TRADE LIBERALIZATION AND INFRASTRUCTURE DEVELOPMENT: EVIDENCE FROM THE ECONOMIC COMMUNITY OF WEST AFRICAN STATES

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Abstract

Not much is known in the literature concerning the role of trade-oriented policies in promoting infrastructural development particularly for African countries. This study examines the role of trade liberalization on infrastructural development in Africa using data from 15 member-countries in the Economic Community of West African states (ECOWAS) over the period 1993 to 2018. Data was obtained from the World Bank's World Development Indicators and the African Development Bank. Measures of infrastructure considered include transport, energy, telecommunication and the composite infrastructure index. Findings are provided with use of the PARDL model. The results showed no significant effect of trade liberalization on all measures of infrastructure except for telecommunication where significant positive effects were observed but only in the long run. Long run estimates also showed negative effect of increase in tax revenue on infrastructure development specifically for transport. Findings further showed positive effects of increase in real income on energy and the composite index on infrastructure in the long run with short run results depicting negative effects. Evidence provided suggests the key role of trade liberalization in boosting infrastructure development mainly for telecommunication. In pursuing trade-oriented programs, governments in the region should focus on promoting infrastructure in the areas of transport and Energy as the region will continue to lag behind in these key areas in the advent of trade policies. Efforts should also be made to increase budgetary allocations to infrastructure investment in the attempt to maximize trade benefits and ensure sustainable development. This again is important as governments in the African region seek to pursue larger trade bloc operations in the AfCFTA.

Keywords: Trade Liberalization, Infrastructure, ECOWAS, Heterogeneous Panel Data
JEL Classifications: F10, F15, O18

Introduction

Trade liberalization is a universal concept that has received much attention in the global sphere. This is not surprising because of potential economic benefits embedded in implementing trade-oriented policies (Modeste, 2019; Osakwe, et al. 2018; Guei & Roux, 2019; Muhugeta, Sanfillipo & Sundaram, 2018). For instance, policies that favor trade induce static gains or savings when countries do not produce imported goods for which the opportunity cost of domestic production is high. There are also dynamic benefits associated with trade and in this case, it stimulates innovation, technological advancement, competition and sometimes changes in attitudes and institutions that in turn promote economic outcomes (Nowak-Lehmann, 2003; Baldwin, 1992). Policy initiative to maximize trade benefits are often seen in terms of trade bloc operations.

The introduction of trade blocs is recognized to have strengthened international transactions across regions and initiated noticeable increase in private sector development, improvement in infrastructures and strong institutions (EDA Report, 2009). In West Africa, trade bloc operations particularly that of the Economic Community of West African States (ECOWAS) have gained significant attention in recent times. This follows from the agreement by member-countries to launch a new currency in 2020 (Ordu, 2019). The ECOWAS trade liberalization scheme was introduced in 1975 and the main intent was to integrate ECOWAS regional markets in order to improve regional supply side capacity and generate economies of scale and scope. These objectives are pursued through effective cooperation on regional infrastructure and other trade facilitation measures (Umoh & Onye, 2013; Guei & Roux, 2019).

In terms of infrastructural development, the African continent lags behind other regions of the world (Foster & Briceño-Garmendia 2010; Escribano, et al. 2008). Evidence in the literature shows that this shortcoming explains the low transaction in trading activities in the region particularly across trade blocs. Studies that have examined the role of infrastructure in economic performance commonly explore the linkage with economic growth and development (Agenor et al, 2006; Palei, 2015; Muhia et al, 2019). There are also attempts to determine the role it plays in achieving trade improvements particularly in developing economies (Olarreaga, 2016; Gurara et al, 2018; Muhia et al, 2019). However, not much is known concerning the role of trade-oriented policies in promoting infrastructural development especially among countries that operate regional trade blocs. The link between trade liberalization and infrastructure development follows from the free flow of technology, innovation and productivity that in turn impact on overall income level and consequently increased public spending on infrastructural development. This argument is rooted on trade improving macroeconomic income level (Salinas & Aksoy 2006; Majeed et al. 2010; Amjad et al. 2012; Were 2015). Positive effects of trade liberalization on industrial sector performance also have some linkage with infrastructural development as firms invest more on basic infrastructural facilities that promote business operations in order to maximize the benefits of trade (Francois & Manchin, 2013; Sawada, 2015; Ismail & Mahyideen, 2015). In this case, there are likely to be seen, some rise in key infrastructure facilities such as information and communication technology, electricity production and road network. There can also be direct links of trade liberalization with infrastructural provision in terms of new knowledge and ideas that promote production technology for creation of new infrastructure and maintenance of existing ones. Essentially, more liberalized trade should ordinarily promote better technology inflow that induce direct and indirect benefits on infrastructure development.

Despite this association, not much is known concerning the link between trade liberalization and infrastructural development. Focus on this area of study is key to determine whether economies in Africa ordinarily lagging behind other nations have some chance of improving in the level of infrastructure by engaging in international trade (AFDB, 2016). This study essentially determines whether trade liberalization has any influence on infrastructural development in African economies using data from member countries in ECOWAS. Findings are provided for the role of trade liberalization on transport, energy and telecommunication infrastructure. Findings are also shown for the infrastructural index that encompasses more measures of infrastructure. In line with the study objective, contribution of this paper to the literature is in two ways. The first is that findings are provided for the role of trade liberalization in promoting infrastructure development in the ECOWAS. This is important because not much findings are provided in the literature in this regard particularly for ECOWAS. More so, as countries in the African Union pursue implementation of the African Intercontinental Free trade Agreement (AfCFTA), evidence provided will show the potential of the AfCFTA policy in promoting infrastructure in the region. Second, the study provides empirical evidence of the effect of trade liberalization on infrastructure development both in the short and long run and across several infrastructural measures. This will shed light on not only whether the effect exists, but also if the impact is in the long run or only works for a short run period. Findings in this regard are also uncommon in the literature. Thus, the paper is arranged in five sections, the introduction, review of relevant literature, methodology, presentation and discussion of results and concludes with some policy recommendation.

Literature review

Adam Smith (1776), provides clear discussions of the link between international trade and economic development using the concept of absolute advantage. Further argument in support of trade deal was provided by Ricardo (1817) who argued that liberalized trade leads to a "win-win" situation. This situation implies that liberalized trade enhances production and consumption efficiency, which would improve the welfare conditions of the countries involved (Emagne, 2017). Also, the endogenous growth theories have shown over time that liberalizing trade has direct positive effects on growth and this is expected to have spillover effects on

infrastructural development, hence a rise in macroeconomic income and development. Lin (2012) New Structural economic theory which focuses on the structural perspective supports that investment in public infrastructure to a large extent leads to transformation in the economy. Infrastructural development is seen as a great economic transformation which is important to increasing trade and a country's capability.
Several studies have examined the effect of infrastructure on trade and that of trade liberalization on key macroeconomic variables with findings that can be linked to infrastructure development; but the effect of trade liberalization on infrastructural development is not well established. For instance, Khattry (2003) provides findings for the impact of trade liberalization on the level and structure of government expenditure across low-income countries. This study made use of panel data analysis for 80 developing and industralised countries over the period 1970 to 1998. Findings were provided with use of the fixed effect regression to account for country specific characteristics. The study found that trade liberalization led to a fall in tax revenue and increased interest expenditures. That is, policies that promote trade liberalization lead to fiscal squeeze due to fall in tax revenue and increased interest expenditure. In linking this to infrastructure development, the fall in tax revenue will in turn lead to reduced government spending on infrastructure. Nordas et al (2004) for instance looked at the quality of infrastructure in terms of transport (Road and Airport), telecommunication and customs clearance on total bilateral trade, taking into account trade barriers, transport costs and the cost of information. Using the ordinary least square estimation technique, findings reveal that a crucial determining factor of trade performance is the standard of infrastructure. In this study, port efficiency had the largest impact on trade when compared to other infrastructure, while timeliness and access to communication were relatively more important for export competitiveness.

Findings by Rojas et al (2005), took into account distance, import, trade flows and Gross domestic product in examining the effect of infrastructure on trade patterns in ANDEAN community. The results suggest that improvements in infrastructure increase the level of trade activities. This happens because it leads to reduction in production cost and increased access to international market particularly for transportation infrastructure. Bond (2006) examined the link between trade openness and the level of investment in trade related infrastructure, taking into consideration the interactions between trade agreements and infrastructure, as well as cooperative and non-cooperative infrastructure levels in a two-country, two-good model. Findings showed that the relationship between cooperative and non-cooperative investment level depends on the impact of two forms of spillover between countries. The spillover results vary from substitutes/complements between infrastructure investment in neighbouring countries and also from changes in the terms of trade which occurs as a result of the pattern of trade between countries. Similarly, evidence provided by Edmonds and Fujimura (2006), showed that domestic road infrastructure leads to increased trade. However, when considering both cross-border and domestic road infrastructure, cross-border has a positive relationship with trade while domestic infrastructure has a negative relationship with trade. Using the selection-based gravity model of trade to examine the effect of infrastructure, institutional quality, colonial and geographical context and trade preferences on the pattern of bilateral trade, findings by Francois (2007) suggest significant effects of access to well-developed transport and communications infrastructure on export performance and the propensity to take part in trading systems. Another key determinant identified as an influencer of trade is the quality of institution. The role of infrastructure and institutions on trade performance was also examined by Vijil and Wagner (2010). Findings conform to previous evidence showing significant effects of infrastructure on trade sectoral flows, while institutions have limited impact on developing countries'exports. Njikam (2009) examined the effect of infrastructure on industry productivity in Cameroon. The study found that infrastructure stock index had a significant contribution to output growth and increased productivity in both pre and post reform period. However, infrastructural quality had significant effect on productivity in the post reform period. In a related study, findings by Babatunde (2011), on the relationship between trade openness, infrastructure, foreign direct investment and economic growth in sub-Saharan Africa showed that interaction between trade openness and infrastructure leads to increase in international transactions, specifically in foreign direct investment flows. Results provided by Suleiman and Albiman (2014) in Malaysia, showed key role of infrastructure on trade and economic growth specifically in the short run. In this case, the results suggest that tourism, trade, infrastructure and economic growth interact and reinforce each other directly or indirectly.

Evidence provided by Deen-Swarray et al (2012) on the state of infrastructure in ECOWAS and its impact on intra-regional trade showed that existing road infrastructure for member-countries is not sufficient to ensure effective intra-regional trade and as such has led to high transport costs which limits trade. Additional results showed that distance had a negative impact on total trade, exports and imports within the region, while ease of accessibility had positive effects on intra-regional imports. In a similar study, findings by Shepherd (2016) on the interdependence between trade facilitation, infrastructure and the value chain connectivity in SSA showed that SSA countries are relatively marginalized because of high levels of trade costs. More so, weak inter-regional links in the region led to heavy reliance on external markets. Findings suggest that improving infrastructure and trade facilitation is a major avenue for African countries to benefit from global and regional value chain connectivity. Mitra et al (2014) examined some changes in trade policy and its effect on firms" productivity and efficiency in India. The study also looked at the role of exports and imports as an outcome of liberalizing trade, research and development, technology transfer and infrastructure endowment on manufacturing sector performance from 1994 to 2008. Findings from the study show that transport, ICT and energy infrastructure are very important determinant of manufacturing performance in India. The study also found that exports led to knowledge transfer than imports, while research and development is not a productivity enhancing activity and firms tend to rely on purchasing foreign technology.

Findings by Bankole et al (2015) strengthen arguments for key role of infrastructure in Africa with evidence showing that infrastructure development in ICT has a consequential and positive effect on Intra-African trade flows. The results by Donaubauer et al (2015) on the impact of infrastructure on bilateral trade for a panel of 37 developed and emerging economies corroborate findings shown by Bankole et al (2015). In this case, infrastructure such as transportation, communication, energy and finance showed significant and nonlinear effects on trade of consumption goods, capital goods and intermediary. Similar evidence was shown by Ismail and Mahyideen (2015) but in this case the focus was on hard and soft infrastructure and its impact on trade volume for exports and on various economic growth indicators. The results showed that improvements in transport infrastructure (road density network, air, railways, ports and logistics) led to increased trade flow. Of key note was that ICT infrastructure led to increase in trade, as the number of telephone lines, mobile phones, broad band access, internet users and secure internet services were found to positively affect trade for both exporters and importers in Asia. Findings by Isaac and Ntale (2017) on the impact of economic infrastructure on the exports of manufacturing products for the East African Community (EAC) showed that improvements in infrastructure led to huge gains in export of manufactured products. Findings also showed that there are more benefits from hard infrastructure compared to soft infrastructure. Rail, roads and air infrastructure were also shown to be key in boosting exports in the EAC region. Telecommunication and internet connectivity were shown to induce improvements in the business environment of the EAC.

Evidence provided for non-African region such as those in the Asia-pacific countries on the role of infrastructure on trade showed no significant effect of infrastructure stock and its quality on trade (Raychaudhuri & De, 2010). The implication in this case is that improvement of infrastructure is not an important factor for the evolution of more trade. However, recent findings by Li et al (2019), on the impact of transport infrastructure on trade for selected provinces affected by the One Belt, One Road (OBOR) Initiative proposed by China railways and highways, support the key role of infrastructural development on trade. The evidence revealed that transport infrastructure diversity affects trade in the Chinese province affected by the one belt, one road initiative. Similarly, findings by Rehman, Noman and Ding (2020) on the impact of infrastructure on export and trade deficit in selected South Asian countries, showed significant long run impact of aggregate and sub-indices of infrastructure on exports and trade deficits. The evidence suggests that infrastructure positively promotes export and negatively affects trade deficits. Lopez et al (2020) examined the effect of infrastructure quality on trade balances and if a country trade performance was better off post trade liberalization. The study found that differences in infrastructure quality contribute towards bilateral trade imbalances and the effects are emphasized by trade liberalization. In addition, it was shown that infrastructure development needs to occur before or at the same time with liberalizing trade in order to prevent its negative effect on developing economies. Jiya et al (2020) examined the long run effect of economic infrastructure and trade openness on the evolution of manufacturing and service sectors for 14 selected COMESA member countries from 1993 to 2016. Findings show a significant long run dampening effect of trade openness on its relationship between economic infrastructure and manufacturing and economic infrastructure and service output.

Overall, literature evidence showed significant role of infrastructure on trade activities; however, not much evidence is provided for the role of trade on infrastructural development despite the possibility of this linkage. This is particularly motivating with the key role of infrastructure such as Transport, Telecommunication and Energy in promoting trade activities. With the intent of the ECOWAS to raise infrastructure among member countries, examining the role of trade liberalization on infrastructural development is of key concern in the region.

Methodology

Slope homogeneity

In examining the role of trade on infrastructure development among member countries in ECOWAS, we first examined the nature of the slope for the proposed model of the study to check for slope homogeneity/heterogeneity. This is to determine the model that best suits the data set given that the study made use of panel data. Ignoring slope heterogeneity could lead to biased results (Bersvendsen & Ditzen, 2020). Cases of the existence of homogenous slope require the use of models such as the fixed and random effects model or the generalized method of moment estimator; whereas, models with heterogeneous effects include the SURE, mean group estimator and the Panel Autoregressive Distributed Lag (PARDL) model, where the estimations are carried out by three different estimators: the Pooled Mean Group (PMG), Mean Group (MG), and the Dynamic Fixed Effect (DFE) (Samargandi, Fidrmuc & Ghosh, 2014; Bersvendsen & Ditzen, 2020). The use of these techniques allows taking into account country-specific heterogeneity (Samargandi, et al., 2014). Some of the tests used for examining slope homogeneity include the F-Test (requires T > N), the Hausman style tests (valid only if N > T and require strongly exogenous regressors. The xthst test based on Pesaran and Yamagata (2008) and Blomquist, Westerlund (2013) that performs a test of slope homogeneity in panels with a large number observations of the cross-sectional (N) and time (T) dimension. This test can be used for both balanced and unbalanced panels, supports strictly and weakly exogenous regressors, cross-sectional dependence and serial correlated errors (Ditzen & Bersvendsen, 2019; Bersvendsen & Ditzen, 2020). Others include the Bootstrap approaches by Blomquist and Westerlund, (2016), the Delta Test by Pesaran and Yamagata, (2008) and the HAC robust version by Blomquist and Westerlund, (2013). We determine the nature of the slope in the data using the equation

$$Y_{i,t} = \alpha_i + \beta_{1i}' X_{1i,t} + \beta_{2i}' X_{2i,t} + \epsilon_{i,t} \tag{1}$$

Where $i = 1, \dots N \ and \ t = 1, \dots T$. In line with equation 1, we test if the effect of the independent variables say $X_{1i,t}$ and $X_{2i,t}$ on the dependent variable $Y_{i,t}$ is the same across all cross sectional units. That is, we regressed the independent variables for each of the models on the respective dependent variable to determine if the slope coefficient is homogenous. We made use of the xthst test based on Pesaran and Yamagata (2008). The choice of this test follows from the flexibility in its application to both balanced and unbalanced panels, and supports strictly and weakly exogenous regressors, cross-sectional dependence and serial correlated errors.

Cross sectional dependence

We further checked for cross sectional dependence to determine the type of unit root test statistics that will be used in the study. Panel data can be subject to pervasive cross-sectional dependence, whereby all units in the same cross-section are correlated (De Hoyos & Sarafidis, 2006). This is commonly due to the effect of some unobserved common factors. In this study we made use of the Lagrange multiplier (LM) test, developed by Breusch and Pagan, (1980). The LM test is used for testing for cross-sectional dependence in panel-data models. When T >N.

This is illustrated using the standard panel-data model:

$$Y_{i,t} = \alpha_i + \beta X_{i,t} + \mu_{i,t} \tag{2}$$

$i = 1, \dots N \ and \ t = 1, \dots T$

where $X_{1i,t}$ is a K × 1 vector of regressors, β is a K × 1 vector of parameters to be estimated, and αi represents time-invariant individual nuisance parameters. Under the null hypothesis, uit is assumed to be independent and identically distributed (i.i.d.) over periods and across cross-sectional units. Under the alternative, uit may be correlated across cross sections, but the assumption of no serial correlation remains.

Panel unit root test

First generation of panel unit root tests are generally based on the cross-sectional independency hypothesis and hence are only appropriate in cases of no cross-sectional dependence and homogenous panel data. (Hurlin & Mignon, 2007)[i]. Cases of the existence of cross-sectional dependence and heterogeneous panel require the use of second-generation panel unit root test. These tests are well documented in the literature[ii]. In this study we made use of the Pesaran (2003) approach to deal with the problem of cross-sectional dependencies. This approach augments the standard Dickey-Fuller or Augmented Dickey-Fuller regressions with the cross-section average of lagged levels and first-differences of the individual series. If residuals are not serially correlated, the regression used for the ith country is defined as:

$$\Delta y_{i,t} = \beta_i + \alpha_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta \bar{y}_t + v_{i,t} \tag{3}$$

Where $\bar{y}_{t-1} = (\frac{1}{N}) \sum_{i=1}^{N} \gamma_{i,t-1}$ and $\Delta y_{t=} (\frac{1}{N}) \sum_{i=1}^{N} \gamma_{i,t}$

The Pesaran's test is based on these individual cross- sectionally augmented ADF statistics, denoted as CADF and cross-sectionally augmented IPS[iii] denoted as CIPS (Hurlin & Mignon, 2007).

The null hypothesis states the presence of unit root while alternate hypothesis suggests stationarity in the panel.

Empirical model specification for the effect of trade liberalization on infrastructural development

To empirically determine the effect of trade liberalization on infrastructural development in ECOWAS, this study made use of the Panel Autoregressive Distributed Lag (PARDL) model. This model accommodates cases of panel heterogeneity. The PARDL model provides findings for the effect of the independent variables on the explained variable both in the short and long run. (Kannadhasan, Aramvalarthan, Balasubramanian & Aishwaya, 2017).

The unrestricted specification for the autoregressive distributed Lag (PARDL) model for time periods *t=1, 2…..T* and groups *i = 1, 2, …N* with the dependent variable y as shown below;

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} (y_{i,t-j}) + \sum_{j=0}^{q} \theta_{ij} (x_{i,t-j}) + \varepsilon_{it} \tag{4}$$

Where y_{it} stands as the scalar dependent variable, *xit* stands as the k*x1* vector of explanatory variables for group *i*, *u* denoted the fixed effects, λ_{ij}stands as the scalar coefficients of the dependent variables and $\gamma_{ij}s$ stands as the *kx1* coefficient vectors.

Conversion of equation (4) into re-parameterized form gives;

$$\Delta \mathrm{y}_{it} = \phi_i y_{i,t-1} + \beta'_i x_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij} \, \Delta \mathrm{y}_{i,t-j} + \sum_{j=0}^{q-1} \theta'_{ij} \, \Delta x_{i,t-j} + \varepsilon_{it} \tag{5}$$

Based on the assumption that the disturbances $\varepsilon_{it}s$ were independently distributed across *i* and *t*, given zero means and variances to be δ_i^2>0. Also, based on further assumption that ϕ_i <0 for all *i*. the existence of a long run relationship between y_{it} and x_{it} can be defined by

$$y_{it} = \theta'^{x_{it}} + \eta_{it} \tag{6}$$

$$i = 1, 2, \dots \dots \dots \dots . N; t = 1, 2 \dots \dots \dots \dots T$$

Where $\theta_i = {}^{-\beta'_i}\!\big/_{\theta_t}$stands as the *kx1* vector of the long run coefficient and $\eta_{it}\, s$ stands as stationary with possibly non zero means (including fixed effects). This implies that equation 4 can also be written as;

$$\Delta y_{it} = \phi_i \eta_{i,t-1} + \sum_{j=0}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \gamma_{ij} \Delta x_{i,t-j} + \varepsilon_{it} \tag{7}$$

Where

$\eta_{i,t-1}$ Stands as the error correction term with ϕ_i representing the error correction term coefficient which measures the speed of adjustment towards the long run equilibrium.

This method also assumes that error terms are not serially correlated and independent variables follow and are identically distributed. For this study, the lag length is 1 for all the variables. According to Pesaran et al. (1999), an ARDL dynamic heterogeneous panel regression can be written by using ARDL (p, q) approach where 'p' is the lags of dependent variable and 'q'is the lags of independent variables. Thus equation 5 was used as a base model to examine the effect of trade liberalization on infrastructural development.

Using the PARDL model, we examined the effect of trade liberalization on transport, energy and telecommunication infrastructure. We also examined its effect on a composite infrastructure index for ECOWAS. For the empirical model specification, we made use of trade openness as the measure of trade liberalization. Trade openness has the potential to raise infrastructural development as businesses, firms and governments invest more on basic infrastructural facilities that promote business operations and productivity in order to maximize the benefits of trade. In addition, the free flow of knowledge, innovation and new technology across countries can promote the creation of new infrastructure and maintenance of existing ones (Barro and Sala-i-matin, 1990; Francois & Manchin, 2013; Sawada, 2015; Ismail & Mahyideen, 2015; Olarreaga. 2016). We also included other variables that are key predictors of infrastructural development mainly per capital Gross Domestic Product (GDPPC) and tax revenue (TXR). Rise in income can translate to increase in infrastructural investment. This essentially follows from the growth-development link suggesting that increase in development indicators or living standard occurs with increase in income. However, there are possibilities of experiencing increase in overall macroeconomic income without development especially when growth is not inclusive (Edet, 2013; Onyimadu & Okpara, 2015). Tax revenue is used to finance the bulk of government expenditures, especially as it relates to building and maintaining infrastructure. With rising tax revenue, budgetary allocations to infrastructure are generally expected to be on the increase (Ayeni, Afolabi & Adekunle, 2020).
The empirical model specification for the study is hence stated as;

$$INFRD_{it} = \alpha_i + \sum_{j=1}^{P_i} \beta_{ij}\, INFRD_{i,t-j} + \sum_{j=0}^{q_i} \delta_{ij}\, GDPPC_{i,t-j} + \sum_{j=0}^{k_i} \theta_{ij}\, TXR_{i,t-j} + \sum_{j=0}^{I_i} \gamma_{ij} TRO_{i,t-j} + \varepsilon_{it} \tag{8}$$

$Where: i = 1, 2, 3, \dots\dots\dots N\ number\ of\ cross\ section$
$(Here\ i = N = 15)$

$$t = 1, 2, 3 \dots\dots\dots..T\ total\ time\ period\ (T = 16)$$

INFRD = Infrastructure (Measured using Transport, Telecommunication and Energy infrastructure).
GDPPC= Gross Domestic Product real in country *i* at time *t*
TXR_{it}= Tax Revenue in country *i* at time *t*
TRO_{it}= Trade Openness in country *i* at time *t*
ε_{it} = random error term
We examined each infrastructure variable as a separate model using equation 8.
The PARDL model can be applied even if the variables follow different order of integration i.e. I (0) and I (I) or a mixture of both. As suggested by Pesaran et al., (1999), Equation 8 was re-parameterized into the following error correction equation;

$$\Delta \mathrm{INFRD}_{it} = \alpha_i + \beta_i^{*} INFRD_{i,t-1} + \delta_i^{*} GDPPC_{it} + \theta_i^{*} TXR_{it} + \gamma_i^{*} TRO_{it} + \sum_{j=1}^{P_{i-1}} \beta_{ij}^{**}\, INFRD_{i,t-j} + \sum_{j=0}^{q_i} \delta_{ij}^{**}\, GDPPC_{i,t-j} + \sum_{j=0}^{k_i} \theta_{ij}^{**}\, TXR_{i,t-j} + \sum_{j=0}^{I_i} \gamma_{ij}^{**} TRO_{i,t-j} + \varepsilon_{it} \tag{9}$$

Equation (9) is the main equation of estimation where $\beta_i^*, \delta_i^*, \theta_i^*, \gamma_i^*$ *and* $\beta_{ij}^{**}\delta_{ij}^{**}\theta_{ij}^{**}\gamma_{ij}^{**}$ are the long run and short run coefficients respectively. Also

$$\beta_i^* = -(1-\sum_{j=1}^{P_i}\beta_{ij}),\ \delta_i^* = \sum_{j=0}^{q_i}\delta_{ij},\ \theta_i^* = \sum_{j=0}^{k_i}\theta_{ij},\ \gamma_i^*$$

Using equation 9, we examined the data using the Pooled Mean Group (PMG), the Mean Group (MG) as well as the Dynamic Fixed Effect (DFE) estimator. The study differentiated between PMG and MG estimators as PMG impose homogeneity restriction on long run coefficient across countries in ECOWAS while retaining heterogeneity for short-run dynamics. The MG requires not a restriction which in other words allows all coefficients to vary as well as to be heterogeneous in the short and long run. However, PMG estimator according to Pesaran (1999) propositions increases the efficiency of the estimates in comparison to the MG estimator based on long run slope homogeneity. We made use of the Hausman (1978) test statistic to determine whether there is a significant difference between PMG and MG or PMG and DFE estimators and the most efficient estimator that best suits the data.

Data sources and measurement of variables

The data for infrastructure used for the study were sourced from Africa Infrastructure Development Index provided by the African Development Bank (2018). Data for the other variables used in the study were obtained from the World Development Indicators provided by the World Bank (2018). Data used covered countries in the ECOWAS region namely: Benin, Burkina Faso, Cabo Verde, Cote d' Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. The time frame was from 2003 to 2018. The Africa infrastructure development index calculated the composite index for Transport sector, Electricity sector and Telecommunication sector.

The Transport sector, the transport composite index consists of the total paved Roads (km per 10,000 inhabitants) and this is a proxy of access to the paved road network and the Total road Network in km (per km2 of explorable land area).

The electricity index Net Generation (kwh per inhabitant) and this is the total electricity production of a given country, including the energy imported from abroad, it is measured in millions of kilowatt-hours produced per hour and per habitant.

The ICT composite index (ICT) has the total phone subscriptions (per 100 inhabitants). This is the total number of phone subscription in a country, both fixed telephone lines and mobile cellular telephone subscription in a given year, and the number of internet users (per 100 inhabitants), fixed Broadband internet subscribers (per 100 inhabitants) and the international internet Bandwidth (Mbps).

Tax Revenue: This is measured as the share of a country's output that is collected by the government through taxes. For the purpose of this study, tax revenue is measured by the degree to which the government of each ECOWAS countries control the economic resources. This is proxy by the ratio of tax revenue to GDP (OECD, 2016). For this study, tax revenue was examined on infrastructural development which aligned with a study by Worlu and Emeka (2012).

Trade Openness: This is measured by trade to GDP ratio which shows the importance of international transactions relative to domestic transactions. In this study, the indicator is calculated for each country in ECOWAS as a simple average (i.e., the sum of imports and exports of goods and services) relative to GDP (OECD, 2011)

Real Gross Domestic Product: it's the total market value of all final goods and services produced by a country in one year and a measure of economic activity. This is a measure of a country's gross domestic product that has been adjusted for inflation.

Results and Discussion

Preliminary results

The preliminary results for the study are shown in Table 1, 2 and in the appendix. Table 1 presents the descriptive results, and findings for unit root to check for the level of stationarity are shown in table 2. The results in the appendix show the correlation Matrix which is done to ensure that multicollinearity does not exist among the explanatory variables. The correlation matrix presents the degree of correlation between the explained and the explanatory variables. The absolute values range from (0.001-0.679) in the table, thus, it can be concluded that there exists no multicollinearity problem among the explanatory variables, as the values are below the benchmark of 0.80.

Table 1. Descriptive Statistics

S/N	Variable	Mean	SD	Min	Max	Kurtosis	Skewness	Jarque-Bera
1	Transport	7.2926	6.0709	1.2122	28.824	4.0951	1.4564	39.9472
3	Telecommunication	4.0015	5.7487	9.70E-06	29.5078	7.1055	2.0452	138.545
4	Energy	2.2834	2.5649	0.0333	11.356	2.6328	0.9245	14.6595
5	Composite Infrastructure Index	14.15	8.7737	2.2273	50.4307	6.3177	1.8712	103.185
6	GDP	3.20E+10	9.17E+10	3.66E+08	5.68E+11	5.4709	-1.8416	81.1458
7	Tax revenue	14.305	2.3839	4.3817	22.7444	3.4651	-0.3006	2.3832
8	Openness	2.05E-08	1.51E-08	1.32E-12	9.29E-08	14.9714	3.0529	744.9649

Source: Authors Computation 2021

As seen in the table, average index for transport infrastructure for the period of the study is approximately 7.29 with maximum values of about 28.28. For telecommunication infrastructure, average values is about 4.00 and at maximum it is 29.51. Energy infrastructure had mean value of 2.28 with maximum of 11.36 while the composite infrastructure index showed average value of 14.15 and maximum statistic of 50.13. Comparing mean values of infrastructure across the measures used reveals that the ECOWAS region has more shortfall in energy infrastructure provision relative to telecommunication and transport. Transport infrastructure appears to be more in proportion compared to other forms of infrastructure used in the study. The mean value of the composite index for infrastructure showed that it covers more infrastructure measure relative to those used in this study. This follows from the statistics showing higher average value for the composite infrastructure variable relative to the sum of the means for the three categories of infrastructure considered in the study. The statistics for real GDP show average value of approximately 32 billion USD. The standard deviation for GDP is quite high at 31.7 billion. This can, however, be associated with the heterogeneous nature of the data set as commonly seen in panel data studies. Tax revenue as a percentage of GDP is approximately 13.31 percent. This is quite low when compared with those of developed regions of the world. For instance, tax to GDP ratio in the Organization for Economic Corporation and Development was approximately 34.3 % as at 2018 (OECD, 2019), The figures for low tax revenue in the ECOWAS region clearly depicts the low tax base nature of economies in Africa mainly because most economic activities are in the informal sector. On the average, openness measure is about 2.05E-08. The figure is quite low and depicts low trade volume relative to output in the region. Kurtosis measures the flatness and peakness of the distribution of the series. Transport, Telecommunication, composite infrastructure index, tax revenue, GDP and openness shows a leptokurtic distribution relative to the normal, while Energy had a value of 2.63 exhibiting a platykurtic distribution which is less than 3. Skewness measures the asymmetry of distribution around its mean. All the variables were positively skewed with the exception of GDP and tax revenue was negatively skewed with value of -1.84 and -0.30. The Jarque-Bera test had the null hypothesis of normally distributed residuals. For simplicity, we present the result for slope homogeneity and cross-sectional dependence in table 2

Table 2 Result for slope homogeneity and Cross-sectional Dependence

	Model 1 Transport infrastructure	Model 2 Telecommunication	Model 3 Energy	Model 4 All infrastructure index
Xthst test for slope homogeneity H0: slope coefficients are homogenous Delta coefficient	5.921***	2.086**	5.339***	4.927***
Breusch-Pagan LM test of independence	chi2(105) = 554.512***	chi2(105) = 845.869***	chi2(105) = 432.264***	chi2(105) = 639.976***

H0: cross-sectional independence	

Note: P-values in parentheses *** p<0.01, ** p<0.05, * p<0.
Source: Authors Computation 2021

The result for slope homogeneity suggests that all slope coefficients are not identical across cross-sectional units. We had expected the results to show some homogeneity as countries involved in the analysis are from ECOWAS and the involvement in trade activities over time would have initiated some convergence in economic variables (Aboagye & Turkson 2014; Adenikinju & Osakede, 2020). However, due to the heterogeneous nature of most African countries in terms of cultural diversity, population and differences in production capacity there could be a case of non-homogenous slope. The Breusch-Pagan LM test of independence suggests the existence of cross-sectional dependence in the data set.

Panel unit root

Based on result indicating that the data set displays some form of heterogeneity and cross-sectional dependence, the unit root test statistic is examined using the second-generation panel unit root test statistics. Table 3 shows the results for the unit root tests.

Table 3 Results for Unit root tests

	LEVEL			
	CADF		CIPS	
	No Trend	Trend	No Trend	Trend
Transport	-0.945	-0.604	-1.440	-2.001
Telecommunication	1.995	3.932	-0.918	-1.118
Energy	-0.231	1.499	-1.680**	-2.344
Composite Infrastructure Index	-1.109	0.092	-2.035	-2.342
Real GDP	7.061	5.113	-0.522	-2.116
Tax Revenue	4.366	5.539	-0.288***	-0.567***
Openness	6.230	5.419	0.188***	-0.380
	FIRST DIFFERENCE			
	CADF		CIPS	
	No Trend	Trend	No Trend	Trend
Transport	-3.074***	-2.026**	-3.643***	-3.966***
Tele Communication	1.261	2.492	-2.074***	-2.359
Energy	-3.151***	-2.227**	-3.820***	-3.790***
Composite Infrastructure Index	-2.038**	-1.809**	-3.388 ***	-3.572***
Real GDP	1.891	0.645	-3.183***	-3.207***
Tax Revenue	5.814	5.974	-1.063	-1.474
Openness	5.393	6.005	-0.397	-0.926

Note: CADF, Z[t-bar] coefficient reported with *** p<0.01, ** p<0.05, * p<0.1 and CIPS statistic value reported with ***, ** and* denote rejection of the null hypothesis of non-stationary series at 1%, 5% and 10% critical values respectively
Source: Authors Computation 2021

The CADF test also shows stationary series for transport, energy and composite infrastructure index only at first difference 1(1). The CIPS tests reveal that energy, tax revenue and openness are stationary at level 1(0). The CIPS test also indicates stationary series for all the variables at first difference 1(1) except for tax revenue and openness. The order of integration of the variables is therefore a mixture of I (0) and I (1), therefore the PARDL can be estimated.

Regression results

Tables 3, 4, 5 and 6 show the estimation of the panel Autoregressive Distributed Lag model using, the Mean group, Pooled mean group and the Dynamic fixed effect. The upper panel shows the long run estimation and the speed of adjustment (Error correction term), while the lower panel shows the short run estimated coefficients. Also, the infrastructure variables were examined individually with the independent variables, while the last table shows the composite index of all infrastructure and the independent variables in the ECOWAS countries.

Estimates for transport infrastructure

Table 3 presents the results of MG, PMG and DFE estimation as well as the result of Hausman h-test.

Table 3: Results for Pooled Mean group, Mean group, and Dynamic fixed effect estimation on trade liberalization and Transport Infrastructure

Variables	Mean group	Pooled mean group	Dynamic fixed effect
	Long-run coefficients		
Log_GDP	-0.4488(0.8104)	-0.496***(0.047)	0.4613(0.4668)
Tax Revenue	0.0216(0.0463)	-0.017*(0.009)	-0.2847***(0.1156)
Log_Openesss	0.0731(0.1327)	0.036***(0.011)	0.1843(0.1342)
Error-correction coefficient	-0.626***(0.0922)	-0.351***(0.088)	-0.2615***(0.0447)
	Short-run coefficients		
D. Log_GDP	-0.1612(0.3121)	-0.193(0.233)	-0.2951(0.3598)
D. Tax Revenue	0.0139(0.0211)	0.011(0.017)	0.0477(0.0335)
D. Log_ Openness	0.0057(0.0543)	-0.113(0.116)	-0.0444(0.0526)
Intercept		6.483***(1.735)	1.1344(2.6239)
Country (Number of groups)		15	
Observation		225	
Hausman Test	0.22[a]	0.40[b]	7.78[c]
P value	0.9742	0.9408	0.0507

Note: 1. Standard error in parentheses *** p<0.01, ** p<0.05, * p<0.1
2. Hausman test a compares MG to PMG regression results. The test result reveal that PMG is consistent and efficient estimator than MG Hausman test b compares MG to DFE results. The test result reveal that DFE is consistent and efficient estimator than MG. Hausman test c compares DFE to PMG results. The test result reveal that DFE is consistent and efficient estimator than PMG.
Source: Authors Computation 2021

The results show that the log GDP has a negative and insignificant impact on transport infrastructure in the long-run according to MG estimators, a negative and insignificant relationship for the PMG and a positive and insignificant relationship by the DFE estimator. The tax revenue exhibited an insignificant impact by the MG and PMG although it was positive for the former and negative for the latter respectively. However, in the long run, the DFE estimator suggests a negative and significant impact of tax revenue on transport infrastructure. Openness in the long run had a positive relationship for MG, PMG and DFE, but only the PMG estimation had a significant effect.

The Error correction coefficients show that there is cointegration among the variables in the panel and any deviation from the long run equilibrium is corrected here. Thus, the variables are cointegrated at 1% level and the deviations are corrected at the 62%, 35% and 26% for the MG, PMG and DFE respectively. In the short-run, the log GDP all have a negative and not significant for MG, PMG and DFE, while for Tax revenue, it was positive and not significant for MG, PMG and DFE. Lastly, the log openness was also not significant, it had a negative impact for the MG and a negative impact for the PMG and DFE estimation.

In ascertaining the validity and efficiency of long-run homogeneity restriction across the cross-sections, Hausman h-test was tested and reported in Table 4. The result of the test accepts the null hypothesis of homogeneity restriction on the long-run coefficients, as the respective Hausman h-test p-values of 0.9742 and 0.9408 for MG and PMG are both insignificant. This suggests that DFE is a more efficient estimator than MG/PMG. Since, the DFE estimator has been detected as the most efficient, the result of the analysis would be based on the DFE. The DFE estimator result as stated earlier shows that only tax revenue has a negative and significant impact on transport infrastructure in the long run and the variables are cointegrated at 1% level and the deviations are corrected at the 26% level. Finally, in the short run, the coefficients of log GDP, log openness was negative and tax revenue was positive but insignificant. Specifically, it implies that an increase in tax revenue decreases transport infrastructure in the long-run and that transport infrastructure does not respond to a rise in GDP, Tax revenue and openness in the short-run.

Estimates for telecommunication infrastructure

Table 4 presents the results of Telecommunication Infrastructure for the MG, PMG and DFE estimation as well as the result of Hausman h-test.

Table 4: Results for Pooled Mean group, Mean group, and Dynamic fixed effect estimation on trade liberalization and Telecommunication Infrastructure

Variables	Mean group	Pooled mean group	Dynamic fixed effect
		Long-run coefficients	
Log_GDP	28.6731(33.3375)	-4.6471***(1.2404)	-14.4239***(5.0451)
Tax Revenue	-0.1976(1.8288)	0.3021(0.264)	-0.8019(0.6143)
Log_Openness	-14.7217(11.2168)	-0.4559***(0.1062)	1.5831**(0.7925)
Error-correction coefficient	0.0888**(0.0377)	0.1447***(0.0208)	0.0774***(0.0173)
		Short-run coefficients	
D. Log_GDP	1.0109(0.635)	0.3333(0.4437)	-0.5481(0.5424)
D. Tax Revenue	0.0881(0.0751)	0.0938(0.0655)	-0.0139(0.0498)

D. Log_ Openness	-0.1756(0.1249)		-0.2549*(0.1504)	-0.123(0.078)
Intercept	-48.7751***(16.3073)		-13.0407***(2.1399)	-27.6395***(4.5399)
Country (Number of groups)			15	
Observation			225	
Hausman Test	1.40[a]	0.50[b]	8.22[c]	
P value	0.7051	0.9192	0.0416	

Note
1. Standard error in parentheses *** p<0.01, ** p<0.05, * p<0.1
2. Hausman test a compares MG to PMG regression results. The test result reveals that PMG is consistent and efficient estimator than MG Hausman test b compares MG to DFE results. The test result reveals that DFE is consistent and efficient estimator than MG. Hausman test c compares DFE to PMG results. The test result reveals that DFE is consistent and efficient estimator than PMG.
Source: Authors Computation 2021

The results show that in the long run, the GDP coefficients were positive for MG and insignificant while it was negative and significant for PMG and DFE. However, tax revenue was insignificant in the long run for MG, PMG and DFE. For openness, the result indicates that MG estimation was negative and insignificant while PMG had a negative and significant effect and DFE was also significant and positive. The Error correction coefficients results show that the variables are cointegrated at 5% and 1 % level respectively and the deviations are corrected at the 8%, 14% and 7% respectively. In the short-run, the log GDP and tax revenue was not significant for MG, PMG and DFE, while for openness, it was negative and significant for MG, PMG and DFE. The results for the Hausman h-test in testing for the homogeneity indicates that the p-values of 0.7051 and 0.9192 for MG and PMG are both insignificant. This suggests that DFE is a more efficient estimator than MG/PMG.

Therefore, the results would be based on the DFE estimator which shows that GDP has a negative and significant impact in the long run, while openness has a positive and significant impact on telecommunication in the long run. Also, the variables are cointegrated at 1% level and the deviations are corrected at the 7% level. In the short run, the coefficient of openness was negative and significant, while GDP and tax revenue were negative and insignificant. Specifically, it suggests that an increase in GDP decreases telecommunication infrastructure, while an increase in openness increases telecommunication infrastructure in the long-run. It also suggests that telecommunication infrastructure responds to a rise in openness in the short-run, but does not respond to GDP and tax revenue in the short run.

Estimates for energy infrastructure

Findings for the effect of trade liberalization on energy infrastructure are shown in table 5. From table 5, the Hausman test ascertains that the DFE is the most efficient estimator with the p values of MG and PMG being 0.0555 and 0.9993 respectively. Therefore, the results for the DFE would be analyzed.

Table 5: Results for Pooled Mean group, Mean group, and Dynamic fixed effect estimation on trade liberalization and Energy Infrastructure

Variables	Mean group	Pooled mean group	Dynamic fixed effect
	Long-run coefficients		
Log_GDP	-1.2591(2.028)	-0.0573(0.0686)	0.6416**(0.2928)
Tax Revenue	-0.88(0.8443)	-0.0438***(0.0157)	-0.0132(0.0689)
Log_Openness	2.39(2.1957)	-0.0405(0.036)	-0.1115(0.0836)

Error-correction coefficient	-0.5241***(0.1313)	-0.2199**(0.1025)	-0.1948***(0.0384)
		Short-run coefficients	
D. Log_GDP	-0.2961(0.3395)	-0.0731(0.2219)	-0.3061*(0.1684)
D. Tax Revenue	-0.0303(0.0303)	0.0035(0.0094)	0.0119(0.0154)
D. Log_ Openness	0.2002(0.1385)	0.0423(0.0409)	0.0047(0.0243)
Intercept	-13.4862**(5.5216)	0.8942***(0.3455)	-2.6547**(1.2465)
Country (Number of groups)		15	
Observation		225	
Hausman Test	7.58^{a} $0.02b^{b}$	9.54^{c}	
P value	0.0555 0.9993	0.0229	

Note
1. Standard error in parentheses *** p<0.01, ** p<0.05, * p<0.1
2. Hausman test a compares MG to PMG regression results. The test result reveals that MG is consistent and efficient estimator than PMG. Hausman test b compares MG to DFE results. The test result reveals that DFE is consistent and efficient estimator than MG. Hausman test c compares DFE to PMG results. The test result reveals that DFE is consistent and efficient estimator than PMG.
Source: Authors Computation 2021

In the long run, real GDP has a positive and significant relationship with energy infrastructure, while tax revenue and openness had a negative insignificant impact in the long run. The Error correction coefficient indicates that the variables are cointegrated at 1% level and the deviations are corrected at 19%. In the short-run, an increase in real GDP has a negative and significant impact on energy, while Tax revenue and openness were positive and insignificant. This implies that an increase in GDP leads to an increase in energy infrastructure in the long-run and that energy infrastructure responds negatively to a rise in GDP in the short run.

Estimates for the composite infrastructure index

Table 6 presents the composite index of infrastructure for the MG, PMG and DFE estimation as well as the result of Hausman h-test. The results for real GDP reveal a positive and insignificant impact on the composite infrastructure index in the long run for MG and PMG; however, it exhibited a positive and significant impact for DFE in the long run. Tax revenue had a negative and insignificant impact in the long run for MG and DFE, but a significant positive impact for PMG. Findings for openness in the long run, revealed an insignificant negative impact on the composite infrastructure index in the long run for MG and DFE and a positive significant impact for PMG.

Table 6: Results for Pooled Mean group, Mean group, and Dynamic fixed effect estimation on trade liberalization and combination of all infrastructure index

Variables	Mean group	Pooled mean group	Dynamic fixed effect
		Long-run coefficients	
Log_GDP	7.4475(7.2053)	0.8139(0.7447)	16.4891***(4.2434)
Tax Revenue	-0.6907(0.8486)	0.8448***(0.2441)	-0.8179(0.684)
Log_Openness	-1.3253(1.8005)	-0.3499***(0.0612)	-0.6516(0.7459)

Error-correction coefficient	-0.1136***(0.0387)	0.002(0.0544)	-0.0457***(0.0142)
		Short-run coefficients	
D. Log_GDP	-1.4815***(0.4996)	-1.2967**(0.5335)	-1.124***(0.3686)
D. Tax Revenue	0.042(0.0386)	0.0107(0.0191)	0.0515(0.0326)
D. Log_ Openness	-0.0967*(0.0569)	-0.1408(0.0914)	-0.0749(0.0517)
Intercept	-32.9854**(14.4969)	1.0135(1.2857)	-15.6684***(3.0932)
Country (Number of groups)		15	
Observation		225	
Hausman Test	1.53[a] 0.05[b]	15.46[c]	
P value	0.6760 0.9974	0.0015	

Note: 1. Standard error in parentheses *** p<0.01, ** p<0.05, * p<0.1
2. Hausman test a compares MG to PMG regression results. The test result reveals that PMG is consistent and efficient estimator than MG
Hausman test b compares MG to DFE results. The test result reveals that DFE is consistent and efficient estimator than MG. Hausman test c compares DFE to PMG results. The test result reveals that DFE is consistent and efficient estimator than PMG.
Source: Authors Computation 2021

The Error correction coefficients show that there is cointegration among the variables for MG and DFE at the 1% level and the deviations are corrected at 11% and 4% respectively. Furthermore, the short-run coefficient for real GDP all have a negative and significant impact for MG, PMG and DFE, while for Tax revenue, it was positive and not significant for MG, PMG and DFE. The variable capturing openness was also positive but insignificant for MG, PMG and DFE models. The Hausman h-test result shows that DFE is a more efficient estimator than the MG and PMG with p-values of 0.6760 and 0.9974 respectively. Therefore, the results of the analysis would be based on the DFE estimator. As stated earlier, in the long run, there exists a positive and significant impact between GDP and the composite index for infrastructure in the ECOWAS, while tax revenue and openness had a negative and insignificant impact on infrastructure in ECOWAS countries. The ECM coefficient indicates that the variables are cointegrated at 1% level and the deviations are corrected at the 4% level. The short run coefficients show that log GDP has a negative and significant effect on the composite index for infrastructure, while tax revenue and openness were positive and negative respectively but insignificant. The indication therefore is that an increase in log GDP leads to an increase in infrastructural development in ECOWAS countries in the long run, while the infrastructure responds negatively to log GDP in the short run.

Discussion of results

Evidence provided in the study suggests that increase in government receipts in the form of tax revenue does not enhance infrastructure provision for transport in West Africa even in the long run. This is surprising but suggests low consideration for fiscal concerns for infrastructural provision in terms of promoting transport. It can also be connected to poor institutional structures that promote corrupt practices such that allocations in fiscal budget for infrastructure are diverted to other uses (REF). Findings for insignificant effect of openness on transport infrastructure suggest low innovation and technology flow that enhances provision of transport facilities. The evidence is similar to that provided by Raychaudhuri and De (2010) showing no significant relationship between trade and infrastructure. The result is however contrary to that by Nordas et al (2008).

Findings for the effect of trade liberalization on telecommunication infrastructure showing significant positive effect of openness on telecommunication suggest that countries in the region would benefit in this regard with trade-oriented policies even in the long run. In this case, benefits from trade liberalization would promote information and communication technology and likely advance economic activities in terms of industrial sector developments. This is particularly interesting as it is an indication that open border policy in Africa will advance the region in telecommunication infrastructure and hence provide an avenue for moving from the backward position for this form of infrastructure. Findings for positive and significant impact of openness on telecommunication in the long run are in line with evidence provided by (Nordas et al (2008), Bankole et al (2015), Ismail and Mahydeen (2015) and Donaubauer et al (2015). Negative long run effects of real income on telecommunication are against expectation but can however suggest low investment in telecommunication in the region.

Findings for energy infrastructure associate the performance of this infrastructure mainly to real GDP. Evidence suggests improvement in the supply of energy infrastructure with a rise in income in the long run. Short run effects were however negative. The implication therefore is that investments in energy fall with income in the short run period. However, as time progresses, rise in income will initiate an increase in the provision of energy. The intuition therefore is that as economies advance and become more industrialized, the need for energy in advancing the production frontier of industries becomes imperative. Evidence provided also showed that trade liberalization had no significant impact on improvements in energy infrastructure. The results in this case is however contrary to that obtained by Donaubauer et al (2015). Evidence shown for the role of trade liberalization on the overall infrastructure index signify that a positive significant relationship exists with increase in real GDP, Findings also suggest no significant impact of openness on the composite index for infrastructure. Evidence for positive effect of income on the composite index for infrastructure suggests a rise in investment in infrastructure index with increase in income. Findings indicating insignificant effect of openness on the composite infrastructure index is of key concern as it reflects low chance of infrastructure advancement with trade policies. This result is however in line with that of Raychaudhuri and DE (2010).

Conclusion

This study investigated the impact of trade liberalization on infrastructure development (transport, telecommunication and energy) in ECOWAS countries over the period 2003 – 2018. The PARDL model which comprised the MG, PMG and DFE estimators were employed to achieve the objective. The results of the Hausman showed preference for the DFE over MG and PMG estimators. Findings are hence extracted specifically from the DFE estimates. The result for transport infrastructure suggests existence of a negative and insignificant relationship with trade openness in the short run and a positive but insignificant relationship in the long run. This reveals that removal of barriers by ECOWAS countries although positive has no significant effect on transport infrastructure development both in the short and long run period. Surprisingly, tax revenue showed a negative significant effect on transport infrastructure suggesting low concerns for investment in transport infrastructure in public policy objectives and budget spending in Africa.

Findings further showed improvements in telecommunication infrastructure with more openness. The implication therefore is that liberal trade policies promote developments in telecommunication in West Africa. However, findings for the impact of real income suggest inverse relationship with telecommunication. The results further showed insignificant effects of openness on energy infrastructure both in the short and long run, suggesting that liberal trade policies do not promote energy improvements in the African region. The results also suggest a rise in energy infrastructure with increase in macroeconomic income in the long run. The result in the short run is however negative. Findings for the overall infrastructure index showed no significant effect of openness both in the short and long run. However, rise in real GDP had a significant negative effect in the short run and significant positive impact in the long run.

Essentially, evidence provided in this study suggests key role of trade liberalization in boosting infrastructure development mainly for telecommunication in Africa. No noticeable effects were observed for Transport and Energy infrastructure as well as the composite infrastructure index. The implication therefore is that in pursuing trade-oriented programs, governments in the region should focus intently on promoting infrastructure in the areas of transport and Energy as the region will continue to lag behind in these key areas in the advent of trade policies.

Following study findings, efforts should also be made to promote infrastructure improvements in fiscal policy actions in the region. Such efforts should rank high in policy maker's agenda in the attempt to maximize trade benefits and ensure sustainable development. This is again important as governments in the African region seek to pursue larger trade bloc operations in the AfCFTA. The use of country specific studies for countries in the ECOWAS will however provide more informative findings due to the heterogeneous nature of the data set used. While this limitation is important, it does not invalidate the results presented in this study.

References

Aboagye, S., & Turkson, E.F (2014). An empirical investigation of per capita income convergence hypothesis in sub-Saharan Africa. Paper Submitted for Review for CSAE 2014 Conference.

Acosta Rojas, G.E., Calfat, G., & Flôres Jr, R.G. (2005). Trade and infrastructure: Evidences from the ANDEAN Community. FGV EPGE Economics Working Papers (Ensaios Economicos da EPGE) 580, EPGE Brazilian School of Economics and Finance-FGV EPGE (BRAZIL)

Adenikinju, O.O. & Osakede U.A (2020). Per capita income and health outcome convergence in the Economic Community of West African states. *Nigerian Journal of Economic and Social Studies* (NJESS), 62, 3.

Agénor, P-R., Moreno-Dodson, B. (2006), Public infrastructure and growth: new channels and policy implications. Banca d'Italia, Italia.

Ahmad, B.A., Jaini, N., & Zamzamir, B.Z. (2015). The impact of infrastructure on trade in Malaysia. *J Entrepreneurship Bus*, 3(2), pp. 42–49.

Amjad, R; Ghani, E; Din, M., & Mahmood, T. (2012). Export barriers in Pakistan: Results of a firm-level survey. *The Lahore Journal of Economics*, 17, 103-134.

Anderson, J. E., & Van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle. *The American Economic Review 93(1),* 170–192.

Aworawo, F. (2016). Regional integration and development in Africa: Between the rock and a hard place. *Journal of International Studies*, 12,19-30.

Ayeni, O.D., Afolabi, O.J., & Adekunle, A. (2020). Tax revenue, infrastructure development and economic growth in Nigeria. *Nigerian Institute of Social and Economic Research*. https://mpra.ub.uni-muenchen.de/99464.

Babatunde, A. (2011). Trade Openness, Infrastructure, FDI and Growth in Sub-Saharan African Countries. *Journal of Management Policy and Practice*, 12(7), 27-36.

Baldwin, R.E. (1992). Measurable dynamic gains from trade. *J. Polit. Econ*. 100,162–174.

Bankole, F.O., Osei-Bryson, K.M. & Brown, I. (2015). The impacts of telecommunications infrastructure and institutional quality on trade efficiency in Africa. *Information Technology of Development, 21(1),* 29-43.

Barro, R.J., & Martin.X.S. (1990). *Public finance in models of economic growth*. NBER working paper series, 3362.

Bersvendsen, T., & J. Ditzen. J. (2020). XTHST: Testing for slope homogeneity in Stata. CEERP Working Paper Series (11).

Bond, E. W. (2006). Transportation infrastructure investments and trade liberalization. *The Japanese Economic Review*, *57*(4), 483-500.

Bougheas, S., Demetriades, P.O., & Morgenroth, E.L. (1999). Infrastructure, transport costs and trade. *Journal of International Economics, 47(1),* 169–189.

Breusch, T., & Pagan, A. (1980). The Lagrange multiplier test and its application to model specification in econometrics. *Review of Economic Studies 47,* 239–253.

Celbis, G., Nijkamp, P. & Poot, J. (2015). Infrastructure and Trade: A Meta-Analysis. *REGION,* 1(1), 25-64.

De Hoyos, R.E., & Sarafidis, V. (2006) Testing for cross-sectional dependence in panel-data models. *The Stata Journal 6 (4),* 482–496.

Deen-Swarray, M., Adekunle, B., & Odularu. G. (2012). Infrastructure development and intra-regional trade: The case of ECOWAS. *Journal of West African Integration, 1 (1),* 167 – 189.

Ditzen J., & Bersvendsen, T. (2019). XTHST: Stata module to test slope homogeneity in large panels. Statistical Software Components S458714, Boston College Department of Economics, revised 08 Jan 2021.

Donaubauer, J., Glas, A., & Nunnenkamp, P. (2015). Infrastructure and trade: A gravity analysis for major trade categories using a new index of infrastructure, *Kiel Working Paper*, No. 2016, Kiel Institute for theWorld Economy (IfW), Kiel.

Echekoba, F. N., Okonkwo, V. I., & Adigwe, P. K (2015). Trade liberalization and economic growth: The Nigerian experience (1971-2012). *Journal of Poverty, Investment and Development*, 14(1),51-73.

Economic Development Report (2009). Strengthening regional integration for Africa development. United Nations Conference on Trade and development.

ECOWAS (2004). *The ECOWAS trade liberalization scheme*, Status Report, Abuja, Nigeria.

ECOWAS (2016). Infrastructure in ECOWAS. *ECOWAS*. Newsletter

Eddington, R. (2006), *The Eddington transport study: Transport's role in sustaining the UK's productivity and competitiveness*, H. M. Treasury, London

Edet, L.I. (2013). The paradox of economic growth without development in Nigeria. SSRN Electronic Journal 10.2139/ssrn.2559699.

Edmonds, C., & Fujimura, M. (2006). Impact of cross-border road infrastructure on trade and investment in the Greater Mekong Subregion. Third LAEBA Annual Meeting Seoul, South Korea, November 16, 2006. An initiative of the Inter-American Development Bank and the Asian Development Bank Institute.

Edwards, L., & Odendaal, M. (2008). Infrastructure, transport costs and trade: A new approach. *TIPS Research Papers Series 2008.*

Égert, B., Kozluk, T., & Sutherland, D. (2009). Infrastructure and growth: Empirical evidence. Organization for Economic Co-Operation and Development (OECD), *OECD Economics Department Working Paper No. 685.*

Emagne, Y. (2017). Exploring the relationship between Trade liberalization and Ethiopian Economic Growth. *Ethiopian Journal of Economics*, 25(2).

Escribano, A. Guasch, J. L., & Pena J. (2008). Impact of infrastructure constraints on firm productivity in Africa. *Africa Infrastructure Sector Diagnostic*, Working Paper 9. World Bank, Washington, DC.

Fink, C., Mattoo, A. & Neagu. I. C. (2005). Assessing the impact of telecommunication costs on international trade. *Journal of International Economics 67(2),* 428–445.

Foster, V. & Briceño-Garmendia (2010) Africa's Infrastructure: Time for Transformation. *The International Bank for Reconstruction and Development/The World Bank.*

Francois, J., & Manchin, M. (2007). Institutions, infrastructure, and trade. Centre for the Study of Economic and Social Change in Europe, *Economics Working Paper* 77.

Francois, J., & Manchin. M. (2013). Institutions, infrastructure, and trade. *World Bank Policy Research Working Paper Series*. No. 4152. Washington, DC: World Bank.

Guei, K. M. A., & Roux P., (2019) Trade 0penness and economic growth: Evidence from the Economic Community of Western African States Region. *Journal of Economic and Financial Sciences, 12(1),* 2-9.

Gurara**,** D., Klyuev, V., Mwase, N., & Presbitero, A.F. (2018). Trends and Challenges in Infrastructure Investment in Developing Countries. *International Development Policy* 10 (1). DOI: https://doi.org/10.4000/poldev.2802.

Hausman, J., (1978). Specification tests in econometrics; *Econometrica 46(6),*1251-1271.

Hurlin, C., & Mignon, V. (2007). Second Generation Panel Unit Root Tests. Working Papers halshs-00159842, HAL.

Isaac, M.B., & Ntale, S.A. (2017). The Role OF Economic Infrastructure in promoting exports of manufactured products: Trade Facilitation and Industrialization in THE EAC. *Economic policy research center, Research series* No. 139.

Ismail, N. W., & Mahyideen, J. M. (2015). The Impact of infrastructure on trade and economic growth in selected Economies in Asia. *ADBI Working Paper 553*: Asian Development Bank Institute. Available:[http://www.adb.org/publications/impact-infrastructuretrade-and-economic-growth- selected-economies-asia/](http://www.adb.org/publications/impact-infrastructuretrade-and-economic-growth-selected-economies-asia/)

ITF/OECD (2014). Valuing convenience in public transport. ITF Round Tables, No. 156, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789282107683-en

Jiya, A.N., Sama, M,C., & Ouedraogo, I. (2020). Infrastructure, trade openness and economic transformation in Common Market for Eastern and Southern Africa member countries. *Social Science & Humanities*, 2.

Kannadhasan M., Aramvalarthan S., Balasubramanian, P., & Aishwaya, G., (2017). Determinants of dividend policy of Indian manufacturing companies: Panel autoregressive distributed lag analysis: *Academy of Accounting and Financial Studies Journal*, 21(2), 1-13.

Kagochi, J. & Durmaz, N. (2018). Assessing RTAs inter-regional trade enhancement in Sub-Saharan Africa. *Cogent Economics and Finance, 6 (1)* DOI: 10.1080/23322039.2018.1482662

Khalil, A., & Amjad, A. (2019). The effect of trade liberalization on expenditure structure of Pakistan. *MPRA Paper No. 95665*. https://mpra.ub.uni-muenchen.de/95665/.

Khattry, B. (2003). Trade liberalization and the fiscal squeeze: Implications for public investment. *Development and Change*, *34*(3), 401-424.

Li, J. Rim, G., & An, C. (2019). Impact of transport infrastructure on trade: Evidence from the Chinese Inland Provinces under "One Belt, One Road. *Open Journal of Business and Management*, **7**, pp. 2030-2046.

Lin, J.Y. (2012). New structural economics: A framework for rethinking development and policy. Washington, D.C: The World Bank.

Lopez. A.O., & Thia. J.P. (2020). Is poor infrastructure affecting trade liberalization? *Asian Infrastructure Investment Bank, Working Paper. https://www.aiib.org/en/news-events/media-center/working-papers.*

Majeed, S., Ahmed, Q. S. & Butt, M. S. (2010). Trade liberalization and total factor productivity growth (1971-2007). *Pakistan Economics and Social Review*, 48(1), 61-84.

Mitra, A., Sharma, C., & Véganzonès-Varoudakis, M. A. (2014). Trade liberalization, technology transfer, and firms' productive performance: The case of Indian manufacturing. *Journal of Asian Economics*, *33*, 1-15.

Modeste, C. N (2019). The impact of trade liberalization on export supply and poverty in Guyana: Evidence from co-integration Analysis; *The Review of Black Political Economy*, *46(3)*, 230-249.

Moon C.I. (2016). Economic regionalism. encyclopaedia Britannica.inc. https://www.britannica.com/economic regionalism.

Muhia, J.G. & Kuso, Y. (2019). Contribution of infrastructure to economic growth in Africa. *International Journal of Business Marketing and Management (IJBMM), 4 (4),* 43-51.

Mulugeta, F. Z., Sanfilippo, M., & Sundaram, A., (2018). Trade Liberalization, Infrastructure and Firm Performance: Evidence from Ethiopia. *International Growth Center*, Policy Brief 32403.

Njikam.O. (2009). *Trade liberalization, Infrastructure and Industrial performance in Cameroon.* Faculty of Economics and Management, University of Yaounde.

Noorbakhash, F. & Paloni, A. (2000). The De-industrialization Hypothesis, Structural Adjustment Programmes and the Sub-Saharan Dimension, in Jalilian H, Tribe M and Weiss J,eds. (2000). Industrial Development and Policy in Africa: Issues of De-industralisation and Development Strategy. (Cheltenham, Edward Elgar), Chapter 7:107–136.

Nordas, H.K & Piermartini, R. (2004). Infrastructure and trade. *World Trade Organization Staff Working Paper*, No. ERSD-04.

Nowak-Lehman, F. (2003). Trade policy and its impact on economic growth: The Chilean experience in the period of 1960 to 1998. *Applied Econometrics and International development* 3 (2), 25-53.

OECD (2016). Total Tax Revenue in OECD Factbook 2015-2016 Economic, Environmental and Social Statistics, OECD Publishing, Paris. Doi: https://doi.org/10.1787/factbook-2015-85-en

OECD (2011). *Trade openness in OECD science, technology and industry scoreboard 2011*, OECD Publishing, Paris. Doi: https://doi.org/10.1787/sti _scoreboard-2011-60-en

OECD (2019). Revenue Statistics 2019 Tax revenue trends in the OECD. https://www.oecd.org/tax/tax policy/revenue-statistics-highlights-brochure.pdf.

Okoro, A.S., Ujunwa, A., Umar, F., & Ukemenam, A. (2020), "Does regional trade promote economic growth? Evidence from Economic Community of West African States (ECOWAS). *Journal of Economics and Development, 22 (1),* 131-147.

Olarreaga, M. (2016). Trade, infrastructure, and development. *ADBI Working Paper 626. Tokyo: Asian Development Bank Institute*. Available: https://www.adb.org/publications/tradeinfrastructure-and- development

Onyinmadu, C.M. (2015). A case of Growth without development: A comparative study between Nigeria and Malaysia. *MPRA paper* No. 77202.

Ordu, A.U. (2019) An evaluation of the single currency agenda in the ECOWAS region. *Brookings global development update*s. Retrieved from https://www.brookings.edu/blog/africa-in-focus/2019/09/24/an-evaluation-of-the-single-currency-agenda-in-the-ecowas-region/

Osakwe, P. N., Paulino, A. U. S., & Dogan, B., (2018) Trade Dependence Liberalization and Exports Diversification in Developing countries: *UNCTAD research paper* No 20

Palei. T. (2015). Assessing the Impact of Infrastructure on Economic Growth and Global Competitiveness. *Procedia Economics and Finance* 23,168 – 175.

Pesaran, M. H., & Yongcheol S. (1999). An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. In Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium. Edited by Steinar Strøm. Cambridge: Cambridge University Press

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics 22*,265–312.

Raychaudhuri, A., & De. P. (2010). Trade, Infrastructure and Income inequality in selected Asian countries: An empirical analysis. Asia-Pacific Research and Training Network on Trade working paper series, No 82.

Rehman, F.U., Noman, A.A., & Ding, Y. (2020). Does infrastructure increase exports and reduce trade deficit? Evidence from selected South Asian countries using a new Global Infrastructure Index. *Journal of Economic Structures*, Springer; Pan-Pacific Association of Input-Output Studies (PAPAIOS), 9(1), 1-23.

Ricardo, D. (1817). *On the principles of political economy and taxation. (1 ed),* London: John Murray, ISBN 9783487409290.

Saggi. K. (2002). Trade, Foreign direct investment and International technology transfer: A survey. *The world Bank Research observer*, 17 (2), pp. 191-235.
Salinas, G., & Aksoy, A. (2006). Growth before and after trade liberalization. *WPS4062 World Bank Policy Research Working Paper 4062*, November 2006.
Samargandi, N. Fidrmuc, J., & Ghosh, S. (2014). Is the Relationship between Financial Development and Economic Growth Monotonic? Evidence from a Sample of Middle-Income Countries, CESifo Working Paper, No. 4743, Center for Economic. Studies and ifo Institute (CESifo), Munich
Sawada, Y. (2015). The Impacts of Infrastructure in Development: A Selective Survey. *Asian Development Bank Institute,* Working Paper 511.
Sheikh, S. A. & Ahmed, S. (2011). Impact of trade liberalization and domestic economic reforms on technical efficiency of agro-based Industries in Pakistan. *International Journal of Business and Social Sciences, 2(33),* 219-226.
Shepherd, B. (2016). Infrastructure, trade facilitation, and network connectivity in Sub-Saharan Africa. *Journal of African Trade, 3(1),* 1-22.
Smith, A. (1776). *An inquiry into the nature and causes of the wealth of nations (WN).* Oxford University Press
Suleiman, N.N. & Albiman, M.M. (2014). Dynamic relationship between tourism, trade, infrastructure and economic growth: Empirical evidence from Malaysia. *Journal of African Studies and Development, 6 (3),* 49-55.
Umoh, O.J., & onye, K. U., (2013). The Growth Implication of Trade Liberalization in West Africa; *MPRA Paper 88371*, University Library of Munich, Germany
Vigil, M., & Wagner, L. (2010). Does aid for trade enhance export performance? Investigating on the infrastructure channel. *SMART – LERECO Working Paper* 10.
Were, M. (2015). Differential effects of trade on economic growth and investment: A cross-country empirical investigation. *Journal of African Trade* 2, 71–85.
Wook J.J. (2017) The Impact of Trade Liberalization in Africa. *Korea institute for International Economic Policy,* Working Paper 17 (5).
World Bank (2019). World Development Indicators. World Bank.

Appendix

Table 2: Correlation Matrix

Variables	Transport	Telecommunication	Energy	Trade Openness	Taxrev	GDP
Trade Liberalization	1					
Telecommunication	0.396	1				
Energy	0.679	0.481	1			
Trade Openness	0.011	0.018	0.059	1		
Taxrev	0.511	0.395	0.519	0.016	1	
GDP	0.373	0.156	0.038	0.001	0.124	1

[i] Some examples of the first generation unit root test includes the Hadri LM test by Hadri (2000), Harris-Tzavalis unit root test proposed by Harris-Tzavalis unit root test proposed by Harris and Tzavalis (1999). Others include the test proposed by Levin and Lin (1992, 1993), Levin, Lin and Chu (2002), Im, Pesaran and Shin (1997, 2002, 2003) and several others well documented in the literature.
[ii] Second generation tests are also well documented in the literature and includes those proposed by Bai and Ng (2001, 2004), Moon and Perron (2004a), Phillips and Sul (2003a) Pesaran (2003), Choi (2002) etcetera.
[iii] A truncated version, denoted CADF* or CIPS* is also considered to avoid undue influence of extreme outcomes that could arise for small T samples.