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The Effect of the Ebola Virus Disease on intra-regional trade in West Africa

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Abstract

The West African sub-region experienced the World's largest Ebola outbreak after its maiden outbreak in Central Africa. In this background, economic activities were heavily affected hence intra-regional trade shares of affected countries. Given this, the study seeks to investigate the effect of the Ebola Virus Disease on affected countries' shares to intra-regional trade. Additionally, the study seeks to investigate the impact of ECOWAS membership on trade in West Africa. The Poison Pseudo Maximum Likelihood (PPML) was used to estimate the augmented gravity model of international trade. The results showed that the Ebola Virus Disease reduced the share of affected countries' trade to intra-regional partners by two folds. Also, the study showed that ECOWAS membership doubles the level of trade. The study concludes that the ECOWAS should be proactive in their response to disease outbreak by investing in research. Additionally, the study shows that Mauritania will benefit from opting for the ECOWAS.

Keywords: Ebola Virus Disease, Poison Pseudo Maximum Likelihood (PPML), ECOWAS, gravity model of international trade.

Introduction

The Ebola virus disease, formerly Ebola haemorrhagic fever is a severe and fatal illness with a mortality rate of 25%-90% (Etuk, 2015; Tseng & Chan, 2015; Bell et al., 2016). The virus is primarily transmitted to humans through contact with bodily fluids of infected animals and secondarily through humans. These include contact with blood, mucus, saliva, vomit, sweat, fever, urine, breast milk, semen, vaginal secretions, feaces, deceased body, urine of recovered patient among others (Centers for Disease Control and Prevention (CDC), 2014; Baize et al. 2014; WHO, 2018; ILO, 2018). The virus invasion in humans appears to occur through mucosal surfaces, breaks, and abrasions in the skin, or parenteral introduction (Alexander et. al., 2015; Madariaga, 2015). The Ebola virus, which is a zoonotic pathogen virus, was reported to be haboured in bush meats notably fruit bat of the family *Pteropodidae*, with early cases of infection reported in the rural areas (Madariaga, 2015; Kadanali & Karagoz, 2015; Judson et al, 2016). The symptomatology of the disease is like many other diseases, such as malaria, internal bleeding, external bleeding, intense weakness, Lassa fever, extreme fatigue, muscle pains, dizziness, headache, diarrhoea, skin rash, sore throat, impaired kidney, cholera, influenza and typhoid among others, with an incubation period of 2-21 days (Woldemariam & Di Giacomo, 2016). The symptoms were corollary to the high body temperature of the infected persons, about 38°C (100.4°F). The five species of the Ebola Virus, which originates from the family *Filoviridae*, have been pinpointed by the World Health Organization (WHO), notably the Zaire ebolavirus, Sudan ebolavirus, Taï Forest ebolavirus, Reston ebolavirus (which has caused asymptomatic infections in humans but disease in nonhuman primates only) and Bundibugyo ebolavirus (Madariaga, 2015; Bell et al., 2016; Singh et al., 2017). In Africa, the causative viruses were the Zaire ebolavirus, Sudan ebolavirus, and Bundibugyo ebolavirus. The measures taken to curb the outbreak were to wash hands frequently with soap and water, the use of alcohol-based hand sanitizer, the use of disinfectants on public shared facilities, isolation of infected persons, and contact tracing, screening and the practice of social distancing from sick people as recommended of Doctors Without Borders / Médecins Sans Frontières (MSF). More so, the infected patients were advised to stay home as an initial remedy to reduce spread, avoid the use of public transports, seek urgent medical assistance, and adhere to guidelines from medical experts which has been used to curb over 20 outbreaks as well as ensure the safe transportation of infected persons (Kalra et al, 2014; Isakov et al, 2015; Woldemariam & Di Giacomo, 2016; Bell et al., 2016; WHO, 2018; ILO 2018).

The traditional niche of the Ebola Virus Disease on the African continent can be traced to Central Africa notably Yambuku in Zaire (now the Democratic Republic of Congo) and Nzara, South Sudan in 1976 (Peters & LeDuc 1999; Heymann et al. 1999; Kerstiëns & Matthys 1999; Rosello et al. 2015; Breman et al. 2016). The first case was reported in a village near the Ebola River in Zaire which influenced the name of the causative virus (Kalra et al, 2014; Kadanali & Karagoz, 2015). The devastating nature of the disease accounted for a mortality rate of 88% and 66% respectively during its maiden outbreak in Zaire and Nzara (Adegun, 2014). In the year 1995, the disease resurfaced in the Democratic Republic of Congo, which claimed numerous lives including medical professionals, and exposed the vulnerability in the governance and health sector of the economy (Rupavate S, 2014 cited by Adegun (2014); Wagenaar et al, 2018). Since then, traces of the deadly disease was prevalent in the Democratic Republic of Congo, Sudan, Gabon, Congo, South Sudan, and Uganda, with a median of three outbreaks per year and over 30 outbreaks with a death toll close to 1600 (Salaam-Blyther, 2014). Most Ebola-stricken countries were on the back of prolonged civil wars so the disease posed a greater threat to the health sector (Kaasik-Aaslav et al., 2015; Ribacke et al, 2015).

On December 6, 2013, West Africa was hit with the index case in Guéckédou, Guinea, involving the death of a 2-year-old child (Joshi, 2014; Burd, 2015). The child came in contact with the virus while playing near an infected bat according to Robert Koch Research Institute in Berlin. Consequently, similar symptoms were experienced in his mother, sister, and grandmother which led to their demise. Then close contacts began to experience the symptoms and the outbreak began spreading its tentacles to neighbouring villages. Surprisingly, the outbreak had spread wide to neigbouring countries of Sierra Leone and Liberia (Kramer et al, 2016). As a result, the World Health Organization (WHO), the primary body superintended to work out and execute the 2005 International Health Regulations (IHR), was notified on 21 March 2014 by Guinea, followed by Liberia on 30 March and Sierra Leone on 25 May. The WHO confirmed the disease to be Ebola Virus Disease ingrained in empirical research. In the analysis of Kamradt-Scott (2014), the late response of the WHO to the Ebola outbreak was an attributing factor to the spread of the disease.

Nigeria experienced the EVD with the arrival of an infected air traveler from Liberia to Lagos on July 20, 2014, and initiated the spread (Fasina et al., 2014; Shuaib et al., 2014; Althaus et al, 2015). Similarly, a university student infected with the EVD evaded health surveillance for weeks as he travelled to Senegal from Guinea, by road.

The outbreak was officially declared as a Public Health Emergency of International Concern (PHEIC) on August 8, 2014, under the aegis of the 2005 International Health Regulations (IHR) as reported by Reuters, since the WHO estimate the true prevalence to be two to four times higher than the reported figures and the potential of spreading to the international community according to US health authorities and MSF. To buttress, data collection challenges on virus-contracted persons based on responses from correspondents and laboratory staff indicated under-reported cases (Owada et al, 2016; Cori et al, 2017). In response, the Global Alert and Response Network (GOARN) under the auspices of the WHO, and the US Center for Disease Control and Prevention (CDC) deployed a team to complement national efforts toward infection prevention and control (IPC) to extirpate transmission (Mobula et al, 2018). Also, there was a coordinated international effort to activate a Travel and Tourism Taskforce to provide documentation about the travel and tourism sector along with travelers (WHO, 2014; Maphanga, 2019). The failure of independent countries to contain the virus led to the collaborative efforts of the ECOWAS, Mano River Union (MRU), the West African Health Organization (WAHO) under the auspices of the ECOWAS Commission, Health Ministers of States, the African Union Support to Ebola Outbreak in West Africa (ASEOWA) under the auspices of the African Union, private sector partnership of telephone operators namely MTN, Etisalat and Airtel, The African Centre for Disease Control and Prevention (ACDCP), the Ministers of Health of West Africa and the Head of State and Government (HoS&G) which mobilized political and social backing to fight the virus. As a precautionary measure, neighbouring West African countries to the infected countries closed their borders conspicuously Ivory Coast Senegal, Chad among other West African countries, closed their borders with Liberia, Sierra Leone, Guinea, and Nigeria. Air travels were the predominant means of the EVD spread internationally (Bogosh et al., 2014; Gomes et al., 2014). This led to the cancellation of flights to Guinea, Liberia, and Sierra Leone notably from Kenya, South Africa, Ethiopia, Argentina, Brazil, China, Panama, Chile, among others (Ferrel & Agarwal, 2018). According to the Official Airline Guide (OAG), of 590 monthly flights scheduled to Guinea, Liberia, and Sierra Leone, 216 have been cancelled. The Guardian reported that Air Côte d'Ivoire, Nigeria's Arik Air, Togo's ASKY Airlines, British Airways, Emirates Airways, and Kenya Airways cancelled a combined 76 scheduled flights to Guinea, 70 to Liberia, and 70 to Sierra Leone which harmed international trade. Other countries that recorded cases were Mali, Italy, Spain, Germany, the United Kingdom, and the United States of America (Goeijenbier et al, 2014). The WHO issued a regional plan, asking the international community to fill a US$71 million gap, the first in a succession of rising cost estimates, reaching $988 million in a UN appeal in mid-September. However, controversy arose over the ethical allocation of therapies after several Americans and a Spanish national, rather than West Africans, received doses of the scarce ZMapp, an experimental biopharmaceutical (Gostin & Friedman, 2015). Donor countries and organization came to the aid which includes the United States of America (US$937 million), the United Kingdom (US$330 million), Germany (US$172 million), the World Bank (US$137 million), and France (US$108 million), as of 17 February 2015 (UNDG-WCA, 2015). Also, the United Nations Mission for Ebola Emergency Response (UNMEER) contributed $1billion for overall needs and requirements (ONR) as of December 8, 2014 (United Nations Office for the Coordination of Humanitarian Affairs, 2014a; Grépin, 2015). The large aid inflows cushioned the fiscal space even though expenditure rose abruptly which culminated to 8.7 percent in Liberia, 5.4 percent in Sierra Leone, and 1.3 percent in Guinea in 2015 (World Bank, 2016).

This was the World's largest Ebola outbreak due to its uniqueness in size, complexity, duration, morbidity, and coverage. It was the 25th known Ebola Virus Disease (EVD) since the first outbreak in 1976 and affected 10 countries in three continents (Centres for Disease Control and Prevention (CDC), 2014; Ajisegiri et al., 2018). The World Bank estimated that potentially catastrophic consequences may cost up to $25 billion and likely to cost about $32.6 billion by the end of 2015 (WBG, 2014a; Bell et al., 2016). The spread began in the rural area to the more dense urban centres of countries characterized by a high poverty rate coupled with poor infrastructure and institutional settings (Malvy et al, 2019). On December 29, 2014, more than 20,000 infections have been reported with a death toll of 7900. In June 2015, the WHO announced a total of 22,000 children who lost either one or both parents due to the Ebola Virus Disease (UNDG-WCA, 2015). According to the World Health Organization (WHO), 4,809 death was recorded in Liberia, 3,955 death was recorded in Sierra Leone, 2,536 death in Guinea, 8 death recorded in Nigeria and 6 death in Mali culminating in a total death counts of 11,314.

On average, the mortality rate of infected persons was estimated to be 60% and mortality per capita was estimated to be 5 per 10000 for affected countries (World Bank, 2016). The factors that led to the wide-spread was the fragility of the health sectors, home treatment of infected persons, vulnerabilities from past civil wars, social values and structures such as relatively large size funeral rites, greeting, hugging, shaking of hands as well as touching, washing and arranging bodies for burial were rituals ingrained in the culture of Africans, damaged ecological system due to the extractive industry, and inadequate resources deployed in the diagnosis and treatment of infected persons (CDC, 2014; Kalra et al, 2014; Woldemariam & Di Giacomo, 2016; Ajisegiri et al., 2018). In this background, the distrust of government and medical doctors by indigenes was based on the pretense of wrongful diagnose of common illnesses and an acclaimed purported strategy by the government to induce foreign aid (Gostin & Friedman, 2015). The governments were ill-equipped to contain the spread due to corruption, and a lack of timely aid from the international community. As a result, it led to the protest of citizens against the legitimacy of government actions and accusation of misappropriated aid (Gostin & Friedman, 2015; Woldemariam & Di Giacomo, 2016; Bell et al., 2016). Also, the spiritual and superstitious connotations attached to the deceased at the early stages exacerbated the widespread of the disease. Furthermore, health workers and journalists that alarmed the upsurging canker were later declared dead notably in Guinea (Pietropaoli et al, 2015; Woldemariam & Di Giacomo, 2016). Additionally, the level of stigmatization attached to the virus- contracted persons discouraged testing and violated their fundamental right to equality and non-discrimination (MSF, 2014b, The Office of the High Commissioner for Human Rights, 2015). Consequently, patients with minor ailment refrained from visiting the medical centres due to fear of contracting the Ebola virus. Also, there were large protests against isolation centres in communities notably Monrovia, Liberia (Woldemariam & Di Giacomo, 2016). In the report, the WHO reported that 401 Health-care workers had contracted the virus with 232 death count by the end of October 5, 2014. This was attributed to the lack of Personal Protective Equipment (PPE) and poor infection control measures deployed such as inadequate sterilization techniques, reuse of needles, equipment among others (Madariaga, 2015). Kramer et al. (2016) showed that the widespread was facilitated by geographical features such as distance, population density, and border relations. To buttress, Woldemariam & Di Giacomo (2016) acknowledged a major causative factor to the porous nature of African borders. Epstein (2014) argued that the spread of the disease was highly political due to relatively poor infrastructure to contain the disease. The EVD was effectively contained in 2016 after its emergence in the West African sub-region. Nigeria and Senegal the first to be declared Ebola-free in October 2014 (WHO, 2014c), with reported 20 cases with 8 deaths and 1 case with no death respectively, followed by Sierra Leone in March 2016 then Guinea and Liberia in June. The Journal of Infectious Diseases estimated the societal and economic costs of the epidemic to be $58 billion which considered the cost of losing human life, infection control, treatment costs, and death caused by other diseases during the epidemic.

Undeniably, economic activities hitherto trade was brought to an abrupt halt for the most affected countries notably Sierra Leone, Liberia, and Guinea during the epidemic (AfDB, 2020; UNDG-WCA, 2015; Bowles et al, 2016). In effect, GDP per capita was averaged at $125 per person for the three most affected countries during the pandemic (World Bank, 2016). In 2015, the budget deficits were estimated at 8.5 percent of GDP in Liberia, 4.8 percent in Sierra Leone, and 9.4 percent in Guinea. According to the World Bank, there was a 40 percent decrease in the working force. Guinea, Sierra Leone, and Liberia lost $2.2 billion in GDP in 2015, with the private sector, agriculture, production, and trade heavily affected. As a result of the measures taken to contain the disease, the supply chain, and operations of both affected and non-affected countries were affected (British Standards Institution, 2014; Figuiré, 2016). As a result, the Ebola Virus Disease disrupted the economy's recovery and limited the progress on the Millennium Development Goals (MDGs) according to the 2015 United Nations Development Group for West and Central Africa (UNDG-WCA) report. In this background, it led to a decline in the per capita income of the three most affected countries (UN, 2014). Guinea was recovering from economic, political, and social crisis since 2011, Liberia had experienced 14 years of civil strife and the recovery of Sierra Leone from a devastating civil war from 1991-2002. The agriculture sector was affected due to restrictions on movement influencing production volumes, relatively tighter exports, and the loss of labour force through death. According to the World Food Programme (WFP), about a million people faced food shortages due to quarantines in the region. In this background, agriculture accounted for 57 percent of Sierra Leone's GDP, 39 percent of Liberia's, 20 percent of Guinea's, and 22 percent of Nigeria's GDP according to the Food and Agriculture (FAO). Statistically, the labour force which forms the economically active segment of the population (15-44 years) accounted for 59% of total infections by the Ebola Virus Disease in the phase of the poor health sector.

Also, the mining sector was affected due to disrupted production capacity through the shutdown of operations hitherto informal operations, and financial challenges faced by companies of the status quo notably London Mining, Arcelor Mittal SA, China Union, and Rio Tinto PLC, amidst a fall in the international price of bauxite, iron ore and gold at 30-60% during the epidemic (World Bank, 2016). Given this, the Ebola epidemic delayed mining projects meant to be filled by thousands of workers in Guinea, Liberia, and Sierra Leone according to the Wall Street Journal. Furthermore, the transport sector was affected which resulted in high transport costs, travel bans, and border closures which harmed tourism due to stigmatization on citizens and the fear of spread (Ajiboye et al, 2015; WHO, 2014, Shultz et al, 2016).

Unconventionally, one major problem that emanated from the spread of the disease was the conflicts between the populace against the traditional leaders, governments, and foreign investors. In this background, the change in the ecological system due to flooding and wildlife resulting from damages caused by extractive companies coupled with relatively small gains generated from these industries to improve living standards of the populace compounded to the spread of the disease (Redding et al, 2019). Also, some countries with no reported cases such as Cape Verde, Ghana, Gambia, Niger, Guinea Bissau, and Togo among others, were affected economically due to fear of possible outbreak notably the hospitality industry, even though stringent measures were deployed to avoid the spread of the disease across to countries of the status quo. According to the World Travel and Tourism Council, tourist arrivals went down by half from 2014 to 2014.

This has necessitated the investigation of the effect of the Ebola Virus Disease on trade in West Africa. In this background, the main objective of the study is to estimate the effect of the Ebola Virus Disease (EVD) on trade in West Africa. The specific objective is to estimate the effect of ECOWAS membership on trade in West Africa. To the best of my knowledge, there is no empirical study on the effect of the Ebola Virus Disease on trade in West Africa. The existing literature theoretically juxtaposes the effect of the disease in general, on the various variable of interests during the epidemic. This study seeks to estimate the effect of the Ebola Virus Disease on trade exports of affected nations to trading partners in the sub-region. Hypothetically, when countries are under trade treaties, there is a greater tendency of trade and movements across countries. In essence, countries are liable to spread diseases as well and necessitate the effect of ECOWAS membership on trade in West Africa since it is the exclusive body to oversee affairs of the sub-region and in support, all affected countries are members. The study will add up to existing literature on Ebola Virus Disease on trade and the impact of the Economic Community of West African States (ECOWAS) on trade in West Africa.

The rest of the paper is organized as follows: the next section provides the theoretical framework, model, and empirical strategy. Section 3 presents the data and measurement. Section 4 presents the results and discussion. The last section concludes the paper with some policy suggestions.

Literature Review

The Gravity model of international trade

In 1962, Tinbergen propounded the gravity model of international trade, with the then of intuition, emanating from the Newton law of gravity. The gravity model of trade intuitively posits that trade between the two countries depends on their economic strength (GDP or GNP) and inversely related to the trade cost. It states that for two countries to trade, it depends on their level of income and the distance between them. The greater the economic mass of the countries coupled with relatively small distances, then countries will tend to trade more and vice versa. It is calculated as the log product of their economic strength divided by the log distance (log values of the trade costs). The theory can be depicted as $Xij = C\frac{YiYj}{tij}$, where X_{ij} = trade from i to j, C is the constant, Y is the Gross Domestic Product (GDP) and t is the distance between the countries. The model has been consistent in its prowess of using real data to determine the sensitivity of trade flows concerning a policy component. The model is used to empirically investigate the effect of trade costs on trade.

It can be used to analyze the trade cost such as Tariff and non-tariff barriers, transportation cost, corruption, governance, contract enforcement, regional integration agreement, currency unions, and time delays at export/import, trade facilitation among others.

Empirical Literature Review

Adegun (2014) theoretically investigated the effect of the Ebola Virus on the Economy of West Africa through the trade channel using data from the National Bureau of Statistics. The study used graphical representations to explain intra-regional imports and exports of affected countries. The study showed that the Ebola Virus will affect the agricultural sector, mining sector, health, transport, education, and hospitality. The study also showed that the resultant effect would have fiscal impacts due to decreased revenue hitherto increased expenditure. The study concludes that if the virus is not highly contained in the short term, its economic repercussion will be devastating to West Africa. Etuk (2015) evaluated the Ebola disease by examining the West Africa perspective with much focus on the virus, affected countries, the role of the populace, West African and Western world responses to the outbreak, and international response notably WHO during the epidemic. Additionally, the study showed that the agricultural sector, health sector, education, and tourism were heavily affected during the epidemic. The study recommended the need for emergency preparedness and public utilities during disease outbreaks. Alexander et al (2015) examined the possible factors that might have led to the emergence of Ebola in West Africa. The study evaluated the Ebola emergence in the context of why now? And why in West Africa? To expatiate its ecological, sociological, political effect due to the historical implication on the current ameliorated state, and the environmental drivers to the emergence of the virus in line with the effect on humans. Also, the study emphasized the necessary protocols to ensure attenuating the outbreak. Additionally, the study showed that there was an increase in population, poverty, social unrest among others. The study concludes the exigency for prompt disease response in countries with limited resources and recommends the significance of international organizations and Non-governmental Organizations to help curtail the adverse effect of the disease outbreak. Omoleke et al. (2016) evaluated the Ebola Disease in West Africa as a threat to global health, economy, and political stability. The study deployed dataset and information from the World Health Organization (WHO) library and Information Networks for Knowledge database, PubMed, the Social Science Citation Index, WHO International Clinical Trials Registry Platform, among others. The study acknowledged the role of climate, population growth, economic activities, health, transport, trade, foreign investment among others. The study concluded that human factors notably poverty, weak health system, sanitation challenges, poor health-seeking behaviour, climatic change, a change in the ecological system, non-availability of a licensed vaccine among others, enhanced the spread of the disease. The study recommended that governments must be proactive in their commitment to providing quality healthcare facilities to curb any unforeseen health challenges in the future. Maffiola (2018) studied the political economy of health epidemics with a focus on the Ebola outbreak in West Africa. The study sampled out Liberia to evaluate the government response hitherto citizens' reactions to the efforts during the 2014 Ebola outbreak. The reactions of the citizens notably through voting showed if the government was accountable to its citizens. The data used in the study were sourced from the Ministry of Health and Burial teams, ETUs, CCCs, LISGIS, and NEC. The study showed that misplacement of government relief yielded different responses during the general election. The villages that first experienced the outbreak voted against the incumbent government whereas the preceding villages voted in favour. The study concludes that there was a strategic allocation of resources by governments to stimulate the electoral motives of citizens during the health epidemic. Piot et al. (2019) examined the emergent of threats resulting from the lessons learned from Ebola. The study delineated on the political, economic, and health challenges the Ebola disease unraveled on the Economy of West Africa. The study showed that the six lessons learned were; government strengthening its capacity to respond to outbreaks and commensurate domestic and international investment geared towards health care, the need for global action across sectors due to the adverse effect of outbreaks beyond borders, implementing standardized control measures to curtail outbreaks with more vigilance and pro-active decisions, the need for research investment into pathogens that causes outbreaks, social responsiveness as a common goal and the need to address pressing needs and indirect behaviours that affect outbreaks.

Methodology

To investigate the effect of the Ebola Virus Disease on trade, the augmented gravity model of international trade was used. The augmented model is stated as follows;

Model 1

The Effect of EBOLA on trade in West Africa

$X_{ij} = \beta_0 \, lnGDP_{ij} + \beta_1 \, lnPERCAPITA_{ij} + \beta_2 \, lnDISTANCE_{ij} + \gamma BORDER_{ij} + \delta LANG_{ij} + \theta COL_{ij} + \vartheta EBOLA + \beta_3 \, lnGE_{ij} + \beta_4 \, lnVA_{ij} + \beta_5 \, Vol_{ij} + \beta_6 \, lnPSij$ ………………………………………………………………………..3.1

Model 2

The Effect of ECOWAS membership on trade in West Africa

$X_{ij} = \beta_0 \, lnGDP_{ijt} + \beta_1 \, lnPERCAPITA_{ijt} + \beta_2 \, lnDISTANCE_{ij} + \gamma BORDER_{ij} + \delta \, LANG_{ij} + \theta COL_{ij} + \beta_3 \, INFRAS_{ijt} + \beta_4 TAR_{ijt} + \beta_5 \, RL_{ijt} + \beta_6 \, GE_{ijt} + \beta_7 \, VA_{ijt} + \beta_8 \, PS_{ijt} + \beta_9 \, CC_{ijt} + \sigma ECOWAS_{ijt}$……….......3.2

Where i and j denote countries, t denotes time, and the variables are defined: X_{ij} denotes the value of bilateral trade (exports) between i and j, Y is real GDP, *Pop* is population, D_{ij} is the distance between i and j , $BORDER_{ij}$ is a binary variable which is unity if i and j share a land border, *Lang* is a binary variable which is unity if i and j have a common official language, COL_{ij} is a binary variable which is unity if i and j were colonized by the same colonial master, $ECOWAS_{ij}$ is a binary variable which is unity if i and j are members of the ECOWAS and 0 otherwise, Vol_{ij} is measured as the standard deviation of the moving average of the log Real Effective Exchange Rate, ε_{ij} a vector of nuisance coefficients, and represents the myriad other influences on bilateral exports, assumed to be well behaved. Where I= 1, 2, ……N is the number of countries where N=16, t is the time-series dimension of the data (T=18 years), the coefficients $\beta_1\beta_2\beta_3\beta_4\beta_5\beta_6\beta_7\beta_8\beta_9$ are parameters for their respective variables where β_0 is the constant and ε is the error term. The coefficient of interest is ϑ and σ. The coefficient of Ebola is the relevant variable in the first model because not all countries were affected.

Estimation technique

Although authors recommend estimating the gravity model using a log linearized approach, it is now standard to estimate the AvW model with a fixed effect Poisson Pseudo Maximum Likelihood (PPML) since it controls for heteroscedasticity, zero trade and model misspecification (Gourieroux et al, 1984: Silva Santos and Tenreyro, 2011). Thus, the PPML includes observations with zero trade values of which linear estimation techniques will drop because the logarithm of zero is undefined which leads to sampling selection bias. As a result, the omission of relevant observations poses serious problems, and information is loosed (Eichengreen and Irwin, 1996). Furthermore, the robust standard errors do away with problems associated with panel data estimation. Also, PPML fits the data better by controlling for heteroscedasticity than a log-linear model since the error term has a variance occurring at a higher moment which can be influenced by one or more explanatory variables (Santos Silva and Tenreyro, 2006). Thus, the second and highest moment conditions are absent from the estimation procedure. Therefore, the coefficients of log linearized models can be highly misleading due to the presence of heteroscedasticity. Moreover, the PPML, unlike the log-linear estimator estimates the effect of policy variables on trade whereas the log-linear estimator estimates the policy variable on the log of trade which can be misleading. Additionally, the PPML is consistent with a small sample size as well as a large sample size. To buttress, the Monte Carlo simulation test on the best estimator for the gravity model of international trade stipulates the gravity model is best estimated as a non-linear model (Silva-Santo and Tenreyro, 2006; 2011).

Further studies on the best estimator for the coefficients of the gravity model is the PPML (Bobková, 2012; Martin & Pham, 2015, Vavrek, 2018). Given this, the PPML estimation technique becomes the best option to estimate the parameters.

Data and Measurement

The study used a dataset with 4,320 bilateral trade observations spanning from 2000 to 2017 (some observations are missing for the dependent variable). The study used sixteen countries in the West Africa sub-region. A summary of all of these variables, how it is defined, measurement and data sources are presented in Tables 1. Table A1 in the Appendix presents the variables in the model, description, measurement, and expected signs.

Table 1

Definition of variables and data source

Variables	Measurement	Source
Bilateral trade	Export value at levels	IMF Direction Of Trade (DOTs) & UN Comtrade
GDP	log product of GDP at constant $	World Bank's World Development Indicators
GDP per capita	log product of GDP per capita at constant $	World Bank's World Development Indicators
Distance	log product of distance value between country-pairs	CEPII
Tariff	Log product of tariff value	World Bank's ESCAP
Government Effectiveness	Log product of values	World Bank's World Governance Indicators
Voice and Accountability	Log product of values	World Bank's World Governance Indicators
Political Stability and Absence of violence	Log product of values	World Bank's World Governance Indicators
Trade and Transport infrastructure	Log product of values	World Bank's Logistics Performance
Rule of law	Log product of values	World Bank's World Governance Indicators
Corruption Control	Log product of values	World Bank's World Governance Indicators
Volatility	The standard deviation of the moving average of log Real Effective Exchange Rate (REER)	World Bank's World development indictors and Polity V

Variable definition

The export of goods was used as a proxy for bilateral trade between the reporting country and the partner in line with each country's attempts to balance its trade with the other. The data on exports were reported at the levels to suit the non-linear estimation technique procedure. The variable was adopted in the model to represent trade flows between countries since the level of imports is usually underestimated. GDP was used to proxy for the economic mass of the country in the model. The study expected GDP to have a positive relationship with trade. It was measured as the log product of the GDP of country-pairs. GDP per capita was used as a proxy for all other controls that were not specified in the model. The coefficient of GDP per capita used is expected to have a positive relationship with trade. It was measured as the log product of GDP per capita of the country-pairs in the model. Distance is the transportation cost involved in trading between the two countries. The coefficient of distance is expected to have a negative relationship with trade. The higher the transportation cost, the higher the price of the goods to be traded and vice versa. This is because, as distance increases the cost of trading among countries ostensibly increases thereby reducing the volume of trade. GDP per capita was used as a control variable for the effect of institutions on trade to represent market size based on theory. This paper employs five different key indicators of institutional quality as provided by the World Governance Indicators, WGI (2019) database namely; rule of law, voice and accountability, political stability and Absence of Violence, control of corruption and government effectiveness. Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

Also, the control of corruption was captured as the perception of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as the capture of the state by elites and private interests. Furthermore, Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

Voice and Accountability as defined by WGI, Voice and Accountability captures perceptions of the extent to which a country's citizens can participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. Finally, Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism. The various indicators of institutions were measured as the log product of the country-pairs. Tariff is defined as the taxes charged on goods and services imported. According to the World Bank ESCAP, Tariff answers the question, 'Evaluate the effect of tariffs about agricultural goods.' The coefficient of tariff is expected to harm trade. It was measured as the log of the value for the country-pairs. According to the World Bank Logistics Performance Index, the component "Quality of trade- and transport-related infrastructure" includes results from the survey question "Evaluate the quality of trade- and transport-related infrastructure (e.g. ports, railroads, roads, information technology) in-country. The coefficient is expected to have a positive impact on trade. It was measured as the log product of the country-pairs. Real Effective Exchange Rate (REER) as computation of exchange rate volatility due to recent developments in academia (Serenis & Tsuonis, 2014).

Border is defined as the geographic boundaries of political entities such as countries, provinces, states amongst others. The coefficient of sharing a land border is expected to have a positive relationship with trade. Spatial theory of trade depicts that countries sharing border tends to cooperate to enhance trade. The coefficient of Language is expected to have a positive relationship with trade. Adam Smith argued in 'Wealth of Nations' that common language enhances trade and exchange through effectively communicating the task in hand to the trading partners and easily convincing parties to know it is in their best interest.

Modelling the Effect of Disease on Trade

The traditional determinants of trade are GDP, distance, border, common language, and common colonizer. Variables such as Government Effectiveness, Political Stability and Absence of Violence, and Voice and Accountability were introduced into the model. The rationale for these variables is as follows; Disasters are a unique test of governmental accountability (Maffioli, 2018). Also, governments have the opportunity to influence voters, through their responsiveness to crises on how well they can perform. Therefore *Government Effectiveness* was a good proxy for the model. On the other hand, citizens have a chance to learn about the incumbent government's capacity and thus ensure electoral accountability at the time of voting (Maffioli, 2018). Therefore, *Voice and Accountability* was a good proxy for the populace. Additionally, the disease outbreak aroused anger and violence of the populace against their respective governments and traditional leaders, therefore, *Political Stability and Absence of Violence* was a good proxy (Foucault, 1975; Camus, 1991; Price-Smith, 2008; Woldemariam & Di Giacomo, 2016; Omoleke et al., 2016). Trade and transport infrastructure were affected during the Ebola epidemic due to increased price hitherto limited distance coverage resulting from restrictions (AGOA, 2015). Therefore the *quality of trade and transport infrastructure* was a good proxy. Additionally, the decline in economic activities will affect currency performance which would increase the cost of international trade. In this context, *exchange rate volatility* was introduced in the model. Therefore, understanding the efficacy of and motives behind the response to disasters is of paramount policy relevance to provide the right incentives for governments to act appropriately in times of crisis (Maffioli, 2018). Foreign Direct Investment inflow was excluded because its inclusion did not improve the model. However, in regions where FDI inflow has a significant effect on trade, there is a need to add FDI inflow to improve the model.

Modelling the Ebola Disease in the Gravity Model of international trade

The essential factors in the modelling of the disease are the period of occurrence, the affected countries, capturing period ex-ante and ex-post of the disease, and the intra-regional importers of the exports of the affected countries (trading partners in West Africa) since export will dwindle. Using annual data, weight is given to the number of months the disease was prevalent, and its intensity. The period (year) before and after the disease is assigned as 1. The period (year) that the disease affects trade volume of the affected country to trading partners is assigned as 0.

Empirical Results and Discussion

Table 2

PPML estimates for Ebola Virus Disease on Trade in West Africa

Variables	Coefficients
GDP	2.584 **
	(1.029384)
GDP per capita	2.216
	(1.801548)
Distance	-.004 ***
	(.0007524)
Border	2.049**
	(.9703325)
Language	-.233
	(1.55074)
Colonizer	.710
	(1.772207)
Ebola	-1.705 ***
	(.521639)
infrastructure	-12.712 **
	(0.011)
Government Effectiveness	-2.291
	(2.543568)
Voice and Accountability	4.661 ***
	(1.203261)
Volatility	3.056
	(3.102469)
Political Stability and Absence of Violence	3.760
	(1.341768)
_cons	-35.891 **
	(15.61771)

Note: *, ** and *** represent rejection of null hypothesis at 10%, 5% and 1%.
Robust Standard Errors are in the parenthesis.

Author's Estimates

The coefficient of Ebola is found to be negative with an estimated coefficient of -1.705 and statistically significant at 1%. The results show that the Ebola Virus Disease reduced intra-trade exports of affected countries to its partners by two folds, all else equal. This is not startling because the three most affected countries were on the verge of collapse hitherto economic growth dwindled (Adegun, 2014; Etuk, 2015, AfDB, 2019).

Table 3

PPML estimates for the Effects of ECOWAS membership on trade in West Africa

Results for currency union effect on intra-regional trade.

Variables	Coefficients
GDP	.849 **
	(.3962187)
GDP per capita	1.630 *
	(.9239736)
Distance	-.001 **
	(.0003867)
Border	-.0405
	(.3686981)
Language	-.429
	(.7932172)
Colonizer	1.157
	(.7311446)
infrastructure	.578
	(.9158292)
Tariff	.482
	(.3561939)
RL	.655
	(.563937)
GE	.182
	(.8081201)
VA	-.055
	(.3405651)
PS	-.019
	(.2437592)
CC	-.047
	(.1645486)
ECOWAS	2.004***
	(.7588316)
_cons	-11.605 **
	(4.859767)

Note: *, ** and *** represent rejection of null hypothesis at 10%, 5% and 1%.

Robust Standard Errors are in the parenthesis.

Author's Estimates

The coefficient of ECOWAS was positive with a coefficient of 2 and significant at 1%. The result shows that ECOWAS membership doubles the level of trade of members in West Africa. This is not startling because regional trade agreement stimulates trade flows of member-states by eliminating some barriers to trade. Additionally, the ECOWAS had been a voice in ensuring political and economic sustainability, to ensure growth in the sub-region.

Policy Recommendation and Conclusion

The analysis shows that the variables of interests have a significant effect on trade in West Africa. In this context, the study showed that the Ebola Virus Disease reduced trade export shares of affected countries to their intra-regional partners by two folds. The study also showed that ECOWAS membership doubled the level of trade. Ebola was found to have a negative and statistically significant effect on trade in West Africa. In a nutshell, poor regions are most likely to have a greater repercussion on trade hence economic growth when there is an outbreak. In this background, the study recommends that there should be proactive measures towards the potential outbreak of disease by ensuring good sanitation and personal hygiene as well as the preservation of natural habitats through education. Also, hotspots of reported outbreaks should be well broadcasted to ensure stringent measures are taken in areas of the status quo. More so, since the duration of symptoms for most viruses is two to three weeks, there is a need for a month nationwide lockdown with caveats for food suppliers. Furthermore, the notification of an outbreak in any part of the world should signal the implementation of stringent measures at the entry point of countries. In this context, travelers are to be quarantined for a month before allowed to enter the country as a policy variable. Also, evaluating the risk of spread on a national basis to flatten the curve of the spread. Additionally, the ECOWAS should invest more in medical research with herbal drugs inclusive and a potential vaccine for virus-related diseases. Also, countries should initiate on the spot fine of culprits that will incentivize the government and the reporter of the culprits. The ECOWAS membership was found to have a positive and significant effect on trade in West Africa. Therefore, ECOWAS should be proactive in ensuring a sound political and economic environment by improving upon the trade and transport infrastructure specifically railway due to the topography of the land and a relatively cheaper and faster means of transport. Also, the ECOWAS should attenuate the effect of any notable trade barriers to stimulate further trade. Additionally, a medical test result of at least three weeks should be stipulated and emphasized criteria before travelling from one country to another within the sub-region. The study also recommends that there is a relatively greater incentive for Mauritania in rejoining the ECOWAS as compared to its current membership in the Arab Maghreb Union (AMU).

The Effect of Ebola on trade

Number of parameters: 13
Number of observations: 123
Number of observations dropped: 0
Pseudo log-likelihood: -1.677e+09
R-squared: .96067316

(Std. Err. adjusted for 32 clusters in pairings)

trade	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnGDP	2.583855	1.029384	2.51	0.012	.5662989	4.601412
lnpercapita	2.216443	1.801548	1.23	0.219	-1.314526	5.747413
lndistance	-.003814	.0007524	-5.07	0.000	-.0052888	-.0023393
border	2.049413	.9703325	2.11	0.035	.147596	3.95123
lang	-.2334202	1.55074	-0.15	0.880	-3.272814	2.805974
colonizer	.7095882	1.772207	0.40	0.689	-2.763874	4.18305
Ebola	-1.704759	.521639	-3.27	0.001	-2.727152	-.6823652
infrastructure	-12.71167	5.017295	-2.53	0.011	-22.54539	-2.877952
GE	-2.291091	2.543568	-0.90	0.368	-7.276393	2.694212
VA	4.660808	1.203261	3.87	0.000	2.30246	7.019156
volatlity	3.055929	3.102469	0.98	0.325	-3.024799	9.136657
PS	3.760022	1.341768	2.80	0.005	1.130205	6.38984
_cons	-35.89109	15.61771	-2.30	0.022	-66.50123	-5.280954

The Effect of ECOWAS membership on trade in West Africa

```
Number of parameters: 15
Number of observations: 363
Number of observations dropped: 0
Pseudo log-likelihood: -1.902e+10
R-squared: .53173236
                                (Std. Err. adjusted for 78 clusters in pairings)
```

trade	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnGDP	.8491892	.3962187	2.14	0.032	.0726148	1.625764
lnpercapita	1.629767	.9239736	1.76	0.078	-.1811875	3.440722
lndistance	-.0008047	.0003867	-2.08	0.037	-.0015626	-.0000468
border	-.0404739	.3686981	-0.11	0.913	-.7631089	.6821611
lang	-.4294525	.7932172	-0.54	0.588	-1.98413	1.125225
colonizer	1.156959	.7311446	1.58	0.114	-.2760577	2.589977
infrastructure	.5782084	.9158292	0.63	0.528	-1.216784	2.373201
Tariff	.4815705	.3561939	1.35	0.176	-.2165567	1.179698
RL	.6551379	.563937	1.16	0.245	-.4501584	1.760434
GE	.1817317	.8081201	0.22	0.822	-1.402155	1.765618
VA	-.0554966	.3405651	-0.16	0.871	-.722992	.6119987
PS	-.0189212	.2437592	-0.08	0.938	-.4966805	.458838
CC	-.0471887	.1645486	-0.29	0.774	-.369698	.2753206
ECOWAS	2.004066	.7588316	2.64	0.008	.5167831	3.491348
_cons	-11.60545	4.859767	-2.39	0.017	-21.13042	-2.080483