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An Evaluation of the Carbon Dioxide Emissions of a Liquefied Natural Gas Plant in Nigeria

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Abstract

This study evaluates the carbon emissions of a Liquefied Natural Gas (LNG) processing plant in Nigeria. The estimates were determined using the US EPA Emission Factor technique which utilizes the volume of fuel used by the main sources, the heating value of fuel gas and the emission reduction efficiency of the main sources considered. Results indicate that an average of 10.9 million metric tons (mmt) of CO_2 per year is released from the processing plant. The flare point, MR and PR compressors, thermal oxidizers and gas turbine were the highest emitters of CO_2 which amounts to 3.3mmt/yr., 2.7mmt/yr., 1.9mmt/yr. and 1.2mmt/yr. respectively. The heat transfer and regeneration units were the lowest emitters of CO_2, both reaching an average of 1mmt/yr. The average total estimated value of CO_2 emission from the plant represents 11% and 0.03% when compared with Nigeria and global values of 98.93 mmt/yr. and 38,604 mmt/yr. of 2014 respectively. With the continuous emissions of CO_2 on the increase from oil and gas facilities and other anthropogenic sources due to population growth, industrial and transport expansion; mitigating CO_2 emissions is not feasible in the near future. The outcome of these emissions will alter environmental balance and generate reverse reaction. To achieve a near zero CO_2 emission, LNG plant chain would require LNG liquefaction facilities with Carbon Capture and Storage (CCS) systems such as pre-combustion, post-combustion and oxyfuel combustion systems integrated into the liquefaction facility design.

Keywords

Carbon dioxide, Emission Factor, Atmosphere, Natural Gas

1. Introduction

Gases that trap heat in the atmosphere are termed greenhouse gases (GHG). A notable part of these gases is carbon dioxide (CO_2). Carbon dioxide enter the atmosphere through burning fossil fuels i.e. coal, natural gas and oil), solid waste, trees and wood products and also as a result of chemical reactions [1]. Studies have related the impact of CO_2 emissions to the environment [2-4]. Although CO_2 is not really a pollutant considered harmful to human health, it is considered critical to the atmosphere as a greenhouse gas because of its role in propagating climate change. The importance of Carbon dioxide emissions which rarely goes into reaction in the atmosphere lies in its ability to increase the overall heat balance of the earth. It is by far the most significant of the greenhouse gases that allow the influx of solar radiation from the sun while limiting outgoing terrestrial radiation. Nigeria, especially the Niger delta area is home to oil and gas exploration activities and is bound to receive massive CO_2 emissions from related sources, including natural gas processing facilities. It has been revealed that CO_2 component of Nigeria's natural gas composition is about 1.3% [5]. Vast increase in ambient concentration result from burning associated gases and other combustion processes. Compared to other sectors of the petroleum industry, CO_2 emissions from combustion devices are usually the major contributors to total GHG emissions from the LNG operations-chain [6]. It is followed by methane (CH_4) emissions which may be smaller in absolute

terms, but important due to its higher Global Warming Potential (GWP). Whereas CO_2 is primarily associated with process heat and combustion emissions, CH_4 is primarily linked with venting, leakage and fugitive emissions. Carbon dioxide emissions from within an LNG plant vary depending on plant configuration and liquefaction technology. The main sources of CO_2 emissions from a liquefied natural gas plant include gas turbines for electricity generation as well as propane and mixed refrigerant (MR) compressors; thermal oxidizers; heat transfer, regeneration and fractionation units, flare points etc. A typical liquefied natural gas plant in Nigeria is roughly divided into five processes [7] namely: (1) pre-treatment, (2) acid gas removal, (3) dehydration, (4) liquefaction and (5) heavy oil separation. While CO_2 emissions take place in all the stages, the notable emission points are from processes 3 to 5. Table 1 shows the comparison of emissions from natural gas in pounds of emission per million (Btu) of energy consumed. Natural gas, propane, ethylene, propylene, butadiene and butane constitute over 95% of the waste gases flared. In combustion, gaseous hydrocarbons react with atmospheric oxygen to form carbon dioxide and water [8]. During combustion reaction, several intermediate products are formed, and eventually, most are converted to CO_2 and water.

Although the effect of climate change are analysed, the release of the principal gases associated with this phenomenon will remain cogent largely due to the continuous anthropogenic releases.

Table 1. *Emissions Output from Natural Gas.*

Gases	Natural Gas (lb/MMBtu)
Carbon Dioxide	115
Carbon Monoxide	17
Hydrocarbons	1.4
Nitrogen Oxide	100
Sulphur Dioxide	0.6
Particulates	5

Source: [9]

A WHO report in 2015 highlighted the urgency to cut ozone, soot, methane as well as carbon dioxide emissions which all contributes to climate change. It was indicated that the emissions not only produce a strong global warming effect but also contributes to the over 7 million premature fatalities annually connected to emission sources [10]. US greenhouse gas emissions in 2015 revealed that CO_2 emissions constituted about 82% of total emissions [11]. This feat from a developed country as well as the United States withdrawal from the Paris Climate Agreement will only mean that the cut in CO_2 emissions from developing countries like Nigeria will only remain an illusion.

Since CO_2 emissions is likely to be on the increase from developing countries such as Nigeria, carbon capture and storage is a necessary requirement to forestall increasing CO_2 trend. Carbon capture and storage is a practice where CO_2 discharged from large static emission sources such as an LNG plant is captured and deposited geologically in the underground [12]. Capturing and storing of CO_2 involves separating the greenhouse gas from other emission components through the source exhaust and compressing it at high pressure thereby turning it to liquid form and subsequent transportation through pipeline to a suitable site where it can be stored permanently. Carbon capture and storage from fossil fuel is by many seen as a key technological option to reduce CO_2 emissions [12]. There are three main CO_2 capture process, namely: post-combustion, pre-combustion and oxyfuel combustion. Post-combustion encompasses the separation of CO_2 from other gases at the point of release after combustion of the fossil fuel. Special chemicals called amines are used where the CO_2 gas stream is bubbled through an amine solution and bonds with the solution. The CO_2 in the soaked amine solution is then evacuated from the amine capture for storage. Pre-combustion involves separating the CO_2 gas before the fossil fuel is combusted while the oxyfuel combustion entails combusting the fossil fuel in pure oxygen that is void of nitrogen gas. This makes the CO_2 significantly concentrated and easier to capture and compress. When these systems of carbon capture are strictly in place, curtailing CO_2 emissions into the atmosphere from an LNG plant is bound to reduce the cumulative CO_2 emissions released into the atmosphere from the area.

2. Materials and Method

The approach for CO_2 combustion emission from sources in the LNG plant utilized published emission factors that are based on known fuel properties including their carbon content and heating values. The AP 42 compilation of Air Pollutant Emission Factors was first published by the U.S Public Health service in 1968. In 1972, it was revised and issued as the second edition by the U.S Environmental Protection Agency (EPA). In 1985 the sequent fourth edition was split into two volumes. Volume 1 includes stationary point and area source emission factors, and volume 11 includes mobile source emission factors. Volume 1 is currently in its fifth edition and is available on the internet. Volume 11 is no longer maintained as such, but roadway air dispersion models for estimating emissions from on-road vehicles and from non-road vehicles and mobile equipment are also available on the internet. Air pollutant emission factors are representative values that attempts to relate the quantity of a pollutant released to the ambient air with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance or duration of the activity emitting the pollutant (e.g. kilograms of particulate emitted per mega gram of coal burned). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term average. U.S. EPA provided compiled emission factors for criteria and Hazardous Air Pollutants (HAPs) in AP 42 and the factor information Retrieval (FIRE) system FIRE version 6.2

(released April, 1999) in a database management system containing EPA's recommended emission estimation factors for the pollutants. It includes information about industries and their emitting processes, the chemicals emitted, and the emission factors themselves. The emission estimate obtained from using emission factors is based upon emission testing performed at similar facilities and may not accurately reflect emissions at a single source. Thus, the user must put into cognizant, that in most cases, emission factors are averages of available industry-wide data with varying degree of quality and may not be representative for an individual facility within that industry.

The equation for the estimation of emission before emission reduction controls are applied is given by [13] as:

$$E = AxEFx(1-\frac{ER}{100}) \quad (1)$$

Source: [13]

Where,

E = emissions, in units of pollutant per unit of time

A = activity rate, in units of weight, volume, distance or duration per unit of time.

EF = emission factor, in units of pollutant per unit of weight, volume, distance or duration

ER = overall emission reduction efficiency, in %.

The activity rate, 'A' is equal to:

$$A = VXH \quad (2)$$

Where V = Volume of fuel fired

and

H = Heating value of fuel from the fuel gas heating value for Nigeria's natural gas i.e. 48MJ/kg (lower heating value), the heat rate was estimated.

If $1MJ = 948Btu$

Then,

$$48MJ / Kg = 45504Btu / Kg$$

Multiplying this value by the given source fuel gas consumption in kg/hr adjust the outcome in Btu/hr and dividing by one million (1,000,000) gives the outcome in MMBtu/hr. With the known emission factors (EF) values from EPA's documents, emission reduction measures (ER) for analysed sources and the activity rate, the emission rate was determined.

The volume of fuel gas used was determined using the Emission Factor procedure given as:

$$\text{Fuel gas volume (V) in (Ib/hr)} = \frac{P_r(MW)}{E_{ff}xFG_{Hv}} \quad (3)$$

Where,

P_r is the power rate for emission source in Megawatts,

E_{ff} is the efficiency of the emission source at work,

FG_{Hv} is the emission source usable fuel gas heating value.

The Table 2 shows the main CO_2 emission sources from a natural gas processing plant with the various power rate and thermal efficiency.

Table 2. *Key Emission Sources from LNG Plant.*

Sources	Power Rate (MW)	Thermal Efficiency (%)
Gas Turbine	32	33
MR & PR Compressors	71	34
Heat Transfer Unit	36	87
Heat Regeneration Unit	35	90
Fractionation Unit	58	95
Thermal Oxidizer	3	95
Flare Unit	256	98

Source: [5].

3. Results and Discussion

The Table 3 shows the estimated emission rates of CO_2 for the various unit sources from the natural gas processing plant under scrutiny in this study. Results show that an average total of 10.9 mmt/yr. of CO_2 is released from a natural gas processing plant in Nigeria. The flare unit is the highest average producer of CO_2 emissions followed by the MR and PR compressors. The average total estimated value of CO_2 emission from the plant represents 11% and 0.03% when compared with Nigeria and global values of 98.93 mmt/yr. and 38,604mmt/yr. of 2014 respectively [14]. It has been admitted by [15] that about 518.84 million metric tons (mmt) of CO_2 was released to the atmosphere from the use of petroleum products in Nigeria between 1990 and 2009. This amount constituted about 25.94mmt/yr. With the average release of CO_2 from a natural gas processing plant reaching almost half this amount per annum, there is the likelihood that CO_2 emissions will continue to be on the increase due to population and industrial growth and greater demands on all modes of transportation. There are other anthropogenic sources of CO_2 emitted into the atmosphere such as biomass burnings, electricity generation sets, indiscriminate burnings of oil and gas products, vehicular emissions as well as other oil and gas refineries located in the Niger Delta areas of Nigeria. These additional sources also contribute considerably to CO_2 emission in Nigeria.

Table 3. *CO_2 Emissions from Natural Gas Processing Facilities.*

Source	Emission Factor (Ib/mmBtu)	Fuel Heat Rate (mmBtu/hr)	CO_2 Emitted From Source (mmt/yr)
Gas Turbine	118	331	1.2
MR & PR Compressors	118	713	2.7
Heat Transfer Unit	118	141	0.5
Heat Regeneration Unit	118	133	0.5
Fractionation Unit	118	208	0.8
Thermal Oxidizer	118	522	1.9
Flare Unit	118	873	3.3
Average Total Emissions of CO_2			10.9

According to [16], estimation of carbon dioxide emissions using the emission factors from domestic sources in the Niger delta of Nigeria where the LNG plant is located which includes domestic lighting (using generators) and domestic cooking (using firewood and kerosene) accounted to 5.7 Mt/year. This value is about half of the average CO_2 emissions expected from the existing LNG processing facility. Latest measurement of CO_2 levels in the atmosphere has shown 406.7ppm in 2017 from 380ppm as at 2006 [17]. This indicates an average of about 6.6% increase over the last decade.

Carbon dioxide does not permit the easy outgoing of terrestrial radiation, thereby enhancing global warming. Nigeria already experiences unusual weather patterns such as high rainfall, flood, hot weather and drought that can be attributed to climate change. A study conducted by [18], has shown that increase in carbon dioxide emission enhances the ambient temperature of the boundary layer environment. It was emphasized that CO_2 emissions in Nigeria accounted for 96% occurrences of urban warming experienced in Nigerian cities. The high rate of carbon emissions recorded in Nigeria could be attributed to enormous gas flares and enlarged economic activities which increase anthropogenic emissions. It was indicated that CO_2 emissions was more pronounced in the industrial and traffic congested cities than those of the surrounding rural areas. According to [18], CO_2 emissions were higher in northern parts of Nigeria such as Kano, Maiduguri and Sokoto than in the coastal bands of Lagos, Port Harcourt, Warri and Calabar. The reason for the higher trends in the northern areas was attributed to the low vegetal covers and trees prevalent in the areas to absorb the excess CO_2 emissions. While it is important to technologically suppress CO_2 emissions from oil and gas processing plants, there should be other viable means of mitigating the increases. The significance of avoiding excessive deforestation is crucial to extracting the surplus CO_2 concentrations in the atmosphere. It has been reported that the activities of deforestation are prevalent as a result of increased marketable pressure on lands across Nigerian cities thereby diminishing vegetative areas, and this impacts on global warming [19]. Deforestation has been a major concern in Nigeria over the years as the increased clearing and burnings of vegetation releases CO_2 emissions into the atmosphere. More also, the deficit of vegetation cover due to deforestation will impede the ability of destroyed forested areas to retrieve excess CO_2 emissions in the atmosphere. The United Nations Framework Convention on Climate Change (UNFCCC) categorizes two distinct components for reducing climate change prompted by global warming. This includes decreasing the emission of greenhouse gases, and improving adoptable sinks that cuts the excesses of loaded greenhouse gases in the atmosphere. The Kyoto Protocol, an international treaty which extends the 1992 UNFCCC in which most countries including Nigeria are signatories to, identifies the relationship between CO_2 emissions reduction set objectives, emission trading and the requirements for developing economies [19].

In relation to the aspect of this study, to achieve a near zero CO_2 emission contribution, LNG plant chain would require LNG liquefaction facilities with Carbon Capture and Storage (CCS) systems such as pre-combustion, post-combustion and oxyfuel combustion systems integrated into the liquefaction facility design.

3.1. Emission Reduction Challenges in Nigeria

The challenges in reducing greenhouse emissions in Nigeria depend on three areas; the continuous dependence on fossil fuels for revenue generation, deficiency of climate change policies and programs and the perception of the people on the reality of climate change. The Nigerian economy is over 80% dependence on oil and gas revenue in which the LNG is a major source. Although it is an advantage for the nation to harness her natural resources and make life comfortable for the masses, technical inputs to harness these resources such as the processing of natural gas for economic viability should attains its optimal productivity without negatively impacting on the shared environment. However, in the Nigerian context, the end (to obtain the value of natural resource) justifies the means, and as such, business must continue irrespective of what happens to the environment. This renders climate change policies and programs ineffective and the boundary layer environment prone to the future negative effects of climate change. It has been reported by [20] that due to the dilapidated nature of electricity production in Nigeria which have been ongoing for decades, most Nigerians as well as production industries are forced to resort to generating electricity individually for most hours of the day with fossil fuel power generation sets. These also contribute to the buildup of CO_2 emissions in the atmosphere. According to [21], Nigeria is ranked 39th out of 193 countries in the World with over 95,000kt of CO_2 emissions. While this assessment might not generate much concern for policy makers, the true nature of this assessment is being demonstrated in the relationship between the interconnected forces controlling the natural environment. It is well known that the emission of greenhouse gases comes from both controlling and un-controlling sources in Nigeria. However, when releases from controlling sources are not mitigated even when mitigative measures are clear and unambiguous, emissions from controlling sources may outwit that of the un-controlling sources. Reducing CO_2 emissions from fossil fuels will require shifting energy supply investment from fossil fuel dependence to clean energy. This is attainable when all stakeholders mobilize supplementary investment in energy efficiency. In this regard, the quest for technological advancement in Nigeria for clean energy should be foremost and monitored to the latter. The educational sector should be allowed to take the lead and the enabling environment created for clean energy development to thrive.

To overcome these challenges, Nigeria needs a harmonized

and implementable policy that positively responds to climate change; the policy must be such that answerable Agencies can produce adoptable and enforceable greenhouse gas emission control protocols. Also, educationally informing the people on awareness programs and platforms of climate change induced causes and effects should not be concentrated in city centers but also taken to the rural dwellers. The people should be informed of the negative effects of deforestation and the importance of vegetation cover in absorbing CO_2 emissions in the atmosphere.

3.2. Implication of CO_2 Emissions in Nigeria

In order to attain the ultimate level of industrialization for improved economic and sustainable development, developing nations such as Nigeria will continue to create the required pressure of reaching the desired goal. However, when the necessary policies, programs and technicalities are not in place or being implemented to safeguard the quality of the environment, achieving the desired goal will be targeted at the expense of taking undue advantage of the environment. The importance and impact of environmental impact assessment for infrastructural developments and industrial advancement should seek to significantly improve the reduction of greenhouse gas emissions. Although the environmental impact assessment study is a compulsory legal requirement for major project developments in Nigeria, the core aim of the assessment which is to avoid adverse impacts of project development on the environment including the atmosphere has not attain its objective in that direction. When qualitative reports are designed indicating the impacts of any controlled activity on the atmosphere, it is essential that appropriate regulatory agencies monitor and ensure implementation of the necessary mitigative measures adopted by investigators in order to avert negative influences on the environment. As the economy continues to develop, additional CO_2 emissions will be released into the atmosphere due to the avoidance of adaptive techniques in reducing the emissions. According to [22], economic development and preserving the environment are the two major challenges facing humanity. However, it is the environment that is being overwhelmed by the consequences of economic development both from the developed and developing countries [22]. It is important to note that the release of greenhouse gases from the developed and developing countries which engender climate change generate similar impacts. The issue of routine flood disaster happenings is not peculiar to Nigeria alone but also to other developed countries. Therefore, the concern of the developing countries like Nigeria that mitigating CO_2 emissions will jeopardize the economy will only continue to make the environment less important and susceptible to the devastating effects of climate change. The 2012 flood disaster across the Niger Delta where billions of naira was lost is a significant example. Although not many attributed the disaster to the force of climate change, experts believe it was, however, the behavior of policy makers to be better prepared by adhering to the principles of mitigating climate change was unreliable.

4. Conclusion

The intensification of carbon dioxide in the Nigerian atmosphere will engender possible boundary layer complications in the near future. Strategy and policy must be in place to cut anthropogenic releases of carbon dioxide emission especially from the oil and gas industries by 70% if the current rising trend is to be tamed. However, the quest to boost viable economic revenues in Nigeria through the activities of major industries that enhances CO_2 emissions by far outwits the importance of mitigating the increase of carbon emissions. This study provides an overview of average CO_2 emissions from a Liquefied Natural Gas (LNG) plant located in Nigeria. Using the US EPA emission factor technique, it has been shown that an average of 10.9mmt/yr. of CO_2 could be released into the atmosphere from a natural gas processing facility. The outcome from this study have shown that significant levels of CO_2 emissions can emanate from an oil and gas industry like the Liquefied Natural Gas plant, even though the fossil fuel (natural gas) dominant in its operational activities is said to be low in air emissions. As a result of higher CO_2 emissions from the plant, forest vegetation should be maintained around site in order to make for the absorption of CO_2 creating a balance and hence reducing that of the atmosphere majorly as sinks. While CO_2 emission is not considered a pollutant dangerous to human health, its impacts on climate as a greenhouse gas makes it important. Also, Integrating carbon capture as well as heat recovery systems into LNG main process facilities are very viable ways of mitigating excessive emissions of CO_2 into the atmosphere, hence reducing the effects of climate change.

References

[1] Giwa, S. O., Adama, O. O. and Akinyemi, O. O. (2014). Baseline black carbon emissions for gas flaring in the Niger Delta region of Nigeria. *Journal of Natural Science and Engineering*, 20, 373-379.

[2] Ubani, E. C. and Onyejekwe, I. M. (2013). Environmental impact analysis of gas flaring in the Niger Delta region of Nigeria. *American Journal of Scientific and Industrial Reseach,* 4 (2), 246-252.

[3] Isa, R. (2014). Greenhouse Gas (GHG) Emissions and Oil and Gas Revenue in Nigeria. *Academic Journal of Inter disciplinary Studies*, 3 (7), 127-132.

[4] Akpanika, O. I., Etim, J. O. and Udoh, F. D. (2015). Diverting CO_2 Emissions from the Atmosphere through Capture and Geologic Sequestration: The Journey So Far! *Journal of Environment and Earth Science*, 5 (2), 42-52.

[5] Nigeria LNG, (1999). EnvironmentalImpact Assessment report on the expansion project VII, LNG Nigeria Limited, Lagos.

[6] American Petroleum Institute (2015). Consistent Methodology for Estimating Greenhouse Gas Emissions. The LEVON Group, LLC, Version 1.0, Washington DC.

[7] Edokpa, O. D. (2010). Emission and Dispersion of Pollutants from NLNG Plant, Bonny, Nigeria. An Unpublished MPhil Thesis, Institute of Geosciences and Space Technology, RSU, Nigeria.

[8] Ede. P. N., Seiba, I. H. and Igwe, F. U. (2006). "Combustion efficiency determined for selected flare points in the Niger delta area", *African Journal of Environmental Pollution and Health*, 5 (2), 19-25.

[9] American Gas Association (1965). Gas Engineers Handbook, American Gas Association, New York.

[10] WHO (2015). New report identifies four ways to reduce health risks from climate pollutants. WHO Department of Public Health, Environmental and Social Determinants of Health. October 22.

[11] U.S Environmental Protection Agency (2017). Overview of Greenhouse Gases. *Inventory of U.S. Greenhouse Gas Emissions and Sinks*: *1990-2015, Executive Summary*. April.

[12] Akigwe, I. M., Enekwechi, K. E. and Ejikeme, I. (2013). Carbon, Capture and Storage from Fossil Fuel and Biomass – Uses, Transportation, Cost and Potential Role in Stabilizing the Atmosphere. *Academic Journal of Interdisciplinary Studies*, 2 (13), 9-18.

[13] U.S Environmental Protection Agency (1999). Emission Factors and Inventories, from http://www.epa.gov/ttn/chief/net/index.html.

[14] Boden, T. A., Marland, G. and Andres, R. J. (2015). Global, Regional and National Fossil-fuel CO_2 Emissions. Carbon Dioxide Information Analysis Centre, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge Team, U.S.A.

[15] Anomohanran, O. (2011). Estimating the Greenhouse Gas Emission from Petroleum Product Combustion in Nigeria. *Journal of Applied Sciences, 11, 3209-3214*.

[16] Fagbeja, M. A., Hill, J., Chatterton, T., Longhurst, J. and Akinyede, J. (2013). Residential-Source Emission Inventory for the Niger Delta – A Methodological Approach. *Journal of Sustainable Development*, 6, 98-120.

[17] NASA (2017). Carbon dioxide: Latest measurement. July 2017.

[18] Efe, S. I. (2016). Evaluation of Carbon Dioxide Emissions and Temperature Variation in Nigeria Cities. *Journal of Geography, Environment and Earth Science International*, 6 (2), 1-9.

[19] Achike, A. I. and Onoja, A. O. (2014). Greenhouse Gas Emission Determinants in Nigeria: Implication for Trade, Climate Change Mitigation and Adaptation Policies. *British Journal of Environment & Climate Change*, 4 (1), 83-94.

[20] Oyedepo, S. O. (2012). Energy and sustainable development in Nigeria: the way forward. *Energy, Sustainability and Society*, 2 (15), 1-17.

[21] World Bank (2014). Carbon dioxide (CO_2) emissions – country rankings. The Global Ecocomy.com. Retrieved May 8, 2018 from https://www.theglobaleconomy.com/rankings/Carbon_dioxide_emissions/

[22] Aye, G. C. and Edoja, P. E. (2017). Effect of economic growth on CO_2 emission in developing countries: Evidence from a dynamic panel threshold model. *Cogent Economics & Finance*, 5 (1379239), 1-22.