

# Piracy in the Gulf of Guinea: Impacts to Maritime Transportation and Maritime Security

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## Abstract

Piracy attacks in the Gulf of Guinea have taken a worrying trend. Unlike the Somali pirates, the pirates in the Gulf of Guinea target the cargoes, especially the oil laden tankers for their cargo. This disruption is impacting negatively on shipping in this sea lane. There are consequences to be suffered due to these pirate attacks on shipping in this region. This study delves into piracy and Maritime Transportation and Maritime Security in the Gulf of Guinea. The aim of this study is to analyse the impacts of piracy on different economic indicators and measurements with shipping as the vector of maritime transport. The economic indicators such as the liner shipping index, gross domestic product growth rate, imports growth rate, exports as a percentage of gross domestic product, and oil production as oil rents as a percent of gross domestic product. An Input-Output analysis to determine the interdependencies between variables was adopted. A Fixed Effects Model is used to show the relationship between pirate attacks and the countries distance from the Gulf of Guinea. A Correlation Analysis is conducted in respect of the countries and years based on the research question. A Chi Square test is conducted to test the hypotheses.

**Keywords:** Gulf of guinea, maritime security, maritime transportation, economic indicators

## 1. Introduction

Piracy is commonly visualised through images of 18<sup>th</sup> century privateers searching for ships projected to have large payouts. The 18<sup>th</sup> century privateers were armed with guns, swords, knives, and cannons. Today's world still has privateers, albeit armed with more advanced weapons, such as automatic weapons and grenades, as well as more advanced ships. Because of the advanced tactics used by modern privateers, there have been headline cases of piracy, especially since the early 2000s. However, piracy was deemed to be a limited problem prior to 2009 and considered to be a lower concern internationally. Common piracy attacks were attributed to small armed groups in territorial seas, such as in the Gulf of Guinea, in touted efforts to protect Somalia fishing resources (Bradford, 2005; Germond, 2011; Gilpin, 2007; Treves, 2009; Yang, Wang, Bonsall, & Fang, 2009). Not only were these areas hunted by armed groups, but also foreign fisherman and individuals dumping waste products in coastal waters. However, there were also problems related to the inefficient and ineffective government, which increased opportunities for piracy. As a result, piracy became more prominent in different locations, as well as increasingly advanced, in part due to technological advancements and in part due to increased boldness by pirates (Treves, 2009).

## 2. Research Aim

Piracy attacks can be linked to international peace and security threats. The Security Council passed Resolution 733/1992, allowing Chapter VII to be invoked in order to address the piracy situation, citing security threats. The purpose of passing this resolution was to fight piracy within the framework of the United Nation's charter (Rosenberg & Chung, 2008; Samuels, 2008; Treves, 2009). There are concerns regarding piracy law effectiveness, which are established through the United Nation Convention of the Law of the Sea, based on Articles 100 to 107 and 110. Due to the increasing rates of piracy in the Gulf of Guinea, there are increased concerns relating to the impact of these attacks (and attempted) attacks. The aim of this research study is to analyse the impact of piracy on different measurements and economic indicators, such as the liner shipping connectivity index, gross domestic product growth rate, imports growth rate, exports as a percent of gross domestic product, and oil production as oil rents as a percent of gross domestic product.

## 3. Literature Review

Maritime Piracy has been assigned diverse definitions. The most popular are the two given by United Nations Convention on the Law of the Sea (UNCLOS) Article 101 (1982) and the International Maritime Bureau (2008) which gave an encompassing definition. The UNCLOS definition limited piracy to be acts committed solely on the high seas but not most pirate attacks in the Gulf of Guinea happened in the territorial seas or anchorage. The IMB (2008) definition captures this omission by stating Piracy and Armed Robbery as follows:

“An act of boarding or attempting to board any vessel with the apparent intent to commit theft or any other crime and with the apparent intent or capability to use forces in the furtherance of the acts.”

Collier (2007) stated that the Gulf of Guinea countries did not do enough to protect their

coastline due to their inefficient and inadequate security systems. He further stated that, each attack by pirates was well planned and thought out before execution. That the pirates sometimes appeared heavily armed and had faster getaway speed boats and skiffs than the local coast guards or navies.

Tepp (2012) stated that the Gulf of Guinea had eight crucial tendencies which helped to fuel piracy in the Gulf of Guinea. These are: cultural acceptability, good political climate, insufficient security, weak judicial system, under resourced Law enforcement, reward promised, regional conflicts and good geography.

Luff & Konin (2004) put the direct effects of maritime piracy in the Gulf of Guinea at some \$250 million and an estimated amount of \$9 billion saddled on the maritime industry through piracy. Doing trade along these dangerous waters had both direct and indirect effects on maritime transportation they stated.

Ramsbotham (2011) listed the following as some of the direct effects of piracy:

- Cargo fraud using so called phantom ships
- Penalties because of damaged or delayed goods
- Paying ransom money
- Investigative reports and their cost
- Entire ship loss
- Ship and Cargo damage due to an attack
- Ship cargo loss

Money has been a major catalyst in pushing the drive to engage in acts of piracy (Gjelsvik & Bjorgo, 2012), Hansen (2012), Chalk (2009). Clark (2009) stated that ‘opportunity’ was a huge factor for an act of piracy to be committed.

#### **4. Research Questions and Hypotheses**

Piracy attacks in the Gulf of Guinea have become increasingly pervasive in recent years. According to the International Maritime Bureau (2015), Nigeria has been the most affected country due to piracy attacks and the most affected area is the Gulf of Guinea. As a result, piracy has a negative impact on maritime transportation and maritime security, particularly in relation to the development of oil production in the area Bowden (2010). The research questions and hypotheses to be addressed include:

Q1. To what extent does piracy impact the Gulf of Guinea in relation to the liner shipping connectivity index?

H<sub>0</sub>: Piracy has a significant impact on the Gulf of Guinea in relation to the liner shipping connectivity index.

H<sub>1</sub>: Piracy has no impact on the Gulf of Guinea in relation to the liner shipping connectivity

index.

Q2. To what extent does piracy impact the Gulf of Guinea in relation to gross domestic product growth rate?

H<sub>0</sub>: Piracy has a significant impact on the Gulf of Guinea in relation to gross domestic product growth rate.

H<sub>2</sub>: Piracy has no impact on the Gulf of Guinea in relation to gross domestic product growth rate.

Q3. To what extent does piracy impact the Gulf of Guinea in relation to imports growth rate?

H<sub>0</sub>: Piracy has a significant impact on the Gulf of Guinea in relation to imports growth rate.

H<sub>3</sub>: Piracy has no impact on the Gulf of Guinea in relation to imports growth rate.

Q4. To what extent does piracy impact the Gulf of Guinea in relation to exports as a percent of gross domestic product?

H<sub>0</sub>: Piracy has a significant impact on the Gulf of Guinea in relation to exports as a percent of gross domestic product.

H<sub>4</sub>: Piracy has no impact on the Gulf of Guinea in relation to exports as a percent of gross domestic product.

Q5. To what extent does piracy impact the Gulf of Guinea in relation to oil production as oil rents as a percent of gross domestic product?

H<sub>0</sub>: Piracy has a significant impact on the Gulf of Guinea in relation to oil production as oil rents as a percent of gross domestic product.

H<sub>5</sub>: Piracy has no impact on the Gulf of Guinea in relation to oil production as oil rents as a Percent of gross domestic product.

## **5. Data Collection**

The panel data used for this study was obtained from the International Maritime Bureau and the World Bank. Panel data was used because of the consideration of all data uses. The time period assessed is 2007 to 2016. Raw data is shown in the appendix. Data includes coastal countries of Africa. Microsoft Excel was used for data analysis purposes.

### *5.1 Data Variables*

#### **5.1.1 Research Question One**

The first research question asked: To what extent does piracy impact the Gulf of Guinea in relation to the liner shipping connectivity index? The variables being used in relation to this research question are the average of attacks and liner shipping connectivity per year and per country.

### 5.1.2 Research Question Two

The second research question asked: To what extent does piracy impact the Gulf of Guinea in relation to gross domestic product growth rate? The variables being used in relation to this research question are the average of attacks and growth domestic product growth rate per year and per country.

### 5.1.3 Research Question Three

The third research question asked: To what extent does piracy impact the Gulf of Guinea in relation to imports growth rate? The variables being used in relation to this research question are the average of attacks and imports growth rate per year and per country.

### 5.1.4 Research Question Four

The fourth research question asked: To what extent does piracy impact the Gulf of Guinea in relation to exports as a percent of gross domestic product? The variables being used in relation to this research question are the average of attacks and exports as a percent of gross domestic product per year and per country.

## 6. Variables Justification

According to Onuoha (2009), African waterways are some of the most dangerous waters for vessels to cross. These attacks have led researchers to believe that piracy is the largest industry in Somalia, which has led to further attacks. In fact, based on Maritime Piracy Data, there were 3,413 piracy and/or armed robbery events against ships between 2000 and 2009 (Coggins, 2012). This number has increased, despite how maritime concerns have become high on national and international security agendas. In fact, as of 2009, there was a steep increase in maritime threats, leading to increased awareness of threats to both humanitarian and commercial interests, as well as important resources (Vreÿ, 2009). In fact, it is recognised that “maritime piracy imposes direct costs on the immediate victims of the attacks - the crews, the ships and their cargoes, and the shipping companies. Merchant seamen may be injured or killed; ships and cargoes stolen, and higher insurance rates and operating costs borne by companies. At the same time, the indirect costs of maritime piracy are substantial, particularly in humanitarian terms” (Nincic, 2009). Moreover, the threat of piracy has increased, such as in relation to the Tanzanian sea route, which has led to jeopardise to commercial shipping. In Somalia, piracy has hindered humanitarian efforts, such as the delivery of aid for a substantial part of the population. In Nigeria, piracy has severely impacted the fishing industry and regional trade.

Piracy in Somalia and Nigeria alone hinders living situations for many people Nincic (2009). According to Sullivan (2010), “maritime piracy impacts international business and disrupts the global supply chain.” Neethling (2010) argued that there is a close interface between both globalisation and maritime trade, further arguing that “most security challenges confronting Africa have their origin in the lack or failure of governance as states are the primary actors and agents of good order at sea.” This is concerning as “container traffic in West African ports has grown 14 percent annually since 1995” (Osinowo, 2015). Moreover, the Gulf of

Guinea represents the main transit hub and facilitator to the region, as well as for global energy supplies.

According to Osinowo (2015), in 2012, the Gulf of Guinea surpassed that of the Gulf of Aden (infamous for high-seas hijackings) as the region with the highest number of reported piracy attacks in the world. These attacks also tended to be more violent. Given the limited maritime security presence off the West African coast, South American narcotics traffickers have found the region an attractive transit route to Europe. Oil theft and illegal bunkering plague the Gulf of Guinea. Nigeria alone loses between 40,000 and 100,000 barrels a day due to theft. With 40 percent of the region's annual catch estimated to be illegal, unregulated, or unreported, West Africa's waters also endure the highest level of illegal fishing in the world. Trade partners have taken note. In 2013, almost all of the estimated \$10.2 billion worth of regional trade with the United Kingdom moving through the Gulf of Guinea was declared at risk of theft."

## 7. Descriptive Statistics

The goal of descriptive statistics is to describe the data being presented. In this case, data is being described in terms of different variables – piracy attacks, liner shipping connectivity index, growth domestic product growth rate, imports growth rate, exports as a percent of gross domestic product, and oil production as oil rents as a percent of gross domestic product. For this analysis, the descriptive statistics being considered are mean, median, minimum, maximum, and standard deviation (Mann, 1995; Trochim, 2006).

### 7.1 Input-Output Analysis

The input-output model is a quantitative economic analysis, representing the interdependencies between different variables (Clark, 1984). This analysis type was developed by Wassily Leontief (1906-1999) and was built alongside work conducted by Francois Quesnay, Léon Walras, Alexander Bogdanov, L. N. Kraitsman, T. F. Remington, Vladimir Groman, and Vladimir Bazarov. Leontief is noted for being influenced by classical economics – such as works by Karl Marx and Jean Charles Léonard de Sismondi – and was the first to use a matrix representation of the economy (Belykh, 1989). The focus of the model is the inter-relationships within the economy, showing both independence and dependence among sectors (Loucks & Whitney, 1973; Nikaidō, 1970). The following table shows the input requirements:

Table 1. Input requirements

Variable	Piracy Attacks	Variable Y(Note 1)
Piracy Attacks	0	MAXIMUM (Note 2)
Variable Y	1 - MAXIMUM	0

It is recognised that for this study, the input requirements for Variable Y will vary based on the analysis being conducted (based on the research question and related variables) and will be considered a percent of gross domestic product. The gross domestic product average was calculated based on information from the appendix and is shown in the following table:

Table 2. Average Gross Domestic Product

Country	Average gross domestic product	Year	Average gross domestic product
Angola	85.92	2007	36.53
Benin	7.46	2008	39.00
Cameroon	25.49	2009	30.91
Dem. Congo Rep.	17.56	2010	43.20
Egypt	219.83	2011	45.12
Equatorial Guinea	1.17	2012	46.96
Eritrea	16.63	2013	46.26
Ghana	0.88	2014	51.70
Guinea	4.92	2015	53.56
Guinea Bissau	36.43	2016	54.33
Ivory Coast	27.25		
Kenya	42.97	Overall	44.96
Liberia	1.38		
Madagascar	9.11		
Mauritania	4.70		
Morocco	97.26		
Mozambique	11.13		
Nigeria	382.21		
Seychelles	1.07		
Sierra Leone	2.91		
Somalia	0.00		
Tanzania	34.46		
Togo	3.40		

The gross domestic product results are compared with the average for the entire dataset in the following figure:

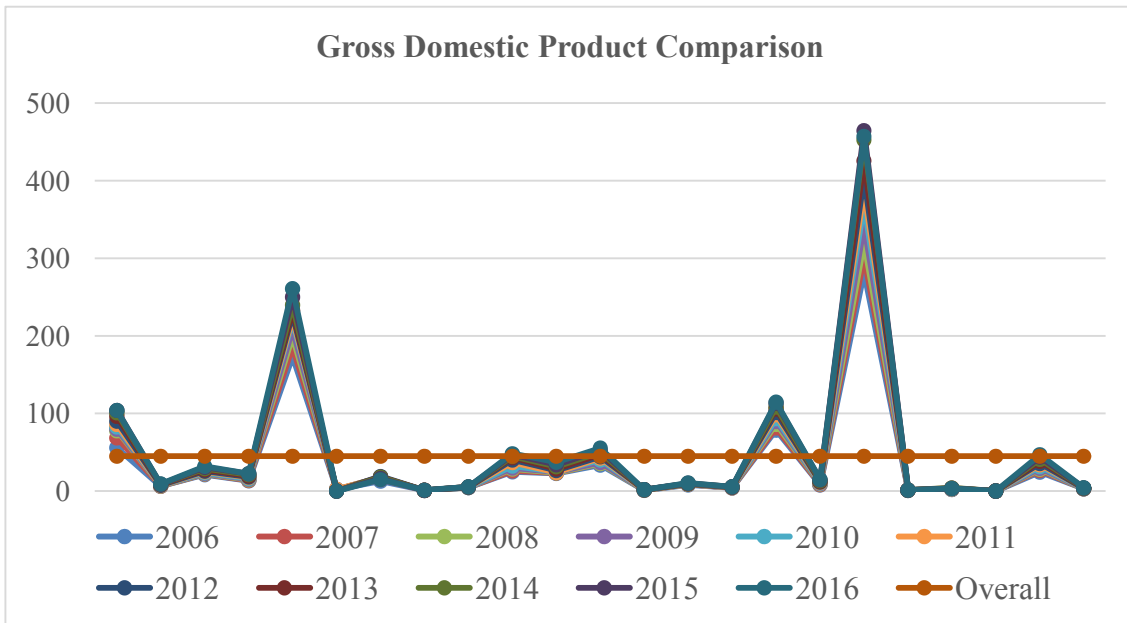


Figure 1. Gross Domestic Product Comparison Source: Author’s Compilation. (2018)

Within the requirements table, the amount required will be the percent times the gross domestic product applicable from the prior table. The formula for the indirect requirements for the first variable (piracy attacks) is

$$a_1 - Xa_b = 1$$

$$a_b - Xa_1 = 0$$

Where  $a_1$  = output of piracy attacks;  $a_b$  = output of Variable Y; and  $X$  = requirement (based on the variable)

### 7.2 Fixed Effects Model

The fixed effects model is used to show the relationship of piracy attacks and the country’s distance from the Gulf of Guinea. The variables used are distance and total distance (see appendix) to determine the relationship held in terms of piracy. For this study; however, the formula will be altered slightly to include piracy attacks, as shown

$$a = \frac{x/y}{z}$$

where  $x$  = country distance;  $y$  = total distance;  $z$  = piracy attacks (Baetschmann, Staub, & Winkelmann, 2015; Blanchard & Landier, 2002; Chen, Schmidt, & Wang, 2014; Hausman & de Leeuw, 1978; Subramanian, Jones, Kaddour, & Krieger, 2009).



### 7.3 Correlation Analysis

The correlation is designed to allow the variable relationship to be shown. The results allow for a single number (“Computing the Pearson Correlation Coefficient,” 2003, “Data Analysis - Pearson’s Correlation Coefficient,” 2015; Sedgwick, 2012). Positive relationships have an upwards slope, whereas negative relationships have a downwards slope. Generally, a positive relationship requires higher scores being paired. The formula for the correlation is:

$$r = \frac{N \sum xy - (\sum x)(\sum y)}{\sqrt{[N \sum x^2 - (\sum x)^2][N \sum y^2 - (\sum y)^2]}}$$

Where  $N$  = sample size;  $\sum xy$  = sum of products;  $\sum x$  = sum of  $x$  values;  $\sum y$  = sum of  $y$  values;  $\sum x^2$  = sum of  $x$ -squared values; and  $\sum y^2$  = sum of  $y$ -squared values. The correlation will be between -1.0 and 1.0 (Sedgwick, 2012).

### 7.4 Chi Square Test

The final test is the chi square test, which is designed for testing the hypotheses. If the test statistic is under the critical value, the null hypothesis is accepted. If the test statistic is over the critical value, the null hypothesis is rejected. The chi square test uses both observations and expected values. The formula for expected values is

$$\frac{(x \times y)}{z}$$

Where  $x$  = the row total;  $y$  = the column total; and  $z$  = the sum of all values.

The formula for the test statistics is

$$\sum \frac{(x - y)^2}{y}$$

where  $x$  = observed value and  $y$  = the expected value (“Chi Square Test,” n.d., *Critical Values of the Chi-Square Distribution.*, n.d.; McHugh, 2013; Niedermeier, Wang, & Zhang, 2016; Penn State Science, 2015; Test, 2015; University of Regina, n.d.). The chi square test is being used for significance in order to provide definitive answers to the hypotheses.

## 8. Application to the Data

### 8.1 Mean

The mean is the average of the data. It is calculated as:

$$\frac{\sum x}{n}$$

where  $\sum x$  = sum of all values and  $n$  = number of values (Babbie, 2010). The mean is found

for both country and year. The data was inputted into Excel (Note 3) and the average output is shown below:

Table 3. Averages by country

	<b>Piracy attacks</b>	<b>Liner shipping connectivity index</b>	<b>Gross domestic product growth rate</b>	<b>Imports</b>	<b>Exports</b>	<b>Oil production</b>
Angola	0.70	14.97	6.59	0.00	56.59	33.24
Benin	2.40	14.34	4.27	9.30	25.46	0.00
Cameroon	1.30	12.00	4.19	9.03	20.34	5.06
Dem.Congo Rep.	4.50	9.49	5.10	3.66	55.51	20.06
Egypt	2.20	54.92	4.19	5.03	20.14	6.93
Equatorial Guinea	0.10	5.41	1.67	2.95	73.44	28.70
Eritrea	0.10	2.98	0.64	0.26	3.39	0.00
Ghana	2.50	18.92	6.84	11.65	34.39	2.36
Guinea	2.80	7.49	2.42	7.58	28.56	0.00
Guinea Bissau	0.10	4.19	3.54	6.82	21.53	0.00
Ivory Coast	2.40	19.54	5.15	5.17	44.96	2.44
Kenya	1.40	11.98	5.23	5.85	19.86	0.00
Liberia	0.60	6.26	5.21	2.40	30.24	0.00
Madagascar	0.10	9.66	2.69	5.91	28.80	0.00
Mauritania	0.10	7.02	3.32	6.45	45.48	3.42
Morocco	0.50	48.96	3.85	5.10	33.63	0.01
Mozambique	1.20	9.30	6.67	17.59	31.82	0.10
Nigeria	26.60	21.07	4.99	4.92	23.95	13.37
Seychelles	0.10	6.49	4.50	0.00	75.09	0.00
Sierra Leone	0.70	6.07	5.43	19.47	21.04	0.00
Somalia	48.90	4.35	0.00	0.00	5.84	0.00
Tanzania	3.50	6.40	6.70	9.99	19.20	0.00
Togo	3.40	3.57	4.19	18.82	41.86	0.00

It is noted that the lowest incidences of piracy attacks are 0.10, occurring in Equatorial Guinea, Eritrea, Madagascar, Mauritania, and Seychelles. The highest rate of piracy attacks is

48.90, occurring in Nigeria. The lowest Liner Shipping connectivity index is 2.98 in Eritrea, whereas the highest Liner Shipping connectivity index is 54.92 in Egypt. The lowest gross domestic product growth rate is 0.00 in Somalia, whereas the highest gross domestic product growth rate is 6.70 in Tanzania. The lowest imports are 0.00 in Angola and Somalia, whereas the highest imports are 19.47 in Sierra Leone. The lowest exports are 3.39 in Eritrea, whereas the highest exports are 73.44 in Equatorial Guinea. The lowest oil production is 0.00 in Benin, Entree, Guinea, Guinea Bissau, Kenya, Liberia, Madagascar, Seychelles, Sierra Leone, Somalia, Tanzania, and Togo. However, the highest oil production is in Angola.

Table 4. Averages by year

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Piracy attacks	4.65	4.26	5.83	7.87	9.43	5.35	3.00	1.96	1.22	2.61
Liner shipping connectivity index	9.44	11.25	12.15	11.79	12.60	13.80	13.58	15.22	16.63	16.31
Gross Domestic Product Growth Rate	6.15	4.71	2.88	3.96	5.18	5.23	5.26	4.14	2.09	2.73
Imports	14.94	7.22	1.86	11.24	10.27	10.05	7.99	2.68	1.09	1.32
Exports	37.36	36.44	31.84	34.00	35.97	35.45	33.98	32.93	27.14	25.81
Oil production	7.83	8.20	4.29	5.41	6.68	6.31	5.28	4.39	1.90	0.00

The lowest piracy attacks were 1.22 in 2015, whereas the highest piracy attacks were 9.43 in 2011. The lowest Liner Shipping connectivity index were 9.44 in 2007, whereas the highest Liner Shipping connectivity index were 16.63 in 2015. The lowest gross domestic product growth rate was 2.09 in 2015, whereas the highest gross domestic product growth rate was 6.15 in 2007. The lowest imports were 1.09 in 2015, whereas the highest imports were 14.94 in 2007. The lowest exports were 25.81 in 2016, whereas the highest export rates were 37.36 in 2007. The lowest oil production was 0.00 in 2016, whereas the highest oil production was 8.20 in 2008.

### 8.2 Median, Minimum, and Maximum

The median, minimum, and maximum is only being shown in relation to the countries. The median is the number that occurs in the middle of a dataset that has been ordered numerically. The minimum is the smallest data point. The maximum is the largest data point (Nick, 2007). To do this, the data was inputted into Excel (Note 4) and the following output was observed based on the variable:

Table 5. Median, minimum, and maximum

	<b>Piracy attacks</b>	<b>Liner shipping connectivity index</b>	<b>Gross Product Rate</b>	<b>Domestic Growth</b>	<b>Imports</b>	<b>Exports</b>	<b>Oil production</b>
Median	1	8.42	4.56		3.58	28.89	0.00
Minimum	0	0.00	-20.49		-32.89	0.00	0.00
Maximum	160	68.28	20.72		96.67	107.99	48.50

### 8.3 Standard Deviation

Standard deviation is important because it shows the distance from the mean a data point is. This is calculated using:

$$s = \sqrt{\frac{1}{N-1} \sum_{i=1}^N (x_i - \bar{x})^2}$$

where  $N$  = sample size;  $x_i$  = data point; and  $\bar{x}$  = mean (Hebl, 2015; Mann, 1995; Nick, 2007; Trochim, 2006). The mean is found for both country and year. The data was inputted into Excel (Note 5) and the average output is shown below:

Table 6. Standard deviation by country

	<b>Piracy attacks</b>	<b>Liner shipping connectivity index</b>	<b>Gross Domestic Product Growth Rate</b>	<b>Imports</b>	<b>Exports</b>	<b>Oil production</b>
Angola	0.82	3.03	6.70	0.00	14.83	17.62
Benin	6.22	6.25	1.87	13.26	4.02	0.00
Cameroon	1.64	2.64	1.34	7.13	2.79	2.76
Dem. Congo Rep.	2.59	1.34	2.38	14.12	7.50	9.35
Egypt	2.74	3.15	1.94	13.70	7.43	3.63
Equatorial Guinea	0.32	6.09	10.06	23.04	11.71	13.97
Eritrea	0.32	2.41	4.58	13.54	4.57	0.00
Ghana	1.96	1.60	3.37	17.53	6.94	2.66
Guinea	2.10	2.12	2.00	14.08	2.84	0.00

Guinea Bissau	0.32	1.23	2.93	21.89	4.86	0.00
Ivory Coast	1.65	0.62	4.83	15.71	6.77	1.61
Kenya	1.17	4.73	2.20	5.86	2.63	0.00
Liberia	0.70	0.94	4.03	6.77	17.19	0.00
Madagascar	0.32	1.44	3.12	12.88	3.69	0.00
Mauritania	0.32	1.90	2.42	13.63	6.83	2.64
Morocco	0.53	1.14	1.39	7.50	2.23	0.01
Mozambique	1.03	18.41	1.05	18.82	1.73	0.05
Nigeria	11.04	1.09	2.74	32.56	12.13	8.39
Seychelles	0.32	4.86	3.85	0.00	40.21	0.00
Sierra Leone	0.82	1.46	10.59	31.22	7.39	0.00
Somalia	58.87	1.23	0.00	0.00	7.54	0.00
Tanzania	5.02	1.17	1.09	16.08	1.55	0.00
Togo	4.77	0.71	1.23	32.55	5.16	0.00

**Table 7. Standard deviation by year**

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Piracy attacks	10.83	9.26	18.07	30.20	34.69	11.68	6.78	4.15	3.04	7.83
Liner Shipping Connectivity Index	407.84	407.73	407.77	408.07	408.14	408.12	408.38	408.31	408.26	408.50
Gross Domestic Product Growth Rate	5.05	5.36	2.70	3.71	3.64	3.67	4.66	2.76	6.10	3.88
Imports	23.02	11.23	15.57	11.05	23.04	22.97	19.59	10.60	14.04	9.39
Exports	24.67	24.82	23.71	23.81	22.77	22.07	19.58	18.23	14.97	14.55
Oil production	15.13	15.78	8.20	10.83	12.47	11.88	10.03	8.35	4.01	0.00

#### 8.4 Input-Output Analysis

The input-output analysis is conducted based on a direct and indirect requirements table. The input requirements, based on the research questions are:

Table 8. Requirements table

		Piracy attacks	Liner Shipping Connectivity Index
<b>Question 1</b>	Piracy attacks	0	68.28
	Liner Shipping Connectivity Index	31.62	0
		Piracy attacks	Gross Domestic Product Growth Rate
<b>Question 2</b>	Piracy attacks	0	20.72
	Gross Domestic Product Growth Rate	79.28	0
		Piracy attacks	Imports Growth Rate
<b>Question 3</b>	Piracy attacks	0	96.67
	Imports Growth Rate	3.333	0
		Piracy attacks	Exports
<b>Question 4</b>	Piracy attacks	0	107.99
	Exports	-7.99	0
		Piracy attacks	Oil production
<b>Question 5</b>	Piracy attacks	0	48.50
	Oil production	51.50	0

The following table shows the gross domestic product results, based on the previous table and relevant average gross domestic product (which must meet the average gross domestic product of the entire system):

Table 9. Gross domestic product results (based on country)

	<b>Question 1</b>	<b>Question 2</b>	<b>Question 3</b>	<b>Question 4</b>	<b>Question 5</b>
Angola	0.00	58.67	0.00	17.80	0.00
	27.17	0.00	68.12	0.00	2.86
Benin	0.00	5.09	0.00	1.55	0.00
	2.36	0.00	5.91	0.00	0.25
Cameroon	0.00	17.40	0.00	5.28	0.00
	8.06	0.00	20.21	0.00	0.85
Dem. Congo Rep.	0.00	11.99	0.00	3.64	0.00
	5.55	0.00	13.92	0.00	0.59

Egypt	0.00	150.10	0.00	45.55	0.00
	69.51	0.00	174.28	0.00	7.33
Equatorial Guinea	0.00	0.80	0.00	0.24	0.00
	0.37	0.00	0.93	0.00	0.04
Eritrea	0.00	11.35	0.00	3.45	0.00
	5.26	0.00	13.18	0.00	0.55
Ghana	0.00	0.60	0.00	0.18	0.00
	0.28	0.00	0.70	0.00	0.03
Guinea	0.00	3.36	0.00	1.02	0.00
	1.56	0.00	3.90	0.00	0.16
Guinea Bissau	0.00	24.87	0.00	7.55	0.00
	11.52	0.00	28.88	0.00	1.21
Ivory Coast	0.00	18.61	0.00	5.65	0.00
	8.62	0.00	21.60	0.00	0.91
Kenya	0.00	29.34	0.00	8.90	0.00
	13.59	0.00	34.07	0.00	1.43
Liberia	0.00	0.94	0.00	0.29	0.00
	0.44	0.00	1.09	0.00	0.05
Madagascar	0.00	6.22	0.00	1.89	0.00
	2.88	0.00	7.22	0.00	0.30
Mauritania	0.00	3.21	0.00	0.97	0.00
	1.49	0.00	3.73	0.00	0.16
Morocco	0.00	66.41	0.00	20.15	0.00
	30.75	0.00	77.11	0.00	3.24
Mozambique	0.00	7.60	0.00	2.31	0.00
	3.52	0.00	8.82	0.00	0.37
Nigeria	0.00	260.97	0.00	79.19	0.00
	120.85	0.00	303.02	0.00	12.74
Seychelles	0.00	0.73	0.00	0.22	0.00
	0.34	0.00	0.85	0.00	0.04
Sierra Leone	0.00	1.99	0.00	0.60	0.00
	0.92	0.00	2.31	0.00	0.10
Somalia	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00

Tanzania	0.00	23.53	0.00	7.14	0.00
	10.90	0.00	27.32	0.00	1.15
Togo	0.00	2.32	0.00	0.70	0.00
	1.08	0.00	2.70	0.00	0.11

Table 10. Gross domestic product results (based on year)

	Question 1		Question 2		Question 3		Question 4		Question 5	
2007	0.00	24.94	0.00	7.57	0.00	35.31	0.00	39.45	0.00	17.72
	11.55	0.00	28.96	0.00	1.22	0.00	-2.92	0.00	18.81	0.00
2008	0.00	26.63	0.00	8.08	0.00	37.70	0.00	42.12	0.00	18.92
	12.33	0.00	30.92	0.00	1.30	0.00	-3.12	0.00	20.09	0.00
2009	0.00	21.11	0.00	6.40	0.00	29.88	0.00	33.38	0.00	14.99
	9.77	0.00	24.51	0.00	1.03	0.00	-2.47	0.00	15.92	0.00
2010	0.00	29.50	0.00	8.95	0.00	41.76	0.00	46.65	0.00	20.95
	13.66	0.00	34.25	0.00	1.44	0.00	-3.45	0.00	22.25	0.00
2011	0.00	30.81	0.00	9.35	0.00	43.62	0.00	48.73	0.00	21.88
	14.27	0.00	35.77	0.00	1.50	0.00	-3.61	0.00	23.24	0.00
2012	0.00	32.06	0.00	9.73	0.00	45.40	0.00	50.71	0.00	22.78
	14.85	0.00	37.23	0.00	1.57	0.00	-3.75	0.00	24.18	0.00
2013	0.00	31.59	0.00	9.59	0.00	44.72	0.00	49.96	0.00	22.44
	14.63	0.00	36.67	0.00	1.54	0.00	-3.70	0.00	23.82	0.00
2014	0.00	35.30	0.00	10.71	0.00	49.98	0.00	55.83	0.00	25.07
	16.35	0.00	40.99	0.00	1.72	0.00	-4.13	0.00	26.63	0.00
2015	0.00	36.57	0.00	11.10	0.00	51.78	0.00	57.84	0.00	25.98
	16.94	0.00	42.46	0.00	1.79	0.00	-4.28	0.00	27.58	0.00
2016	0.00	37.10	0.00	11.26	0.00	52.52	0.00	58.67	0.00	26.35
	17.18	0.00	43.07	0.00	1.81	0.00	-4.34	0.00	27.98	0.00

The boundaries, based on these requirements, are shown below:



Table 11. Boundaries (based on country)

		Question 1	Question 2	Question 3	Question 4	Question 5
Angola	Lower	-26.38	-8.00	-37.34	-41.72	-18.73
	Upper	27.17	68.12	2.86	-6.87	44.25
Benin	Lower	-2.29	-0.70	-3.24	-3.62	-1.63
	Upper	2.36	5.91	0.25	-0.60	3.84
Cameroon	Lower	-7.82	-2.37	-11.08	-12.38	-5.56
	Upper	8.06	20.21	0.85	-2.04	13.13
Dem. Congo Rep.	Lower	-5.39	-1.64	-7.63	-8.52	-3.83
	Upper	5.55	13.92	0.59	-1.40	9.04
Egypt	Lower	-67.48	-20.48	-95.54	-106.73	-47.94
	Upper	69.51	174.28	7.33	-17.56	113.21
Equatorial Guinea	Lower	-0.36	-0.11	-0.51	-0.57	-0.26
	Upper	0.37	0.93	0.04	-0.09	0.60
Eritrea	Lower	-5.10	-1.55	-7.23	-8.07	-3.63
	Upper	5.26	13.18	0.55	-1.33	8.56
Ghana	Lower	-0.27	-0.08	-0.38	-0.43	-0.19
	Upper	0.28	0.70	0.03	-0.07	0.45
Guinea	Lower	-1.51	-0.46	-2.14	-2.39	-1.07
	Upper	1.56	3.90	0.16	-0.39	2.53
Guinea Bissau	Lower	-11.18	-3.39	-15.83	-17.69	-7.94
	Upper	11.52	28.88	1.21	-2.91	18.76
Ivory Coast	Lower	-8.37	-2.54	-11.84	-13.23	-5.94
	Upper	8.62	21.60	0.91	-2.18	14.03
Kenya	Lower	-13.19	-4.00	-18.68	-20.86	-9.37
	Upper	13.59	34.07	1.43	-3.43	22.13
Liberia	Lower	-0.42	-0.13	-0.60	-0.67	-0.30
	Upper	0.44	1.09	0.05	-0.11	0.71
Madagascar	Lower	-2.80	-0.85	-3.96	-4.42	-1.99
	Upper	2.88	7.22	0.30	-0.73	4.69
Mauritania	Lower	-1.44	-0.44	-2.04	-2.28	-1.03
	Upper	1.49	3.73	0.16	-0.38	2.42

Morocco	Lower	-29.86	-9.06	-42.27	-47.22	-21.21
	Upper	30.75	77.11	3.24	-7.77	50.09
Mozambique	Lower	-3.42	-1.04	-4.84	-5.40	-2.43
	Upper	3.52	8.82	0.37	-0.89	5.73
Nigeria	Lower	-117.33	-35.60	-166.12	-185.57	-83.34
	Upper	120.85	303.02	12.74	-30.54	196.84
Seychelles	Lower	-0.33	-0.10	-0.46	-0.52	-0.23
	Upper	0.34	0.85	0.04	-0.09	0.55
Sierra Leone	Lower	-0.89	-0.27	-1.26	-1.41	-0.63
	Upper	0.92	2.31	0.10	-0.23	1.50
Somalia	Lower	0.00	0.00	0.00	0.00	0.00
	Upper	0.00	0.00	0.00	0.00	0.00
Tanzania	Lower	-10.58	-3.21	-14.98	-16.73	-7.51
	Upper	10.90	27.32	1.15	-2.75	17.75
Togo	Lower	-1.04	-0.31	-1.48	-1.65	-0.74
	Upper	1.08	2.70	0.11	-0.27	1.75

This is shown in the following figure:

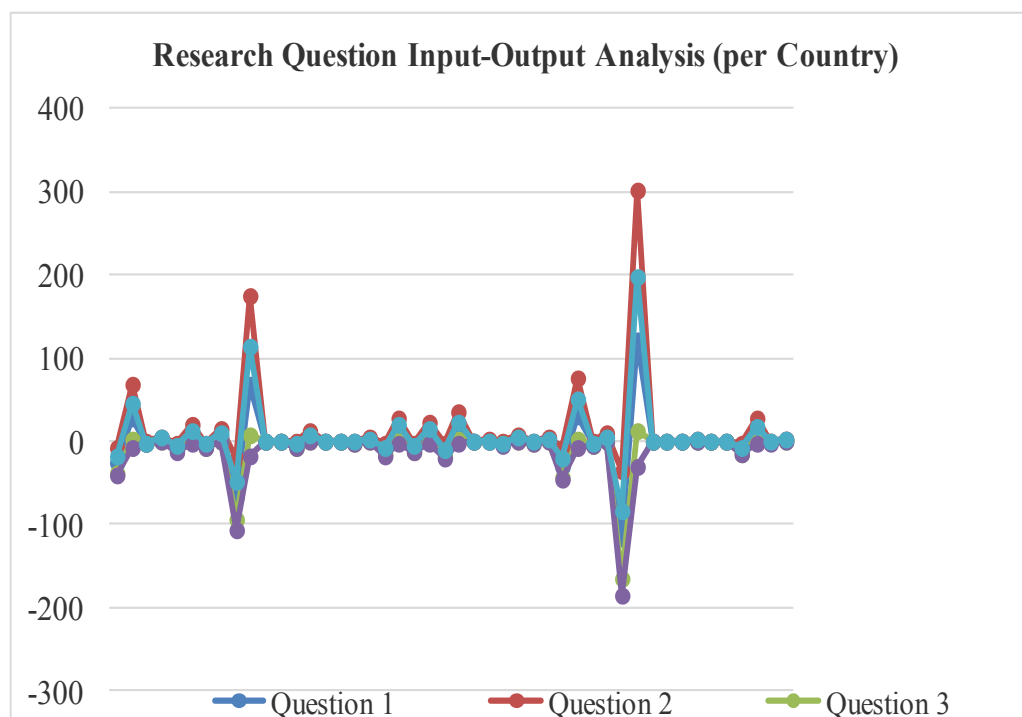


Figure 2. Input-Output analysis (per country) source: author's compilation. (2018)

When determining the sum of all the differences, the input-output result, based on country, is 644.47 (in the comparison of average of attacks and Liner Shipping connectivity); 916.2 (in the comparison of average of attacks and growth domestic product growth rate); 483.92 (in the comparison of average of attacks and imports growth rate); 419.45 (in the comparison of average of attacks and exports as a percent of gross domestic product); and 758.06 (in the comparison of average of attacks and oil production as oil rents as a percent of gross domestic product).

The boundaries for the years are shown below:

Table 12. Boundaries (based on Year)

		Question 1	Question 2	Question 3	Question 4	Question 5
2007	Lower	-11.21	-3.40	-15.88	-17.74	-7.97
	Upper	11.55	28.96	1.22	-2.92	18.81
2008	Lower	-11.97	-3.63	-16.95	-18.94	-8.51
	Upper	12.33	30.92	1.30	-3.12	20.09
2009	Lower	-9.49	-2.88	-13.43	-15.01	-6.74
	Upper	9.77	24.51	1.03	-2.47	15.92
2010	Lower	-13.26	-4.02	-18.78	-20.97	-9.42
	Upper	13.66	34.25	1.44	-3.45	22.25
2011	Lower	-13.85	-4.20	-19.61	-21.91	-9.84
	Upper	14.27	35.77	1.50	-3.61	23.24
2012	Lower	-14.41	-4.37	-20.41	-22.80	-10.24
	Upper	14.85	37.23	1.57	-3.75	24.18
2013	Lower	-14.20	-4.31	-20.11	-22.46	-10.09
	Upper	14.63	36.67	1.54	-3.70	23.82
2014	Lower	-15.87	-4.82	-22.47	-25.10	-11.27
	Upper	16.35	40.99	1.72	-4.13	26.63
2015	Lower	-16.44	-4.99	-23.28	-26.00	-11.68
	Upper	16.94	42.46	1.79	-4.28	27.58
2016	Lower	-16.68	-5.06	-23.61	-26.38	-11.85
	Upper	17.18	43.07	1.81	-4.34	27.98

This is shown in the following figure:

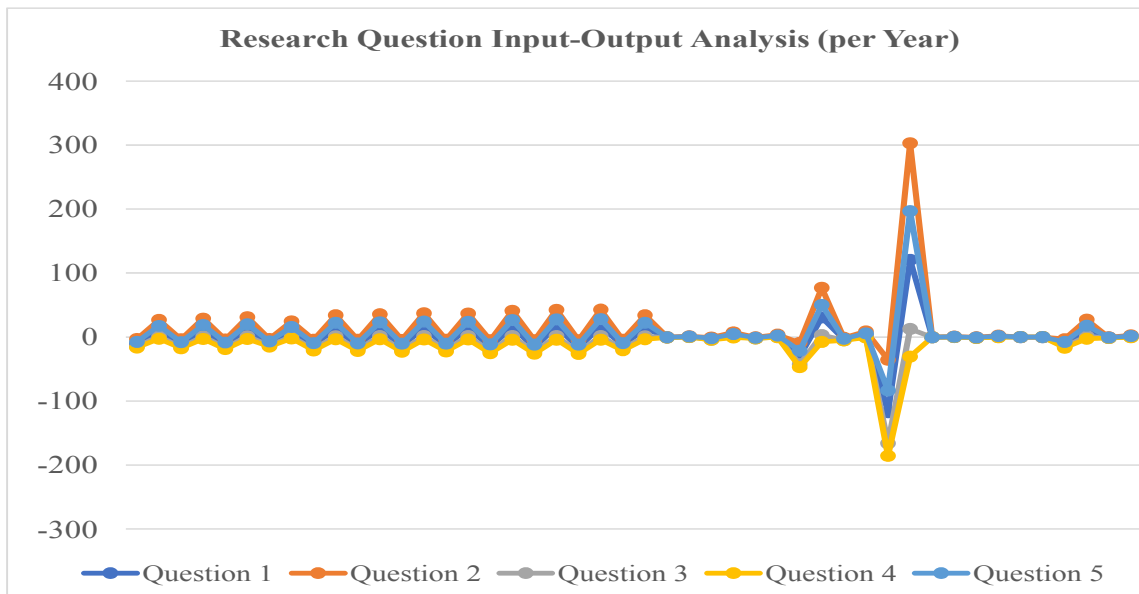


Figure 3. Input-Output analysis (per year) source: author’s compilation. (2018)

When determining the sum of all the differences, the input-output result, based on years, is 300.122 (in the comparison of average of attacks and Liner Shipping connectivity); 392.95 (in the comparison of average of attacks and growth domestic product growth rate); 207.54 (in the comparison of average of attacks and imports growth rate); 179.91 (in the comparison of average of attacks and exports as a percent of gross domestic product); and 325.12 (in the comparison of average of attacks and oil production as oil rents as a percent of gross domestic product). This comparison is shown below:

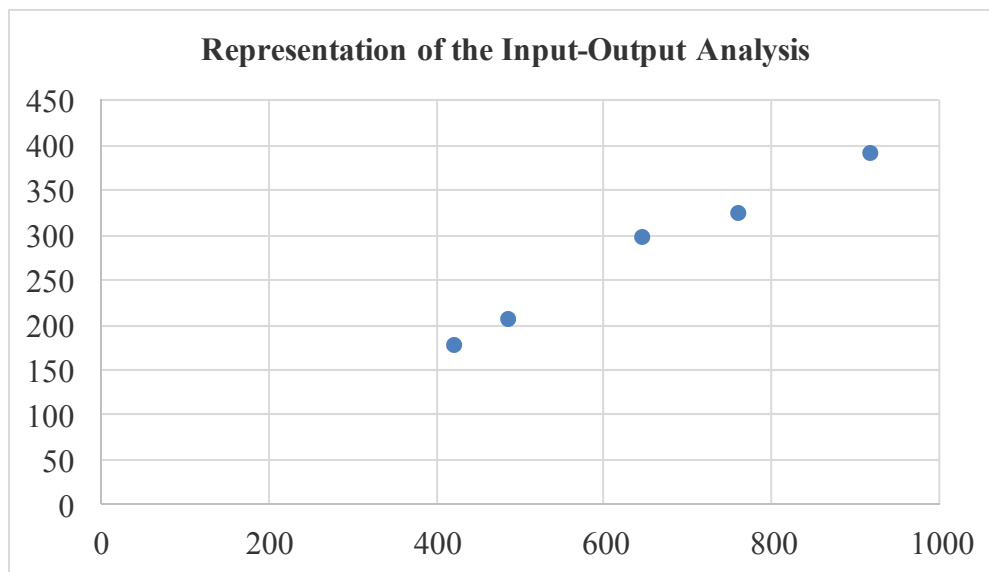


Figure 4. Representation of the Input-Output analysis source: author’s compilation (2018)

### 8.5 Fixed Effects Model

The following table shows the results of the fixed effects model:

Table 13. Fixed effects model

Country	Distance	Total distance	Piracy attacks	
Angola	2,280	57,953	0.70	0.0275
Benin	639	57,953	2.40	0.0265
Cameroon	1,034	57,953	1.30	0.0232
Dem. Congo Rep.	1,412	57,953	4.50	0.1096
Egypt	3,853	57,953	2.20	0.1463
Equatorial Guinea	760	57,953	0.10	0.0013
Eritrea	4,141	57,953	0.10	0.0071
Ghana	705	57,953	2.50	0.0304
Guinea	1,635	57,953	2.80	0.0790
Guinea Bissau	2,266	57,953	0.10	0.0039
Ivory Coast	1,111	57,953	2.40	0.0460
Kenya	3,817	57,953	1.40	0.0922
Liberia	1,488	57,953	0.60	0.0154
Madagascar	5,338	57,953	0.10	0.0092
Mauritania	2,490	57,953	0.10	0.0043
Morocco	3,317	57,953	0.50	0.0286
Mozambique	4,277	57,953	1.20	0.0886
Nigeria	806	57,953	26.60	0.3699
Seychelles	5,821	57,953	0.10	0.0100
Sierra Leone	1,793	57,953	0.70	0.0217
Somalia	4,706	57,953	48.90	3.9709
Tanzania	3,633	57,953	3.50	0.2194
Togo	631	57,953	3.40	0.0370

This is shown in the Figure 5:

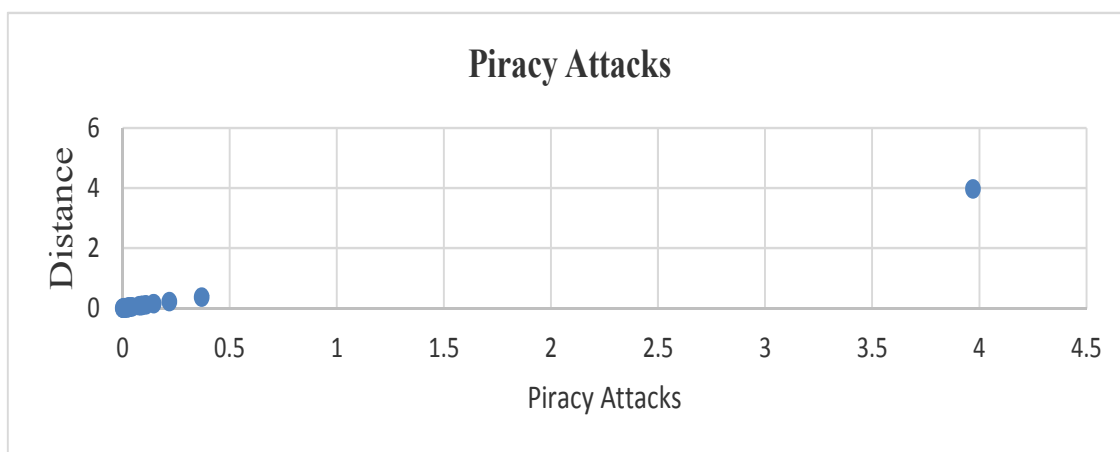


Figure 5. Piracy attacks based on distance source: author’s compilation. (2018)

### 9. Correlation Analysis

The correlation analysis will occur in respect to the countries and years and based on the research questions. The results are shown as follows:

Table 14. Correlation analysis by country (Question 1)

	X	Y	XY	X <sup>2</sup>	Y <sup>2</sup>
Angola	0.70	14.97	10.48	0.49	224.10
Benin	2.40	14.34	34.42	5.76	205.64
Cameroon	1.30	12.00	15.60	1.69	144.00
Dem. Congo Rep.	4.50	9.49	42.71	20.25	90.06
Egypt	2.20	54.92	120.82	4.84	3,016.21
Equatorial Guinea	0.10	5.41	0.54	0.01	29.27
Eritrea	0.10	2.98	0.30	0.01	8.88
Ghana	2.50	18.92	47.30	6.25	357.97
Guinea	2.80	7.49	20.97	7.84	56.10
Guinea Bissau	0.10	4.19	0.42	0.01	17.56
Ivory Coast	2.40	19.54	46.90	5.76	381.81
Kenya	1.40	11.98	16.77	1.96	143.52
Liberia	0.60	6.26	3.76	0.36	39.19
Madagascar	0.10	9.66	0.97	0.01	93.32
Mauritania	0.10	7.02	0.70	0.01	49.28

Morocco	0.50	48.96	24.48	0.25	2,397.08
Mozambique	1.20	9.30	11.16	1.44	86.49
Nigeria	26.60	21.07	560.46	707.56	443.94
Seychelles	0.10	6.49	0.65	0.01	42.12
Sierra Leone	0.70	6.07	4.25	0.49	36.84
Somalia	48.90	4.35	212.72	2,391.21	18.92
Tanzania	3.50	6.40	22.40	12.25	40.96
Togo	3.40	3.57	12.14	11.56	12.74
Totals	106.20	305.38	1,210.90	3,180.02	7,936.00
N	23				
Numerator	-4,580.68				
Denominator	215,333.31				
r	-0.0213				

Table 15. Correlation analysis by year (Question 1)

	<b>X</b>	<b>Y</b>	<b>XY</b>	<b>X<sup>2</sup></b>	<b>Y<sup>2</sup></b>
<b>2007</b>	10.83	407.84	10.83	117.29	166,333.47
<b>2008</b>	9.26	407.73	9.26	85.75	166,243.75
<b>2009</b>	18.07	407.77	18.07	326.52	166,276.37
<b>2010</b>	30.2	408.07	30.20	912.04	166,521.12
<b>2011</b>	34.69	408.14	34.69	1,203.40	166,578.26
<b>2012</b>	11.68	408.12	11.68	136.42	166,561.93
<b>2013</b>	6.78	408.38	6.78	45.97	166,774.22
<b>2014</b>	4.15	408.31	4.15	17.22	166,717.06
<b>2015</b>	3.04	408.26	3.04	9.24	166,676.23
<b>2016</b>	7.83	408.50	7.83	61.31	166,872.25
Totals	136.53	4,081.12	136.53	2,915.16	1,665,554.67
N	10				
Numerator	-555,830.01				
Denominator	1,488,338.72				
r	-0.3735				

For the first research question, there is a negative correlation for both the individual countries

and years, suggesting that there is a negative relationship between piracy attacks and the Liner Shipping index.

Table 16. Correlation analysis by country (Question 2)

	<b>X</b>	<b>Y</b>	<b>XY</b>	<b>X<sup>2</sup></b>	<b>Y<sup>2</sup></b>
Angola	0.70	6.59	4.61	0.49	43.43
Benin	2.40	4.27	10.25	5.76	18.23
Cameroon	1.30	4.19	5.45	1.69	17.56
Dem. Congo Rep.	4.50	5.10	22.95	20.25	26.01
Egypt	2.20	4.19	9.22	4.84	17.56
Equatorial Guinea	0.10	1.67	0.17	0.01	2.79
Eritrea	0.10	0.64	0.06	0.01	0.41
Ghana	2.50	6.84	17.10	6.25	46.79
Guinea	2.80	2.42	6.78	7.84	5.86
Guinea Bissau	0.10	3.54	0.35	0.01	12.53
Ivory Coast	2.40	5.15	12.36	5.76	26.52
Kenya	1.40	5.23	7.32	1.96	27.35
Liberia	0.60	5.21	3.13	0.36	27.14
Madagascar	0.10	2.69	0.27	0.01	7.24
Mauritania	0.10	3.32	0.33	0.01	11.02
Morocco	0.50	3.85	1.93	0.25	14.82
Mozambique	1.20	6.67	8.00	1.44	44.49
Nigeria	26.60	4.99	132.73	707.56	24.90
Seychelles	0.10	4.50	0.45	0.01	20.25
Sierra Leone	0.70	5.43	3.80	0.49	29.48
Somalia	48.90	0.00	0.00	2,391.21	0.00
Tanzania	3.50	6.70	23.45	12.25	44.89
Togo	3.40	4.19	14.25	11.56	17.56
Totals	106.20	97.38	284.96	3,180.02	486.83
N	23				
Numerator	-3,787.77				
Denominator	51,104.73				
r	-0.0741				



Table 17. Correlation analysis by year (Question 2)

	X	Y	XY	X <sup>2</sup>	Y <sup>2</sup>
2007	10.83	5.05	10.83	117.29	25.50
2008	9.26	5.36	9.26	85.75	28.73
2009	18.07	2.70	18.07	326.52	7.29
2010	30.2	3.71	30.20	912.04	13.76
2011	34.69	3.64	34.69	1,203.40	13.25
2012	11.68	3.67	11.68	136.42	13.47
2013	6.78	4.66	6.78	45.97	21.72
2014	4.15	2.76	4.15	17.22	7.62
2015	3.04	6.10	3.04	9.24	37.21
2016	7.83	3.88	7.83	61.31	15.05
Totals	136.53	41.53	136.53	2,915.16	183.60
N	10				
Numerator	-4,304.79				
Denominator	15,663.87				
r	-0.2748				

For the second research question, there is a negative correlation for both the individual countries and years, suggesting that there is a negative relationship between piracy attacks and the gross domestic product growth rate.

Table 18. Correlation analysis by country (Question 3)

	X	Y	XY	X <sup>2</sup>	Y <sup>2</sup>
Angola	0.70	0.00	0.00	0.49	0.00
Benin	2.40	9.30	22.32	5.76	86.49
Cameroon	1.30	9.03	11.74	1.69	81.54
Dem. Congo Rep.	4.50	3.66	16.47	20.25	13.40
Egypt	2.20	5.03	11.07	4.84	25.30
Equatorial Guinea	0.10	2.95	0.30	0.01	8.70
Eritrea	0.10	0.26	0.03	0.01	0.07
Ghana	2.50	11.65	29.13	6.25	135.72
Guinea	2.80	7.58	21.22	7.84	57.46

Guinea Bissau	0.10	6.82	0.68	0.01	46.51
Ivory Coast	2.40	5.17	12.41	5.76	26.73
Kenya	1.40	5.85	8.19	1.96	34.22
Liberia	0.60	2.40	1.44	0.36	5.76
Madagascar	0.10	5.91	0.59	0.01	34.93
Mauritania	0.10	6.45	0.65	0.01	41.60
Morocco	0.50	5.10	2.55	0.25	26.01
Mozambique	1.20	17.59	21.11	1.44	309.41
Nigeria	26.60	4.92	130.87	707.56	24.21
Seychelles	0.10	0.00	0.00	0.01	0.00
Sierra Leone	0.70	19.47	13.63	0.49	379.08
Somalia	48.90	0.00	0.00	2,391.21	0.00
Tanzania	3.50	9.99	34.97	12.25	99.80
Togo	3.40	18.82	63.99	11.56	354.19
Totals	106.20	157.95	403.33	3,180.02	1,791.13
N	23				
Numerator	-7,497.63				
Denominator	101,113.38				
r	-0.0742				

Table 19. Correlation analysis by year (Question 3)

	<b>X</b>	<b>Y</b>	<b>XY</b>	<b>X<sup>2</sup></b>	<b>Y<sup>2</sup></b>
2007	10.83	23.02	10.83	117.29	529.92
2008	9.26	11.23	9.26	85.75	126.11
2009	18.07	15.57	18.07	326.52	242.42
2010	30.2	11.05	30.20	912.04	122.10
2011	34.69	23.04	34.69	1,203.40	530.84
2012	11.68	22.97	11.68	136.42	527.62
2013	6.78	19.59	6.78	45.97	383.77
2014	4.15	10.60	4.15	17.22	112.36
2015	3.04	14.04	3.04	9.24	197.12
2016	7.83	9.39	7.83	61.31	88.17
Totals	136.53	160.50	136.53	2,915.16	2,860.45

N	10
Numerator	-20,547.77
Denominator	61,921.13
r	-0.3318

For the third research question, there is a negative correlation in both countries and years, suggesting that there is a negative relationship between piracy attacks and the imports growth rate.

Table 20. Correlation analysis by country (Question 4)

	X	Y	XY	X <sup>2</sup>	Y <sup>2</sup>
Angola	0.70	56.59	39.61	0.49	3,202.43
Benin	2.40	25.46	61.10	5.76	648.21
Cameroon	1.30	20.34	26.44	1.69	413.72
Dem. Congo Rep.	4.50	55.51	249.80	20.25	3,081.36
Egypt	2.20	20.14	44.31	4.84	405.62
Equatorial Guinea	0.10	73.44	7.34	0.01	5,393.43
Eritrea	0.10	3.39	0.34	0.01	11.49
Ghana	2.50	34.39	85.98	6.25	1,182.67
Guinea	2.80	28.56	79.97	7.84	815.67
Guinea Bissau	0.10	21.53	2.15	0.01	463.54
Ivory Coast	2.40	44.96	107.90	5.76	2,021.40
Kenya	1.40	19.86	27.80	1.96	394.42
Liberia	0.60	30.24	18.14	0.36	914.46
Madagascar	0.10	28.80	2.88	0.01	829.44
Mauritania	0.10	45.48	4.55	0.01	2,068.43
Morocco	0.50	33.63	16.82	0.25	1,130.98
Mozambique	1.20	31.82	38.18	1.44	1,012.51
Nigeria	26.60	23.95	637.07	707.56	573.60
Seychelles	0.10	75.09	7.51	0.01	5,638.51
Sierra Leone	0.70	21.04	14.73	0.49	442.68
Somalia	48.90	5.84	285.58	2,391.21	34.11
Tanzania	3.50	19.20	67.20	12.25	368.64

Togo	3.40	41.86	142.32	11.56	1,752.26
Totals	106.20	761.12	1,967.73	3,180.02	32,799.58
N	23				
Numerator	-35,573.22				
Denominator	423,849.09				
r	-0.0839				

Table 21. Correlation analysis by year (Question 4)

	X	Y	XY	X <sup>2</sup>	Y <sup>2</sup>
2007	10.83	24.67	10.83	117.29	608.61
2008	9.26	24.82	9.26	85.75	616.03
2009	18.07	23.71	18.07	326.52	562.16
2010	30.2	23.81	30.20	912.04	566.92
2011	34.69	22.77	34.69	1,203.40	518.47
2012	11.68	22.07	11.68	136.42	487.08
2013	6.78	19.58	6.78	45.97	383.38
2014	4.15	18.23	4.15	17.22	332.33
2015	3.04	14.97	3.04	9.24	224.10
2016	7.83	14.55	7.83	61.31	211.70
Totals	136.53	209.18	136.53	2,915.16	4,510.79
N	10				
Numerator	-27,194.05				
Denominator	77,546.53				
r	-0.3507				

For the fourth research question, there is a negative correlation in relation to both country and year, suggesting that there is a negative relationship between piracy attacks and exports as a percentage of gross domestic product.

Table 22. Correlation analysis by country (Question 5)

	X	Y	XY	X <sup>2</sup>	Y <sup>2</sup>
Angola	0.70	33.24	23.27	0.49	1,104.90
Benin	2.40	0.00	0.00	5.76	0.00
Cameroon	1.30	5.06	6.58	1.69	25.60
Dem. Congo Rep.	4.50	20.06	90.27	20.25	402.40
Egypt	2.20	6.93	15.25	4.84	48.02
Equatorial Guinea	0.10	28.70	2.87	0.01	823.69
Eritrea	0.10	0.00	0.00	0.01	0.00
Ghana	2.50	2.36	5.90	6.25	5.57
Guinea	2.80	0.00	0.00	7.84	0.00
Guinea Bissau	0.10	0.00	0.00	0.01	0.00
Ivory Coast	2.40	2.44	5.86	5.76	5.95
Kenya	1.40	0.00	0.00	1.96	0.00
Liberia	0.60	0.00	0.00	0.36	0.00
Madagascar	0.10	0.00	0.00	0.01	0.00
Mauritania	0.10	3.42	0.34	0.01	11.70
Morocco	0.50	0.01	0.01	0.25	0.00
Mozambique	1.20	0.10	0.12	1.44	0.01
Nigeria	26.60	13.37	355.64	707.56	178.76
Seychelles	0.10	0.00	0.00	0.01	0.00
Sierra Leone	0.70	0.00	0.00	0.49	0.00
Somalia	48.90	0.00	0.00	2,391.21	0.00
Tanzania	3.50	0.00	0.00	12.25	0.00
Togo	3.40	0.00	0.00	11.56	0.00
Totals	106.20	115.69	506.10	3,180.02	2,606.61
N	23				
Numerator	-646.05				
Denominator	127,658.81				
r	-0.0051				

Table 23. Correlation analysis by year (Question 5)

	X	Y	XY	X <sup>2</sup>	Y <sup>2</sup>
2007	10.83	15.13	10.83	117.29	228.92
2008	9.26	15.78	9.26	85.75	249.01
2009	18.07	8.20	18.07	326.52	67.24
2010	30.2	10.83	30.20	912.04	117.29
2011	34.69	12.47	34.69	1,203.40	155.50
2012	11.68	11.88	11.68	136.42	141.13
2013	6.78	10.03	6.78	45.97	100.60
2014	4.15	8.35	4.15	17.22	69.72
2015	3.04	4.01	3.04	9.24	16.08
2016	7.83	0.00	7.83	61.31	0.00
Totals	136.53	96.68	136.53	2,915.16	1,145.49
N	10				
Numerator	-11,834.42				
Denominator	39,314.60				
r	-0.3010				

For the final research question, there is a negative correlation in relation to both country and year, suggesting that there is a negative relationship between piracy attacks and oil production as oil rents as a percentage of gross domestic product.

## 10. Chi Square Test

The chi square test results are shown below:

Table 24. Chi square test for research question 1 (by country)

Piracy	Variable Y					
	Expected	Observed	Expected	Total		
0.70	4.04	14.97	11.63	15.67	2.76	0.75
2.40	4.32	14.34	12.42	16.74	0.85	0.26
1.30	3.43	12.00	9.87	13.30	1.32	0.38
4.50	3.61	9.49	10.38	13.99	0.22	0.08
2.20	14.74	54.92	42.38	57.12	10.67	2.86
0.10	1.42	5.41	4.09	5.51	1.23	0.32

0.10	0.79	2.98	2.29	3.08	0.61	0.16
2.50	5.53	18.92	15.89	21.42	1.66	0.48
2.80	2.66	7.49	7.63	10.29	0.01	0.00
0.10	1.11	4.19	3.18	4.29	0.92	0.24
2.40	5.66	19.54	16.28	21.94	1.88	0.54
1.40	3.45	11.98	9.93	13.38	1.22	0.35
0.60	1.77	6.26	5.09	6.86	0.77	0.22
0.10	2.52	9.66	7.24	9.76	2.32	0.61
0.10	1.84	7.02	5.28	7.12	1.64	0.43
0.50	12.76	48.96	36.70	49.46	11.78	3.07
1.20	2.71	9.30	7.79	10.50	0.84	0.24
26.60	12.30	21.07	35.37	47.67	16.62	9.70
0.10	1.70	6.49	4.89	6.59	1.51	0.39
0.70	1.75	6.07	5.02	6.77	0.63	0.18
48.90	13.74	4.35	39.51	53.25	89.97	284.19
3.50	2.55	6.40	7.35	9.90	0.35	0.14
3.40	1.80	3.57	5.17	6.97	1.43	0.72
106.20		305.38		411.58	457.55	
Df	21.00					
Alpha	0.05					
Critical Value	32.67					

Table 25. Chi square test for research question 1 (by year)

Piracy	Variable Y				
	Expected	Observed	Expected	Total	
4.65	3.64	9.44	10.45	14.09	0.28
4.26	4.00	11.25	11.51	15.51	0.02
5.83	4.64	12.15	13.34	17.98	0.31
7.87	5.07	11.79	14.59	19.66	1.54
9.43	5.69	12.60	16.34	22.03	2.47
5.35	4.94	13.80	14.21	19.15	0.03
3.00	4.28	13.58	12.30	16.58	0.38
1.96	4.43	15.22	12.75	17.18	1.38

1.22	4.61	16.63	13.24	17.85	2.49	0.69
2.61	4.88	16.31	14.04	18.92	1.06	0.32
46.18		132.77		178.95	13.50	
Df	8.00					
Alpha	0.05					
Critical Value	15.51					

Table 26. Chi square test for research question 2 (by country)

Piracy		Variable Y				
Observed	Expected	Observed	Expected	Total		
0.70	4.04	6.59	3.49	7.29	2.53	1.46
2.40	4.32	4.27	3.19	6.67	0.33	0.27
1.30	3.43	4.19	2.63	5.49	0.85	0.58
4.50	3.61	5.10	4.59	9.60	0.05	0.05
2.20	14.74	4.19	3.06	6.39	0.39	0.31
0.10	1.42	1.67	0.85	1.77	0.73	0.41
0.10	0.79	0.64	0.35	0.74	0.21	0.13
2.50	5.53	6.84	4.47	9.34	1.16	0.82
2.80	2.66	2.42	2.50	5.22	0.00	0.00
0.10	1.11	3.54	1.74	3.64	1.70	0.91
2.40	5.66	5.15	3.61	7.55	0.60	0.46
1.40	3.45	5.23	3.17	6.63	1.23	0.81
0.60	1.77	5.21	2.78	5.81	1.95	1.13
0.10	2.52	2.69	1.33	2.79	1.26	0.68
0.10	1.84	3.32	1.64	3.42	1.59	0.85
0.50	12.76	3.85	2.08	4.35	1.38	0.81
1.20	2.71	6.67	3.76	7.87	2.06	1.27
26.60	12.30	4.99	15.11	31.59	6.22	20.53
0.10	1.70	4.50	2.20	4.60	2.20	1.18
0.70	1.75	5.43	2.93	6.13	1.95	1.15
48.90	13.74	0.00	23.39	48.90	21.45	0.00
3.50	2.55	6.70	4.88	10.20	0.62	0.49
3.40	1.80	4.19	3.63	7.59	0.08	0.07



106.20	97.38	203.58	84.94
Df	21.00		
Alpha	0.05		
Critical Value	32.67		

Table 27. Chi square test for research question 2 (by year)

<b>Piracy</b>		<b>Variable Y</b>				
Observed	Expected	Observed	Expected	Total		
4.65	3.64	6.15	5.17	10.80	0.17	0.16
4.26	4.00	4.71	4.29	8.97	0.04	0.04
5.83	4.64	2.88	4.17	8.71	0.36	0.57
7.87	5.07	3.96	5.66	11.83	0.47	0.73
9.43	5.69	5.18	6.99	14.61	0.43	0.63
5.35	4.94	5.23	5.06	10.58	0.01	0.01
3.00	4.28	5.26	3.95	8.26	0.40	0.33
1.96	4.43	4.14	2.92	6.10	0.47	0.36
1.22	4.61	2.09	1.58	3.31	0.15	0.12
2.61	4.88	2.73	2.55	5.34	0.01	0.01
46.18		42.33		88.51	5.46	
Df	8.00					
Alpha	0.05					
Critical Value	15.51					

Table 28. Chi square test for research question 3 (by country)

<b>Piracy</b>		<b>Variable Y</b>				
Observed	Expected	Observed	Expected	Total		
0.70	4.04	0.00	0.42	0.70	0.62	0.00
2.40	4.32	9.30	7.00	11.70	1.13	0.57
1.30	3.43	9.03	6.18	10.33	1.96	0.90
4.50	3.61	3.66	4.88	8.16	0.45	0.41
2.20	14.74	5.03	4.32	7.23	0.17	0.10
0.10	1.42	2.95	1.82	3.05	1.03	0.43

0.10	0.79	0.26	0.22	0.36	0.01	0.01
2.50	5.53	11.65	8.46	14.15	1.79	0.87
2.80	2.66	7.58	6.21	10.38	0.45	0.25
0.10	1.11	6.82	4.14	6.92	2.59	1.05
2.40	5.66	5.17	4.53	7.57	0.14	0.08
1.40	3.45	5.85	4.34	7.25	0.79	0.39
0.60	1.77	2.40	1.79	3.00	0.30	0.15
0.10	2.52	5.91	3.59	6.01	2.22	0.91
0.10	1.84	6.45	3.92	6.55	2.44	1.00
0.50	12.76	5.10	3.35	5.60	1.36	0.60
1.20	2.71	17.59	11.24	18.79	5.35	2.30
26.60	12.30	4.92	18.85	31.52	15.31	39.43
0.10	1.70	0.00	0.06	0.10	0.09	0.00
0.70	1.75	19.47	12.06	20.17	6.77	2.82
48.90	13.74	0.00	29.24	48.90	43.49	0.00
3.50	2.55	9.99	8.07	13.49	0.68	0.37
3.40	1.80	18.82	13.29	22.22	3.43	1.63
106.20		157.95		264.15	146.83	
Df	21.00					
Alpha	0.05					
Critical Value	32.67					

Table 29. Chi square test for research question 3 (by year)

Piracy	Variable Y				Total		
	Observed	Expected	Observed	Expected			
4.65	3.64	14.94	11.71	19.59	1.32	0.70	
4.26	4.00	7.22	6.86	11.48	0.03	0.02	
5.83	4.64	1.86	4.60	7.69	2.42	4.03	
7.87	5.07	11.24	11.43	19.11	0.00	0.00	
9.43	5.69	10.27	11.78	19.70	0.29	0.22	
5.35	4.94	10.05	9.21	15.40	0.11	0.07	
3.00	4.28	7.99	6.57	10.99	0.46	0.25	
1.96	4.43	2.68	2.77	4.64	0.00	0.00	

1.22	4.61	1.09	1.38	2.31	0.09	0.08
2.61	4.88	1.32	2.35	3.93	0.67	0.80
46.18		68.66		114.84	11.58	
Df	8.00					
Alpha	0.05					
Critical Value	15.51					

Table 30. Chi square test for research question 4 (by country)

Piracy		Variable Y				
Observed	Expected	Observed	Expected	Total		
0.70	4.04	56.59	50.28	57.29	5.68	0.70
2.40	4.32	25.46	24.45	27.86	0.30	0.04
1.30	3.43	20.34	18.99	21.64	0.69	0.09
4.50	3.61	55.51	52.66	60.01	1.10	0.15
2.20	14.74	20.14	19.60	22.34	0.10	0.01
0.10	1.42	73.44	64.54	73.54	8.81	1.08
0.10	0.79	3.39	3.06	3.49	0.25	0.03
2.50	5.53	34.39	32.37	36.89	0.90	0.12
2.80	2.66	28.56	27.52	31.36	0.28	0.04
0.10	1.11	21.53	18.98	21.63	2.45	0.30
2.40	5.66	44.96	41.56	47.36	1.99	0.26
1.40	3.45	19.86	18.66	21.26	0.56	0.07
0.60	1.77	30.24	27.06	30.84	2.67	0.33
0.10	2.52	28.80	25.36	28.90	3.34	0.41
0.10	1.84	45.48	40.00	45.58	5.38	0.66
0.50	12.76	33.63	29.95	34.13	3.24	0.40
1.20	2.71	31.82	28.98	33.02	2.00	0.25
26.60	12.30	23.95	44.36	50.55	67.30	17.39
0.10	1.70	75.09	65.98	75.19	9.01	1.10
0.70	1.75	21.04	19.08	21.74	1.45	0.18
48.90	13.74	5.84	48.04	54.74	265.66	304.90
3.50	2.55	19.20	19.92	22.70	0.19	0.03
3.40	1.80	41.86	39.72	45.26	0.83	0.11

106.20	761.12	867.32	712.85
Df	21.00		
Alpha	0.05		
Critical Value	32.67		

Table 31. Chi square test for research question 4 (by year)

Piracy		Variable Y				
Observed	Expected	Observed	Expected	Total		
4.65	3.64	37.36	36.87	42.01	0.05	0.01
4.26	4.00	36.44	35.72	40.70	0.11	0.01
5.83	4.64	31.84	33.06	37.67	0.32	0.05
7.87	5.07	34.00	36.74	41.87	1.47	0.22
9.43	5.69	35.97	39.84	45.40	2.69	0.42
5.35	4.94	35.45	35.80	40.80	0.03	0.00
3.00	4.28	33.98	32.45	36.98	0.52	0.07
1.96	4.43	32.93	30.62	34.89	1.25	0.16
1.22	4.61	27.14	24.89	28.36	1.46	0.19
2.61	4.88	25.81	24.94	28.42	0.22	0.03
46.18		330.92		377.10	9.26	
Df	8.00					
Alpha	0.05					
Critical Value	15.51					

Table 32. Chi square test for research question 5 (by country)

Piracy		Variable Y				
Observed	Expected	Observed	Expected	Total		
0.70	4.04	33.24	17.70	33.94	14.87	7.27
2.40	4.32	0.00	1.25	2.40	1.36	0.00
1.30	3.43	5.06	3.32	6.36	1.00	0.60
4.50	3.61	20.06	12.81	24.56	4.48	2.62
2.20	14.74	6.93	4.76	9.13	1.08	0.68
0.10	1.42	28.70	15.02	28.80	13.58	6.52

0.10	0.79	0.00	0.05	0.10	0.06	0.00
2.50	5.53	2.36	2.53	4.86	0.01	0.01
2.80	2.66	0.00	1.46	2.80	1.59	0.00
0.10	1.11	0.00	0.05	0.10	0.06	0.00
2.40	5.66	2.44	2.52	4.84	0.00	0.00
1.40	3.45	0.00	0.73	1.40	0.80	0.00
0.60	1.77	0.00	0.31	0.60	0.34	0.00
0.10	2.52	0.00	0.05	0.10	0.06	0.00
0.10	1.84	3.42	1.84	3.52	1.49	0.73
0.50	12.76	0.01	0.27	0.51	0.27	6.55
1.20	2.71	0.10	0.68	1.30	0.54	3.34
26.60	12.30	13.37	20.84	39.97	2.92	4.17
0.10	1.70	0.00	0.05	0.10	0.06	0.00
0.70	1.75	0.00	0.36	0.70	0.40	0.00
48.90	13.74	0.00	25.50	48.90	27.77	0.00
3.50	2.55	0.00	1.82	3.50	1.99	0.00
3.40	1.80	0.00	1.77	3.40	1.93	0.00
106.20		115.69		221.89	109.16	
Df	21.00					
Alpha	0.05					
Critical Value	32.67					

Table 33. Chi square test for research question 5 (by year)

Piracy	Variable Y				Total		
	Expected	Observed	Expected	Observed			
4.65	3.64	7.83	6.51	12.48	0.29	0.22	
4.26	4.00	8.20	6.50	12.46	0.49	0.35	
5.83	4.64	4.29	5.28	10.12	0.20	0.23	
7.87	5.07	5.41	6.92	13.28	0.36	0.42	
9.43	5.69	6.68	8.40	16.11	0.38	0.44	
5.35	4.94	6.31	6.08	11.66	0.01	0.01	
3.00	4.28	5.28	4.32	8.28	0.23	0.18	
1.96	4.43	4.39	3.31	6.35	0.38	0.27	
1.22	4.61	1.90	1.63	3.12	0.05	0.04	

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2.61	4.88	0.00	1.36	2.61	1.48	0.00
46.18		50.29		96.47	6.04	
Df	8.00					
Alpha	0.05					
Critical Value	15.51					

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## 11. Conclusions

Research question 1 stated: To what extent does piracy impact the Gulf of Guinea in relation to the Liner Shipping connectivity index? The hypothesis was: Piracy has a significant impact on the Gulf of Guinea in relation to the Liner Shipping connectivity index. The null hypothesis was: Piracy has no impact on the Gulf of Guinea in relation to the Liner Shipping connectivity index. The chi square test for countries showed that the null hypothesis was rejected, suggesting that countries are greatly impacted. However, the chi square test for years showed that the null hypothesis was accepted, suggesting that in the long run, piracy attacks have no impact on the Liner Shipping connectivity index.

Research question 2 stated: To what extent does piracy impact the Gulf of Guinea in relation to gross domestic product growth rate? The hypothesis was: Piracy has a significant impact on the Gulf of Guinea in relation to gross domestic product growth rate. The null hypothesis was: Piracy has no impact on the Gulf of Guinea in relation to gross domestic product growth rate. The chi square test for countries showed that the null hypothesis was rejected, suggesting that countries are greatly impacted. However, the chi square test for years showed that the null hypothesis was accepted, suggesting that in the long run, piracy attacks have no impact on the gross domestic product growth rate.

Research question 3 stated: To what extent does piracy impact the Gulf of Guinea in relation to imports growth rate? The hypothesis was: Piracy has a significant impact on the Gulf of Guinea in relation to imports growth rate. The null hypothesis was: Piracy has no impact on the Gulf of Guinea in relation to imports growth rate. The chi square test for countries showed that the null hypothesis was rejected, suggesting that countries are greatly impacted. However, the chi square test for years showed that the null hypothesis was accepted, suggesting that in the long run, piracy attacks have no impact on the imports growth rate.

Research question 4 stated: To what extent does piracy impact the Gulf of Guinea in relation to exports as a percent of gross domestic product? The hypothesis was: Piracy has a significant impact on the Gulf of Guinea in relation to exports as a percent of gross domestic product. The null hypothesis was: Piracy has no impact on the Gulf of Guinea in relation to exports as a percent of gross domestic product. The chi square test for countries showed that the null hypothesis was rejected, suggesting that countries are greatly impacted. However, the chi square test for years showed that the null hypothesis was accepted, suggesting that in the long run, piracy attacks have no imports on exports as a percent of gross domestic product.

The final research question stated: To what extent does piracy impact the Gulf of Guinea in relation to oil production as oil rents as a percent of gross domestic product? The hypothesis was: Piracy has a significant impact on the Gulf of Guinea in relation to oil production as oil rents as a percent of gross domestic product. The null hypothesis was: Piracy has no impact on the Gulf of Guinea in relation to oil production as oil rents as a percent of gross domestic product. The chi square test for countries showed that the null hypothesis was rejected, suggesting that countries are greatly impacted. However, the chi square test for years showed that the null hypothesis was accepted, suggesting that in the long run, piracy attacks have no impact on the oil productions as oil rents as a percent of gross domestic product.

**Inferences:** The Gulf of Guinea is a very significant region endowed with huge reserve of natural resources. These natural resources also consist of large deposits of oil and natural gas. This region is fertile ground for illegal, unreported, unregulated (IUU) fishing due to its vast pristine fishing grounds that draws in several fleets of vessels to do fishing. From the literature it is worth noting the effects on maritime transport and security. Shipping does not operate in a vacuum but will thrive in a security assured domain. By the literature, it is necessary to determine also the impacts vis à vis maritime transportation and security and how some economic indicators were impacted by pirate attacks.

As a lasting solution to curtail the incidence of piracy the study observed it prudent to end all forms of financial help to nations keeping or harbouring pirates. Governments of the Gulf of Guinea are to exhibit good governance to bring domestic satisfaction and prevent any nefarious activities like piracy from happening. More piracy monitoring stations should be employed to maintain effective listening and monitoring. Patrolling of their seas must be done by their navies and they must be well equipped. There should be more naval collaboration and exercises with the advanced navies to sharpen their surveillance and patrol skills. Information should flow freely and the regional block of the Gulf of Guinea should share information with other organisations like AFRICOM, INTERPOL, and NATO should be done.

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## Notes

Note 1. For all research questions, one of the variables is piracy attacks. Variable Y refers to the other corresponding

Note 2. The maximum value is found in the descriptive statistics section..

Note 3. Excel function: = AVERAGE(RANGE).

Note 4. Excel function: = MEDIAN(RANGE); = MIN(RANGE); and = MAX(RANGE).

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Note 5. Excel function: = STDEV.S (RANGE).

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