6 below shows the results for model specification computed using the Ramsey RESET test.

Table 4.6: model specification results

Hypothesis	**Decision Rule**	**P-Value**
H_0: Model incorrectly specified	Reject H_0 if p-values are greater than 0.05.	0.1576

Basing on the results from Table 4.6, the researcher rejected the null hypothesis of model mis-specification since the p-values are greater than 0.05. This therefore means that the model is correctly specified and is therefore adequate for estimation.

4.2 Regression Results

Since the results from the above diagnostic tests justifies the regression of the aforementioned model, the researcher then proceeded to the estimation of the model using OLS. The results obtained from the regression are presented in the table below.

Table 4.7: Regression results.

Variable	**Co-Efficient**	**Standard Error**	**T-Statistic**	**P-Value**
C	0.783315	0.577887	1.355482	0.1879
GDP	0.004687	0.001871	2.505517	0.0194
GDP^2	-3.19E-06	1.26	-2.529130	0.0184
FDI	0.034806	0.032485	1.071471	0.2946
TO	-0.012399	0.002819	-4.398256	0.0002
GOV	0.011012	3.10717	3.106717	0.0048
EDU	-0.004937	0.004654	-1.060797	0.2993

R^2 =0.769219 Adjusted R^2 = 0.711524

Probability (F-Statistic) = 0.00001 F-Statistic = 13.33247

D-W statistic = 1.594719

NB: The full version of the results will be displayed in Appendix C.

From the results presented in the table above, the equation estimated from the model specified in chapter three can be written as follows.

$$CO_2 = 0.783315 + 0.004687GDP - 3.19E - 06GDP^2 + 0.0111012GOV - 0.012399TO + 0.034806FDI - 0.004937EDU$$

4.3 Interpretation of Results

R^2 determines the goodness of fit of the model. From this study on the impact of economic growth on environmental quality in Zimbabwe, about 76% of the variations in carbon emission are explained by economic growth, trade openness, education, foreign direct investment and government expenditure on education. The remaining 24% is captured by the error term and is explained by other variables outside the model for example technology, control of corruption, and population growth.

In determining the significance of the whole model, the researcher used the p-value (F-statistic). The probability of 0.000001, shows that the model is significant at 5%.Model specification, which was tested using the Ramsey-RESET method, show that the model is correctly specified. The significance of the variables is determined by t-statistic and the p-values. The variables with probabilities less than 0.05 are statistically significant. These include GDP, GDP^2, TO and GOV. However, in this research the intercept, FDI and EDU failed to be significant.

Economic growth (GDP) has shown to negatively affect environmental quality in Zimbabwe. This is shown by the positive relationship between economic growth and carbon emission (CO_2). This means that a 1unit increase in economic growth, leads to a 0.004687 increase in carbon emission. The increase in carbon emission resulting from an increase in the growth rate thereby denotes a decline in environmental quality. This means that environmental quality is of less concern in developing countries like Zimbabwe. The major focus is economic growth neglecting its impact on environmental quality and this is in support of the EKC hypothesis. The policies formulated in Zimbabwe in this era are based on discretion. To curb the high levels unemployment, the government of Zimbabwe encouraged the emergence of SME's. These private investors do not bear the economic cost of the environment, thus undermining environmental quality.

The squared variable of economic growth (GDP^2) has shown to have a positive effect on environmental quality. This shows that in the long-run, continued economic growth can result in the improvement of the environmental quality. This is explained by the inverse relationship between GDP^2 and carbon emission (CO_2). This means, in the long-run, a 1unit increase in GDP leads to a 0.00000319 decrease in CO_2 emission thereby an improvement in environmental quality. From the EKC theory, the increase in the national income will lead to increased innovations. The society will have a better understanding of the need for environmental quality thereby the increased income will be used to compensate for environmental quality loss assuming equal distribution of the income.

Both economic growth and growth squared are in support of theory since they bear the expected signs according to the EKC hypothesis. From the results presented above it can be shown that economic growth negatively affects environmental quality but then in the Zimbabwean case, there exists a turning point level of income of approximately $735 per capita,which is slightly above the average level of income per capita recorded of $689, at which beyond it the society will begin to consume a quality environment assuming continued economic growth.

From the results presented above, government expenditure (GOV) also increases carbon emission in Zimbabwe. The obtained sign of this variable is in support with Bernauer and Koubi (2006) who argued that government expenditure accelerated environmental deterioration. This may be due to the fact that the effect of GOV on the environment is a long-run phenomenon. GOV is a form of human capital investment. It fuels growth and thereby increases carbon emission in transitional dynamics. In the short-run, government expenditure on investments like education would direct some funds that could have been used in financing environmental protection towards investments which may in the long-run help in environmental protection.

Trade openness (TO) have a positive effect on environmental quality. Trade openness helps in determining the level of dependency of LDCs like Zimbabwe. Since economic activities in Zimbabwe are generally declining, the nation is basically dependent on other nations and this is shown by a greater magnitude of trade deficit. However, the Pollution Haven Hypothesis (PHH) assumes that this variable negatively affects environmental quality. From the analysis in this research, trade openness opposes theory. This may be due to the fact that even though Zimbabwe depends on foreign products, it does not necessarily mean that the foreign market dumps their poor quality goods to Zimbabwe. As a nation opens to trade, relationships are created amongst the nations thereby reducing the level of dumping. According to Frankel and Rose (2005) trade proved to be favorable to the environment since countries that depend much on trade have minimum internal production thereby reducing the emission levels. The results from this study however are in support of the Factor Endowment Hypothesis (FEH) which assumed that LDCs like Zimbabwe are labour abundant thereby they engage in the production of labour intensive goods which are less polluting and then import the dirty goods from developed nations which produce the capital intensive goods.

Furthermore, foreign direct investment (FDI) is also hypothesized to negatively affect environmental quality. This is due to the fact that developing nations like Zimbabwe are regarded as pollution havens where foreign investment on the production of polluting goods is directed to them as per the PHH theory. However, from the analysis in this research, FDI has a positive effect on environmental quality even though it is statistically insignificant. Brock and Taylor (2010) argues that FDI inflows may contribute to sustainable economic development since it may result in efficient resource use and transfer of newer technologies.

The results also show that education (EDU) in Zimbabwe has a positive effect on the environment. The relationship between CO_2 emission and EDU can be direct or indirect. As the number of educated people in a society increases, this may help in coming up with new technologies that may contribute in emission reduction. Education (EDU) is a form of human capital development which also increases the level of economic activity, thus the indirect effect of education on environmental quality. As for the direct effect, an increase in EDU may result in policies that consider the environmental cost of production thereby improving environmental quality as postulated by Kinda (2015). Even though this variable is statistically insignificant, its obtained sign is in support with theory.

4.4 Conclusion

From the results obtained in this chapter, economic growth has a significant impact on environmental quality with a negative effect in the short-run and a positive effect in the long-run. The results obtained in this chapter thus set the basis for policy recommendations thereby paving way for the next chapter.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

5.0 Introduction

As outlined in the objectives section of this research, this chapter thereby outlines the policy recommendations drawn from this research. It also gives suggestions on future researches in the context of environmental economics. This chapter also marks the end of this research thereby outlines the conclusion for the whole project.

5.1 Summary of the Study

This research mainly focused on the impact of economic growth on environmental quality in Zimbabwe for a period covering 1985 to 2015. A comprehensive background on the trends of economic growth and carbon emission was given so as to determine how economic growth and carbon-dioxide emission have been performing in the past years. The increase in the atmospheric temperatures resulting from human activity has motivated this study. The researcher evaluated the available theory and empirics on the environmental impact of economic growth. Basing on the model adapted from the available literature, the researcher then estimated the environmental impact of economic growth quantitatively. The results obtained have created a basis for policy recommendation thus outlined in this chapter.

The objectives of this study have been attained since the researcher managed to determine the impact of economic growth on environmental quality in Zimbabwe. The researcher also managed to come up with the quantitative analysis of the environmental impact of economic growth.

5.2 Conclusions

The main objective of this study was to determine the impact of economic growth on environmental quality in a manner of explaining the EKC hypothesis to the Zimbabwean case. The objective was attained using OLS method.

Based on the results presented in chapter four, economic growth accelerates carbon emission in the early stages of development and this is explained by the co-efficient of GDP. The co-efficient of GDP^2 explains the impact of continued growth on the environment and from this study it can be noted that continued growth in the long-run improves the quality of the environment. These findings are therefore in line with those of Wilson (2010) and Alege and Ogundipe (2013).

In conclusion, some policy recommendations are provided by the researcher as per the findings from this research. These policies will be meant to provide measures for improving the environmental quality of Zimbabwe taking into consideration the impact of economic growth. Since growth is an exogenous variable, the government can manipulate it in a manner to improve environmental quality therefore the policy recommendations outlined in the next chapter mainly focus on GDP and GDP^2.

5.3 Policy Recommendations

Based on the findings of this research, the researcher gives some policy recommendations that policy makers may consider in the quest of improving the quality of the environment in Zimbabwe.

The short-run negative effects of economic growth are inevitable since the environment is an asset from which raw materials are extracted and on which by-products are deposited. Economic growth is a need for the improvement for the societal well-being even though it negatively affects the environmental quality. It does not make any economic sense to formulate policies that hinder economic growth as a way to improve environmental quality. However, based on the results obtained from this research, the researcher suggests policies that increase the rate of economic growth since it can someday lead to a clean environment.

Policies to efficiently manage the natural resources are essential in Zimbabwe so as to avoid any hindrances on economic growth. Sustainable development goals as put forward by UNDP (2014) suggest that less developing nations like Zimbabwe need to have sustainable economic growth and have at least 7% economic growth rate per annum. Preservation does not necessarily mean non-use but it means wise use, argued Tietenberg and Lewis (2012), therefore resource preservation may be the considered as equally important and should be integrated in all sectors of the economy that is the mining sector, agricultural sector and the tourism sector. The government should embark in urgent action to combat climate change and eliminate emission maybe through pollution quotas, embargos of some products and levy pigouvian taxes in emitting industries. This can help in minimizing emission resulting in quality environmental improvement.

The government can increase investments in research and development that can help in coming up with new ideas. This will help in coming up with better technologies that can help firms in the production of cost-effective goods in as far as the environmental cost is concerned. Better or improved technologies facilitate growth thereby increasing national income. The better technologies also in effect reduce the carbon emission rate. The UNDP (2014) also suggested technological innovations as a way to improve economic growth.

Infrastructure and human capital investment play a crucial role in fostering economic growth. There is a strong correlation between expenditures on education and infrastructure and economic growth. However, the government of Zimbabwe has been devoting a much lower proportion of its income to capital expenditure with an expenditure as low as 1.97% in 2010. The major contributor to low economic growth levels in Zimbabwe is underinvestment. The government also has to consider increasing the levels of government expenditure towards investments for example education. There is also need to increase funds towards infrastructure investment. These involve roads and buildings among other things. This is regarded to as capital accumulation. Increased capital accumulation increases the capital available per worker thus the capital-labor ratio. With the increased capital formation, labor productivity increases leading to growth. If growth increases, the level of national income also increases which therefore means that *ceteris paribus*, people would compensate for the loss in environmental quality thereby increasing it quality and reducing emissions.

Growth in developing nations like Zimbabwe may be hard to purse with own resources. The government needs to create a favorable environment that attracts foreign investment into the country to boost economic growth since increased foreign investment results in increased output. Foreign investment may also bring in new efficient technology and new innovations that can increase national productivity as well as taking care of the environment. This therefore means the policies formulated should be conducive for foreign investors as a way of boosting the economic growth of the country.

To ensure the positive impact of growth, there is also need for the government to promote private investment. It may do so by offering subsidies as well as restructuring of the tax structures so as to lure private investors into business. This will increase the level of economic activities thereby increasing national income.

With all these suggestions in mind, the increase in economic growth may facilitate environmental degradation in the short-run but may be accompanied by environmental quality in the long-run since continued growth may lead to better care of the environment.

5.4 Suggestions for Future Studies

Due to time and data constraints, the researcher did not exhaust everything on the research on the environmental impact of economic growth therefore suggests some areas in which other researchers may look into as well. These include determining the direction of causality between economic growth and environmental degradation as well as the impact of environmental quality on economic growth since some researchers like Abdulai and Ramcke (2009) suggested that environmental degradation may also affect the economic growth of a country. Another area of study may be ascertaining the impact of agricultural production on the environment in Zimbabwe. Since there may be other variables that may have been included in the model, the researcher thereby suggest that other researchers may also look into their environmental impacts, for example population growth and technology provided the data is readily available.

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APPENDICES

APPENDIX A: DATA SET

year	co2	Gdp	gdp2	Edu	gov	to	fdi
1985	1.2	651.0397	423852.6	126.201	7.41926	44.21368	0.050532
1986	1.37	692.6673	479788	123.72	7.523	45.57035	0.119744
1987	1.67	725.3858	526184.5	113.677	11.64476	45.2906	-0.45254
1988	1.54	813.6754	662067.6	107.73	12.33729	44.10035	-0.23076
1989	1.5	836.7876	700213.5	105.436	12.28423	45.06254	-0.12286
1990	1.63	862.5866	744055.6	97.425	12.45426	45.65925	-0.13896
1991	1.75	827.4869	684734.6	102.183	12.8543	51.05155	0.032292
1992	1.72	631.9906	399412.1	100.206	23.04827	63.71249	0.221432
1993	1.54	601.8669	362243.7	103.818	29.4302	63.16706	0.425898
1994	1.42	619.8351	384195.6	103.2433	44.43398	71.1195	0.502837
1995	1.37	628.1849	394616.3	103.282	39.7948	79.15679	1.655119
1996	1.3	742.5727	551414.2	103.08	4.645284	72.06962	0.945851
1997	1.21	728.4008	530567.8	102.872	9.207786	82.20506	1.583901
1998	1.21	538.2849	289750.6	101.088	3.978563	88.51404	6.940053
1999	1.36	568.444	323128.5	99.9	4.169219	70.92266	0.860307
2000	1.14	547.3589	299601.7	100	4.146642	74.06741	0.346788
2001	1.11	548.0587	300368.4	102.885	4.492202	67.89787	0.056069
2002	1.03	507.348	257402	97.454	4.271047	66.80735	0.408381
2003	0.9	453.3512	205527.3	96.104	3.391376	70.45199	0.066346
2004	0.82	454.3607	206443.6	82.49	5.150906	76.03961	0.149855
2005	0.91	444.7605	197811.9	88.17	2.327073	76.04371	1.786206
2006	0.83	414.7962	172055.9	90.02	3.527423	82.82065	0.734768
2007	0.79	396.9982	157607.6	66.14	3.21957	84.1729	1.301978
2008	0.6	325.6786	106066.5	52.97	3.094307	109.5216	1.168557
2009	0.64	605.8241	367022.9	88.6	3.03874	68.4788	1.254961
2010	0.69	713.6035	509230	95.79	1.97333	100.3704	1.21952
2011	0.74	839.0928	704076.7	99.8	5.634	122.3121	2.852117
2012	0.75	955.6485	913264	102.447	8.38322	96.10745	2.488552
2013	0.77	1011.227	1022581	99.938	8.48536	88.78498	2.450483
2014	0.92	1027.407	1055566	106.1149	8.42933	79.56088	2.985966
2015	0.88	1018.693	1037736	109.0482	8.5421	75.597	2.483764

Data sources and units of measurement

Variable	Units of measurement	source
CO_2	Metric tonnes per capita	Countryeconomy.com
GDP	Current US Dollars	WDI
GDP^2	Current US Dollars	WDI
GOV	% of total government expenditure	WDI
TO	Trade openness ratio	WDI
FDI	Net inflows % of GDP	WDI
EDU	Primary school enrolment, % of gross enrolment. (2000=100)	WDI

APPENDIX B: DIAGNOSTIC CHECKS

B1: Unit Root Tests

Carbon-Dioxide

Null Hypothesis: D(CO2) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.799249	0.0000
Test critical values:	1% level	-2.647120	
	5% level	-1.952910	
	10% level	-1.610011	

*MacKinnon (1996) one-sided p-values.

Gross Domestic Product (GDP)

Null Hypothesis: D(GDP) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.031182	0.0002
Test critical values:	1% level	-2.647120	
	5% level	-1.952910	
	10% level	-1.610011	

*MacKinnon (1996) one-sided p-values.

Gross Domestic Product Squared (GDP^2)

Null Hypothesis: D(GDP2) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.477329	0.0011
Test critical values:	1% level	-2.647120	
	5% level	-1.952910	
	10% level	-1.610011	

*MacKinnon (1996) one-sided p-values.

Foreign Direct Investment (FDI)

Null Hypothesis: FDI has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.433745	0.0168
Test critical values:	1% level	-2.644302	
	5% level	-1.952473	
	10% level	-1.610211	

*MacKinnon (1996) one-sided p-values.

Government Expenditure (GOV)

Null Hypothesis: D(GOV) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.073128	0.0000
Test critical values:	1% level	-2.647120	
	5% level	-1.952910	
	10% level	-1.610011	

Education (EDU)

Null Hypothesis: D(EDU) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.095955	0.0000
Test critical values:	1% level	-2.647120	
	5% level	-1.952910	
	10% level	-1.610011	

*MacKinnon (1996) one-sided p-values.

Trade Openness (TO)

Null Hypothesis: D(TO) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.650930	0.0000
Test critical values:	1% level	-2.647120	
	5% level	-1.952910	
	10% level	-1.610011	

*MacKinnon (1996) one-sided p-values.

B2: Co-Integration

JOHANSEN TEST

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.866614	58.42083	47.07897	0.0021
At most 1 *	0.760893	41.49449	40.95680	0.0435
At most 2	0.502486	20.24580	34.80587	0.7978
At most 3	0.449021	17.28571	28.58808	0.6366
At most 4	0.291313	9.985893	22.29962	0.8362
At most 5	0.162484	5.142135	15.89210	0.8757
At most 6	0.081954	2.479724	9.164546	0.6816

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

B3: Autocorrelation

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.935864	Prob. F(1,23)	0.3434
Obs*R-squared	1.212064	Prob. Chi-Square(1)	0.2709

B4: Heteroscedasticity

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.181107	Prob. F(6,24)	0.3492
Obs*R-squared	7.066893	Prob. Chi-Square(6)	0.3147
Scaled explained SS	11.58769	Prob. Chi-Square(6)	0.0718

B5: Multicollinearity

	EDU	FDI	GDP	GDP2	GOV	TO
EDU	1	-0.0889093...	0.55401233...	0.46638113...	0.25294554...	-0.5367227...
FDI	-0.0889093...	1	0.16632189...	0.20791056...	-0.1522750...	0.60346454...
GDP	0.55401233...	0.16632189...	1	0.98940049...	0.12682450...	-0.1071840...
GDP2	0.46638113...	0.20791056...	0.98940049...	1	0.07777568...	-0.0407690...
GOV	0.25294554...	-0.1522750...	0.12682450...	0.07777568...	1	-0.2088293...
TO	-0.5367227...	0.60346454...	-0.1071840...	-0.0407690...	-0.2088293...	1

B6: Model Specification

Ramsey RESET Test
Equation: UNTITLED
Specification: CO2 EDU FDI GDP GDP2 GOV TO C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.460685	23	0.1576
F-statistic	2.133600	(1, 23)	0.1576
Likelihood ratio	2.750052	1	0.0973

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.072571	1	0.072571
Restricted SSR	0.854874	24	0.035620
Unrestricted SSR	0.782304	23	0.034013

LR test summary:

	Value	df
Restricted LogL	11.67012	24
Unrestricted LogL	13.04515	23

APPENDIX C: REGRESSION RESULTS

Dependent Variable: CO2
Method: Least Squares
Date: 09/22/17 Time: 03:16
Sample: 1985 2015
Included observations: 31

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EDU	-0.004937	0.004654	-1.060797	0.2993
FDI	0.034806	0.032485	1.071471	0.2946
GDP	0.004687	0.001871	2.505517	0.0194
GDP2	-3.19E-06	1.26E-06	-2.529130	0.0184
GOV	0.011012	0.003544	3.106717	0.0048
TO	-0.012399	0.002819	-4.398256	0.0002
C	0.783315	0.577887	1.355482	0.1879

R-squared	0.769219	Mean dependent var	1.139032
Adjusted R-squared	0.711524	S.D. dependent var	0.351391
S.E. of regression	0.188732	Akaike info criterion	-0.301298
Sum squared resid	0.854874	Schwarz criterion	0.022505
Log likelihood	11.67012	Hannan-Quinn criter.	-0.195746
F-statistic	13.33247	Durbin-Watson stat	1.594719
Prob(F-statistic)	0.000001		