

## Analysis of air cargo traffic at airports in Nigeria and Ghana

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### Article history:

Received: July 30, 2023

1st Revision: September 29,  
2023

Accepted: November 04, 2023

### DOI:

[10.14254/jsdtl.2023.8-2.2](https://doi.org/10.14254/jsdtl.2023.8-2.2)

**Abstract:** Fluctuations that characterise airport traffic make planning for efficient operations difficult. This study examines air cargo traffic at Murtala International Airport, Lagos, Nigeria, and Kotoka International Airport, Accra, Ghana. The study focused on the trend of cargo volume, origin, and destination and forecasted the cargo volume at the airports. Air cargo data from 1991-2022 were collected from the Federal Airport Authority of Nigeria (FAAN) and Ghana Airport Company Limited (GACL). Descriptive techniques using line graphs and GIS mapping were used to analyse data. Time series techniques of moving and weighted averages, exponential smoothing, and least square techniques were used to forecast the cargo volume of the airports. The study found a characteristic fluctuating pattern of cargo flow. Nigeria's dominating export cargo types are general goods, edible items, and hair attachments. Ghana's dominating export cargo types were pineapple, general goods, and papaya. Germany, followed by Ethiopia and Turkey, dominate the origin of import cargo, while the United Kingdom, UAE, and Turkey dominate the destination of export cargo from Nigeria. Luxembourg, Turkey, and the UK dominate the origin of import cargo, while the UK, Netherlands, UAE, and Qatar dominate the destination of export cargo in Ghana. The least-square technique predicts 3.67% and 2.3% growth of cargo traffic in Nigeria and Ghana, respectively. An increasing trend in cargo volume was predicted for both airports. Both countries need to strategise on their relationships with other countries and develop policies that will increase cargo flow by air.

**Keywords:** air cargo, cargo types, origin flow, destination flow, cargo forecast

## **1. Introduction**

Increasing urbanisation and income distribution have allowed air transportation to spread across all regions and countries (Airbus, 2011). At the same time, the globalisation of production and consumption markets has increased the air carriage of goods substantially since the 1970s (Brorsson, 2016). Also, the characteristic dispersed and distorted geographical locations of people and resources make the transportation of goods worldwide intertwined in a complex system of production and distribution that requires linkages through transportation modes via terminals such as airports. At the same time, there is increasing demand for air transport due to increased disposable income and consumption of goods and services. The relaxation of the constraints on airline route designations, flight service frequency, and pricing through multilateral air transport agreements facilitated international cargo operations across airports worldwide. These arrangements on bilateral agreements between countries arise from global air transport liberalisation, which has enhanced bilateral treaties such as the Open Skies Agreement (Zhang & Zhang, 2002).

Air cargo transport as part of the logistics sector (Onder & Kuzu, 2014) has become increasingly important in response to the development in global manufacturing effects (Erma et al., 2014) and the need for cargo movement across the globe. Air cargo transportation system is designed to provide fast and efficient shipment of goods (Buzdugan, 2005) from origin to destination. It is efficient because it is the fastest mode of transport and is used safely to carry high-value goods. The high level of innovations in the air transport industry to combat negative externalities, environmental impact, and high cost makes air cargo operations efficient and important to the nation's trade (Bernhard, 2015).

As characterised by fluctuations, the flow of cargo traffic at airports results in challenges facing airport authorities in planning efficient operations. This issue is reflected in the inability of airport managers to plan and carry out cargo operations with reduced cost by classifying cargo volume according to types, origin, and destination. The fluctuations in airport cargo traffic also pose serious challenges to airport managers, airlines, and terminal operators alike. The challenge is reflected in the difficulties faced by airport stakeholders in predicting cargo traffic for effective planning.

According to Chang (2014), airlines must accurately predict air transport demand under a bilateral agreement system. Accurate analysis and reliable forecasts (for both short and long term) of cargo traffic at airports are crucial for airport managers in planning and provision of infrastructure. Therefore, the problems of accurately predicting air cargo demand have attracted considerable research interest (Chang, 2014; Lakew & Tor, 2014). The inability of airports to handle cargo traffic efficiently has been a limitation to cargo traffic analysis by different stakeholders (airport managers, airlines, handling companies, airport planners and economists) over the years. This may be complex in the West African sub-region due to the poor nature of cargo traffic documentation by types and volume, origin and destination, poor airport infrastructure provision and maintenance, and poor organisation and political structure in West Africa (Bofinger, 2008). The central question that this study answers is what is the types, origin and destination, and the future air cargo volume at airports in Nigeria and Ghana.

To this end, this paper contributes to existing literature by examining the trend of cargo traffic at the airports in Nigeria and Ghana. Therefore, the objectives of the study are to identify air cargo traffic by types, origins, and destinations and predict the future cargo volume of the airports for planning purposes.

The paper is structured under six (6) sections. After this, section 2 presents the literature review, section 3 dwells on the research methods, section 4 presents the results, section discusses the results, and section 6 concludes the paper with policy recommendations.

## **2. Literature review**

A search for literature on African air cargo traffic with a specific interest in Nigeria and Ghana revealed that not much is available in terms of empirical research on the air cargo sub-sector of the economies. However, various studies on the flow of passengers, aircraft movement (Afolayan et al., 2012), flight operations with emphasis on safety and security, airline services, and passengers' airline choice (Ukpere et al., 2012) and issues on policy and bilateral agreements (Danjuma et al., 2014) have received much attention from scholars. Other works covering air transport demand (Aderamo, 2010); airport choice and cargo volume (Adenigbo & Ubogu 2012, 2014); airport development (Aun, 2013);

airport concessions (Adeniran & Gbadamosi, 2017); and airport decoupling (Shakyi & Azunu, 2013); airport contribution to communities (Moomen, 2012); airport deregulation (Akwei et al., 2012); bird strike (Holbech et al., 2015); cargo agents' airport choice (Adenigbo, 2016) had also been carried out in Nigeria and Ghana. With the flourishing nature of studies in other aspects of the air transport industry, issues on the fluctuating trend of air cargo traffic seem to have been neglected among researchers within the West Africa sub-region.

Many studies relating to air cargo traffic and operations have been carried out extensively in other regions of the world. These studies include that of Hwang and Shia (2011), Kupfer *et al.* (2016), Georgescu (2012), Kolbre et al. (2013), Breitbatch et al. (2014); Lakew and Tok (2014), Versnel (2014); Onder and Kuzu (2014); and Bernhard (2015) to mention a few. Feng, Li and MaxShen (2015) reviewed the literature on air cargo operations, compared theoretical studies with the practical problems of airlines, freight forwarders, and terminal service providers, and highlighted the gaps between previous research and practical realities. Like the research focus in West Africa, there is a need to consider airport cargo traffic with a detailed classification by type, origin, and destination. Notwithstanding, the above literature forms a vast amount of literature on related issues for identifying common themes and providing an empirical basis for developing the present study.

The fact that literature is scarce with a specific interest in air cargo in the two selected West African countries, coupled with inadequate studies on the trend analysis of cargo traffic at airports, is a knowledge gap in the overall air transport studies. Also, analysing air cargo traffic in different countries might not produce the same results for developing nations. The dearth of empirical studies relating to the pattern of the flow of air cargo in the West Africa sub-region calls for attention.

The problem and the research gaps in the analysis of air cargo movement in terms of types, origins, and destinations in Nigeria and Ghana are important to be addressed by research. It is these research gaps in knowledge that this study fills using Murtala Muhammed and Kotoka International airports in Lagos and Accra, respectively. The choice of the two international airports was informed because they both serve as major airports in the West Africa sub-region. This supports the World Bank study by Bofinger (2008) that identified Nigeria and Ghana among the five countries with the highest growth rate of 60% and more since 2001 in the whole of Africa continent. Also, ICAO (2016) ranked Lagos and Accra airports first and second in West Africa with the number of international freight traffic handled among African airports.

### 3. Research method

The specific data types required for the study are the cargo volume handled at both airports from 1991 – 2022, cargo types, origins, and destinations of cargo flow. The overall cargo volume data from 1991 - 2022 were collected from the Federal Airports Authority of Nigeria (FAAN) and Ghana Airports Company Limited (GACL). Data on cargo volume per type, origin, and destination were collected from NAHCo Aviance, Nigeria, and Ghana Airports Company Limited (GACL).

Data on cargo types at Lagos airport were extracted from the available records of the Nigerian Aviation Handling Company (NAHCo Aviance). The data on cargo types at Accra airport were collected from GACL. To analyse the origin and destination of cargo at the Lagos airport, the import and export cargo tonnage of NAHCo Aviance was collected as classified by airlines and airport/country of origin and destination. That of Ghana was the cargo traffic of all the private terminals at the airport as classified by airlines and airport/country of origin and destination.

The overall cargo throughput was analysed with a line chart to show the time series. The examination of the types of cargo at the airports was done using descriptive statistics involving figures and tables showing the frequency, percentage, and ranks. To examine the origin and destination of cargo, flow analysis using GIS mapping was adopted to identify the countries' spatial trend of cargo flow. The analytical technique highlights the volume, types, origin, and destination of cargo traffic at Nigeria and Ghana airports.

Moving averages, weighted averages, exponential smoothing, and the least square method were used to forecast cargo volume at both airports. The moving average only indicates that the data is subject to random fluctuations. It is employed in the modelling of univariate time series data. The output variable linearly depends on the current and various past values in stochastic terms. It is based on the

arithmetic mean mathematical concept. The model uses the previous year's cargo volume as a baseline to forecast. A 3-year moving average model follows;

$$\text{Mov. Ave}(3) = \frac{(D1 + D2 + D3)}{3}, \quad (1)$$

Where:

Mov.Ave (3) is the fourth-year predicted cargo volume

D1, D2, D3 = cargo volume for years 1, 2, and 3, respectively

For prediction, weighted averages assign heavier weights to the current year's cargo volume. The total of the weightings equals one. The weighted average is computed by multiplying the given cargo volume by the associated weighting and adding the results. A model is produced by a three-year weighted average of 0.2, 0.3, and 0.5.

$$\text{WMA} = (D1 \cdot 0.2 + D2 \cdot 0.3 + D3 \cdot 0.5) \quad (2)$$

Exponential smoothing is a technique for removing seasonal and irregular components from a trend. It is possible to control not only the seasonal component over time but also the rate of change and the smoothness of the trend cycle component.

It is calculated as follows;

$$\begin{aligned} F_2 &= F_1 + \alpha (A_1 - F_1) \\ WF_2 &= F_1 + \alpha (A_1 - F_1), \end{aligned} \quad (3)$$

Where:

$F_2$  is the forecasted value of cargo traffic

$F_1$  is the forecast for the first period

$A_1$  is the actual value of the first-period

$\alpha$  is the smoothing factor, which varies between 0.0 and 1.0

It is to be noted that as  $\alpha$  increases, the ability to smooth down decreases. The  $\alpha$  value of 1.0 makes a forecast highly sensitive, while the  $\alpha$  value of 0 results in an insensitive forecast.

The least square regression method is suitable for forecasting data with random variation and trends. The mathematical representation for the least square method takes;

$$Y = a + bx \quad (4)$$

where: Y = Forecast

x = Year

a = Intercept

b = trend (slope)

## 4. Results and discussion

### 4.1. Overall trend of cargo traffic in Nigeria from 1991-2022

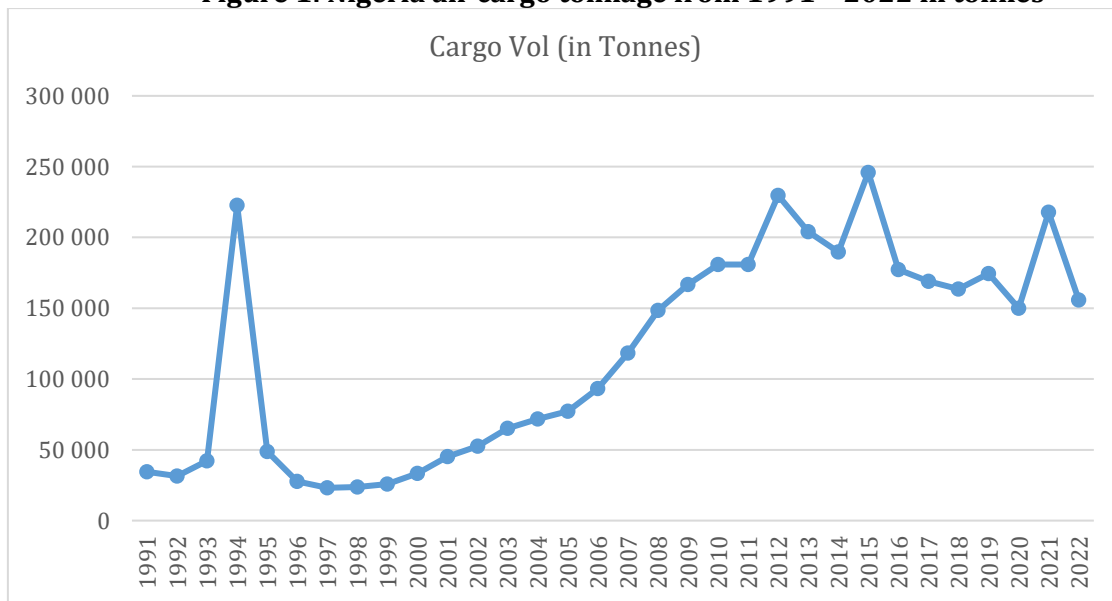
Air cargo traffic represents the flow of cargo volume by types, origins, and destinations over time through an airport. This flow gives a pattern that is irregular and seasonal. The information provided in Figure 1 shows Nigeria's air cargo traffic trend from 1991 – 2022. Figure 1 shows an increasing pattern in the air cargo volume in Nigeria. This pattern rose from 34,415 Tonnes in 1991 to 245,916 Tonnes in 2015 and 155,766 Tonnes by 2022. The volume of cargo traffic dramatically increased from 42,143 Tonnes in 1993 to 222,789 Tonnes in the year 1994, having a 741.42% increase rate, and dropped to 48,724 Tonnes in 1995 and 27,755 Tonnes by the year 1996. Afterwards, Nigeria's increasing trend in cargo volume continued gradually until 2012, when cargo volume recorded 229,625 Tonnes. Notwithstanding, cargo volume dropped to 189,754 Tonnes in 2015 and 177,257 Tonnes in 2016 to reflect the state of Nigeria's economy.

Notably, the surge in cargo volume in 1994 suggested a boom in the trading volume of Nigeria resulting from high demand for goods and services. The trend in air cargo volume in Nigeria is accounted

for by factors such as population, economy, and political and government policies. The international deregulation of air transport and trade liberalisation policy is another issue, while the effect of the truncated democratic regime of the country cannot be exempted.

The increase in cargo traffic continued steadily from 1996 till 2012. This implies an improvement in cargo traffic operations of Nigeria resulting from an increasing population with attendant forces of demand and supply. The reduction recorded from 229,625 Tonnes in 2012 to 189,754 Tonnes in 2014, perhaps because of the economic downturn that ravaged the world during the period. Remarkably, cargo volume increased in 2015 and reduced to 177,257 Tonnes in 2016. Notable decline in cargo volume at Lagos Airport from 177.257 Tonnes in 2016 to 150.060 Tonnes in 2020 reflects the effect of the government's policy restricting the importation of certain goods into the country and the impact of the downward exchange rate of Nigeria's currency. The increasing nature of the overall trend of air cargo volume in Nigeria implies that cargo operations will continue to contribute to the development of air transportation and improvement in the traffic volume at airports of the country.

**Figure 1: Nigeria air cargo tonnage from 1991 - 2022 in tonnes**



Source: FAAN Headquarters

The trend of air cargo growth in Nigeria shows a mix of positive and negative growth rates over the years between the years 1991 - 2016. The positive rates indicate a corresponding percentage increase in the air cargo volume handled in Nigeria. The negative rates show a corresponding percentage decrease in Nigeria's air cargo volume compared to the previous year. The highest percentage growth rate of 741.42% was recorded in 1994. This implies an increase in the volume of air cargo handled in Nigeria for 1994. The highest negative rate of -81.65% was recorded in the following year, 1995, resulting from the surge in total cargo volume handled in 1994. After the growth recorded in 1994, negative growth rates followed till the year 1996, having - 51.24% rate of decrease compared with the cargo volume handled in 1995.

It is worth noting that air cargo traffic in Nigeria maintained a steady upward growth from the year 1999 up till the year 2010. This reflects the effect of the democratic government that became entrenched in May 1999. The dividends of democracy are such that it cuts across all sectors of the economy to promote the growth and development of countries. Apart from the effect of democracy, the steady positive growth in Nigeria's air cargo traffic can also be attributed to the prosperity of the people, resulting in increasing import and export activities. The steady positive cargo growth rate also reflects the increasing population of Nigeria with its resultant market size for the production and consumption of goods.

Notwithstanding, the positive growth during this period (1999 - 2010) implies a growth in the economy of Nigeria. Air cargo growth rate was reduced by -7.76% in 2011 and increased to 35.57% in the following year, 2012, but later reduced by -28.90% as of 2016. A further negative change depicting

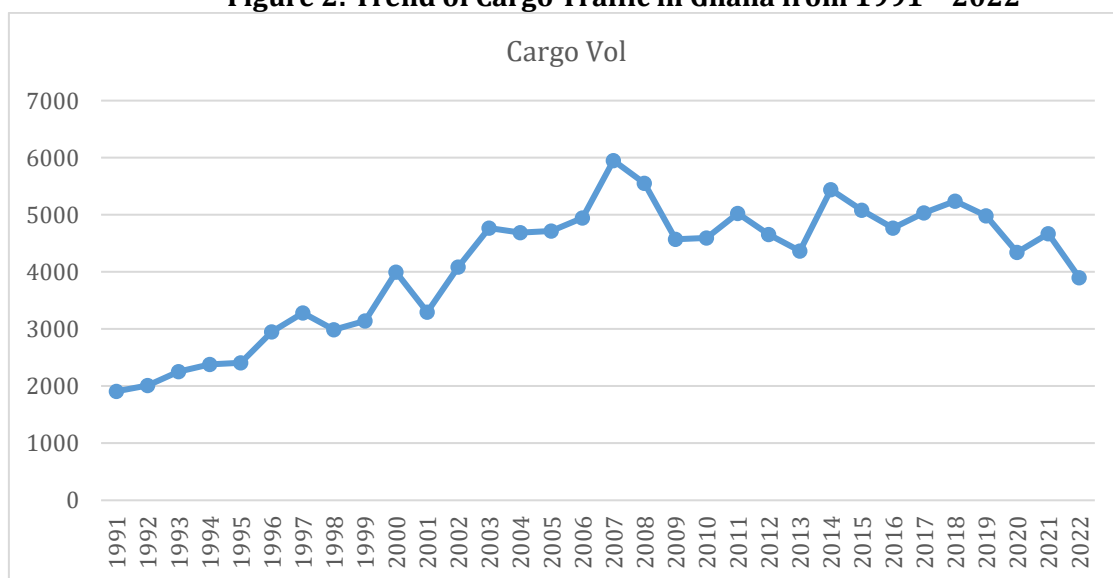
cargo volume reduction in Nigeria was extended from 2016 to 2022. This implies a threat to the economy of Nigeria, which was characterised by the global economic recession.

#### 4.2. Trend of air cargo traffic in Ghana

The trend of air cargo traffic in Ghana shown in Figure 2 covers from 1991 – 2012. An observation of the pattern of the cargo volume, as presented in Figure 2, shows a gradual growth in the volume of cargo traffic up till year 1997. After that, the pattern shows fluctuations up till 2016. It is important to note that the highest volume of cargo traffic at the airport was recorded in 2007, accounting for 59.51 million Ton-Km. This results from the government's implementation of critical economic and trade policies.

The Ghana air cargo volume handled with its percentage change shows a mix of positive and negative growth rates from 1991 to 2022. The positive rates indicate a corresponding percentage increase in the air cargo volume handled in Ghana. The negative rates show a corresponding percentage decrease in air cargo volume compared with the previous year. However, it is noted that more of the percentage changes over the years are positive. This implies that Ghana's air cargo volume has grown progressively over the years. The highest percentage growth rate of 24.55% was recorded in 2014. This implies an increase in the volume of air cargo handled in Ghana for 2014. The highest negative rate of -17.67% was recorded in the following year 2009.

**Figure 2: Trend of Cargo Traffic in Ghana from 1991 – 2022**



Source: GACL

#### 4.3. Types of cargo flow at Lagos Airport, Nigeria

Air cargo traffic flows in such a way that airports can handle various types of cargo. Different types of cargo can be carried by dedicated cargo aircraft and in the belly of passenger aircraft. Air cargo is divided into general, perishable, and dangerous goods. Furthermore, air cargo is frequently perceived as high-value and time-sensitive goods. The latter denotes the distinct advantage of air cargo over other modes of transportation. This study, however, extracted data on export cargo handled by NAHCo Aviance to identify cargo types in examining the trend of cargo traffic at Lagos airport. Table 1 shows the volume (kg) of export cargo handled by NAHCo Aviance. Table 1 is organised to classify information into major cargo types and ranked by total cargo tonnage per type.

General goods had the highest volume of cargo types at airports in Nigeria. Blood sample records the least amount of cargo. General cargo, which accounted for 692,741 kg of total cargo exports, is a type that includes a variety of goods rather than a single type of good. They are ordinary goods flown in groups. The edible items that come after general cargo in tonnage account for 617,364 kg of the total cargo volume. Individuals who travel to other countries carry more edible and personal effects

(450,126Kg). The tonnage of edible and personal effects may reflect, to some extent, the large number of passengers passing through the airport.

**Table 1: Cargo types (outflow) at Lagos airport**

Category	Specific Type	Tonnage in kg	Per cent	Rank
Food & Agricultural Products	Dried Fish	25127	0.50	22
	Frozen Foods	3629	0.07	32
	Kolanuts	49051	0.97	18
	Live Animals	842	0.02	36
	Live Fish/Snail	78860	1.56	12
	Moringa	119796	2.36	11
	Palm Oil/Kernel	3305	0.07	33
	Edible Items	662182	13.07	2
	Vegetable/Fruits	211112	4.17	8
	Animal Skin	597575	11.80	4
Electrical, Computers & Machine Parts	Aircraft Parts	26469	0.52	21
	Phones and Accessories	9679	0.19	26
	Communication Parts	314	0.01	40
	Computer Parts and Accessories	7482	0.15	27
	Electrical Parts	15241	0.30	23
	Electronics	381	0.01	38
	Plasma TV	266	0.01	43
	Spare Parts	203788	4.02	9
	Exhaust Fibre	219269	4.33	7
	Tools & Equipment	70673	1.40	15
Pharmaceuticals & Medical Equipment	Medical Equipment	5049	0.10	29
	Pharmaceutical	297	0.01	41
Cosmetics and Beauty Products	Beads	5593	0.11	28
	Cosmetics	74729	1.48	14
	Hair Attachment	666218	13.15	3
Stones and Precious Metals	Rough Topaz	55623	1.10	16
	Stones	4830	0.10	30
Clothes & Textiles	Textiles	773	0.02	35
	Clothes	76880	1.52	13
Leather & Shoes	Processed Leather	241961	4.78	6
	Shoes	191354	3.78	10
General Goods & Cargo Consolidation	Diplomatic Cargo	14724	0.29	25
	Cargo Consolidation	25166	0.50	20
	General Cargo	764036	15.08	1
	Personal Effects	510585	10.08	5
Research/Lab Samples	Water Sample	376	0.01	42
	Aquatic Plants	219	0.00	44
	Biological Subs	667	0.01	37
	Blood Sample	213	0.00	45
	Crude Oil Sample	370	0.01	39
Religious Books & Materials	Books	55710	1.10	17
	Church Materials	14149	0.28	24
Dead Bodies	Human Remains	4614	0.09	31
Chemicals	Chemical	3420	0.07	34
Courier Shipments	Courier	43122	0.85	19
<b>Total</b>		<b>5065719</b>	<b>100.00</b>	

Source: NAHCo Aviance Export Department. (2017)

A closer look at Table 1 reveals the most common cargo types for export at Lagos airport. This is suggested by the fact that these cargoes were handled throughout the year. General cargo, edible items, hair attachments, personal effects, exhaust fibre, spare parts, shoes, live fish and snails, clothes, and cosmetics are among them. Tools and equipment, rough topaz, books (mostly religious books), couriers, aircraft parts, dried fish, church materials, beads, and human remains are among the others. Although some of these cargoes do not have the highest tonnage, they significantly contribute to the airport's overall export cargo operations. These cargoes are frequently seen in the NAHCo warehouse's export section.

#### 4.4. Types of cargo traffic at Accra airport

The cargo traffic at airports is diverse such that its handling requires different types with different handling equipment and processing. The general classification of air cargo is built on time and value. This highlights the importance of air cargo transportation over other modes of transport in any country. Nevertheless, the cargoes that flow through airports are of different types with specific requirements that need to be highlighted in examining the trend of cargo traffic at airports. Given this, the specific cargo types that flow through the airport were examined. Data on cargo volume based on different cargo types from the records of GACL were collected.

The study classified the specific types of airport cargo flow by volume. The classification includes agricultural products, live animals, cosmetics and beauty products, courier shipment, ornamentals and flowers, general goods, and cargo consolidation. As indicated in Table 2, agricultural products include cassava, food items, fresh fish, mangoes, Pawpaw, Pineapple, cut fruits, limes, vegetables and yam. Hair cream and shea butter form the beauty products. Mails and goods that are handled by courier services form the courier shipment. The general goods and cargo consolidation comprise goods of different types and sizes in small packages grouped and owned by individuals. Diplomatic cargo is classified as owned and transported by the governments through agencies and organisations.

**Table 2: Types of export cargo handled at Accra airport**

	Cargo Types	Tonnage in Kg	Percent	Rank
Food and Agricultural Products	Cassava	760	0.007	19
	Food Items	746,264	7.218	6
	Fresh Fish	58,598	0.567	10
	Mangos	355,078	3.434	8
	Papaya (Pawpaw)	1,085,541	10.500	3
	Pineapple	3,600,982	34.830	1
	Cut Fruit	1,055,788	10.212	4
	Limes	13568	0.131	13
	Vegetables	167,427	1.619	9
	Yams	918,206	8.881	5
Live Animals	AVI – Live Animals	8731	0.084	14
Cosmetics & Beauty Products	Passion (Hair Cream)	684,959	6.625	7
	Shea Butter	50,148	0.485	12
High Valued Goods	Bullion – Gold	8458	0.082	15
Courier Shipment	Courier	5133	0.050	16
	Mail	57,318.60	0.554	11
Ornamentals & Flowers	Flowers	1471	0.014	18
General Goods & Cargo Consolidation	Diplomatic Goods	1937	0.019	17
	General Cargo	1,518,313	14.686	2
	<b>Total</b>	<b>10349868.6</b>	<b>100</b>	

Source: GACL Cargo Operations Department (2017)

Table 2 presents the types of export cargo by tonnage (kg) handled at Accra airport, having a total of 10,349,868.6 Kg. The first four cargo types, which account for more than 1 million Kg, are pineapple, general cargo, pawpaw and cut fruits. Pineapple, which ranked first among the cargo types, accounts for 3,600,982Kg representing about 35% of total cargo exported from the airport. General cargo, the



second-ranked cargo type, accounted for about 15% of total export cargo tonnage handled by Swissport. The third and fourth-ranked cargo types are pawpaw and cut fruits, which recorded approximately 10.5% and 10% of cargo tonnage, respectively.

On the other hand, some cargo types at the airport could not account for 1% of the total cargo tonnage. These cargo types are fresh fish, mail, shea butter, limes, live animals, gold, courier, diplomatic goods, flowers, and cassava. That pineapple has the highest tonnage of cargo export may not imply that it is the most frequent cargo type at the airport, but it is proof of the weight of pineapples compared to other cargo types. It is to be noted from Table 2 that food and agricultural products dominate the export of cargo at Accra airport. This implies that Ghana's economy is expected to be strong with the export of local products. It also indicates that the Ghana government may have to invest more in agriculture to develop the sector for greater export of products for economic purposes.

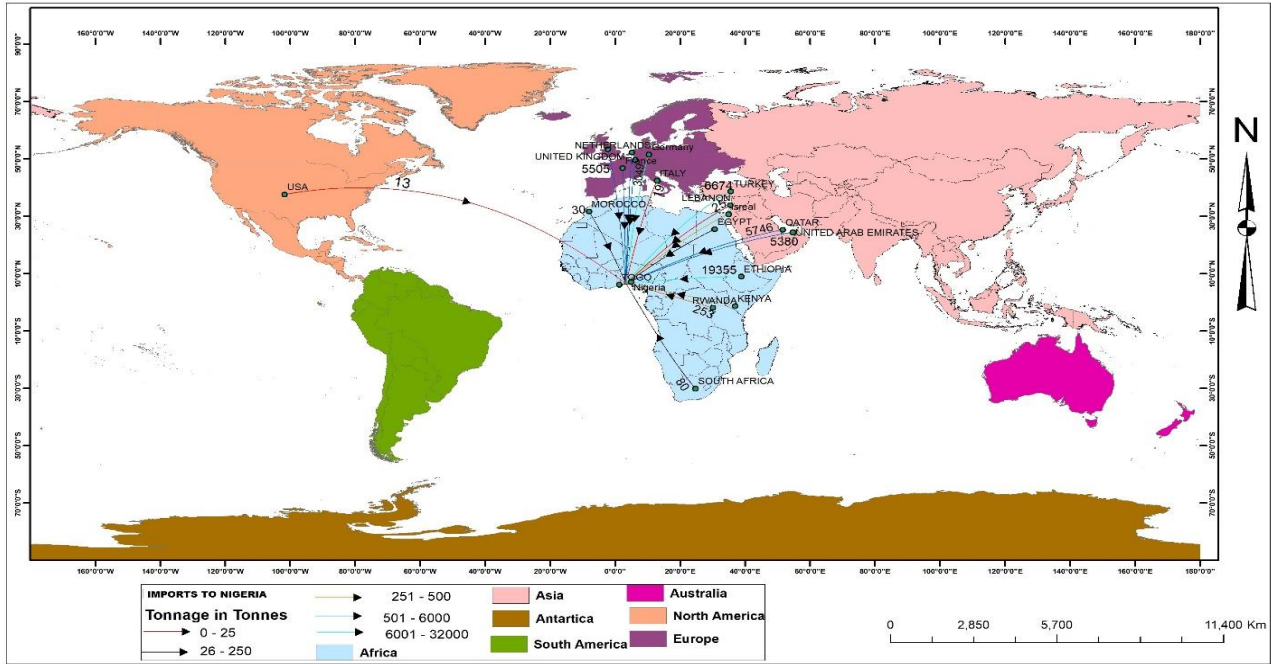
#### **4.5. Origin and destination of air cargo traffic at Lagos Airport**

The air cargo volume imported into Nigeria through Lagos Airport accounted for the country's largest share of air cargo traffic. Apart from the fact that Lagos is the first international airport in Nigeria, Lagos is a cosmopolitan city with the highest concentration of international businesses, commercial and trading activities in Nigeria, and one of the busiest cities in Africa. The population of Lagos represents a market force surpassing the overall population of many African countries. As a result, Lagos Airport emerged as the busiest airport in Nigeria and West Africa. Cargo flows in and out of Nigeria through the airport from different countries. The spread of the countries from which cargo comes into Nigeria across the globe indicates the level of commercial and social interactions between Nigeria and other countries.

The spatial distribution of the origins of imported cargo to Nigeria is presented in Figure 3. This Figure shows the world's six continents with lines indicating the direction and volume of cargo flow to Nigeria. The results from Figure 3 indicate that the USA, with about 3 million Ton-Km of cargo imported to Nigeria, is the only country with cargo flow to Nigeria in North America. There was no air cargo flow to Nigeria from South America, Australia, and major parts of Asia continents. However, it is noteworthy that most air cargo flow to Nigeria is from European countries, countries closer to Africa in Asia, and a few African countries. This is a major indication that distance contributes to the volume of trade and exchange between countries.

Cargo traffic is directional, having origin and destination. It is a flow where the traffic "from" is termed inflow/inbound, and traffic "to" is termed outflow/outbound. The level of outbound cargo traffic to the UK is associated with the large number of Nigerians living in the UK. The traffic will result from the need to transport personal effects and general goods as well as goods required to be transported for business purposes in the UK. This perhaps is generated from the long-existing relationship between Nigeria and the UK, which commenced during the colonial reign. The UAE-destined cargo traffic may indicate the level of movement between Lagos and Dubai due to tourism activities and the trade policy of the UAE.

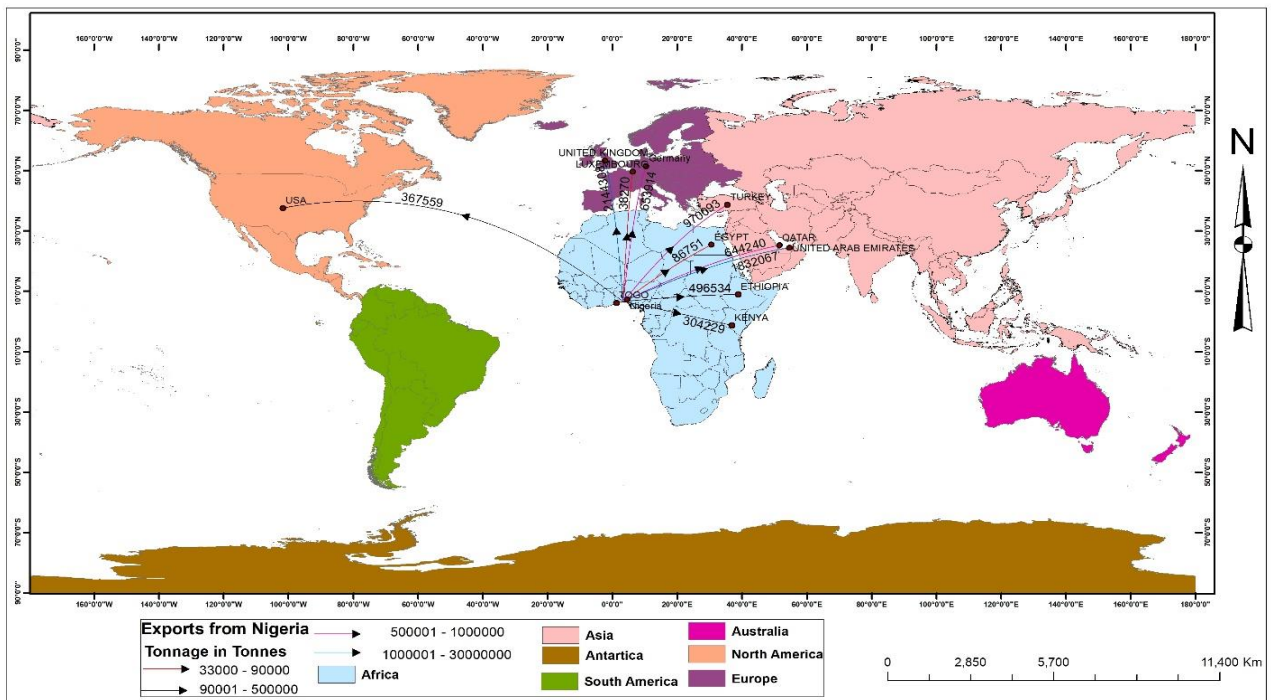
Figure 3: Spatial flow of air cargo to Nigeria from other countries



Source: ArcGIS Flow Analysis

The spatial distribution of the destinations of export air cargo from Nigeria, as presented in Figure 4, was generated using ArcGIS. This Figure shows the world’s continents, indicating the direction and volume of cargo flow from Nigeria to other countries. The information in Figure 4 reflected that 367,559 tonnes of air cargo were destined for the USA in North America. As for the origins, there were no air cargo flows from Nigeria to South America, Australia, and major parts of Asia. It is observed that the continents that form the major origin of cargo from Nigeria also form the major destinations. This indicates the directional characteristics of traffic flow for cargo in Nigeria.

Figure 4: Spatial flow of air cargo from Nigeria to other countries of the world



Source: ArcGIS Flow Analysis

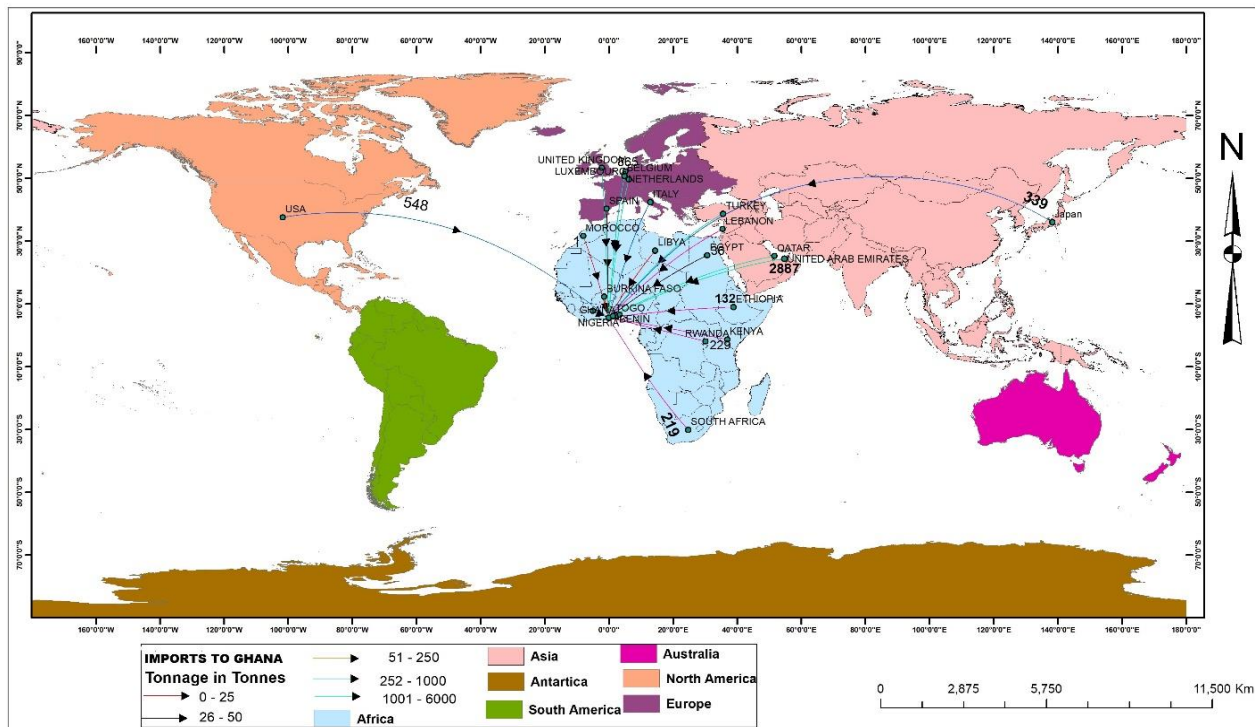
### 4.6. Origin and destination of Air cargo in Ghana

The air cargo types that flow in and out of Ghana come from and go to different countries worldwide. This results from the airport being located in the country's capital city, where major economic activities of the people and government transactions are domiciled. The headquarters of different private and public organisations are also located in Accra. This and other factors make Accra airport account significantly for air transport operations in West Africa.

Figure 5 depicts the spatial distribution of imported cargo by air to Ghana using ArcGIS Flow Analysis. It depicts the world's continents, with the origin and volume of cargo inflow to Ghana from other countries. Figure 5 shows that 548 tons of air cargo were airlifted to Ghana from the United States of America. There were no air cargo flights from South America, Australia, or other major Asian continents to Ghana. Nonetheless, the cargo inflow to Ghana came from Japan (with 339 Tonnes), which Nigeria lacked. This implies that Ghana has more trade interactions than Nigeria. Both countries, however, receive cargo from similar parts of the world.

Traffic is characterised by a directional flow of goods and services indicating origin and destination. The frequency and volume of traffic in each direction differ at any given time. This causes variations in the traffic flow trend. There is outflow cargo traffic for every airport with inflow cargo traffic, albeit not in the same proportional volume or frequency.

**Figure 5: Spatial flow of air cargo to Ghana from other countries of the world**



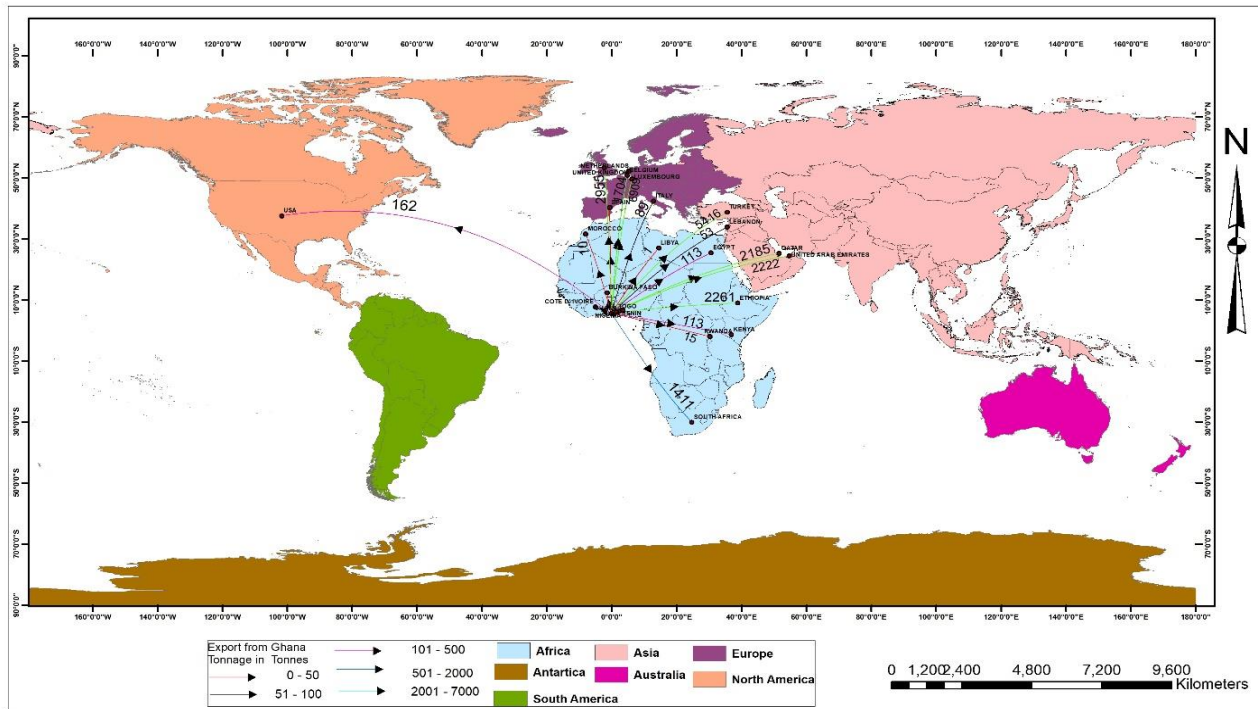
Source: ArcGIS Flow Analysis

The spatial distribution of export of air cargo to different countries of the world from Ghana is presented in Figure 6. The Figure shows the world's continents, indicating the destination and volume of air cargo outflow from Ghana to other countries. The results from Figure 6 indicate that 162 tonnes of air cargo were transported from Ghana to the USA in North America. There were no air cargo flows to Ghana from South America, Australia, and major parts of Asia continents. Notably, Nigeria and Ghana have represented cargo outflow to similar regions of the world continents.

In summary, the overall volume of air cargo traffic in Nigeria and Ghana from 1991 - 2016 showed an increasing trend and fluctuating pattern. It is indicative that Nigeria has more cargo volume than Ghana. This is not surprising because the population and economy of Nigeria are far more than Ghana's. Nigeria exported various cargo types, where General cargo was dominant in weight, but Ghana exported more agricultural products, where pineapple was dominant in weight. The major cargo origins to

Nigeria are Germany, Ethiopia, and Turkey, while Ghana's are the UK, Netherlands, and UAE. The major cargo destinations from Nigeria are the UK, UAE, and Turkey, while Ghana's are Luxembourg, Turkey, and the UK.

**Figure 6: Spatial flow of air cargo from Ghana to other countries of the world**



Source: ArcGIS Flow Analysis

#### 4.7. Forecasting air cargo traffic in Nigeria and Ghana

The demand for air cargo is expected to increase due to countries' growing trade and economy because of the effects of globalisation and trade liberalisation. Also, improvements in political stability, free market system, technological advancement, and growing e-commerce will contribute to improving air cargo demand among nations. The increasing rate at which different products are being transported by air internationally is enormously influencing cargo traffic operations at airports. The proof of this development is reflected in the economic strides of countries through trade in the form of exports and imports, which are handled at airports. This implies that changes are expected with the volume of cargo that will be transported between nations as the years go by. To this end, this study is set to forecast the volume of cargo traffic in Nigeria and Ghana, respectively.

Time series techniques of moving and weighted average, exponential smoothing and least square method were used to forecast cargo trends. The moving and weighted averages were designed such that the level of fluctuations in the trend is minimised. The weighted average is designed to attach a weight to the data set to reduce further the seasonality rate in the trend of air cargo traffic of the airports. The methods can undertake short-term prediction of values. Figure 7 indicates that the forecast of the moving average technique is expected to record an increase of 3.6% in cargo traffic. The weighted average analysis shows that cargo traffic is expected to grow by 1.3%.

The exponential smoothing method of forecasting cannot change the seasonal component over time but also control the rate of the changes and smoothness of the trend cycle component. It makes use of Alpha ( $\alpha$ ) values for predictions. The value of  $\alpha$  is between 0 and 1. The value of  $\alpha$  for prediction is random, but  $\alpha = 0$  gives an insensitive forecast, while  $\alpha = 1$  gives a highly sensitive forecast. It, therefore, indicates that as  $\alpha$  increases, the ability to smooth a trend down decreases.

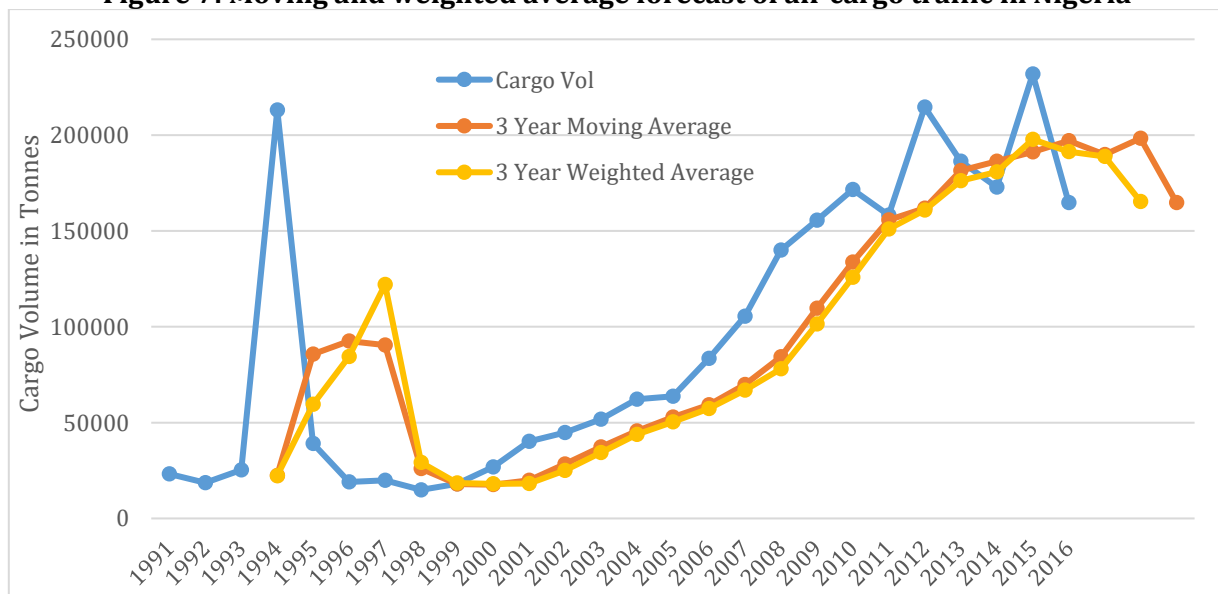
Figure 8 shows the smoothing of the trend in air cargo traffic at  $\alpha = 0.1$  and  $0.3$  was employed. The exponential trend at  $\alpha = 0.3$  that predicts 6.3% increase in the rate of air cargo volume in Nigeria in the forward years. The trend at  $\alpha = 0.1$  predicts a 9.1% increase rate.

The least square method of forecast is an attempt to make a forecast of cargo traffic into the nearest future. The analysis can predict a longer period than the moving and weighted averages. Figure 9 shows the trend of cargo volume in Nigeria, the trend line, and the forecast line of cargo -volume, respectively.

The forecast from Figure 9 shows that air cargo traffic in Nigeria will grow by 3.67% in the forward years. The least square method provides a more realistic forecast than the moving and weighted averages. The  $R^2 = 0.6048$  implies that 40% of both endogenous and exogenous factors will influence the accuracy level of the prediction. In other words, the prediction of cargo traffic is 60% accurate. It is imperative from the least square forecast that air cargo traffic in Nigeria is expected to grow up to 260,656.8 Tonnes by the year 2026. This implies the need for capacity provision to handle the traffic efficiently.

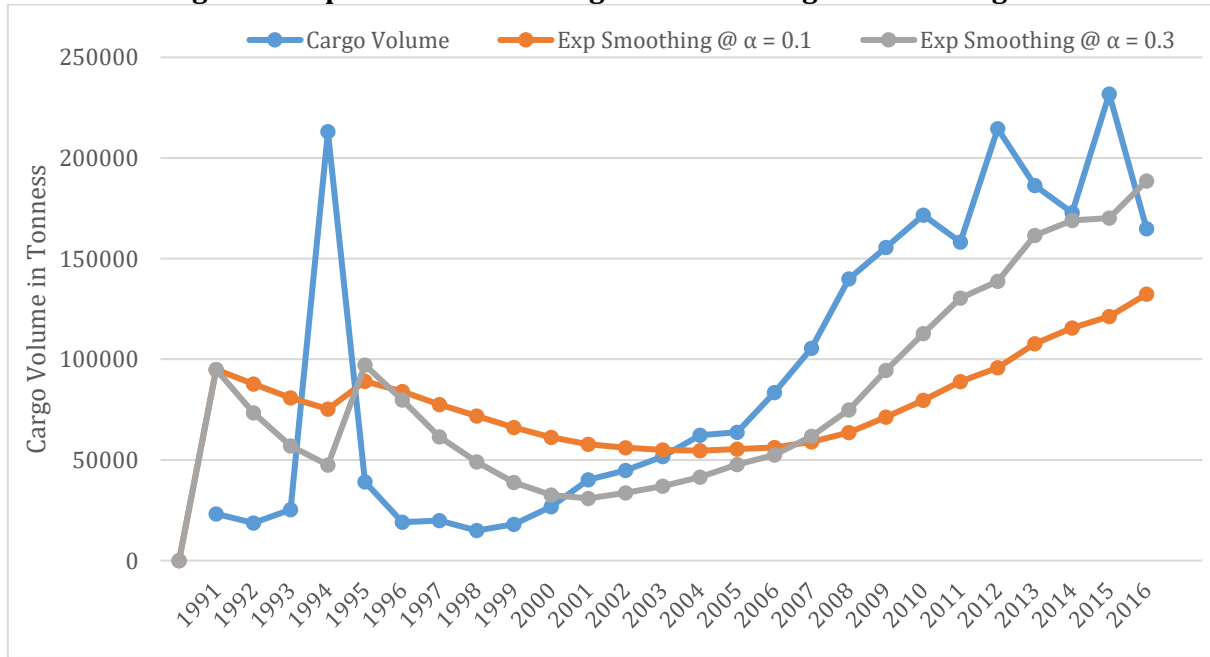
The study considers the results of the Least Square regression method to be more reliable than the other techniques of forecasting employed. This is because the least square technique can make long-term forecasts which the exponential trend line could not achieve. The prediction that cargo traffic will grow at the rate of 3.67% in the forward years in Nigeria is with a higher level of accuracy than the 6.3% and 9.1% predicted by exponential smoothing at  $\alpha = 0.3$  and 0.1, respectively. All things being equal, the least square prediction of 3.6% implies that more demand for air cargo operations will be made in the near future.

**Figure 7: Moving and weighted average forecast of air cargo traffic in Nigeria**



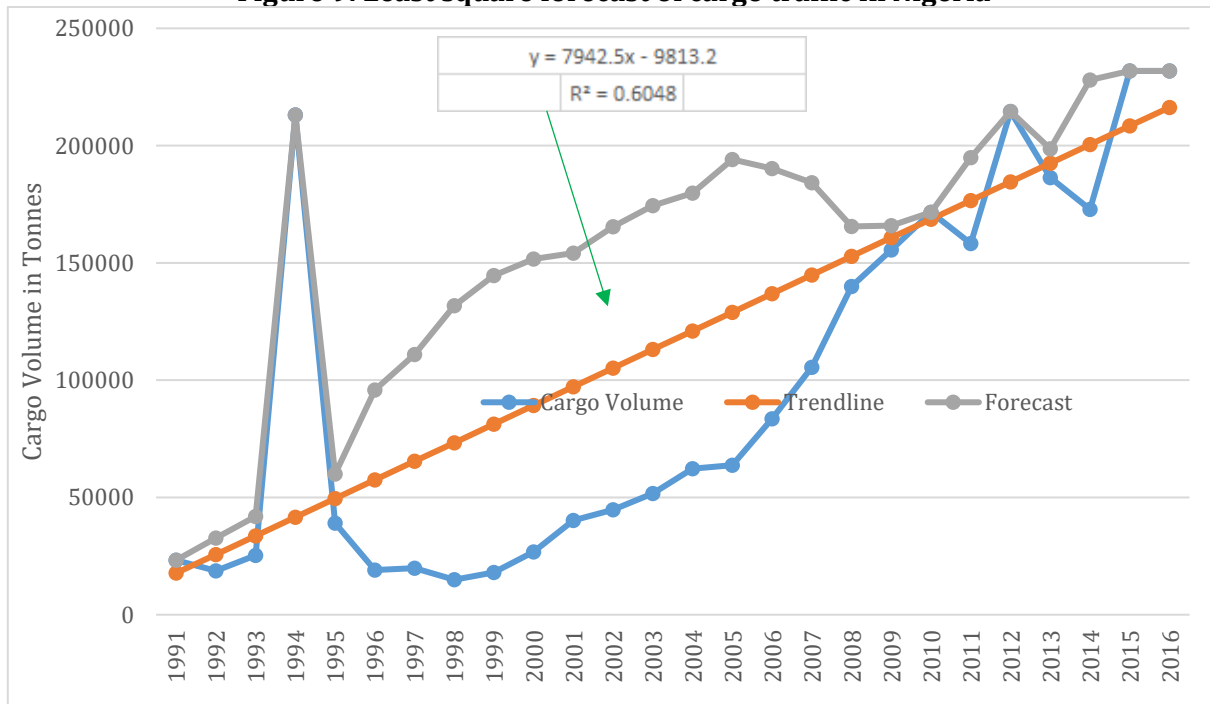
Source: Author's computation of FAAN data on air cargo

**Figure 8: Exponential smoothing forecast of cargo traffic in Nigeria**



Source: Author’s computation of FAAN data on air cargo

**Figure 9: Least square forecast of cargo traffic in Nigeria**



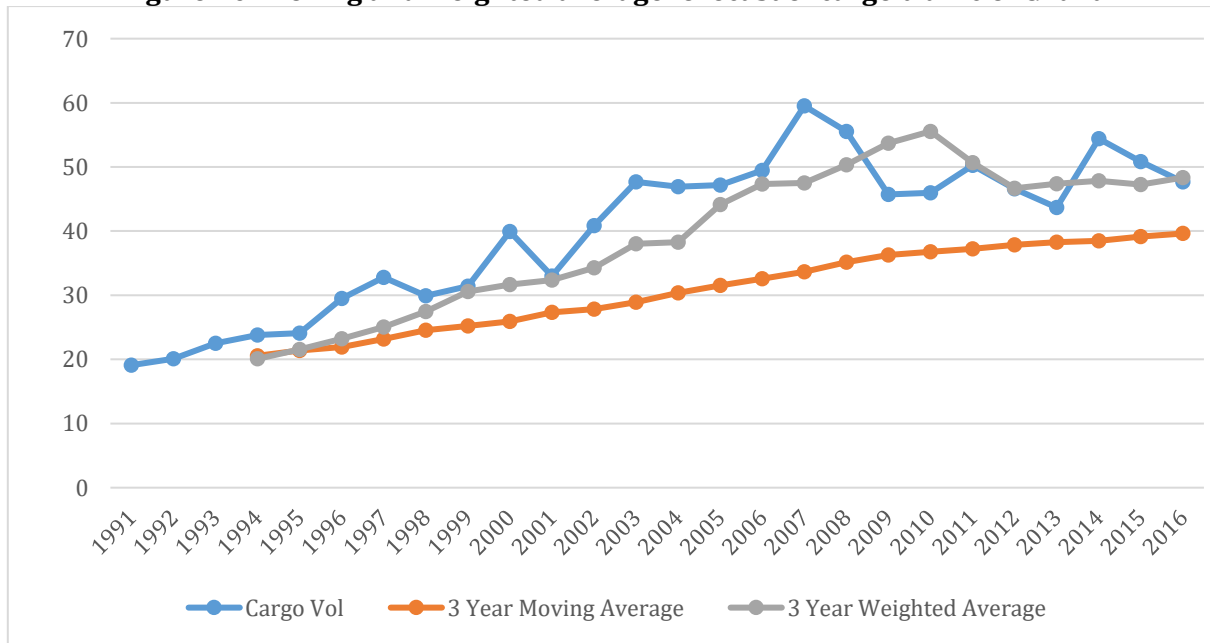
Source: Author’s computation of FAAN data on air cargo

The air cargo volume of Ghana was subjected to trend analysis. These techniques are moving and weighted averages, exponential smoothing, and least square analysis. Figure 10 shows that the forecast of the moving average technique in Ghana is expected to grow by 1.17%. The weighted average analysis shows that air cargo traffic in Ghana will grow at a rate of 7.6%.

The exponential smoothing method of forecast cannot change the seasonal component over time but also control the rate of the changes and smoothness of the trend cycle component. Figure 11 shows the smoothing of the trend in cargo traffic at  $\alpha = 0.1$  and  $0.3$ , respectively. This shows that air cargo traffic in Ghana would be smoothed down to 46 million ton-km at  $\alpha = 0.1$  and 49 million ton-km at  $\alpha = 0.3$ .

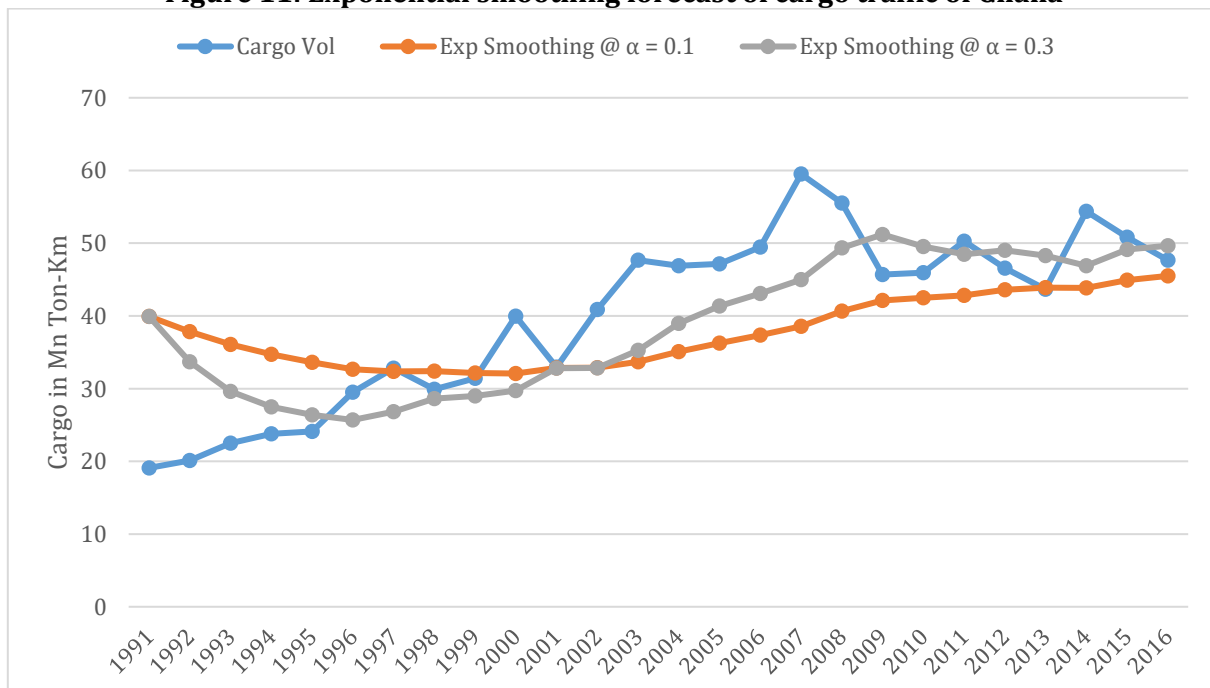
The least square method is an attempt to make a forecast of cargo traffic into the nearest future. The least-square can predict a longer period than the moving and weighted averages. Figure 12 shows the trend line and the forecast trend of cargo, respectively. The forecast from Figure 12 shows that air cargo traffic in Ghana will grow at a rate of 2.37%. The least square method provides a more realistic forecast than the moving and weighted averages. The  $R^2 = 0.7611$  least square indicates that 76% of the prediction is accurate, while 24% of exogenous factors will influence the accuracy of the prediction. In other words, the prediction of Ghana air cargo traffic is 76% accurate. This implies the need for capacity provision for efficient cargo operations as expected.

**Figure 10: Moving and weighted average forecast of cargo traffic of Ghana**

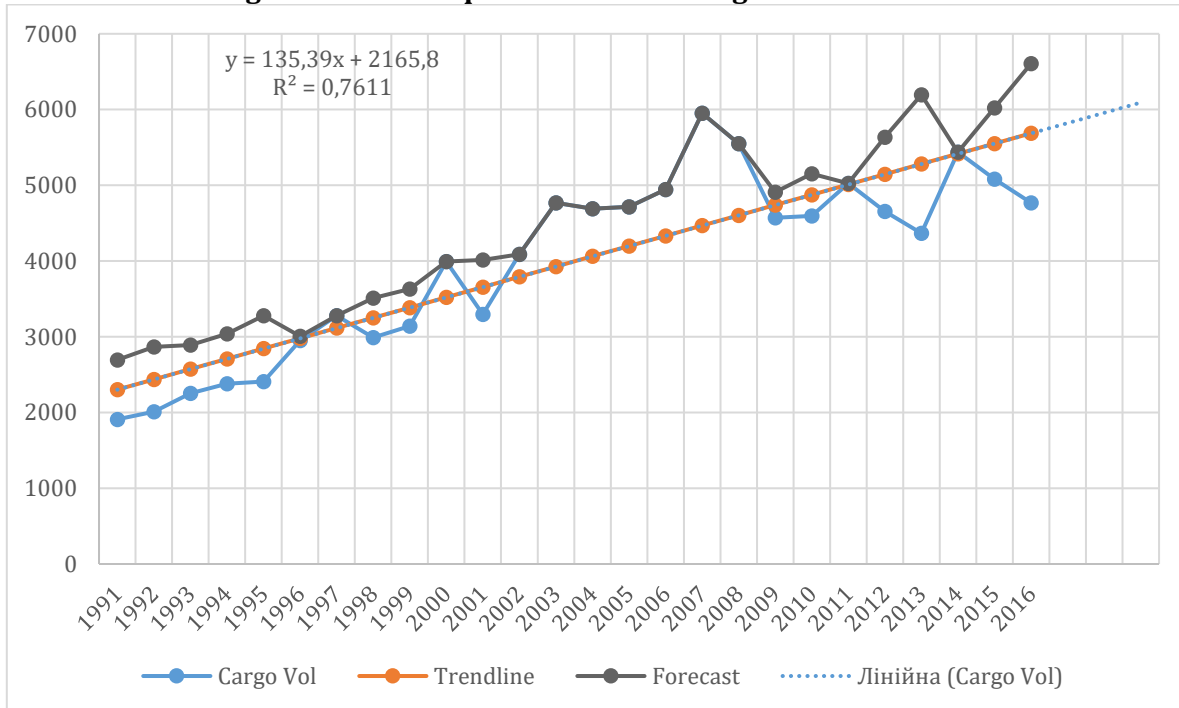


Source: Author’s computation of GACL data on air cargo

**Figure 11: Exponential smoothing forecast of cargo traffic of Ghana**



Source: Author’s computation of GACL data on air cargo

**Figure 12: Least square forecast of cargo traffic of Ghana**

Source: Author's computation of GACL data on air cargo

The air cargo volume of Ghana was subjected to trend analysis. These techniques are moving and weighted averages, exponential smoothing, and least square analysis. Figure 10 shows that the forecast of the moving average technique in Ghana is expected to grow by 1.17%. The weighted average analysis shows that air cargo traffic in Ghana will grow at a rate of 7.6%.

## 5. Discussion of results

The study established that fluctuations characterise the trend in air cargo volume in Nigeria and Ghana over the years. Air transport stakeholders find this issue difficult to address with a straight-jacketed approach because the factors responsible for the fluctuating pattern are most external to airport operations, such as economic and geographical. Other scholars, such as Akinyemi (2023), detailed the nature of fluctuations in the air cargo volume of South Africa, Egypt, Nigeria, and Kenya. IATA (2023) also described the fluctuations in air cargo volume as an uneven trend and stated the obvious increase and decrease in global cargo volumes from 1999 to 2022. The finding of this study about the characteristic fluctuations of cargo volume at airports implies that it should no longer be an unexpected event for airport managers and airlines globally.

This study found that food and agricultural products dominate export cargo in Ghana, and general goods dominate exports in Nigeria. The result achieves the objective of the study in cargo traffic analysis for airlines and airport planning. For airlines, the result supports the findings of Chao & Li (2017) that different cargo type combinations on aircraft affect chargeable weights, which means higher revenue for airlines, and recommends an effective combination of cargo types increased airline loading rate and revenue. This study also aligns with IATA (2022), which categorised air cargo into two groups: general and special cargo. The general cargo, such as retail and consumer goods, dry goods, hardware, textiles, etc, do not need extra precautions and special handling while in transit. The specialised goods require extra precautions in handling and comprise sub-groups (IATA, 2022).

Examining cargo traffic by origin and destination is crucial to airport planning and airlines' business model. This study found that air cargo origins and destinations in Nigeria and Ghana are mainly from/to some European and Asian countries. It implies that both countries have sustained relationships with the European countries resulting from colonisation and with Asia countries for trade and tourism. In line with this study, Chung and Han (2013) analysed the origin and destination of cargo transshipment



at airports in Northeast Asia and highlighted China, the United States, and Japan as major cargo origins and the US and Japan as the major destinations.

## **6. Conclusion and policy implications**

The trend of air cargo traffic in Nigeria and Ghana shows the characteristic fluctuating pattern of flows. The major types of cargo dominating Nigeria's air cargo export are general goods, edible items, and hair attachment. The dominant cargo types in Ghana were pineapple, general goods, and papaya. Agriculture products form the major export cargo of Ghana. It was further found that Germany, followed by Ethiopia and Turkey, dominates the origin of import cargo to Nigeria while the United Kingdom, UAE and Turkey dominate the destination of export cargo from Nigeria. In Ghana, Luxembourg, Turkey, and the UK dominate the origin of import cargo, while the UK, Netherlands, UAE, and Qatar dominate the destination of export cargo. The forecast of cargo traffic in Nigeria and Ghana using the least-square forecast technique predicts 3.67% and 2.37% growth of cargo traffic in Nigeria and Ghana, respectively.

This study attempts to provide insight to address the problems traffic fluctuations cause air cargo stakeholders in implementing growth plans by revealing cargo types, origins, destinations, and future traffic growth rates in Nigeria and Ghana. The findings imply that stakeholders need to look at the dominating cargo types, origins, and destinations of cargo flow to understand traffic patterns for appropriate planning decisions. It also shows the predicted future cargo growth rates that prompt airports and airlines to plan their capacity for effective service delivery.

The study, therefore, recommends that Nigeria should strengthen policies towards the exportation of various cargo types, especially agricultural products while sustaining the dominant export of hair attachment and other cargo types. This should be done to learn from Ghana, which facilitates more export of her agricultural products. Also, Nigeria must strategise to strengthen its relationships with other countries, especially Germany, Ethiopia, the UK, UAE, and Turkey, as cargo handlers strive to develop new business opportunities with foreign airlines such as Lufthansa and Ethiopian Airlines. Similarly, Ghana needs to strengthen its relationships with countries such as Belgium, Germany, Turkey, UK, Netherlands, UAE, and Qatar for more trade facilitation with increased flight frequency of airlines such as Cargolux, Turkish, British Airways, Emirates, Qatar, and DHL. Also, Nigeria and Ghana need to improve their relationships with other countries through a Bilateral Air Service Agreement (BASA) to promote an exchange of goods.

There is a need for both countries to prepare the capacities to handle the expected increase in cargo traffic at their airports. To achieve this, the focus for improved capacity in terms of adequacy and condition of equipment and facilities should be on private terminal operators. This will ensure the airports' capacity meets the expected future increase in cargo traffic of the countries.

This study is limited to air cargo traffic in Nigeria and Ghana, focusing on the types, origin, and destinations of cargo at the Murtala Muhammed and Kotoka International airports of the countries, respectively. Future study needs to look at the air cargo traffic of the airports with their capacity assessment.

## **Acknowledgement**

The author is grateful to the management of the organisations that provided the data for the study.

## **Funding**

This research received no external funding.

## **Conflicts of Interest**

The author declares no conflict of interest.

## Ethical Declaration

A part of the data used in this paper has been published in: "Advances in Airline Economics, in: The International Air Cargo Industry, volume 9, pages 283-302, Emerald Group Publishing Limited and Latin American Journal of Trade Policy, 5(12).

## Citation information

Adenigbo, A. J. (2023). Analysis of air cargo traffic at airports in Nigeria and Ghana. *Journal of Sustainable Development of Transport and Logistics*, 8(2), 23-42. doi:10.14254/jsdtl.2023.8-2.2.

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