Volume: 26, Issue: 1
Page: 49-71
2023

International Journal of Science and Business

Journal homepage: ijsab.com/ijsb

IJSAB International

Impact of Population growth, Energy consumption and GDP on CO2 emissions in Congo brazzaville

MBOUSSA MOUI RIDEL

Abstract

Since the industrial revolution, many studies have looked at the connection between environmental markers of progress and that environment. Using annual time-series data from 1990 to 2020, this study investigates the connections between population increase, energy use, economic expansion, and carbon dioxide emissions in Brazzaville, Congo. This study is significant because it enables us to evaluate the IPAT premise that CO2 emissions are mostly influenced by population expansion, economic growth, and technological advancement. The study uses the ARDL bound test method. The results demonstrate both short- and long-term relationships among the variables (population growth, energy consumption, economic growth, and CO2 emissions), with all variables having a positive impact on CO2 emissions in the short term. However, in the long run, energy consumption has a positive impact on CO2 emissions, in addition to the negative effects of population growth and economic growth on CO2 emissions, because without the adoption of low-carbon technological advancements. Ultimately, the results support the IPAT hypothesis in the Congo-Brazzaville economy, according to which population growth does not affect CO2 emissions because the country's authorities strictly enforce family planning policies to reduce CO2 emissions. When energy consumption affects environmental quality, the Government should develop new renewable energy sources to reduce carbon dioxide emissions.

IJSB
Accepted 17 July 2023
Published 21 July 2023
DOI: 10.58970/IJSB.2155

ISSN: 2520-4750 (Online) 2521-3040 (Print)

Keywords: *Population, Congo, economic, energy consumption, CO2 emissions, technological, environment, planning.*

About Author (s)

MBOUSSA MOUI RIDEL (Corresponding Author), Research Student, School of Economics, Capital University of Economics and Business (CUEB), Beijing, China.

Introduction

Birth rates, death rates, and migration rates determine population growth （United Nations Department of Economic and Social Affairs, Population Division 2021). Between 1960 and 2021, the number of residents of the Republic of Congo increased from 1.02 million to 5.84 million, an increase of 473.1% in 61 years. The Republic of the Congo had the highest increase of 6.91% in 2015. 2020 saw the smallest increase at 2.34%. During the same period, the total population of all countries increased by 160.2% (Francois Cailleteau2015). In 2020, the number of residents in the Congo increased by approximately 131,000 people. In the same year, the death rate was 6.9 per 1,000 inhabitants (approximately 38,600 cases), and the birth rate was 31.2 per 1,000 inhabitants (approximately 174,000 births). As a result, approximately 4,400 residents immigrated to other countries. The Republic of the Congo has averaged 6,953 yearly deaths over the past ten years (Population growth in worldwide comparison). The number of births per year is 171,343. Between 2012 and 2021, the mean age in the Republic of Congo will increase by 0.69 years, from 18.81 to 19.50 years (median). Accordingly, approximately 68% of the inhabitants live in the country's largest cities. The urbanization rate is growing at an annual rate of 3.0% « The population of continents and states».

Oil extraction, which accounts for 60% of domestic income and 80% of exports, dominates the Congolese economy (Coface). The nation's reliance on oil renders it susceptible to changes in the price of commodities (PND, 2012-2016). In 2000, the Congolese economy saw real growth of 4.6%, up from a negative 3.3% in 1999. Congo's economic outlook remains positive but could be clouded by the European sovereign debt crisis (IMF). Forecasts for 2012 and 2013 are based on real GDP growth of 5.7 per cent in 2012, 4.7 per cent in 2013, and 5.3 per cent in 2011 (Google Congo Yellow Pages of Africa). These forecasts are based on the assumption that at least half of the 16 plants under construction are already in full production. Investments in the Brazzaville Industrial Zone and the continuation of the State Investment Plan provided a 55% real increase in capital expenditures in 2012. However, the economy's heavy reliance on oil makes it vulnerable to external shocks and explains the smaller impact of growth on employment (World Bank, ILO modeled estimate). There is a need to accelerate reform programs and improve the business environment to develop the private sector, which must play a leading role in diversifying the country's economy and creating jobs (UNICONGO 2020).

Congo ranks 181 out of 183 countries in Doing Business 2012. Although the Congolese economy has performed relatively well in recent years, unemployment remains high, especially among young people (International Labor Office 2010-2011). According to the Employment and Informal Sector Study (EESIC) conducted in 2009, the national unemployment rate is 16%. However, 25% of 15- to 29-year-olds are unemployed, and when a broader definition is taken into account that includes discouraged job seekers, the number rises to more than 42%. High youth unemployment is attributable to several factors. Recent economic growth appears to be more balanced; there has not been a major shift in the economy's structure, which remains dependent on the oil sector's performance. The economy's high dependence on oil explains the relatively small impact of growth on employment, poverty and slow progress towards the MDGs; it underscores the need to develop non-oil sectors. This requires addressing the infrastructure deficit (particularly in the energy and transport sectors), a serious bottleneck to the country's economic and social development and a major obstacle to promoting private sector development (Angus Maddison 2013). Accelerating the implementation of the recently adopted action plan to improve the business environment is also crucial. In this context, two public authorities' priorities are establishing a one-stop shop and reducing the tax burden.

One of the top ten fastest-growing nations in sub-Saharan Africa is the Republic of Congo. However, population growth, rapid urbanization, and degradation caused by population growth have negatively affected the quality of CO2 emissions over the past few decades. The main cause of environmental degradation, high energy use, and high carbon dioxide emissions is, in fact, rapid economic growth (Abbasi et al 2022; Uzair Ali et al 2022), which is a situation that was also present during the early stages of economic development in areas with relatively developed economies and concentrated populations. On the other hand, since peace was restored in the Congo after the political instability it experienced in 1990, the economy of the Congo has returned to normal operation thanks to countless developments in technology and chemistry, with large-scale secondary and tertiary industries. The death rate dropped dramatically. At the same time, a large part of the population in the region benefits from resource supply, which leads to changes in population size and labour supply; changes in population size, labour supply and income may cause changes in human capital accumulation, people's savings rate and human capital Accumulation will cause changes in the amount of pollution and have a certain degree of impact on CO2 emissions. Since the country's economic confidence recovery, the Congolese economy has been based on secondary and secondary industries and is capital-intensive rather than supply-intensive. However, the energy needs of many industries in the Congo may still be necessary; the latter generally generate more polluting emissions and degrade CO2, so the main challenge for the authorities is to take care of these different industries and grow stringent environmental security and economic stabilization measures (Compendium of environment statistics, 2000).

Moreover, the supply and demand of energy to achieve the same GDP under different economic structures are also different, which will have a certain impact on CO2. The economy of the Republic of the Congo is essentially oil-based...but economic prosperity affects the environment; the extraction of crude oil brings associated gases to the surface. These are sometimes released as combustion (flare) gases. Exhaust fumes indicate the presence of large amounts of hydrogen sulfide in the air and the presence of carbon dioxide masses in the environment. In addition, the conversion of crude oil into fuel in the extractive industry uses adulterated gasoline injected with high doses of motor oil. As a result, this practice has resulted in vehicles emitting polluting smog containing carbon dioxide, thereby deteriorating the environment, which has allowed the Congolese economy to develop (Energy Information Administration, 2001). However, it has restricted the Congolese economy's ability to grow sustainably. In order to create policy suggestions for sustainable economic development in Congo, a thorough analysis of the effects of population expansion, energy consumption, and economic growth on CO2 emissions is necessary. Congo and enrich theoretical research on sustainable development in the Congo region.

Since ancient times, the issue of environment and growth has been the subject of numerous studies by pioneers seeking to find a balance between the two. The Environmental Kuznett Curve Theory is one of many studies. According to the argument, environmental deterioration will first be brought on by economic growth. The relationship between the nation and the environment begins to improve, and the rate of environmental degradation declines, nevertheless, after economic growth reaches a certain level. However, the income and environment of most developed countries in the world are improving, while the economic development of Congo is still better (Guillaume Gaulier and Nina Kousnetzoff 2007). To determine whether Congo's economic development can match the Environmental Kuznett Curve and to present some policy recommendations, this article will examine the effects of population expansion, energy consumption, and economic growth on environmental degradation. Make recommendations for the development of Africa, especially Congo Brazzaville.

The Impact Model of Population, Wealth, and Technology, or IPAT, is a tool we use to evaluate the significance of environmental degradation-related issues in the Congo. It is a simple and commonly used model for identifying relationships among factors contributing to environmental impacts to formulate policy recommendations for the sustainable development of the Congolese economy. The future growth of the Congolese economy depends greatly on this. In Congo Brazzaville, this study looks into the connections between CO2 emissions, population increase, and economic growth. The research framework of this study is therefore divided into five chapters: the first chapter is an introduction that elaborates on the research background; the second chapter includes fundamental concepts like population growth, energy consumption, economic growth, carbon dioxide emissions, and a literature review related to these concepts. The third chapter largely discusses how Brazzaville, Congo's population increase, energy consumption, and economic expansion are now affecting CO2 emissions. We employ the ARDL limits test method to check the Relationship between variables in Chapter 4 since it makes use of the IPAT model, and then we analyse the results. In chapter five, which serves as the conclusion, we also offer policy suggestions for helping Congo strike a balance between environmentally sound development and sustainable economic growth.

Basic Concepts and Literature Review

Basic concepts

Concepts Related to population growth

Population growth is the increase in people in a dispersed population or group. In 1800, the global population topped 1 billion after centuries of slow and unequal development. That was the start of the contemporary growth of human populations, which increased slowly but steadily over the following 150 years, peaking at 2.5 billion in 1950. The first half of the 20th century saw an unparalleled acceleration in growth rates. The outcome was a more than doubling of the global population, which reached 6.5 billion in 2005 (United Nations 1962, 1973, 2007). Before reaching a peak of about 10 billion in the latter part of the 21st century, this population growth is anticipated to last for a number of decades. A population is a group of organisms of the same species living in the same area simultaneously. They are described by characteristics such as population size (the number of individuals in the population), population density (how many people are in a particular area), population growth (how large the population is), or population changes over time). Population growth helps scientists better predict future changes in population size and growth rates. This is crucial for answering questions about biodiversity conservation and population growth. Additionally, studying population growth helps scientists understand why population sizes and growth rates vary. Finally, studying population growth allows scientists to understand the interactions between organisms and their environment.

- Human population growth

Concepts Related to energy consumption

Concepts Related to CO_2 Emissions

Carbon dioxide (CO2), also known as carbon dioxide or carbon dioxide, is an inorganic compound formed by combining two chemical elements, carbon and oxygen. CO2 is a colourless, odourless, tasteless, nonflammable, water-soluble and chemically stable gas under normal conditions. It arises primarily from living organisms (produced during respiration), organic matter's combustion and microbial degradation, and the manifestations of certain geological processes, including volcanic emissions and the chemical alteration of certain minerals. Carbon dioxide is removed from the atmosphere through uptake by surface water bodies, including oceans, and the effectiveness of the photosynthetic process. Due to its molecular structure, carbon dioxide absorbs part of the infrared solar radiation and re-emits it as thermal radiation. This is how atmospheric carbon dioxide contributes to the greenhouse effect that causes global warming.

CO2 is a natural constituent of ambient air with an average volume content of approximately 0.04%. Its concentration in outdoor air is usually measured in parts per million - ppm (International Organization for Standardization - ISO, 2012), currently estimated at 41 ppm. However, it may vary depending on location, time of day, Variety, and Year. Atmospheric carbon dioxide concentrations have increased by about 80 ppm over the past century due to global industrialization, deforestation, and increased use of fossil fuels. Over the past 60 years, the average annual increase in atmospheric carbon dioxide concentrations has been about 100 times faster than in previous decades. Outdoors, whether urban or rural, the sources of CO2 emissions are mainly related to different processes involving the burning of fossil or biofuels.

Concepts Related to economic growth

Economic growth refers to the increase in overall productivity measured by Gross Domestic Product (GDP). Productivity refers to the propensity of a country to use its resources to produce goods and services. Any increase in productivity signals faster economic growth. There are two ways to measure economic growth, including real economic growth and nominal economic growth. Real economic growth occurs when the rate of change in aggregate productivity increases. For example, suppose a country becomes more capable of producing goods and services yearly due to increased natural and human resources or other factors. In that case, its real economic growth is said to have increased. Nominal economic growth, as opposed to real economic growth, occurs when a country's GDP increases solely because of higher commodity prices or wages. It is just quantitative growth, not real growth because the country needs to show extraordinary progress in any real sense. So this kind of economic growth is determined by the inflation rate, which differs from what a country should pursue. Economic growth is measured only partially regarding increased production of goods and services. Yes, that is productivity, but some goods and services are more valuable than others. This means that quantity is not important, but the quality and value of goods and services. This is real productivity. Therefore, economic growth is measured in dollars. Factors hindering economic growth include unemployment, inflation, brain drain, poverty, scarcity of natural resources, scarcity of human resources, shortage of foreign investment, education setbacks, social ills, terrorism, public disorder, poor sanitation, standard deviation, Etc. In order to promote economic growth, the best way is to enhance energy resources. For example, a non-landlocked country rich in natural resources, whose strategic importance is its greatest advantage on the world map. However, when these resources are not fully developed or utilized, the state is deprived of the right to use them fully.

The country may need more wealth to invest in these resources, but it may invite foreign investment. Second, the labour force and human resources are the main indicators of economic growth. Next comes technological advancement, without which no economy can grow in this era of rapid development. All these factors, in turn, address the problems of poverty and low living standards. Moreover, there will be no brain drain. Brain drain is the continued flow of human resources from one country to another because other countries offer better opportunities. It is the worst misfortune a nation can face and the greatest obstacle to economic growth.

Literature Review

Sulaiman et al. (2018) investigates whether population growth increases greenhouse gas emissions from increased human activity in Nigeria using an autoregressive distributed lag model covering the periods 1971-2000, 1971-2005, and 1971 and CO2 emissions-2010 recursively. The results show that population is not a determinant of CO2 emissions over the three long-term periods. However, economic growth was found to be the only determinant of long-term CO2 emissions during the study period. In the short run, however, almost all explanatory variables and their lags, namely population growth, economic growth, and energy consumption, are important in determining CO2 emissions. The results show that population growth, which is the focus of the study, can only determine CO2 emissions in the short run.

Relationship between population growth and energy consumption

Hong Vo et al. (2021) examines the causal relationship between renewable energy consumption, population, carbon dioxide emissions, and economic growth using time-series data from the Association of Southeast Asian Nations (ASEAN) region. In addition, relatively new and advanced autoregressive panel vector models and Granger non-causality tests for heterogeneous panels have been used for nearly three decades in a sample of seven ASEAN countries since 1990. The results show that using renewable energy sources first responds to population growth and leads to carbon dioxide (CO2) emissions. Second, economic growth and the use of renewable energy largely explain the evolution of energy consumption. Third, there is a two-way Granger causality for every pair between energy consumption, economic growth, and CO2 emissions. Acheampong (2018) Apply panel vector autoregressive (PVAR) and generalized system of momentum (System-GMM) methods to examine the dynamic causality among economic growth, carbon emissions, and energy consumption. Provided energy to 116 countries between 1990 and 2014. The empirical results of this study establish key relationships with important policy implications using a multivariate model. First, economic growth does not lead to energy consumption at the global and regional levels. Second, economic growth has no causal effect on carbon emissions except in the global and Caribbean-Latin American regions; however, economic growth negatively affects global, Caribbean, and Latin American regions. Third, carbon emissions have a positive effect on economic growth. Fourth, energy consumption positively promotes economic growth in Sub-Saharan Africa but negatively drives global economic growth in the Middle East and North Africa, Asia Pacific and the Caribbean, and Latin America. Fifth, energy use has a favorable effect on carbon emissions in the Middle East and North Africa but a detrimental effect on them in Sub-Saharan Africa, the Caribbean, and Latin America. The MENA region and the global sample are the only places where carbon emissions influence energy use.

Relationship between economic development and energy consumption

Waheed et al. (2019) Review economic growth, energy consumption, and carbon emissions surveys, including single-country and cross-country studies. Several countries are covered as of 2019. The survey focuses on country coverage, modelling approach, time, and empirical results. The literature review of this research paper is based on (i) the direction of causality between economic growth and carbon emissions; (ii) economic growth and energy consumption; (iii) energy consumption and carbon emissions. We can draw the general perception from a review of these studies that the published literature is contradictory. First, most previous studies have shown that economic growth and energy consumption are important sources of carbon emissions; however, the impact of economic growth on carbon emissions has been widely reported in developing countries. In contrast, in developed countries, carbon emissions are not linked to economic development. Second, as far as developing countries are concerned, higher energy consumption will lead to faster economic growth. For developed countries, there is less dependence between energy consumption and economic growth. Finally, increased energy consumption is a major cause of carbon emissions in developing and developed countries. Bekun et al. (2018) explore the link between energy consumption and economic growth in South Africa from 1960 to 2016, considering capital issuance, jobs, and CO2. This study applied the common cointegration method of Bayer and Hanck (2013), Pesaran et al. (2001) limit tests and Kripfganz and Schneider (2018) critical values and approximate p-values. However, empirical evidence confirms the existence of long-run equilibrium relationships among the variables studied. The Granger causality test shows a one-way causal relationship between energy consumption and economic growth, which verifies the energy-induced growth hypothesis. The study reveals an inverted U-shaped pattern between energy consumption and long-term economic growth. Antonakakisa et al. (2016) Applying panel vector autoregressive (PVAR) and impulse response function analysis to energy consumption (and its subcomponents), CO2 emissions and The dynamic interrelationships between GDP data production, energy and the environment. The results show that the effects of different types of energy consumption on economic growth and emissions vary across country groups. Furthermore, the causal relationship between aggregate economic growth and energy consumption is bidirectional, which justifies the feedback assumption. Finally, through the case analysis of the inverted U-shaped CEK, we found that the continuous growth process has exacerbated the phenomenon of greenhouse gas emissions. In this regard, we cannot provide any evidence to prove that developed countries can get rid of environmental pollution. Govindaraju VC and Tang CF (2013) provide more robust evidence for the link between CO2 emissions, economic growth, and coal consumption in China and India using the latest and robust cointegration estimation techniques. In addition, causal relationships between variables were examined more thoroughly using Granger causality tests. The empirical results show that the variables in China are co-integrated, but those in India are not. In other words, there is a long-term relationship between China's CO2 emissions, economic growth, and coal consumption. Granger causality tests in China reveal strong evidence for a one-way causality from economic growth to CO2 emissions. In addition, there are two-way causal relationships between economic growth and coal consumption and between short- and long-term CO2 emissions and coal consumption. In the case of India, only short-term causality was detected. The Causal Relationship between economic growth and CO2 emissions and CO2 emissions and coal consumption runs in both directions. However, there is only one-way Granger causality between India's economic growth and coal consumption. Long X et al. (2015) focused on the 1952–2012 period in China to examine the relationship between energy use, carbon emissions, and economic growth. They examine the connection between energy consumption, carbon emissions, and economic growth using Granger causality, after which they examine the static and dynamic regression of carbon emissions and economic growth determinants. The findings indicate that coal has a major impact on both economic expansion and carbon emissions. CO2 (carbon dioxide) emissions, coal, gas, and power usage are all related to GDP. Salahuddin and Gow (2014) investigated the empirical relationships between economic growth, energy use, and carbon dioxide emissions, computed the trend of decoupling effects, and lastly studied the development of carbon emission inequalities. Carbon CO2 in GCC countries (GCC countries). The findings indicate strong positive relationships between energy use and CO2 emissions, economic expansion, and both short-term and long-term energy use. Economic growth and CO2 emissions did not appear to be significantly correlated. Granger carbon dioxide emissions and energy consumption interact, and there is a one-way causal link between economic growth and energy consumption. Except for Saudi Arabia, all GCC nations experienced absolute and relative decoupling over the study period. Different levels of emission inequality in the area are caused by variations in Gini index values. Over time, differences in CO2 emissions among energy providers and economic sectors have dramatically decreased.

Relationship between economic development and CO2 Emissions

Mardani et al. (2018) provide a comprehensive overview of the Relationship between carbon dioxide emissions and economic growth based on Web of Science data. Moreover, a systematic qualitative method and meta-analysis called "Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)" was proposed. Thus, the results show that the link between CO2 emissions and economic growth justifies policy choices that must reduce emissions by imposing constraints on economic growth. Due to the two-way causality, other CO2 emissions are stimulated to higher or lower levels as economic growth increases or decreases, so potential reductions in emissions are expected to affect economic growth negatively Khan et al (2020). Begum et al. (2014) Using econometric methods to study the dynamic impact of GDP growth, energy consumption and population growth on CO2 emissions in Malaysia 1970 from 2007 to 2007. The empirical results of the ARDL boundary test method show that during 1970-1980, per capita CO2 emissions decreased with the increase of per capita GDP (economic growth); however, from 1980 to 2009, with the further increase of per capita GDP, per capita Carbon dioxide emissions have increased dramatically. This is also supported by the Dynamic Ordinary Least Squares (DOLS) test and the Sasabuchi-Lind-Mehlum U test (SLM U test). Therefore, the EKC assumption did not hold in Malaysia during the study period. The results also show that per capita energy consumption and GDP have long-term positive effects on per capita carbon emissions. However, the population growth rate has no significant impact on per capita carbon dioxide emissions. Begum et al examine the dynamic impact of GDP growth, energy consumption and population growth on CO2 emissions. The empirical results of the ARDL boundary test method show that during 1970-1980, per capita CO2 emissions decreased with the increase of per capita GDP (economic growth); however, from 1980 to 2009, with the further increase of per capita GDP, per capita Carbon dioxide emissions have risen sharply. This is also supported by the Dynamic Ordinary Least Squares (DOLS) test and the Sasabuchi-Lind-Mehlum U test (SLM U test). Therefore, the EKC assumption did not hold in Malaysia during the study period. The results also show that per capita energy consumption and GDP have long-term positive effects on per capita carbon emissions. However, the population growth rate has no significant impact on per capita carbon dioxide emissions. Heidari et al. (2015) studied the Relationship between economic growth, carbon dioxide (CO2) emissions, and energy consumption, aiming to test the Kuznets analysis (EKC) environmental curve hypothesis in five ASEAN countries (Association) validity. Southeast Asian countries (Indonesia, Malaysia, Philippines, Singapore, and Thailand) by applying panel smooth transition regression (PSTR) models as a new econometric technique. The empirical results show that (per capita GDP level is lower than 4686 US dollars) environmental degradation intensifies with economic growth. In comparison, in the second case (per capita GDP is higher than 4686 US dollars), the trend of environmental degradation is the opposite. The results also showed that the energy consumption of the first or second scenario increased carbon dioxide. The overall results support the validity of the EKC hypothesis in ASEAN countries.

Relationship between energy Consumption and CO2 Emissions

Bilgili et al. (2016) used a panel dataset of 17 OECD nations for the period of 1977–2010, using FMOLS and DOLS estimations in the panel, to study the dynamic influence of renewable energy consumption on CO2 emissions. The findings indicate that CO2 emissions are adversely and positively influenced by per capita GDP and per capita GDP squared, respectively, and that usage of renewable energy increases CO2 emissions. Another important point in this research is that the EKC's efficacy is independent of the income levels of the panel countries for which it is supposed to hold. Dogan and Inglesi-Lotz (2017), Using some control variables and applying an econometric approach, accounting for heterogeneity and cross-sectional dependencies across a small group of countries; by analyzing real income and biomass energy consumption For the effect of carbon dioxide (CO_2) emissions, they found that the EKC assumption holds that biomass energy consumption reduces CO_2 emission levels. Gu et al. (2019) Based on the interaction model, using the data of 30 provinces in China, the impact of energy technology progress and energy consumption on China's carbon emissions were estimated. The main results from 2005 and 2016 are as follows: (1) an inverted U-shaped relationship exists between energy technology progress and carbon emissions. (2) Thanks to technological progress, energy consumption presents an inverted U-shaped effect on carbon emissions. (3) The direct and technical effects of my country's energy technology progress have reached an inflexion point. This suggests that they first increase carbon emissions and then decrease carbon emissions, although the rebound effect continues to have a positive effect on increasing carbon emissions. (4) The biggest difference between regions with different energy technology levels is reflected in the direct and technical effects of energy technology progress on CO2 emissions, and there is almost no difference in the rebound effect. Akadiri et al (2019) Apply the cointegration frontier test and Toda-Yamamoto for Granger causality test and examine the relationship relationship between carbon emissions, energy consumption and economic growth in Iraq Causality and long-term relationships for the period 1972-2013. However, empirical results show a one-way causal relationship between economic growth to energy consumption and carbon emissions to long-term energy consumption. The results show no feedback relationship between economic growth, carbon emissions, and energy consumption in Iraq. Mohiuddin et al (2016) Using time series data covering 1971 to 2013 to study carbon dioxide emissions, energy consumption (E.C.), GDP, and energy production from oil, coal, and natural gas in Pakistan. However, this study uses a vector error correction model to estimate the long-run equilibrium relationship. The results show a long-term equilibrium relationship among energy consumption (E.C.), coal power generation, natural gas power generation, oil power generation, GDP and carbon dioxide emissions. In addition, there is evidence of one-way causality from energy consumption to CO2 emissions, gas power generation to carbon emissions, energy consumption to CO2 production, oil power generation, electricity production, gas to GDP, and GDP to GDP. Electricity is produced from oil. Finally, the generalized impulse response analysis evidence shows three components of CO2 emissions in Pakistan, including electricity consumption, natural gas generation, and GDP. Jammazi and Aloui (2015) examine the intersection of CO2 emissions, economic growth and energy consumption in six Gulf Cooperation Council countries (Saudi et al. and Qatar) for the period connect. They use wavelet window cross-correlation (WWCC), which combines multiscale decomposition and lead/lag cross-correlation. The results highlighted a bilateral causal effect between E.C. and, E.G., whereas only a unidirectional relationship was found between E.C. and CO2 emissions. The strength of the linkage peaks on coarser (long-term) scales. Furthermore, decoupling effects are evident in the short run but become less pronounced in the long run. Overall, the results support the so-called neighbourhood effect hypothesis, as we found striking similarities in the patterns of relationships between variables across countries.

Description of Congo Brazzaville’s Current Situation and Problem Discovery

Current status and problems of emissions

Population Growth Status

According to ECOM's 2005 report, the country's total population was estimated at 3,396,500 inhabitants, compared to only 1,909,248 inhabitants in the 1984 Population and Housing Census and an annual average of 3.2% between 1985 and 2005. Currently, the population is estimated at 5,876,500 inhabitants (ECOM), 51.7% female and 48.3% male, 58.4% of which live in the country's major cities and 41.6% in rural areas. The average population density is 15.4 people per square kilometre, with an annual population growth rate of 10.2% in 2013, 42% for the 0-14 age group. The median age also shows that the population is extremely young, so half is under 18.7. The demographic transition has only begun: fertility rates remain high, at more than six children per woman. At the same time, mortality levels have stagnated and remained high for at least the past decade. The overall mean family size was 5.1 persons, with insignificant differences by area of residence. This class is dominated by large families and couples with children, at 34.2% and 33.5%, respectively (Population Division of the United Nations Secretariat 2017). Large single-parent and nuclear single-parent families followed at 11.1 per cent and 8 per cent, respectively. Another feature is residential preferences: the strong dispersion of the population complicates the coverage of basic social and economic services. The Congolese population is urban, from 43.3% in 1975 to 61% in 2007. This increase results from a combination of natural population growth and rural exodus. Cities are attractive centres for young people, but increasingly they are home to deteriorating living and environmental conditions in rural areas and victims of conflict.

Population Growth Problems

According to ALM Region forecasts, the population is growing rapidly and steadily. In a self-sufficient scenario, this number could reach about 7 million by 2050 and 10 million by 2100. Food security sensitivity can be high if wealth or food production does not follow demographic trends. Sustained high fertility rates lead to rapid population growth, associated with rising poverty rates, low rates of primary education, persistently high infant and maternal mortality rates, and environmental degradation...

In rural areas of the Congo, women typically carry out all agricultural tasks. Pregnancy or health problems prevent women from growing enough fruit and vegetables to feed their families, and their children go hungry or malnourished. Malnourished children are at risk of delayed physical or cognitive development, which compromises their chances of living long, healthy and productive lives and contributes to an intergenerational cycle of poverty. High fertility is a public health problem in Congo, especially for women whose pregnancies are less than two years apart, leaving them vulnerable to disease. He said that pregnant women sometimes do not have time to care for their health or children. Early marriage is another factor reducing women's right to a controlled reproductive life, often leading to early and multiple pregnancies. In Congo, more than half of women aged 20 to 49 said they were married before their 18th birthday, and about one in five were married before their 15th birthday. Many girls are initiated at 12 or 13 and then considered for marriage. When it comes to getting married, it is due to the influence exerted by family members, and daughters are obliged to respect and obey, so it is difficult to violate these cultural customs.

(1) If Congolese women could make or influence their decisions, they would have fewer children. Education plays a vital role in this. Contraceptive methods are generally more commonly used by women with higher levels of education. In Congo, only 1 in 10 women with no formal education use contraception; in those who have completed at least secondary education, they account for 4 in 10. According to the Congo Reproductive Health Profile, higher levels of education are also associated with better reproductive health outcomes, meaning better health for mothers and their babies. However, nationally, fewer than half of girls complete fifth grade; many become pregnant and drop out. Girls who continued their education beyond four were likelier to delay their first pregnancy. If they reach second or first, they are more likely to understand their potential societal role and consider their future career. Then they have a wider range of options and possibilities.

(2) The vicious cycle of fertility, poverty, health, and lack of education in rural areas is especially difficult to break. Extended families are harder to feed, but they represent a

form of social protection in Congo and have little social safety net. Children represent family capital. It is widely believed that having children is a means of gaining power. In Congo, family members help with household chores, and children are considered wealthy.

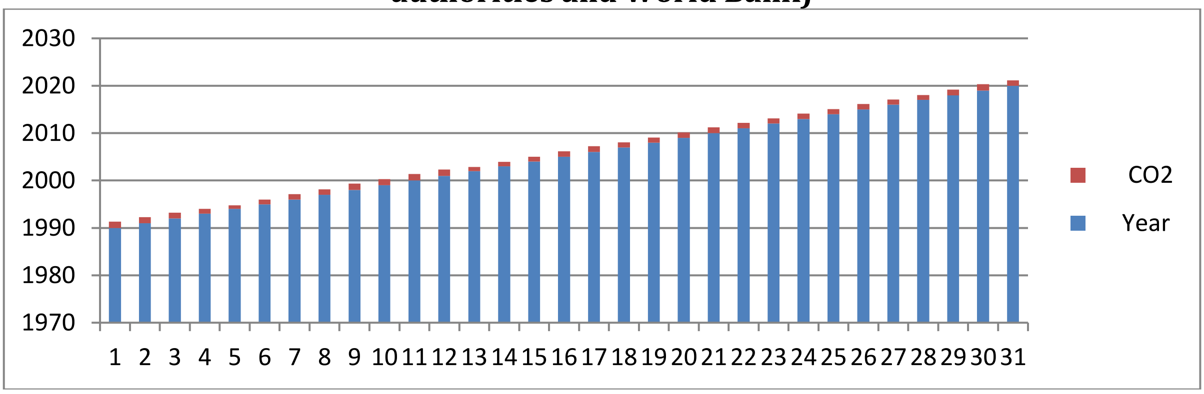
(3) In Congo, where rapid population growth has changed surface conditions through residential construction or various development projects, water erosion has a greater impact than in rural areas. Soil erosion caused by gullies is very serious. Between 2014 and 2017, the estimated yield was more than 201,101.120 tonnes, or 50.275.28 tonnes/ha/year. Such large volumes of soil have had nutritional and environmental impacts, notably silting sanitation facilities and water levels in the Brazzaville port of the Congo River. In addition, these deposits exploit the physicochemical properties of water in wells and streams. In addition, through settling, these sediments cause siltation at the bottom of waterways and can contaminate springs and undeveloped wells near waterways. Erosion products engulfed houses in the plateau's shallows or depressions and at the levee's foot. This is the case in the Mouhoumi district of Mfilou district, where 153 houses were buried.

CO_2 emissions status and problem

CO_2 Emissions Status

The energy sector was responsible for 80% of CO2 emissions in 2000. Its total amount is 1,292.10 Gg, of which the energy production industry dominates, followed by the transportation industry. In 2000, the carbon dioxide emissions of various industries were as follows: the energy industry accounted for 65.93%; transportation accounted for 29.78%; residential buildings accounted for 0.51%. Compared to the level of CO2 emissions calculated in the initial national communication, six years later, compared to the level of CO2 emissions in 2000, the subsequent evolutions occurred: the energy sector saw a net increase of almost 37.93% due to the importance of the oil business; the transport and residential emissions dropped significantly, by 28.72% and 10.49%, respectively.

Figure 3.1: Congo-Brazzaville CO2 emission Evolution (Source: Congo Republic authorities and World Bank)



We note that emissions were very low until 1990, a period of instability marked by the civil war. Until 2002, growth in emissions remained relatively slow. In 2010, Congo emitted 4.96 million tons of carbon dioxide per year. In 1990, this figure decreased to 2.01 million tons per year. Emissions continue to increase rapidly; we now emit over 15 million tons annually. Growth in emissions has slowed in recent years but has yet to peak. This graph shows the growth of Congo's emissions from 1990 to the present. In recent years, we have seen increased CO2 emissions (fossil fuels, industry, land use, Etc.). This means that total emissions have been roughly stable over the past decade. In Congo, until 2002, total emissions were concentrated in the southern part of the country. In 2002 more than 80% of shows were produced at Pointe-Noire; even in 1990, they accounted for more than 70% of annual emissions. Nevertheless, things have changed dramatically over the past few decades. In 2015, we witnessed a significant increase in emissions in other parts of the country, especially in the north, as new oil deposits were discovered. Today, Congo is one of the countries in Africa responsible for just under a third of emissions. Congo, one of the major oil producers, has a relatively small population compared to many African countries, making it one of the world's largest emitters of carbon dioxide per capita, and its total annual emissions are also low. In 2015, Congolese emissions per capita were 1.12 tons. It is also much lower than neighbouring countries with similar living standards, such as Côte d'Ivoire, Cameroon, and Benin. The Republic of Congo aims at the short-term rise and long-term development and is still among the developing countries with low greenhouse gas emissions. Emissions from the energy sector include subsectors such as energy, transport, households and services.

CO_2 Emissions Problems

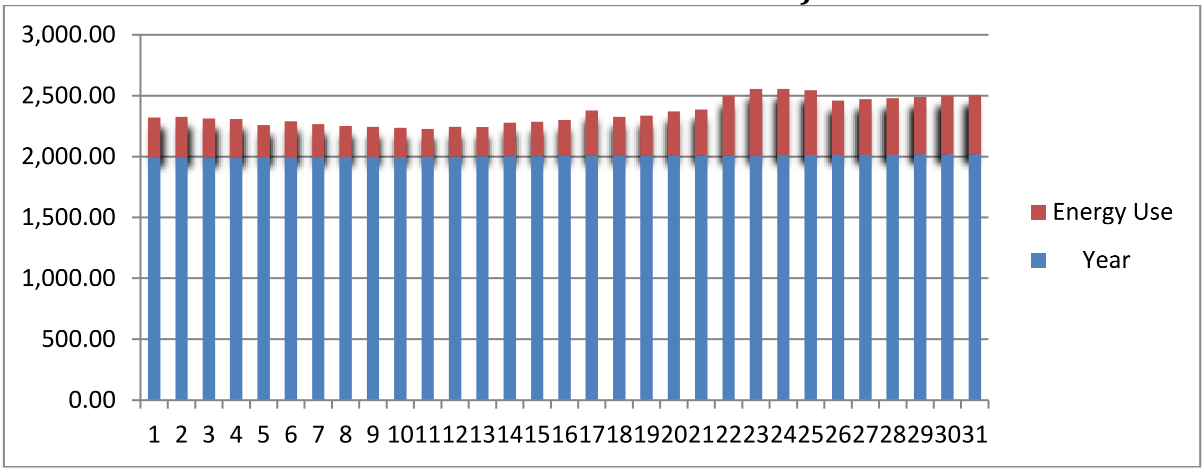
The distribution of CO2 emissions in 2000 is as follows, according to statistics: Transportation, 65.93%; housing, 29.78%; and energy industries. As a result of these emissions, average maximum temperatures in the Congo have increased by 0.76°C and average minimum temperatures by 0.69°C. The Congolese population emits large amounts of gas, exacerbating the greenhouse effect. As a result, greenhouse gas emissions continue to rise despite the potentially disastrous and irreversible consequences on a national scale. Congo's forests are the lungs of Africa; they help preserve the soil and regulate the regional and global climate...but that does not stop forests and small everywhere from being overexploited on national territory. In Congo, different modes of travel and energy sources generate greenhouse gas emissions. Vehicles generally emit more carbon dioxide but also more fine particulate matter, which is harmful to health. Brazzaville's spatial growth and population explosion led to increased transport needs. As demand increases, carbon dioxide emissions build up and travel through the air to the people who use vehicles daily to get some people to work and others to provide goods and services. Therefore, people with weaker body systems (older people) are prone to lung and respiratory diseases, which can lead to death.

Energy Consumption Status and problem

Energy Consumption Status

In the Congo, 90% of domestic energy comes from firewood and charcoal, with an estimated annual consumption of 300,000 tonnes (equivalent to the exploitation of 5,000 hectares of natural forest (Marien et al., 2013). This consumption is scattered throughout the Except for the supply of Zeville, which generally has no impact, Brazzaville's timber resources are distributed within a radius of 80 km, mainly concentrated in the province of Poole (Gallery Forest). Transport, agro-industry, industry, Etc., mainly use fuel and fossil fuels, and other Quantities are limited globally. As long as supplementary or alternative energy sources fall out of favour, these fossil fuels will gradually decline in the coming years, while their costs will continue to increase.

Figure 3.2: Congo-Brazzaville Energy consumption per capita (Source: Congo Republic authorities and World Bank)



In Congo, basins found in oil-bearing formations kilometres deep have become laudable due to rising oil prices. However, the extraction of these resources only indirectly contributes to the country's energy independence, as these resources are exported for sale on the world market, and there needs to be more local refining to meet the country's needs. The same is true for manufacturing some commonly used fertilizers based on nitrogen, phosphorus and potassium (N, P, K), which can be synthesized from natural gas but must be imported.

Biofuels may have a bright future in Congo because it has many lands, and its development does not need to support national food production. However, their production required a significant intensification of cultural practices to their credit. This is not possible in the short term in traditional Congolese agriculture but could be developed by external players with the technological and financial assets to face global competition. Conversely, Congo has other assets, such as hydroelectric power (there are two dams at the moment), that are destined to grow in the short term with the development of the Congo River and its tributaries. Therefore, Congo will still face the problem of paid imports of petroleum products in the next few years. This is why countries must strive to promote fuel energy savings in all sectors, by supporting local energy production (biofuels, electricity, coastal wind) and by resuming or starting complementary transport (rail, river and coastal shipping), especially through the use of intermodal transport systems (road/rail/shipping).

Energy Consumption Problems

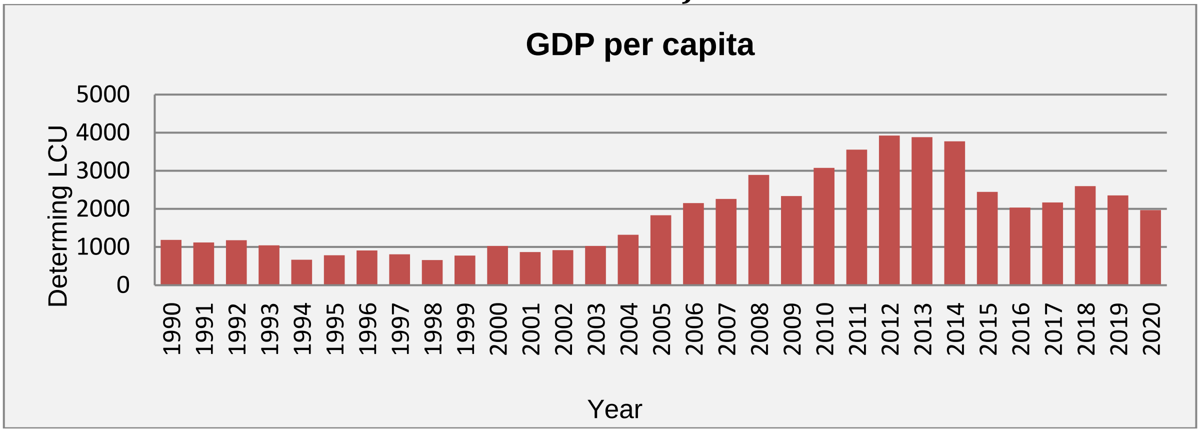
Congo has huge potential for hydropower, gas and oil, yet people need access to multiple forms of energy (electricity, oil and gas). According to ECOM's findings, the most commonly used lighting method in urban areas is kerosene lamps (70.1%), followed by electricity (27%). Kerosene lamps, which make up 97% of all lighting sources in rural regions, are widely used. In terms of the fuel used to prepare food, 44.1% of the middle class use coal, compared to 70% of the poor. In Brazzaville, these two categories accounted for 36.3% and 17.4%, respectively. The wood and charcoal provided by the forest are the main sources of energy for the inhabitants of Brazzaville, especially for cooking and heating. This reliance on wood leads to the disappearance of small forests in cities, making soils more vulnerable to degradation processes as forests help protect and regulate global and regional climates. The use of wood and charcoal for energy is common in the Brazzaville region, destroying the peri-urban forest ecosystems that regulate the climate.

Economic Growth Status and Problems

Economic Growth Status

Congo's economic integration is low and monolithic, mainly dependent on the exploitation of oil and timber and mainly exported in the original state. Other riches include copper, diamonds, iron and energy resources, of which the potential for hydroelectric power has yet to be fully exploited. Since 1960, this economic structure has changed. As a result, agriculture's share of GDP gradually declined: 27.1 per cent in 1960, 22.2 per cent in 1970, 11.7 per cent in 1980, 12 9 per cent in 1990, and 4.4 per cent in 2000 (National Institute of Statistics of Congo 2015). Agricultural production falls far short of domestic demand, and the country still relies heavily on food imports for 90 per cent of its cereal and 50 per cent of its fish needs. This is all the more paradoxical given that the country has 10 million hectares of potential agricultural production, but only 2% of it, or 200,000 hectares, has been exploited. During the same period, the proportion of the manufacturing industry was 9.2%, 1.2%, 7.5%, 8.4% and 3.5%; the export value of the extractive industry (mainly oil today) was 0.7% in 1960, 1.2% in 1970, and 33.6% in 1980 %, 28.9% in 1990 and 65.5% in 2000. Logging was the country's main export resource until 1973 and has been the country's main export resource since that year. Oil became the main extractive industry and the country's main export item. In 2004, the petroleum sector accounted for 51.6% of GDP and 69.5% of public revenue. Oil production has been on a downward trend since the late 1990s: 4.9% in 1999, -1% in 2000, -7.5% in 2001, -4.9% in 2002, -4.9% in 2003, 1.5% in 2004, 0.4% per year. Real GDP growth improved from 2000, largely due to higher oil prices or dollar appreciation: 7.6% in 2000; 3.8% in 2001; 4.6% in 2002, 1% in 2003 and projected 2004 3.7%. However, the structural performance of the economy has remained the same, mainly because it remains dependent on a small number of cash crops (crude oil and timber), the sale of which (mainly in the raw state) provides almost all public resources. Thus, an economy's strong dependence on basic goods favours the expansion of rentier sectors at the expense of productive sectors, negatively affecting long-term growth potential and thus protecting basic goods. The country remains highly indebted, with total outstanding debt estimated at CFA 3,856.3 billion as of 31 December 2004. However, the Government is making major efforts to reduce this debt, which stood at CFA francs 4,322.4 billion in 2000. The debt service burden fell between 1990 and 2002, from 19% to 10.8% of GDP and 35.3% to 14.1% of exports of goods and services. The basic economic and collective infrastructure, which directly affects the living conditions of the people, is weak and especially severely degraded. As a result, some 17,300 kilometres of the road network, of which only 1,235 kilometres are paved, have deteriorated and need maintenance. Most of the rural railways, which serve as distribution channels for rural products are blocked, resulting in a sharp decline in the purchasing power of residents and aggravated poverty. Traffic on the Congolese railway network (795 km) has dropped significantly due to severely ageing equipment and unsafe lines. Ports, maritime and river facilities have not been immune to this degradation. The air transport industry centred on the two major international airports of Brazzaville and Pointe-Noire is very backward and still needs to develop to face sub-regional competition effectively. Most secondary airports serving remote populations need to be in better condition, which can lead to navigational safety issues. In 2020, the unemployment rate is estimated at 10.3%, and the poverty rate is 46.1%, exacerbated by post-COVID-19 unemployment. Central government operations resulted in a budget surplus of 1.4% of GDP, compared with a deficit of 1.7% in 2020. The debt ratio fell to 101% in 2020. In 2020, within the framework of the Central African Economic and Monetary Community (CEMAC), inflation was contained at 2.0%. and CAMCA) standards.

Figure 3.3: Congo-Brazzaville GDP per capita (Source: Congo Republic authorities and World Bank)



In the early 2000s, the Congolese Government launched a large-scale structural reform and governance strengthening plan to save Congolese peace and promote Congolese economic and social development. Within this framework, China created a 2008–2010 poverty reduction strategy. The plan was created as part of the Heavily Indebted Poor Countries Initiative's preparations towards its completion point, which intends to lighten Congo's load by eliminating the majority of its external debt. Against this backdrop, the Government launched a massive reform and investment program and major innovations in economic governance. Between 2008 and 2010, an economic program enabled the Congo to make commendable economic progress, as demonstrated by the sustained growth of approximately 7.0% and inflation within normal limits (approximately 3%).

Economic Growth Problems

The Republic of the Congo is going through a difficult period of persistently weak macroeconomic fundamentals, while at the regional and international levels, conditions appear to be more favorable. In 2017, the economic growth rate of the Republic of Congo fell for the second consecutive year to -3.1%, after -2.8% in 2016. The reason for this underperformance is the ongoing impact of the economic crisis on the industry. Excluding oil, the oil sector shrank again to -7.9%, which improved this year as national production rose 15.3%. Layoffs and a hiring freeze have occurred in the private sector as a result of the buildup of wage arrears and the overall downturn in activity. Additionally, the twin deficits in 2017 (public finances and foreign accounts) continued and were still sizable. The Republic of the Congo's macroeconomic statistics are down, whereas sub-Saharan Africa and the rest of the world saw positive growth of 2.4% compared to 3% in 2017. The cyclical weakness in the non-oil sector results from a combination of important socioeconomic factors that remain due to economic structural weakness. Aside from the effects of the Dutch Syndrome, which has limited the development of Congo's productive sector for decades, various factors have hampered economic recovery. For example, the Poole crisis disrupted rail traffic between Pointe-Noire and Brazzaville, completely disrupting the company Chemins de Fer Congo-Océan (CFCO) operations. The company's 2012 net accounting results fell by CFA 8.7 billion and were cancelled in 2017. The massive damage to railway equipment and infrastructure especially shattered emergency, rehabilitation and equipment plans for the Congo-Ocean railway. This situation has led to a slowdown in economic activity, negatively affecting the country's supply chain, despite the opening of the Pointe-Noire-Dolisie-Brazzaville road. Nonetheless, this path makes it possible to control inflation by boosting supply in Brazzaville. The economic crisis deepened, and GDP declined sharply from -2.8% in 2016 to -3.1% in 2017. Non-oil activity fell sharply by 7.9% in 2017. Pressure on the financial position of private businesses Accumulated delinquency caused most businesses to reduce activities and personnel. Nearly four out of five companies reported turnover in 2016, while just 7 per cent improved, according to Unicongo, the Congolese employers' federation. In 2017, this situation remained almost unchanged, with 71% of companies reducing their activity by a third. The slowdown in activity, mostly in the non-oil sector, is believed to be due to tight cash and weak demand, leading to about 12,000 job cuts in 2016 and about 3,000 in 2017.

Research Methodology

Data and Analysis

As was already noted, "IPAT" is a term used to represent the environmental impact (I) of population size (P), wealth (A), and technology (T). The Congo time series data utilised in this study span the years 1990 through 2020. We attempted to choose carbon dioxide emissions as the dependent variable for this study, and then we selected population, GDP, and energy consumption as the explanatory variables. The World Development Indicators (2017) published by the World Bank are the single source of all the data suggested in this study. The automotive research regression distribution delay model was used in this study to get efficient results. It is essentially a standard least square regression with the dependent, independent, and dependent variable delays. As introduced by Pesaran et al. (2001). There are various requirements that must be satisfied before using an autoregressive distributed lag model. Conditions are described below. Other explanatory variables are constant at the I (1) level, while only the dependent variable CO2 is stable at the I (0) level. No variable in process i (2) is non-stationary, and if a variable in process i (2) is non-stationary, we never apply ARDL.
Economic analysis demonstrates that variables have a long-term relationship since the variance and mean equivalents' dispersion remains constant. Other values' dispersion, such as mean and deviation, can occasionally show divergent trends over time, leading to unsatisfying outcomes. ARDL co integration and link co integration approaches can therefore be used in this situation. The ARDL approach can handle i (0), i (1), or both under typical operating conditions; it does not essential that all variables be non-stationary at i (0). The statistical value F also affects how correlations between variables are found over both the short and long term. When the F-statistic value is less than the lower critical value, it indicates that there is a long-term relationship between the variables. If the statistical value F is greater than the critical upper limit, it indicates that there is a long-term relationship between the variables. Short-term relationships exist between the variables. Because it offers several benefits that other models do not, this model stands out from the competition. Its ability to manage many vectors is one benefit. The ai (2) variable, however, is not applicable to the ARDL model. Following the ARDL's fundamental requirements is crucial in the case of prediction. The model requirements are clear and the impact on forecasts and policies is practical if these criteria are satisfied (Nkoro & Uko, 2016).

Methodology

The usage of the ARDL model is one feature of this work. The usage of ARDL is crucial since it contributes to establishing the connection between carbon dioxide emissions, population energy demand, and economic expansion. This pattern is used in a certain method; first, we looked at the ideal lag, and then we looked at the short- and long-term correlations between the variables. Finally, the stability and convergence of the model are checked.

Econometric model

We suggest a model to describe the effects of Congo's carbon dioxide emissions based on IPAT (i); Population (P), Gross Domestic Product (A), and Energy Consumption (T) are the many variables used.

$$CO_2 = \alpha_0 + \alpha_1 Pop + \alpha_2 EC + \alpha_3 GDP + \varepsilon \quad \text{.......} (1)$$

Among them, CO2 represents carbon dioxide emissions (kg/2010 USD GDP), POP represents population growth, E.C. represents per capita energy consumption in kilograms of oil equivalent, GDP represents per capita GDP (constant 2010 USD), β0 represents the intercept, and ε represents per capita GDP wrong term.

Unit root tests

As mentioned earlier, we have proposed the use of the ARDL model. ARDL can estimate variables without Root of unity at i (0) and i (1), or both, which means that different levels or the first Static variable cannot be estimated. However, if the variable is fixed or there is no Root of unity in i (2), it is impossible to apply ARDL (Pesaran et al., 2001), because it breaks the hypothesis of correlation test. Dickey Fuller test (ADF) is used to verify the Root of unity, where the null hypothesis is that there is a Root of unity, and the alternative hypothesis is that there is no Root of unity. The improved Dickey Fuller statistics contain negative numbers. For negative values of state T, the chance of rejecting the null hypothesis at any level of significance is high. As of March 2009, this might be 5% or 10%.

$\Delta E_t = \alpha + at + \gamma E_{t-1} + \delta 1 \Delta E_{t-1}$ ………………………………………………………………….. (2)

The above equation is defined by utilising the restrictions =0 and =1 associated with random walk modeling, where represents intercept, represents slope, and p indicates translation order. The red pool information criterion, the Hannan Quinn information criterion, and the Bayesian information criterion are three approaches we have to validate the t-value of the coefficient and additional validation information criterion. Additionally, the Root of unity indicates that the alternative hypothesis is γ =0 and the null hypothesis is γ <0. $DFT = \gamma / S.E.(\gamma)$ ……………………………………………………………………………………… (3)

If the statistical value is computed using the formula above, it is compared against the critical value of the Dickey-Fuller test. If the case arises, H0 is rejected if the value of the state t is less than the critical value, indicating the lack of a univalent race.

Short and long-term elasticity

Model:

$$\Delta\ CO_{2t} = \mu 0 + \sum_{i=1}^{p} \mu_{1i} \Delta \log CO2_{2t-i} + \sum_{i=1}^{p} \mu_{2i} \Delta \log GDP_{2t-i} + \sum_{i=1}^{p} \mu_{3i} \Delta \log POP_{t-i} + \sum_{i=1}^{n} \mu_{4i} \Delta \log EC_{2t-i} + \varphi_2 \log CO2_{2t-1} + \varphi_3 \log GDP_{t-1} + \varphi_4 \log POP_{t-1} + \varphi_5 \log EC_{t-1} + \varepsilon t \quad \text{…….. (4)}$$

The variables CO2, POP, ENR, and PIB are those indicated above, and in the formula, stands for the difference, 0 for the intercept, and t for the error term. In relation to this equation, express the dynamics of errors. As a result, the final portion of the equation, show the long-term relationship between the dependent and independent variables as well as the dependent variable. The equation also takes into account how variables change over time. The model estimates (p+1)k number of regressions to verify the optimal lag length for each variable, and p shows the optimal lag length for the kth variable used to estimate the equation. This delay length method is based on Akaike's Information Criterion (AIC) and Schwarz's Bayes' Criterion (SBC). The bounds test method is based on F statistics and Wald statistics. The null hypothesis of this approach is that there is no long-run association between the variables. In the association test method, if the value of the F statistic is large, then the upper bound, it is concluded that there is a long-term association between the variables, and H0 is rejected; if the value of the F statistic is low, then the conclusion is drawn, In this case, there is no long-term correlation between the variable and H0, and if the value falls between the upper and lower bounds, the result is not indeterminate (Pesaran et al., 2001).

Stability

Understanding long-term correlations allowed for the development of the Error Correction Model (ECM), which has proven stable in use.

Model:

$$\Delta CO_{21} = \mu o + \sum_{i=1}^{p} \mu_{1i} \Delta logCO2_{2t-i} + \sum_{k=0}^{n} \mu_{2i} \Delta logGDP_{2t-i} + \sum_{i=1}^{p} \mu_{3i} \Delta logPOP_{t-i} + \sum_{k=0}^{n} \mu_{4i} \Delta logEC_{t-i} + \varphi_2 logCO_{2t-1} + \varphi_3 logGDP_{t-i} + \varphi_4 logPOP_{t-1} + \varphi_5 logEC_{t-1} + nECT_{t-1} + \varepsilon_t \quad \text{.......} (5)$$

The following is the definition of equation (5), where η indicate the growth rate at which equilibrium levels are reached across various time periods. An estimated error correction term called ECTT-I is based on both short- and long-term models.

Result and discussion

Heteroscedasticity

The Breusch-Pagan test is designed to detect any linear form of heteroscedasticity. Breusch-Pagan/Cook-Weisberg tests the null hypothesis that the error variances are all equal and the alternative hypothesis that the error variances are a multiplicative function of one or more variables. The Breusch-Pagan-Godfrey test (sometimes called the BreuschPagan test) is a test of the variance of the regression error variance. It measures the increase in the error of an explanatory variable.

Table 4.1: Heteroscedasticity test: Breusch-Pagan-Godfrey

F-statistic	0.40
Obs*R-squared	0.0425
Scaled explained SS	0.65859366
Prob. F(3 , 27)	0.0158
chi2(1)	1.47
Pro > Chi2 (1)	0.22

For this result, the alternative hypothesis states that the error variance increases (or decreases) as the predicted value of Y increases. A large chi-square indicates heteroscedasticity, so a small chi-square (chi2) value suggests that heteroscedasticity may not be a problem (or at least if it is, it is not). Not a multiplicative function of prediction. Finally, the above table shows that the heteroscedasticity results indicate that the model has a constant variance and that the F-statistic is insignificant at the 5% critical value and is lower than the table value.

Serial correlation

Breusch (1978) and Godfrey (1978) did extend the B-P-L B method to test for autocorrelation in models with weakly exogenous regressors. The Breusch-Godfrey test was independently developed by these two authors in a 1978 publication and was intended to be applied to subsequent datasets under weak exogenous or dominant regression assumptions. The test is easy to apply, works well in the presence of lagged dependent variables, is valid for general assumptions about error serial correlation, and is asymptotically equivalent to the Lagrangian multiplier (L.M.) test. Breusch-Godfrey serial correlation LM test:

Table 4.2: Breusch-Godfrey serial correlation LM test

Lags (p)	Chi2	df	Prob > chi2
4	15.062	4	0.0046

In this case, the regressor (unit vector) is, of course, strictly exogenous.

Table4.3. Unit Root Test Results: Considering All Tea Plantations

Variables	Level			First difference		
	t-statistic	Critical value	Prob.	t-statistic	Critical value	Prob.
CO_2	-3.405	-1.701	0.0010***	-4.496	-1.708	0.0001***
GDPPC	-0.084	-1.701	0.4669	-2.657	-1.708	0.0068***
Energy Use	-0.522	-1.701	0.3029	-3.056	-1.708	0.0026***
Pop Growth	-2.105	-1.701	0.0222	-5.515	-1.708	0.0000***

*** Indicates significant at 1% level. Rappelons que la valeur critique retenue ici est celle de 5%
The results of the unit root tests are reported in Table 4.3. The table shows the output of the augmented Dickey-Fuller, which shows that the series is not horizontally stationary; however,

we find that the series is stationary at the first difference because the t-statistic value is above the critical value, and The probability values are all significant at the last critical value (5%). Since the series is stationary at the first difference, we can evaluate short- and long-term ARDL tests.

Table4.4. Bound Test

The decision criterion for an association test is that we can reject the null hypothesis test at the 10%, 5%, or 1% significance level. If the calculated F-statistic is greater than the critical value for the upper bound I(I), you can conclude that cointegration does not exist. In other words, the two parties have a long-term cooperative relationship. Reject the null hypothesis. Estimate the long-term model, the error correction model (ECM). However, if the calculated F-statistic is less than the critical value of the lower bound I(0), we conclude that there is no cointegration and no long-run relationship. Do not reject the null hypothesis. Estimate short-term models and autoregressive distributed delay (ARDL) models; nevertheless, if the calculated F statistic is between the lower bound I(0) and the upper bound I(I). This test is considered indeterminate.
Null hypothesis: no relationship between levels

Table4.4. Bound Test

F-statistic	5.478			
Case	3			
Critical Value Bounds				
Significance	10%	5%	2.5%	1%
Lower Bound	2.72	3.23	3.69	4.29
Upper Bound	3.77	4.35	4.89	5.61

The F-statistic is more than all limitations and less than 1%, according to the findings of the chain test. The values of the F statistic are first significant inside the upper limit, with the exception of 1% (10%, 5%, and 25%). It is therefore proven that the model shows a long-term link between the variables. Therefore, we reject the null hypothesis. The table shows the short- and long-term evolution of the Congo Brazzaville economy. However, we find that GDP per capita, energy consumption, and population growth are positively correlated with CO2 emissions in the short run, with estimated elasticities of 1.03%, 0.16%, and 0.41%. Considering energy consumption, similar results are found in the long run, with an estimated elasticity of 0.16%. Contrarily, with elastic estimates of -0.33% and -0.19%, respectively, per capita GDP and population growth have a long-term negative correlation with carbon dioxide emissions.

ARDL

ARDL Cointegration and Long-Term Form
Dependent variable: CO2

ARDL (2,2,2,1) regression

Co-integrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNEnergy Use)	0.2647885	0.2203133	1.20	0.245
D(LNGDPPC)	0.8233907	0.4207791	1.96	0.066
D(LNPOPG)	0.2921684	0.1311073	2.23	0.039
CointEq(-1)	1.248716	1.974301	0.63	0.535
Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNEnergy Use)	0.1613532	0.1376206	1.17	0.534
D(LNGDPPC)	- 0.3319212	0.4365564	2.99	0.064
D(LNPOPG)	- 0.1938621	.2096487	-0.92	0.008
C	1.248716	1.974301	0.63	0.535

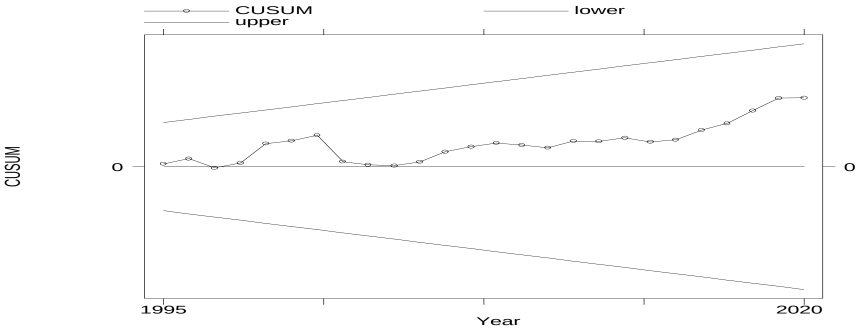
Note: R squared: 0.6759

The above table shows the results of short-term and long-term ARDL model estimates. One of the most important findings in the results of the ARDL model is that in the long run, the increase in energy use increases CO2 emissions more than economic growth and population rate semester. On the other hand, in the short run, population growth increases CO2 emissions more than energy use and growth. Regarding the use of energy that will increase carbon dioxide emissions more, the results are related to the assumptions made by the predecessors, Lai et al. (2019). Energy consumption is the main driver of carbon emissions in the construction sector. Energy consumption is considered one of the largest contributors to carbon emissions (Wang et al., 2011; Zaman & Abd-el Moemen, 2017). It can be seen that economic growth has a short-term positive and long-term negative impact on CO2 emissions, which means that when GDP increases by 1%, CO2 emissions will increase by 0.823% in the short term. At the same time, when GDP increases by 1%, CO2 emissions decrease by -0.331% in the long run. The short-term result is because at the beginning of a country's development because there is no high-end technological progress for emission reduction, GDP growth is accompanied by increased CO2 emissions. Since a country's GDP development is accompanied by a decline in carbon dioxide emissions, this is a long-term outcome. The nation may attain the same production level with reduced carbon dioxide emissions by creating new low-carbon technology. The long-term results show that increased economic growth has lowered CO2 emissions, which correlates with the goal of the Government of the Republic of Congo through its Development Action Plan (DAP) to insert the gross domestic product of the country's economy in support of reducing CO2 emissions. In the long run, the effect of population growth on CO2 emissions is negative, which confirms that high population growth itself is not the cause of environmental degradation caused by large CO2 emissions, so it is better to adopt policies that control the consumption of a country's population. This result correlates with recent research by Toth and Szigeti (2016), demonstrating that the population itself is not the cause of environmental degradation; rather, people's consumption patterns; Begum et al. (2015) studied the impact of POPs on CO2 emissions and found that POPs had no significant impact on environmental quality, although they predicted that POPs might hurt CO2 emissions from the Malaysian economy in the long run.

CUSUM

The outcomes of the CUSUM test are shown in Figure 1; the model stabilises over time as its values fall between two dashed lines, as seen in the figure below, proving its significance at a key value of 5%.

Figure 5.1: Cumulative Linear



5.7. CUSUM Sum of squares

Figure 5.2: Quadratic cumulative

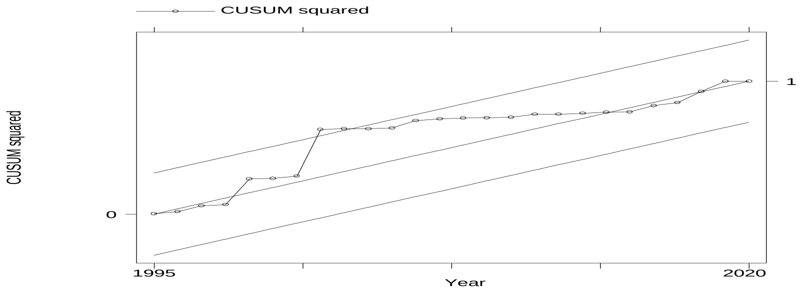


Figure 1 and Figure 2 show the results of the CUSUM test and the sum of squares, respectively. As can be seen from the figure above, the cumulative sum is still within the model's confidence region, which verifies that the model's significance meets the 5% threshold.

Conclusion

In this study, we investigate the impact of population growth, energy consumption, and economic growth on CO2 emissions in Brazzaville, Congo, between 1990 and 2020, using the IPAT assumption in the Congolese economy. However, sustainable development goals include economic growth and the environment. Since then, coordinating these two branches for a better future has been a bottleneck for developed and developing countries. On the other hand, this work has achieved remarkable results. CO2 emissions increase with energy consumption and population growth, while economic growth reduces CO2 emissions, which means economic growth is still an influential factor in reducing CO2 emissions. In order to achieve respectful sustainable development, the Congolese authorities should adopt cleaner production, low-emission technologies, long-lasting and efficient appliances, and sustainable production based on the diversity of renewable energy sources to reduce emission efficiency into the atmosphere through hazardous substances.

References:

United Nations Department of Economic and Social Affairs, Population Division (2021). Global Population Growth and Sustainable Development. UN DESA/POP/2021/TR/NO. 2.

https://www.worlddata.info/africa/congo-brazzaville/populationgrowth.php

"The population of continents and states", Population & Avenir, no. 685, November-December 2007.

Bilgili, F., Koçak, E., & Bulut, Ü. (2016). The dynamic impact of renewable energy consumption on CO 2 emissions: A revisited approach to the Environmental Kuznets Curve. Renewable and Sustainable Energy Journals, 54, 838–845. doi:10.1016/j.rser.2015.10.080

Dogan, E., & Inglesi-Lotz, R. (2017). Analyzing the effects of real income and biomass energy consumption on carbon dioxide (CO 2) emissions: Empirical evidence from the panel of biomass-consuming countries. Energy, 138, 721–727. doi:10.1016/j.energy.2017.07.136

Waheed, R., Sarwar, S., & Wei, C. (2019). The survey of economic growth, energy consumption and carbon emission. Energy Reports, 5, 1103–1115. doi:10.1016/j.egyr.2019.07.006

Mardani, A., Streimikiene, D., Cavallaro, F., Loganathan, N., & Khoshnoudi, M. (2018). Carbon dioxide (CO2) emissions and economic growth: A systematic review of two decades of research from 1995 to 2017. Science of The Total Environment. doi:10.1016/j.scitotenv.2018.08.229

Sulaiman, C., Abdul-Rahim, A. S. (2018). Population Growth and CO2 Emission in Nigeria: A Recursive ARDL Approach. https://journals.sagepub.com/doi/pdf/10.1177/2158244018765916

Begum, R A., Sohag, K., Sharifah Mastura Syed Abdullah, S M S A., Jaafar, M.(2014) CO2 emissions, energy consumption, economic and population growth in Malaysia. http://dx.doi.org/10.1016/j.rser.2014.07.205

Duc Hong Vo & Anh The Vo Renewable energy and population growth for sustainable development in the Southeast Asian countries. https://energsustainsoc.biomedcentral.com/articles/10.1186/s13705-021-00304-6

Toth, G., Szigeti, C., 2016. The historical ecological footprint: from over-population to over-consumption. Ecol. Indic. 60, 283–291. https://doi.org/10.1016/j. ecolind.2015.06.040.

Begum, R.A., Sohag, K., Abdullah, S.M.S., Jaafar, M., 2015. CO2 emissions, energy consumption, economic and population growth in Malaysia. Renew. Sust. Energy. Rev. 41, 594–601. https://doi.org/10.1016/j.rser.2014.07.205.

Alex O. Acheampong. Economic growth, CO2 emissions and energy consumption: What causes what and where? https://doi.org/10.1016/j.eneco.2018.07.022

Gu W., Zhao X., Yan X., Wang C, Li Q. (2019) Energy technological progress, energy consumption, and CO2 emissions: Empirical evidence from China. https://doi.org/10.1016/j.jclepro.2019.117666

Waheed, R., Sarwar, S. and Wei, C. (2019). The survey of economic growth, energy consumption and carbon emissions. Energy Reports, 5, 1103–1115. doi:10.1016/j.egyr.2019.07.006

Bekun, F V. , Emir, F. , Sarkodie, S A. (2018). Another look at the Relationship between energy consumption, carbon dioxide emissions, and economic growth in South Africa. https://doi.org/10.1016/j.scitotenv.2018.11.271

Debone, D., Leite, V.P., & Miraglia, S.G.E.K. (2021). Approach to modelling carbon emissions, energy consumption and economic growth: a systematic review. Urban Climate, 37, 100849. http:// dx.doi:10.1016/j.uclim.2021.100849

Antonakakisa, N. , Chatziantonioub, l. , Filisc G. (2016). Energy consumption, CO2 emissions, and economic growth: An ethical dilemma. http://dx.doi.org/10.1016/j.rser.2016.09.105

Zamana, K., Moemenb M A. (2017). Energy consumption, carbon dioxide emissions and economic development: Evaluating alternative and plausible environmental hypothesis for sustainable growth. http://dx.doi.org/10.1016/j.rser.2017.02.072

Ardakani, M.K., Seyedaliakbar, S.M., 2019. Impact of energy consumption and economic growth on CO2 emission using multivariate regression. Energy Strateg. Rev. 26, 100428. https://doi.org/10.1016/j.esr.2019.100428.

S.S. Akadiri, F.V. Bekun, E. Taheri, A.C. Akadiri (2019). Carbon emissions, energy consumption and economic growth: a piece of causality evidence, Int. J. Energy Technol Policy ,15 (2–3), 320–336.

O. Mohiuddin, S.A. Sarkodie, M. Obaidullah, (2016). The Relationship between carbon dioxide emissions, energy consumption, and GDP: recent evidence from Pakistan, Cogent Eng. 3 (1) (2016).

Magazzino, C. (2015). Economic growth, CO2 emissions and energy use in Israel. International Journal of Sustainable Development & World Ecology, 22, 89–97.

Alshehry AS, Belloumi M. (2015). Energy consumption, carbon dioxide emissions and economic growth: the case of Saudi Arabia. Renew Sustain Energy Rev , 41, 237–47.

Begum RA, Sohag K, Abdullah SMS, Jaafar M. (2015). CO2 emissions, energy consumption, economic and population growth in Malaysia. Renew Sustain Energy Rev , 41, 594–601.

Govindaraju V.C., Tang C.F. (2013). The dynamic links between CO2 emissions, economic growth and coal consumption in China and India. Appl Energy , 104, 310–8.

Heidari H, Katircioğlu ST, Saeidpour L. (2015). Economic growth, CO2 emissions, and energy consumption in the five ASEAN countries. Int J Electr Power Energy Syst , 64, 785–91.

Jammazi R, Aloui C. (2015). On the interplay between energy consumption, economic growth and CO2 emission nexus in the GCC countries: a comparative analysis through wavelet approaches. Renew Sustain Energy Rev , 51, 1737–51.

Long X, Naminse EY, Du J, Zhuang J. (2015). Nonrenewable energy, renewable energy, carbon dioxide emissions and economic growth in China from 1952 to 2012. Renew Sustain Energy Rev , 52, 680–8.

Salahuddin M, Gow J. (2014). Economic growth, energy consumption and CO2 emissions in Gulf Cooperation Council countries. Energy , 73, 44–58.

Cite this article:

MBOUSSA MOUI RIDEL (2023). Impact of Population growth, Energy consumption and Economic growth on CO2 emissions in Congo brazzaville. *International Journal of Science and Business, 26*(1), 49-71. doi: https://doi.org/10.58970/IJSB.2155

Retrieved from http://ijsab.com/wp-content/uploads/2155.pdf

Published by

IJSAB International