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Reinvest the Relationship between Exports and Economic growth in African Countries: New Insights from Innovative Econometric Methods

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Abstract: This research examined the relationship between exports and economic growth in Africa. It employed many innovation econometric methods including Panel FMOLS and DOLS Estimates; Panel VECM; Panel ARDL Model; Pooled OLS, Random Effect Model, Fixed Effect Model and Hausman Test; Panel Pairwise Granger Causality Tests; Panel Toda-Yamamoto Causality Test; and Panel GMM Model. The findings suggested that the estimates of each model prove that there is a positive bidirectionnel relationship between exports and economic growth. Data includes 49 African countries for the period 1960-2018. These empirical results have some notable policy implications.

1. INTRODUCTION

Economists use the term growth conventionally to describe an increase in output over the long term. According to Perroux's (1961) definition, economic growth corresponds to "the sustained increase over one or more long periods of a dimension indicator, for a nation, the net aggregate product in real terms". Kuznets (1955) definition goes further and asserts that growth occurs when GDP growth is greater than population growth.

Indeed, growth is a fundamental process of contemporary economies, based on the development of factors of production, linked in particular to the industrial revolution, access to new mineral and energy resources as well as technical progress. It transforms people's lives as it creates more goods and services. In the long term, growth has a significant impact on the demographics and the standard of living of the societies that form it. Likewise, the enrichment that results from economic growth can help reduce poverty. For this reason, economic growth determines how the assessment of a country's well-being or economic performance has been and continues to be at the center of much debate.

Indeed, several researchers have undertaken investigations into the sources of economic growth. In several cases, they used the neoclassical production function where the variable economic growth is explained by the variables capital and labor.

Other authors have in addition to the above formulation included factors such as macroeconomic variables {See Senhadji (1999); Guillaumont *et al* (1999); Bakari and Tiba (2019); Abdelhafidh and Bakari (2019)} and socio-political variables {See Ram (1986); Sheehey (1993); Vedder and Gallaway (1998); Yuk, W. (2005)}.

Among the variables considered to be essential determinants of growth, we find the export variable {See Krueger (1978); Schenzler (1982); Balassa (1985); Ram (1987); Fosu (1990); Sengupta (1993); Ghatak (1998); Islam (1998)}.

The reason why the export variable is taken into account is that economic growth could be obtained through an expansion of exports. Indeed, exports of goods and services are seen as an engine of economic and social development thanks to their power to influence economic growth and poverty reduction. They are also a source of foreign currency inflows to cover imports. Finally, they constitute a potential component of state revenue thanks to the customs duties that they can generate or when they are carried out by public enterprises.

For these reasons, we attempt in this work to reinvest empirically by using several econometrics methods the nexus between exprorts and economic growth in Africain countries.This article consists of four sections. After this introductory part, section 2 provides an overview of the global literature. Section 3 introduces the data. Section 4 presents the econometric approch. Section 5 introduces the research methods and results. Section 6 highlights some of the policy implications that can be drawn from the research results and provides conclusive comments.

2. LITERATURE SURVEY

Exports are considered to be one of the most important macroeconomic variables for a country's growth. Many empirical and theoretical studies have attempted to explain the relationship between exports and economic growth. The objective of this section is to provide an overview of the main studies that have examined theoretically and empirically the link between exports and economic growth based on their results.

2.1. Theoretically

When considering the causal relationship between exports and economic growth, four different situations can be considered.

2.1.1. Economic growth induced by the expansion of exports

According to Krugman (1987), an expansion of the export sector leads to an increase in demand for the products of the country in question, which guides to an increase in the real product. Also, through Verdoon's law which states that "the change in productivity resulting from specialization in the production of goods attributable to increased exports, through improved qualifications and skills in the sector and a reallocation of resources from less performing to more efficient sectors would lead to an increase in product", this expansion can lead to economic growth.

In addition, and according to Romer (1990), an expansion of the export sector provides access to new technologies as well as new management techniques, essential for economic growth in a highly competitive world. This hypothesis, is also known in Verdoon's law as the ''learning by exporting''.

2.1.2. Export expansion driven by economic growth

According to Kaldor (1964) and Krugman (1984) economic growth leads to an improvement in talents, skills and techniques, elements which contribute to the expansion of exports. Similarly, Michaely (1977) and Helleiner (1986) argue for the need for a minimum level of development before observing the beneficial effects of expansion of exports.

Among the studies that support the idea of an expansion of exports driven by economic growth are Ghartey (1993); Oxley (1993); Kunst and Martin (1989). The hypothesis of learning by exporting is also supported. However, Aw *et al* (1997) indicated this argument is that, contrary to Verdoon's Law, it is not the export-oriented firms that become more productive and therefore influence economic growth, but rather the successful firms that become more productive.

2.1.3. Circular relationship between exports and economic growth

Helpman and Krugman (1985) have argued that the expansion of exports as a result of productivity gains and cost savings Scale will lead to a reduction in production costs and therefore lead to a substantial improvement in productivity.

This improvement in productivity will in turn lead to an increase in exports and so on. In other words, as Krishna *et al*. (1998), every effect has a cause and every cause has an effect. Thus, export expansion leads to economic growth, and economic growth leads to export expansion.

2.1.4. Lack of a cause and effect relationship between exports and economic growth

Finally, Chow (1987) and Yaghmaian (1994) completely opposed the previous ones suggests the possibility that there is no causal relationship between exports and economic growth, by indicating that the paths of economic growth and export expansion are determined by other economic variables. these mean that there is no consensus as to the causality between exports and economic growth for many reasons: (i) Empirical results vary from one type of study to another and even within the same type of study according to the size of the sample, the countries considered, the variables included in the analysis; (ii) The lack of consensus does not mean that the problem of the direction of causality between exports and economic growth is irrelevant. On the contrary, it is even crucial for decision-makers to be informed about the causal relationship between these variables so as to take it into account in the development and implementation of policies and strategies; and (iii) This lack of causality is an indication of the specificity of economies and an invitation to revisit approaches to development. From the above it emerges from the need for a country-by-country analysis of the causal direction between exports and economic growth.

2.2. Empirically

Numerous studies have examined the export-led growth hypothesis. Initial studies only searched the relationship between exports and economic growth. These studies used time series analysis, cross-sectional data and the ordinary least squares (OLS) method provided support for a positive relationship between export and economic growth {See: Michaely (1977); Balassa (1978); Tyler (1981); Feder (1983); Kavoussi (1984)}.

Michaely (1977) found a strong positive correlation between exports and GDP growth in developped countries. In 11 developing countries, Balassa (1978) studied the relationship between exports and economic growth over the period 1960 and 1973 and signed that exports have a positive effect on economic growth. For the periods 1960 - 1977, Tyler (1981) examined the relationship between export expansion and economic growth for the periods 1960-1977 and found a high positive correlation between economic growth and exports. Feder (1983), looking for the same relationship for industrializing countries. He concluded that there is a positive relationship between exports and economic growth. In the case of 73 developing countries and for the periods 1960-1973, Kavoussi (1984) tested the nexuq between exports and economic growth and obtained the results that the expansion of exports resulted in much higher economic performance.

Empirical studies in recent years reach to concentrate on the causality of the direction between exports and economic growth applying causality tests. It should be esteemed that while some of these studies applied simple Granger or Sims causality tests, others utilized a cointegration and error correction model. The empirical studies drived using these tests are complex and generally contradictory to each other. While some studies support the existence of a causal relationship between exports and economic growth, other studies prove that there is no significant relationship between these two variables. Therefore, unlike the robust empirical evidence employed at the start, some findings may cast doubt on the export-led growth assumption. The relationship between foreign trade and growth is complex and fickle. The different countries and periods selected, the econometric method used in the causality analysis and the differences in the selection of data brought out different results.

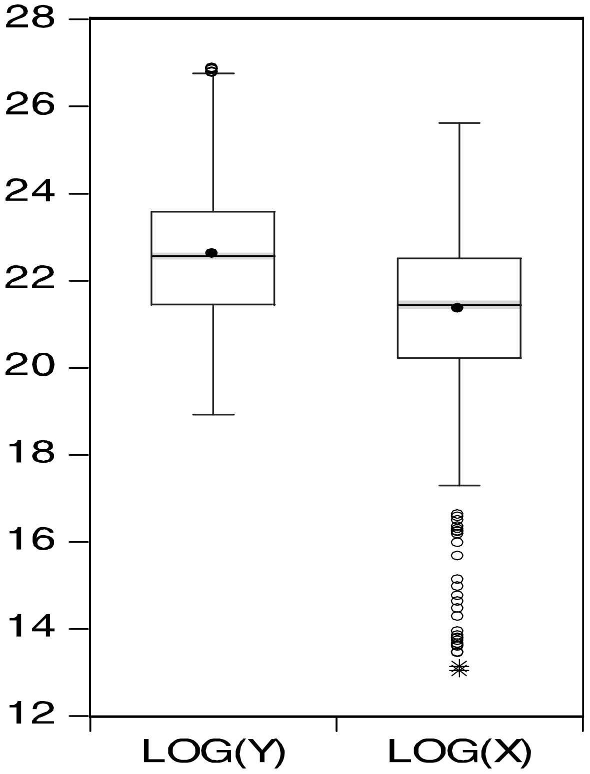
By using cointegration analysis and error correction model, Bakari (2017a) searched the impact of exports on economic growth in the short run and the long run for the case Gabon for the period 1980 - 2015. He found that exports have a negative effect on economic growth in the long run. In another study made for the case of Sudan by Bakari (2017b) to study the nexus between exports and economic growth. He found that there is no relationship between exports and economic growth in the long run. Again, Bakari (2017c) examined the relationship between exports and economic growth in Egypt for the periods between 1965 and 2015 was tested by using Johansen co-integration analysis of Vector Error Correction Model. He found again that exports have negative impact on economic growth. These also the same results in another study made by Bakari (2018) in the case of Tunisia for the period 1965 to 2016. In other research Bakari *et al* (2018) examined the nexus between exports and economic growth in Nigeria using cointegration analysis and vector error correction model over the period 1981 - 2015. The results show that there is no relationship between exports and economic growth in the long run and in the short run. In India and over the period 1960 to 2017, Bakari and Fakraoui (2019) found that there is no relationship between exports and economic growth in the long run by applying cointegration analysis and vector error correction model.

Generally, there are only a few studies dealing with the causality between exports and economic growth in developping countries, particularly in the African countries. The existing empirical evidence based on the testing of causality between these two variables is mixed and contradictory. Only further research can verify the extent of support for or against the causality between exports and economic growth in African countries.

3. DATA

Annual data on real exports and real GDP are supplied by the World Development Indicators of the World Bank for the period 1960-2018. The sample includes 49 African countries which are: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo-Dem -Rep, Congo-Rep, Cote d'Ivoire, Egypt, Equatorial Guinea, Eritrea, Eswatini, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria,

Figure 1: Boxplot of real GDP and real Exports at log level



Rwanda, Senegal, Sierra Leone, South Africa, South Sudan, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe. Table 1 presents the descriptive statistics and correlation matrix of the variables used in the study at actual and logarithmic level. According to the correlation matrix, Exports (X) are positively correlated with economic growth (Y).

The pictorial representation of descriptive statistics has been shown by making a boxplot in Figure 1. It shows that mean values are around the median values, which shows that the distribution is approximately normal. There are no extreme or far outliers in the sample. In the case of Exports variable, there are some near outliers (dots outside the whiskers) because of logarithmic transformation of the variable. When we transform a variable having a value less than 1, it gives us a negative value. The lower is the number, the higher the negative value. Therefore, our data is appropriate to proceed for panel analysis.

4. ECONOMETRIC APPROCH

In this work, we will study the relationship between exports and economic growth in Africa for the period 1960 - 2018 using the application of a set of models and techniques related to Panel data econometrics. Among these models and techniques, we will apply: Panel Unit Root Tests, Panel Cointegration Tests, Panel FMOLS, Panel DOLS, Panel VECM, Panel ARDL Model, Pooled OLS, Random Effect Model, Fixed Effect Model, Hausman Test, Panel Pairwise Granger Causality Tests, Panel Toda-Yamamoto Causality Test and Panel GMM Model.

5. EMPIRICAL ANALYSIS

5.1. Panel Unit Root Tests

In the empirical process, first of all, we adopt panel unit root tests to identify the order of integration of the variables in our panel setting. We use five panel unit root tests, namely LLC Test, IPS Test , Breitung Test , ADF-Fisher Test and PP-Fisher Test. Among the up tests, the most folk those are Levin *et al* (2002) (LLC), which undertake homogeneity in the dynamics of the autoregressive coefficients (AR) for all members of the panel. The test of Im *et al* (2003) (IPS) is more aggregate than the LLC test because heterogeneity is permitted in dynamic and intertemporal panel data. These two tests are based on the ADF test.

Levin *et al* (2002) suggest a panel-based ADF test that encloses parameters γi by maintaining them identical across cross-sectional regions, as appeared in the following:

$$\Delta Y_{it} = c_i + \gamma_i Y_{i,t-1} + \sum_{j=1}^{k} c_j \, \Delta Y_{i,t-j} + e_{it}$$

Where $t = 1,\ldots..,T$ time periods, and $i = 1,\ldots\ldots, N$ members of the panel. LLC checks the null hypothesis of $\gamma_1 = \gamma_2 = \gamma = 0$ for all *i*, against the alternative hypothesis $\gamma_1 = \gamma_2 = \gamma < 0$ for all *i*, with the test instituted on the statistics $t_\gamma = \frac{\hat{\gamma}}{s.e.(\hat{\gamma})}$

The LLC test presumes homogeneity in the dynamics of the autoregressive coefficients (AR) for all the members of the panel. More specifically, the LLC test supposes that each individual unit in the panel shares the same AR (1) coefficient, but enables an individual effect, temporal effects and possibly a temporal trend. Lags in the dependent variables can be presented into the model to permit serial correlation in errors.

The test implied by Im *et al* (2003) licenses heterogeneity between units in a dynamic panel framework and is founded on individual Augmented Dickey- Fuller (ADF) regressions:

$$\Delta Y_{i,t} = \rho_i \gamma_{it-1} + \sum_{k=1}^{pt} \gamma_{ik} \Delta Y_{it-k} + Z_{it}\delta + \varepsilon_{it}$$

Where Y_{it} represents each variable considered in our model, p is the number of lags for the free correlation residuals, Z_{it} marks the vector of deterministic variables in the model, including fixed effects or individual trends, and δ is the corresponding vector coefficients.

$$H_1 = \begin{Bmatrix} \rho_i = 0 & \text{for } \; i = 1, \ldots N \\ \rho_i < 0 & \text{for } \; i = N+1, N+2 \ldots. N \end{Bmatrix}$$

Where: N presents the number of cross-sections. Im *et al* (2003) involve separate unit root tests for the N cross-section units. IPS test offers the utilization of a group mean t-bar statistic, where the statistics for each ADF test are averaged over the entire panel; again, adjustment factors are required to interpret the distribution of the t-bar into a standard normal variable under the null hypothesis. The average of the individual ADF statistics is defined as follows:

$$\bar{t} = \frac{1}{N} \sum_{i=1}^{N} (t_{pi})$$

Where: t_{pi} designes the individual t-statistic for inspecting the null hypothesis. In the null hypothesis, all the series of the panel are non-stationary processes; in the alternative, a fraction of the series in the panel is supposed to be stationary.

Breitung (2000) propounds a t-ratio type test statistic to examine a unit root of the panel. By numerical analysis, he requires that his test has "pleasant" power properties in a certain local unit neighborhood. Breitung's (2000) test diverges from Levin *et al*'s (2002) test in two respects. First, to produce the standardized process, the autoregressive component of the model is eliminated:

$$\Delta Y_{it} = \frac{\Delta Y_{it} - \sum_{k=1}^{\rho t} \gamma_{ik} \Delta Y_{it-k}}{S_i}$$

$$Y_{it-1} = \frac{Y_{it-1} \sum_{k=1}^{\rho t} \gamma_{ik} \Delta Y_{it-k}}{S_i}$$

The proxies are transformed:

$$\Delta Y_{it} = \sqrt{\frac{(T-t)}{T-t+1}} \left[\Delta Y_{it} \frac{\Delta Y_{it+1} + \cdots + \Delta Y_{it+T}}{T-t} \right]$$

$$\Delta Y_{it-1} = Y_{it-1} - c_{it}$$

Where S_i presents the estimated standard errors;

$$\text{And } c_{it} = \begin{Bmatrix} 0 & \text{With intercept or trend} \\ \mathrm{Y_{it}} & \text{With intercept no trend} \\ \mathrm{Y_{it}} - \left(\mathrm{T^{-1}(t-1)}\right)\mathrm{Y_{iT}} & \text{With intercept and trend} \end{Bmatrix}$$

Maddala and Wu (1999) suggest a unit root panel test, which has its provenance in the work of Fisher (1932). Their test fundamentally looks at the p-values of the individual country test statistic for a unit root and compounds it with a panel statistic. The test is chi-square allocated with two degrees of liberty and has the subsequent form:

$$\tau = -2 \sum_{i=1}^{N} log_e \pi_i$$

Where: π_i is the p-value of the test statistic in unit i. A major advantage of this test is that it can be applied inattentive of whether the zero value is integration or a stationarity. The p values are studied from the ADF test and the PP test. The naturalness of this test and its validity with the selection of the offset length and the sample size make its use interesting.

Table 2 points the panel unit root test results. All the variables are uttered in natural logarithms so that elasticities can also be resolved. Five sets of results from these tests establish that all the variables are integrated of order one.

5.2. Panel Cointegration Tests

We adopt panel cointegration tests to find cointegration relationship between exports and economic growth. Among these tests, we utilize Pedroni Residual Cointegration Test, Johansen Fisher Cointegration Test and Kao Residual Cointegration Test.

Pedroni (1997, 1999, and 2004) has proposed a panel cointegration method founded on residuals which also let great heterogeneity through individual effects, slope coefficients and individual linear trends across countries. Pedroni (2004) examines the following type of regression:

$$Y_{it} = \alpha_i + \gamma_i t + \beta_i X_{it} + e_{it}$$

The possibility of individual effects and individual linear trends are allowed respectively by the parameters α_i and γ_i. The slope coefficients β_i are also permissible to vary according to the individuals, therefore in general the cointegration vectors can be heterogeneous between the members of the panel. The variables Y_{it} and X_{it} are affected to be integrated of order one, pointed out I(1) (for a time series panel of observables Yit and Xit for members $i = 1,\ldots, N$ over time periods $t = 1,\ldots T$).

Pedroni (1999) derived the asymptotic distributions and analyzed the performance of small samples from 7 different statistics to check the cointegration of the panel data. Pedroni's tests can be distributing into two class: The first four tests statistics are based on integrating along the ADF, which is often named the "inside" dimension (hereinafter called "sign"). These tests are the statistics of the v panel, the rho panel, the PP panel and the ADF panel. These statistics group together the autoregressive coefficients between different members for the unit root tests on the estimated residues. The last three test statistics are founded on the dimension "between" (hereinafter called "group"). These tests are the statistics of the rho group, the PP group and the ADF group. These statistics are founded on the means of the individual autoregressive coefficients linked with the unit root residuals tests for each country in the panel. The seven tests are performed on the residuals estimated from a model based on the regression of the equation. (9). Subsequently, Pedroni (1999), the average panel statistics of heterogeneous panel and heterogeneous group are premeditated as follows:

Panel v-statistic:

$$Z_v = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} L_{11i}^{-2} \, e_{it-1}^{2} \right)^{-1}$$

Panel rho-statistic:

$$Z_{rho} = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} L_{11i}^{-2} \, e_{it-1}^{2} \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} L_{11i}^{-2} \left(e_{it-1} \Delta e_{it} - \vartheta_i \right)$$

Panel PP-statistic:

$$Z_t = \left(\sigma^2 \sum_{i=1}^{N} \sum_{t=1}^{T} L_{11i}^{-2} \, e_{it-1}^{2} \right)^{-\frac{1}{2}} \sum_{i=1}^{N} \sum_{t=1}^{T} L_{11i}^{-2} \left(e_{it-1} \Delta e_{it} - \vartheta_i \right)$$

Panel ADF-statistic:

$$Z_t^{*} = \left(S^{*2} \sum_{i=1}^{N} \sum_{t=1}^{T} L_{11i}^{-2} \, e_{it-1}^{*2} \right)^{-\frac{1}{2}} \sum_{i=1}^{N} \sum_{t=1}^{T} L_{11i}^{-2} \, e_{it-1}^{*} \Delta e_{it}^{*}$$

Group rho-statistic:

$$W_{rho} = \sum_{i=1}^{N} \left(\sum_{t=1}^{T} e_{it-1}^{2} \right)^{-1} \sum_{t=1}^{T} \left(e_{it-1} \Delta e_{it} - \vartheta_i \right)$$

Group PP-statistic:

$$W_t = \sum_{i=1}^{N} \left(\sigma^2 \sum_{t=1}^{T} e_{it-1}^{2} \right)^{-\frac{1}{2}} \sum_{t=1}^{T} \left(e_{it-1} \Delta e_{it} - \vartheta_i \right)$$

Group ADF-statistic:

$$W_t^* = \sum_{i=1}^{N} \left(\sum_{t=1}^{T} S_i^2 e_{it-1}^{*2} \right)^{-\frac{1}{2}} \sum_{t=1}^{T} (e_{it-1}^* \Delta e_{it}^*)$$

Where e_{it} is the estimated residual form of Equation (;;) and L_{11i}^{-2} is the estimated long-run covariance matrix for Δ_{it}. The other terms are precisely limited in Pedroni (1999) with the suitable lag length specified by the Newey-West method. The panel statistics and group statistics count on the null hypothesis, H_0: $\rho_i = 1$ for all i, versus the alternative hypotheses H_1: $\rho_i = \rho < 1$ and H_1: $\rho_i < 1$ for all i, respectively. Where, ρ_i is the estimated autoregressive coefficient of the residuals in the ith unit. All seven tests are disseminated as being standard normal asymptotically. For the panel v-statistics large positive values reference rejections, whereas large negative values for the enduring test statistics mention rejection of no cointegration. The critical values are also scaled by Pedroni (1999).

For panel data, Kao (1999) characterizes two tests below the null hypothesis of no cointegration. One is an Augmented Dickey-Fuller type test and another is a Dickey-Fuller type test. For the Dickey-Fuller type test Kao introduces two sets of specification. In the bivariate case Kao (1999) regard the next model:

$$\mathrm{y_{it} = \alpha_i + \beta x_{it} + e_{it} i = 1, \dots N, t = 1, \dots T}$$

Where

$$y_{it} = y_{it-1} + u_{it}$$

$$x_{it} = x_{it-1} + \varepsilon_{it}$$

α_i is the fixed effect switching through the cross-section observations, $\beta$is the slope parameter, y_{it} and x_{it} are independent random walks for all i. The residual series e_{it} should be I(1) series.

Now Kao specify a long run covariance matrix of$w_{it} = (u_{it}, \varepsilon_{it})'$ is appointed by

$$\Omega = \lim_{T\to\infty} \frac{1}{T} E \left(\sum_{t=1}^{T} w_{it} \right) \left(\sum_{t=1}^{T} w_{it} \right)' = \Sigma + \Gamma + \Gamma' \equiv \begin{bmatrix} \sigma_{0u}^2 & \sigma_{0u\varepsilon} \\ \sigma_{0u\varepsilon} & \sigma_{0\varepsilon}^2 \end{bmatrix}$$

Where

$$\Gamma = \lim_{T\to\infty}\frac{1}{T}\sum_{k=1}^{T-1}\sum_{t=k+1}^{T}E(w_{it}w'_{it-k}) \equiv \begin{bmatrix}\Gamma_u & \Gamma_{\varepsilon u}\\ \Gamma_{\varepsilon u} & \Gamma_u\end{bmatrix}$$

And

$$\Sigma = \lim_{T\to\infty}\frac{1}{T}\sum_{t=1}^{T}E(w_{it}w'_{it}) \equiv \begin{bmatrix}\sigma_u^2 & \sigma_{u\varepsilon}\\ \sigma_{u\varepsilon} & \sigma_\varepsilon^2\end{bmatrix}$$

The Dickey-Fuller test can be painstaking to the estimated residual using:

$$\hat{e}_{it} = \rho\hat{e}_{it} + v_{it}$$

The null and alternative hypothesis may be recorded as:

$$H_0 : \rho = 1$$

$$H_1 : \rho < 1$$

The OLS estimate of ρ is given by:

$$\hat{\rho} = \frac{\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{e}_{it}\rho\hat{e}_{it-1}}{\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{e}_{it-1}^2}$$

Further calculation for Dickey-Fuller, Kao points the subsequent statistics:

$$DF_\rho^* = \frac{\sqrt{N}\,T(\hat{\rho}-1) + 3\sqrt{N}\hat{\sigma}^{2}{}_{v}/\hat{\sigma}^{2}{}_{0v}}{\sqrt{3 + 36\hat{\sigma}^{4}{}_{v}/(\hat{\sigma}^{4}{}_{0v})}} \sim N(0,1)$$

$$DF_t^* = \frac{t_p + \sqrt{6N}\hat{\sigma}_v/(2\hat{\sigma}_{0v)}}{\sqrt{\hat{\sigma}_{0v}^2/(2\hat{\sigma}_v^2) + 3\hat{\sigma}_v^2/(10\hat{\sigma}_{0v}^2)}} \sim N(0,1)$$

Where

$$t_\rho = \frac{(\hat{\rho}-1)\sqrt{\sum_{i=1}^{N}\sum_{i=1}^{T}\hat{e}_{it-1}^{*2}}}{S_e}$$

$$S_e^2 = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=2}^{T}(\hat{e}_{it}^* - \rho\hat{e}_{it-1}^*)^2$$

$$\hat{e}_{it}^{*} = y_{it}^{*} - \hat{\alpha}_{i}^{*} - \hat{\beta}^{*} x_{it}^{*},$$

$$\hat{\beta}^{*} = \frac{1}{N}\sum_{i=1}^{N}\sum_{t=1}^{T}\frac{1}{T^{2}}(x_{it}^{*} - \bar{x}_{i}^{*})^{2}$$

In the case of strong exogeneity and no serial correlation$(\sigma_u^2 = \sigma_{0u}^2 = \sigma_v^2 = \sigma_{0v}^2)$, the test statistics become:

$$DF_{\rho} = \frac{T\sqrt{N}(\hat{\rho} - 1) + 3\sqrt{N}}{\sqrt{10.2}} \sim N(0,1)$$

$$DF_{t} = \sqrt{1.25}t_{p} + \sqrt{1.875N} \sim N(0,1)$$

These tests do not intended estimate of the long-run variance-covariance matrix. For the Augmented Dickey-Fuller test, estimated residual is

$$\hat{e}_{it} = \rho\hat{e}_{it-1} + \sum_{j=1}^{p}\varphi_{j}\,\Delta\hat{e}_{it-j} + v_{itp}$$

Under the null of no cointegration, the ADF test take the from

$$t_{ADF} = \frac{(\hat{\rho} - 1)[\sum_{i=1}^{N} e_i' Q_i e_i]^{\frac{1}{2}}}{S_v}$$

Further calculation Kao evinces the following statistics:

$$ADF = \frac{t_{ADF} + \sqrt{6N}\hat{\sigma}_v/(2\hat{\sigma}_{0v})}{\sqrt{\hat{\sigma}_{0v}^2/(2\hat{\sigma}_v^2) + 3\hat{\sigma}_v^2/(10\hat{\sigma}_{0v}^2)}} \sim N(0,1)$$

For estimation of long run parameter when we obtain the estimates of w_{it} and $\widehat{w}_{it}$ then we get:

$$\hat{\Sigma} = \begin{bmatrix}\hat{\sigma}_u^2 & \hat{\sigma}_{u\varepsilon}\\ \hat{\sigma}_{u\varepsilon} & \hat{\sigma}_{\epsilon}^2\end{bmatrix} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\widehat{w}_{it}\widehat{w}_{it}'$$

And

$$\widehat{\Omega} = \begin{bmatrix}\hat{\sigma}_{0u}^2 & \hat{\sigma}_{0u\varepsilon}\\ \hat{\sigma}_{0u\varepsilon} & \hat{\sigma}_{0\epsilon}^2\end{bmatrix} = \frac{1}{NT}\sum_{i=1}^{N}\left[\frac{1}{T}\sum_{t=1}^{T}\widehat{w}_{it}\widehat{w}_{it}' + \frac{1}{T}\sum_{\zeta}^{l}\overline{w}_{\zeta l}\sum_{t=\zeta+1}^{T}(\widehat{w}_{it}\widehat{w}_{it-\zeta}' + \widehat{w}_{it-\zeta}\widehat{w}_{it}')\right]$$

Where$\bar{w}_{\zeta l}$ is a weight function or a kernel.

Johansen (1988) suggests two different techniques, one of them is the likelihood ratio trace statistics and the other one is maximum eigenvalue statistics, to establish the attendance of cointegration vectors in non stationary time series. The trace statistics and maximum eigenvalue statistics have exposed in equation (...) and (...) respectively

$$\lambda_{Trace}(r) = -T \sum_{i=r+1}^{n} \ln (1 - \hat{\lambda}_i)$$

And

$$\lambda_{max}(r, r+1) = -Tln(1 - \hat{\lambda}_{r+1})$$

Where T is the sample size and $\hat{\lambda}_i$ is the the highest canonical correlation between residuals from the three dimensional processes and residual from the three dimensional differentiate processes. For the trace test puts to test the null hypothesis of at most r cointegration vector against the alternative hypothesis of full rank *r* = *n* cointegration vector, the null and alternative hypothesis of maximum eigenvalue statistics is to verify the r cointegrating vectors against the alternative hypothesis of *r* + 1 cointegrating vectors. Using Johansens (1988) test for cointegration, Maddala and Wu (1999) regard Fisher's (1932) suggestion to mix individuals tests, to suggest an alternative to the two previous tests, for testing for cointegration in the full panel by combining individual cross-sections tests for cointegration.

If π_i is the *p*-value from an individual cointegration test for cross-section *i*, then under the null hypothesis for the whole panel:

$$-2 \sum_{i=1}^{N} log\,(\pi_i) \rightarrow \chi^2 2N$$

Where, χ^2 values based on MacKinnon-Haug-Michelis (1999) p?values for Johansen's cointegration trace test and maximum eigenvalue test.

The results of Pedroni (1999) Residual Cointegration Test (See Table 4 and Table 5) propose a rejection of the null hypothesis of non-cointegration at least at the level of significance of 5%. There is therefore a long-term relationship between exports and economic growth. The results of the Kao (1999) residual co-integration tests reject non-cointegration at the 5% significance level. This means that there is a long-run equilibrium relationship between Exports and Economic Growth (See Table 6). Also, the results of Johansen (1988) Fisher Cointegration Test confirm the existence of a long-term relationship between the two variables (See Table 6).

5.3. Panel FMOLS and DOLS Estimates

According to Kao and Chiang (2001), the OLS estimation technique lends super-convergent and biased estimators and reckons on nuisance parameters with the existence of correlated series. They indicated that there are several drawbacks in the analysis of time series which can lead to an increase in the background of the panel data and seem to increase with the existence of the problem of heterogeneity. There are several methodologies to overcome these disadvantages, such as fully modified OLS (FMOLS) and dynamic OLS (DOLS) which are proposed by Phillips and Hansen (1990), Saikkonen (1991), Stock and Watson (1993), and Kao and Chiang (2001). It should be noted that the FMOLS estimator is used by Pedroni (2001 a,b) in order to avoid the problem of endogeneity between the regressors. In this context, he supposed the specification as follows:

$$W_{i,t} = \alpha_i + \beta_i X_{i,t} + \tau_{i,t}$$

Consequently, $W_{i,t}$ and $X_{i,t}$ are cointegrated with slopes β_i, which can or can not be homogeneous on i. In the same way, Pedroni (2001a, b) affected the second specification in order to increase the cointegration vector by including the differences in lead and regressor delay, which drives to controling the feedback effect. Therefore, cointegration regression can be rewritten as follows:

$$W_{i,t} = \alpha_i + \beta_i X_{i,t} + \sum_{k=-k_i}^{ki} \gamma_{i,k} \Delta X_{i,t-k} + \tau_{i,t}$$

It should be renowned that: $\omega_{i,t} = \left(\hat{\tau}_{i,t}, \Delta X_{i,t}\right)$ and $\Omega_{i,t} = \lim_{T\to\infty} E\left[\frac{1}{T\left(\sum_{t=1}^{T}\omega_{i,t}\right)\left(\sum_{t=1}^{T}\omega_{i,t}\right)'}\right]$ represents the long-run covariance for this cointegrated vector.

So, the panel FMOLS estimator assumes the next specification:

$$\hat{\beta}^{*}_{FMOLS} = \frac{1}{N}\sum_{i=1}^{N}\left[\left(\sum_{t=1}^{T}\left(X_{i,t}-\bar{X}_i\right)^2\right)^{-1}\sum_{t=1}^{T}\left(X_{i,t}-\bar{X}_i\right)W^{*}_{i,t} - T_{\hat{\gamma}_i}\right]$$

Where $W_{i,t}^{*} = W_{i,t} - \overline{W}_i - \left(\frac{\widehat{\Omega}_{2,1,i}}{\widehat{\Omega}_{2,2,i}}\right)\Delta X_{i,t}$ and $\hat{\gamma}_i = \hat{\Gamma}_{2,1,i} + \widehat{\Omega}_{2,1,i}^{0} - \left(\frac{\widehat{\Omega}_{2,1,i}}{\widehat{\Omega}_{2,2,i}}\right)\left(\hat{\Gamma}_{2,2,i} + \widehat{\Omega}_{2,2,i}^{0}\right)$.

Saikkonen (1991) poseed the DOLS methodology for the first time in the context of time series. Then, following Saikkonen (1991), Kao and Chiang (2001) and Mark and Sul (2003) followed this methodology and employed the background to the panel data. Therefore, the panel DOLS estimator has the following specification:

$$\hat{\beta}_{DOLS}^{*} = \frac{1}{N}\sum_{i=1}^{N}\left[\left(\sum_{t=1}^{T} Z_{i,t}Z_{i,t}'\right)^{-1}\left(\sum_{t=1}^{T} Z_{i,t}\widetilde{W}_{i,t}\right)\right]$$

Where $Z_{i,t} = \left[X_{i,t} - \overline{X}_i, \Delta X_{i,t-k_i}, \dots, \Delta X_{i,t+k_i}\right]$ is vector of regressors, and $\widetilde{W}_{i,t} = W_{i,t} - \overline{W}_i$

Hence, when these variables have a cointegration relationship, we use the panel FMOLS and the panel DOLS to investigate the long-term relationship between variables. The FMOLS and DOLS estimation findings are recorded in Table 7. The obtained coefficients estimated from the cointegrating regression can be used as the long-run elasticities.

5.4. Panel VECM

Panel VECM model allows us to distinguish between "short-term" and "long-term" Granger causality. Thus, the following model can be applied to examine the causal relationships between variables:

$$\begin{bmatrix}\Delta\mathrm{Log}\ (\mathrm{Y})_{\mathrm{it}}\\ \Delta\mathrm{Log}\ (\mathrm{X})_{\mathrm{it}}\end{bmatrix} = \begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix} + \begin{bmatrix}\beta_{11.1} & \beta_{12.1}\\ \beta_{21.1} & \beta_{22.1}\end{bmatrix} \times \begin{bmatrix}\Delta\mathrm{Log}\ (\mathrm{Y})_{\mathrm{t-1}}\\ \Delta\mathrm{Log}\ (\mathrm{X})_{\mathrm{t-1}}\end{bmatrix} + \cdots + \begin{bmatrix}\beta_{11.\mathrm{n}} & \beta_{12.\mathrm{n}}\\ \beta_{21.\mathrm{n}} & \beta_{22.\mathrm{n}}\end{bmatrix}$$

$$\times \begin{bmatrix}\Delta\mathrm{Log}\ (\mathrm{Y})_{\mathrm{t-n}}\\ \Delta\mathrm{Log}\ (\mathrm{X})_{\mathrm{t-n}}\end{bmatrix} + \begin{bmatrix}\theta_1\\ \theta_2\end{bmatrix}\mathrm{ECT}_{\mathrm{t-1}} + \begin{bmatrix}\varepsilon_{1\mathrm{it}}\\ \varepsilon_{2\mathrm{it}}\end{bmatrix}$$

Where Δ is the first difference operator; $i = 1,\dots, N$ indicates the country; $t = 1, \dots, T$ indicates the time period; the various α, β and θ are parameters have to be estimated; $\varepsilon_{\mathrm{it}}$ is assumed to be serially uncorrelated error term; ECT is the one period lagged error correction term derived from the co-integration vector. As the VECM structure is used, all variables are considered being endogenous variables.

The results of the Vector Error Correction Model (VECM) are described in Table 7. In the long term, it is concluded that exports have a positive effect on economic growth; a 1% increase in log (X) exports leads to a 0.282334% increase in log (Y) economic growth. It is coherent with most of the previous studies mentioned above which they found that exports cause growth in the long run, such as; Konstantakopoulou and Mike (2017), Reza *et al* (2018) and Dritsaki (2013).

On the other hand, we conclude that economic growth has no effect on long-term exports. It is in line with the studies of Berasaluce and Romero (2017) Bakari (2017) and Bakari *et al* (2018). In the short term, the results of the VECM Model estimate prove the existence of a two-way causal link between economic growth and exports. These are the same results found Hussain (2014) and Bakari (2017).

5.5. Panel ARDL Model

The Panel ARDL model {introduced by Pesaran *et al*. (1999)} enables for the recognition of short- and long-term relationships and can be classed as an error correction model. This model is very relevant because it can examine possible long-term relationships regardless of the integration order of the variables, whether I (1) or mutually integrated (I (0) and I (1)). However, this technique cannot be practiced when the series are integrated of order 2. In addition, this model gives consistent and efficient estimators because it removes the problems ensuing from endogeneity by including lag length for both endogenous and exogenous variables. In line with Pesaran *et al*. (1999), the ARDL (p, q) model, including the relationship between exports and economic growth in the short run and in the long run, is expressed as follows:

$$\begin{aligned}\Delta \log(Y)_{it} = {} & \alpha_{1i} + \beta_{1i}\log(Y)_{it-1} + \beta_{2i}\log(X)_{it-1} + \sum_{j=1}^{p} \delta_{1i}\, \Delta \log(Y)_{it-j} \\ & + \sum_{i=0}^{q} \delta_{2i}\, \Delta \log(X)_{it-j} + \varepsilon_{1it}\end{aligned}$$

$$\begin{aligned}\Delta \log(X)_{it} = {} & \alpha_{1i} + \beta_{1i}\log(X)_{it-1} + \beta_{2i}\log(Y)_{it-1} + \sum_{j=1}^{p} \delta_{1i}\, \Delta \log(X)_{it-j} \\ & + \sum_{i=0}^{q} \delta_{2i}\, \Delta \log(Y)_{it-j} + \varepsilon_{2it}\end{aligned}$$

The selection of a lagged variable is based on the AIC (Akaike Information Criterion) and the Schwarz criterion (SBC: Schwarz Bayesian Criterion). Table 7 presents the results of the ARDL Model Panel estimate. These results prove the existence of a positive bidirectionel causality relationship between exports and economic growth in the long term and in the short term {According to the results of the ARDL Model Panel, a 1% increase in exports log (X) leads to a 0.044096% increase in economic growth log (Y). Likewise, a 1% increase in economic growth log (Y) leads to a 0.419746% increase in exports log (X)}. It is in line with the studies of Yusoff and Nuh (2015); Tan and Tang (2016); and Rahman and Shahbaz (2013), which indicated the existence of a positive bidirectional causality relationship between trade (Exports or/and Imports) and economic growth in the long run and in the short run.

5.6. Pooled OLS, Random Effect Model, Fixed Effect Model and Hausman Test

According to Roy and Rayhan (2011); Subasat and Bellos (2011); Kahouli and Maktouf (2014); Kahouli and Maktouf (2015); Paniagua (2015); Bakari and Mabrouki (2017); Bakari and Tiba (2019), the static gravity model remains the eclectic model for empirical studies on international trade.

In our case, the basic model is written and modeled as follows:

$$\Delta\log(\mathrm{Y})_{\mathrm{it}} = \alpha_{1\mathrm{i}} + \beta_{1\mathrm{i}}\Delta\log(\mathrm{X})_{\mathrm{it}} + \gamma_{\mathrm{i}} + \varepsilon_{\mathrm{t}}$$

$$\Delta\log(\mathrm{X})_{\mathrm{it}} = \alpha_{1\mathrm{i}} + \beta_{1\mathrm{i}}\Delta\log(\mathrm{Y})_{\mathrm{it}} + \gamma_{\mathrm{i}} + \varepsilon_{\mathrm{t}}$$

Where, 'γ' is a country-specific effect not observed, 'ε' is the term error, '*i*' is the individual dimension of the panel (the country) and '*t*' is the temporal dimension.

Theoretically, the question is whether to delimit the equation according to the methodology of panel data with fixed individual effects or random individual effects. Our goal here is not to expose the whole theory of different forms of individual effects or different types of specifications in the context of panel data analysis. We will try to describe the two types of individual effects most used in the literature, namely fixed effects and random effects. The Hausman test is the most used theoretical solution to determine which of the two types of estimates (fixed effects or random effects) would be the most appropriate. If the probability of the Hausman Test is minimal than 5%, in this case the fixed-effect model is significant and will be preserved. However, if the probability of the Hausman Test is more than 5% the random effect model is significant and will be holded.

In the case where the variable which designates economic growth log (Y) is dependent, and according to the results of the estimates include in Table 7. The estimation of the Pooled OLS model indicates that exports have a positive effect on economic growth (an increase 1% of exports log

(X) leads to a 0.179009 % increase in economic growth log (Y)). Otherwise, the results of the estimation of the fixed effect model also confirm that exports have a positive impact on economic growth (a 1% increase in exports log (X) leads to a 0.176260 % increase in economic growth log (Y)). Likewise, the results of the random effect model assert that exports have a positive effect on economic growth (a 1% increase in exports log (X) leads to a 0.176260 % increase in economic growth log (Y)). In our case, we have the probability that the Hausman test is high than 5% to a value equal to 7.07% of the Hausman test. This means that the random effect model is significant and will be retained. We can conclude from the use of this empirical methodology that exports are a source of economic growth. These results are identical to the studies by Abdullahi *et al* (2013); Alavinasab (2013); Velnampy and Achchuthan (2013); Azeez *et al* (2014); Turan and Karamanaj (2014); Hamdan (2016); Ofeh and Muandzevara (2017), and which used empirical estimations based on linear regressions and static gravity models.

In the case where the variable which designates exports log (X) is dependent and according to the results of the estimates included in Table 7. The estimate of the Pooled OLS model indicates that economic growth has a positive effect on exports (an increase 1% of economic growth log (Y) leads to an increase of 1.413432% in exports log (X)). Otherwise, the results of the estimation of the fixed effect model also confirm that economic growth has a positive impact on exports (a 1% increase in economic growth log (Y) leads to a 1.402317% increase in exports log (X)). Equally, the results of the random effect model assert that economic growth has a positive effect on exports (a 1% increase in economic growth log (Y) leads to a 1.414048% increase in exports log (X)). In our case, we have the probability that the Hausman test is greater than 5% to a value equal to 30.88% of the Hausman test. This means that the random effect model is significant and will be kept. As a conclusion here, we confirm the Growth-Led-Export hypothesis. we did not find any studies that study the effect of economic growth on exports using estimates based on the Pooled OLS, Random Effect Model, Fixed Effect Model and Hausman Test. In fact, our ad hoc specification of equation (5) gives the same results of Panel Pairwise Granger Causality Tests, Panel Toda-Yamamoto Causality Tests and Panel ARDL Model in our study and the same results of other studies based onPanel VECM such as Safdari *et al*. (2011), and Mahmoodi and Mahmoodi (2016). This presents one of our contributions in this study.

5.7. Panel Pairwise Granger Causality Tests

Granger (1969) developed a methodology for analyzing the causal relationships between time series, which named the Granger Causality test.

This test was developed by Dumitrescu and Hurlin (2012) in order to check for Granger causality in panel datasets. The causal relationship between exports log (X) and economic growth log (Y) can be examined within the following bivariate representation:

$$\log(Y)_{i,t} = \alpha_i + \sum_{k=1}^{K} \beta_{ik} \log(Y)_{i,t-k} + \sum_{k=1}^{K} \gamma_{ik} \log(X)_{i,t-k} + \varepsilon_{i,t}$$

$$\log(X)_{i,t} = \alpha_i + \sum_{k=1}^{K} \beta_{ik} \log(X)_{i,t-k} + \sum_{k=1}^{K} \gamma_{ik} \log(Y)_{i,t-k} + \varepsilon_{i,t}$$

Where $\log(Y)_{i,t}$ and $\log(X)_{i,t}$ are the observations of two stationary variables for individual 'i' in period 't'. Coefficients are permitted to dissent across individuals (note the 'i' subscripts attached to the coefficients) but are assumed time- invariant. The lag order K is supposed to be identical for all individuals.

The process to establish the existence of causality is to test for significant effects of past values of log (X) on the present values of log (Y) and to test for significant effects of past values of log (Y) on the present values of log (X). Based on p-values, we can reject or accept the null hypotheses. The null hypothesis, which corresponds to the absence of causality for all individuals in the panel, is therefore defined as:

$$H_0: \beta_{i1} = \cdots = \beta_{iK} = 0 \qquad \forall_i = 1, \ldots, N$$

The alternative hypothesis, which corresponds to the existence of causality for all individuals in the panel, is therefore defined as:

$$H_1 \; : \; \beta_{i1} = \cdots = \beta_{iK} = 0 \qquad \forall_i = 1, \ldots, N_1$$

$$\beta_{i1} \neq 0 \; or \ldots or \; \beta_{iK} \neq 0 \quad \forall_i = N_1 + 1, \ldots, N$$

Where $N_1 \in [0, N\text{-}1]$ is unknown.

Table 7 reported results of Panel Pairwise Granger Causality Tests. It is clear that there is a bidirectional causality relationship between exports and economic growth.

5.8. Panel Toda-Yamamoto Causality Test

Toda and Yamamoto (1995) sophisticated a modern practicability of Granger causality based on an augmented VAR modeling by pressing a modified

Wald tests (MWald) statistique, and it can be used with all the integration series types I(0), I(1) and I(2) for both non co-integrated or co-integrated variables. The Panel Toda-Yamamoto Causality Test steps regulates from four steps. The first step is to discover the maximum order of integration between the variables dmax where is the higher order of integration. The second step is to define the optimal lag order (K) of VAR model in levels as usually choosed by Akaike information criterion (AIC), Schwarz information criterion (SIC), Hannan-Quin information criterion (HQ), the final prediction error (FPE) and the sequential modified LR test statistique (LR). The third step is to estimate the VAR model (VAR(K+dmax)) as follows:

$$\Delta\log\,(\mathrm{Y})_{\mathrm{it}} = \alpha_{1\mathrm{it}} + \sum_{\mathrm{i}=1}^{\mathrm{h+d}} \beta_{1\mathrm{it}}\Delta\log\,(\mathrm{Y})_{\mathrm{i,t}-1} + \sum_{\mathrm{j}=1}^{\mathrm{l+d}} \gamma_{1\mathrm{it}}\Delta\log\,(\mathrm{X})_{\mathrm{i,t}-\mathrm{j}} + \varepsilon_{1\mathrm{it}}$$

$$\Delta\log\,(\mathrm{X})_{\mathrm{it}} = \alpha_{2\mathrm{it}} + \sum_{\mathrm{j}=1}^{\mathrm{l+d}} \gamma_{2\mathrm{it}}\Delta\log\,(\mathrm{X})_{\mathrm{i,t}-1} + \sum_{\mathrm{i}=1}^{\mathrm{h+d}} \beta_{2\mathrm{it}}\Delta\log\,(\mathrm{Y})_{\mathrm{i,t}-\mathrm{j}} + \varepsilon_{2\mathrm{it}}$$

Where 'd' is the maximal order of integration of the variables in the system ; 'h' and 'l' are the optimal lag length of log (Y) and log (X); and ε_{1it} and ε_{2it} are error terms and which are presupposed to be white noise with zero mean constant variance and no autocorrelation. The final step of the Panel Toda-Yamamoto Causality Test is applying the Wald test statistic to check the causal relationships between the two variables.

It is clear from Table 7 that there is a bidirectional causality relationship between exports and economic growth. Similarly, and according to the Panel Toda-Yamamoto Causality Test, we can affirme the existence of the export-led-growth hypothesis and the growth-led-export hypothesis in Africain countries.

5.9. Panel GMM Model

GMM estimation was formalized by Hansen (1982), and it become one of the most extensively used methods of estimation for models in economics and finance analysis. Indeed several studies like Managi *et al* (2009), Law (2009), Fukase (2010), Das and Paul (2011), Felbermayr *et al* (2011) and Ulasan (2015), affirm that this model is very effective on the empirical works which treat the impacts and the determinants of international trade.

In order to estimate the GMM in our model, we require appending the lagged dependent variable in order to resolve the endogeneity bias. As a result, we consider GMM method Equations. Regression equations will be as follows:

$$\Delta \log(\mathbf{Y})_{it} = \alpha_{1i} + \beta_{1i}\Delta \log(\mathbf{Y})_{it-1} + \gamma_{1i}\Delta \log(\mathbf{X})_{it} + \mu_i + \varepsilon_{it}$$

$$\Delta \log(\mathbf{X})_{it} = \alpha_{2i} + \gamma_{2i}\Delta \log(\mathbf{X})_{it-1} + \beta_{2i}\Delta \log(\mathbf{Y})_{it} + \mu_i + \varepsilon_{it}$$

Where $\log(Y)_{it-1}$ is the lagged variable of $\log(Y)_{it}$; $\log(X)_{it-1}$ is the lagged variable of $\log(X)_{it}$; α, β and γ are the parameters to be estimated; μ_i represents the individual effects; t denotes the time; and ε_{it} designates the model error term.

During the application of this technique, we will apply an estimate based on GMM regression only. Then we will delimit the GMM model equation according to the panel data methodology with fixed individual effects or random individual effects. Finally, we will use the Hausman test to determine which of the two types of estimates (fixed effects or random effects) would be more appropriate. If the probability of the Hausman test is at least 5%, in this case, the GMM model with fixed effect is significant and will be kept. However, if the probability of the Hausman test is greater than 5%, in this case, the GMM random effect model is significant and will be retained.

According to the findings of the estimates encompass in Table 7 and in the case where the variable which designates economic growth log (Y) is dependent. The estimation of the GMM model indicates that exports have a positive effect on economic growth (an increase 1% of exports log (X) leads to a 0.695745 % increase in economic growth log (Y)). Otherwise, the results of the estimation of the GMM model with fixed effect also confirm that exports have a positive impact on economic growth (a 1% increase in exports log (X) leads to a 0.691365 % increase in economic growth log (Y)). Likewise, the results of the GMM Model with random effect assert that exports have a positive effect on economic growth (a 1% increase in exports log (X) leads to a 0.695745 % increase in economic growth log (Y)). In our case, we have the probability that the Hausman test is high than 5% to a value equal to Hausman Test in GMM Model 50, 99% of the Hausman test. This means that the GMM Model with the random effect is significant and will be retained. We conclude according to this methodology the existence of Export-led-growth hypothesis in African countries.

In the case where the variable, which designates exports log (X), is dependent. The estimate of the GMM Model indicates that economic growth has a positive effect on exports (an increase 1% of economic growth log (Y) leads to an increase of 1.420677 % in exports log (X)). Otherwise, the results of the estimation of the GMM Model with fixed effect also confirms that economic growth has a positive impact on exports (a 1% increase in economic growth log (Y) leads to a 1.407795% increase in exports log (X)). Equally, the results of the GMM Model with random effect assert that economic growth has a positive effect on exports (a 1% increase in economic growth log (Y) leads to a 1.421259% increase in exports log (X)). In our case, we have the probability that the Hausman test is greater than 5% to a value equal to 26, 13% of the Hausman test. This means that the random effect model is significant and will be kept. As a conclusion here, we confirm the Growth-Led-Export hypothesis.

6. CONCLUSION

Current research uses many innovative econometric methods to test the relationship between exports and economic growth in 49 African countries for the period 1960 - 2018. Empirical results show that all models indicate that there is positive bidirectionnel causality between exports and economic growth (only in Panel VECM indicate that there is a positive unidirectional causality from export to economic growth). These results prove that exports are a source of economic growth in African countries.

We main policy implications can be drawn from these findings. First, economic planners and policy makers in African countries may want to know the important role that exports play in the economic development of various countries. The government and economic planners need to work together to attract foreign investment and promote international trade. The establishment of a free trade zone will provide more incentives for foreign investors who produce manufactured goods for export. In addition, special tax incentives can be given to domestic and foreign merchants engaged in international trade. Good infrastructure and living conditions will greatly improve the investment environment. Second, economic planners and policy makers in sub-Saharan African countries may want to know that the link between exports and economic growth is not always stable. This highlights the need to develop policies aimed at achieving stable and sustainable relationships between exports and economic growth. One of the feasible measures may be to promote R&D activities aimed at improving export quality and promoting export activities.

Future research on this topic will need to use the latest available data and reliable data sets. In addition, an advanced statistical technique needs to be considered, including a breakpoint unit root test that combines structural breakage in the junction and trend. Rigorous research techniques and the latest available data may deepen our understanding of the link between exports and growth and provide much-needed insights for the formulation of more enlightened economic policies.

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Table 1: Descriptive statistics and Correlation Matrix of the Variables

	At log level			At level	
Descriptive statistics	LOG(Y)	LOG(X)	**Descriptive statistics**	Y	X
Mean	22.86931	21.37640	Mean	2.88E+10	8.71E+09
Median	22.79138	21.44569	Median	7.91E+09	2.06E+09
Maximum	26.87467	25.61588	Maximum	4.69E+11	1.33E+11
Minimum	19.20503	13.04457	Minimum	2.19E+08	462577.9
Std. Dev.	1.491520	1.928297	Std. Dev.	6.22E+10	1.86E+10
Skewness	0.414698	-0.484565	Skewness	4.022363	3.682754
Kurtosis	2.799202	4.235278	Kurtosis	21.49968	18.48341
Jarque-Bera	57.58989	194.9502	Jarque-Bera	32183.43	23249.45
Probability	0.000000	0.000000	Probability	0.000000	0.000000
Sum	43405.95	40572.40	Sum	5.46E+13	1.65E+13
Sum Sq. Dev.	4220.125	7053.674	Sum Sq. Dev.	7.35E+24	6.53E+23
Observations	1898	1898	Observations	1898	1898
Correlation Matrix	LOG(Y)	LOG(X)	**Correlation Matrix**	Y	X
LOG(Y)	1	0.8966410892003462	Y	1	0.9475100857209885
LOG(X)	0.8966410892003462	1	X	0.9475100857209885	1

Source: Calculations done by authors based on the Eviews 9 software

Table 2. Panel unit root test results

Series	LOG(Y)				LOG(X)			
Exogenous variables	Individual effects		Individual effects, individual linear trends		Individual effects		Individual effects, individual linear trends	
Method	***Statistic***	***Prob.*****	***Statistic***	***Prob.*****	***Statistic***	***Prob.*****	***Statistic***	***Prob.*****
Null: Unit root (assumes common unit root process)								
Levin, Lin & Chu t*	-1.1990	0.1153	-1.14642	0.1258	-1.27933	0.1004	-1.21980	0.1113
	-17.879	0.0000	-17.9472	0.0000	-22.8165	0.0000	-21.6288	0.0000
Breitung t-stat			2.86106	0.9979			1.63832	0.9493
			-17.3787	0.0000			-11.7625	0.0000
Null: Unit root (assumes individual unit root process)								
Im, Pesaran and Shin W-stat	7.3854	1.0000	1.58250	0.9432	4.39077	1.0000	-0.92386	0.1778
	-22.154	0.0000	-21.5747	0.0000	-20.9734	0.0000	-15.4947	0.0000
ADF - Fisher Chi-square	62.738	0.9979	95.2729	0.5592	83.0071	0.8605	140.208	0.0033
	720.43	0.0000	632.628	0.0000	710.162	0.0000	591.135	0.0000
PP - Fisher Chi-square	92.954	0.6251	78.7016	0.9240	132.883	0.0110	167.462	0.0000
	1208.3	0.0000	1107.80	0.0000	1120.64	0.0000	985.615	0.0000
Notes: *, ** and *** denotes significance at the 1%, 5% and 10% level.								
( ) denotes stationarity in level;								
[ ] denotes stationarity in first difference;								

Source: Calculations done by authors based on the Eviews 9 software

Table 3. Lag Order Selection Criteria

VAR Lag Order Selection Criteria						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	2837.164	NA	7.02e-05	-3.889114	-3.881865*	-3.886410*
1	2839.586	4.833322	7.03e-05	-3.886949	-3.865201	-3.878836
2	2846.881	14.54030	7.00e-05	-3.891469	-3.855222	-3.877947
3	2853.301	12.77844	6.98e-05	-3.894789	-3.844043	-3.875857
4	2855.912	5.190178	6.99e-05	-3.892884	-3.827639	-3.868543
5	2872.112	32.15491*	6.87e-05	-3.909619	-3.829875	-3.879869
6	2876.625	8.946118	6.87e-05*	-3.910323*	-3.816080	-3.875164
7	2879.621	5.928966	6.88e-05	-3.908945	-3.800203	-3.868377
8	2881.412	3.541229	6.90e-05	-3.905915	-3.782675	-3.859938
**** indicates lag order selected by the criterion***						
LR: sequential modified LR test statistic (each test at 5% level)						
FPE: Final prediction error						
AIC: Akaike information criterion						
SC: Schwarz information criterion						
HQ: Hannan-Quinn information criterion						

Source: Calculations done by authors based on the Eviews 9 software

Table 4. Pedroni Residual Cointegration Test: Alternative hypothesis: common AR coefs. (within-dimension)

Trend assumption	No deterministic trend				Deterministic intercept and trend			
	Statistic	Prob.	Weighted Statistic	Prob.	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-1.852257	0.9680	-2.379248	0.9913	-7.031540	1.0000	-7.653340	1.0000
Panel rho-Statistic	-47.14578	0.0000	-48.69323	0.0000	-38.13628	0.0000	-40.13607	0.0000
Panel PP-Statistic	-30.38490	0.0000	-32.29929	0.0000	-36.37129	0.0000	-37.28943	0.0000
Panel ADF-Statistic	-3.164956	0.0008	-2.566686	0.0051	1.186280	0.8822	-0.031785	0.4873
Notes: *, ** and *** denotes significance at the 1%, 5% and 10% level.								

Source: Calculations done by authors based on the Eviews 9 software

Table 5. Pedroni Residual Cointegration Test: Alternative hypothesis: individual AR coefs. (between-dimension)

Trend assumption	No deterministic trend		Deterministic intercept and trend	
	Statistic	Prob.	Statistic	Prob.
Group rho-Statistic	-28.84520	0.0000	-20.63813	0.0000
Group PP-Statistic	-29.96611	0.0000	-33.90001	0.0000
Group ADF-Statistic	-4.559848	0.0000	2.167327	0.9849
Notes: *, ** and *** denotes significance at the 1%, 5% and 10% level.				

Source: Calculations done by authors based on the Eviews 9 software

Table 6. Results of Johansen Fisher and Kao Residual Cointegration Tests

Johansen Fisher Panel Cointegration Test					***Kao Residual Cointegration Test***		
Trend assumption: Linear deterministic trend					Trend assumption: No deterministic trend		
Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)					Null Hypothesis: No cointegration		
Hypothesized No. of CE(s)						t-Statistic	Prob.
	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.	ADF	5.458088	0.0000
None	292.4	0.0000	221.7	0.0000	Residual variance	0.008557	
At most 1	213.3	0.0000	213.3	0.0000	HAC variance	0.000816	
Notes: *, ** and *** denotes significance at the 1%, 5% and 10% level.							

Source: Calculations done by authors based on the Eviews 9 software

Table 7. Results of Estimation Panels Methods

	X => Y		***Y => X***	
Methods	Coefficient	P-Value	Coefficient	P-Value
Panel FMOLS	0.089174***	0.0000	0.960321***	0.0000
Panel DOLS	0.229045***	0.0000	1.376921***	0.0000
Panel VECM: Long Run	0.282334***	0.0000	3.541910	0.5032
Panel VECM: Short Run	83.05849***	0.0000	12.34855**	0.0546
ARDL Model: Long Run	0.044096***	0.0000	0.419746***	0.0000
ARDL Model: Short Run	0.151036**	0.0252	0.721378***	0.0001
Pooled OLS	0.179009***	0.0000	1.413432***	0.0000
Random Effect Model	0.178573***	0.0000	1.414048***	0.0000
Fixed Effect Model	0.176260***	0.0000	1.402317***	0.0000
Hausman Test in Gravity Model		0.0707		0.3088
Pairwise Granger Causality Tests		0.0525*		0.0368**
Toda-Yamamoto Causality Test		0.0662*		0.0496**
Panel GMM	0.695745***	0.0000	1.420677***	0.0000
Panel GMM: Random Effect Model	0.695745***	0.0000	1.421259***	0.0000
Panel GMM: Fixed Effect Model	0.691365***	0.0000	1.407795***	0.0000
Hausman Test in GMM Model		0.5099		0.2613
Notes: ***, ** and * denotes significance at the 1%, 5% and 10% level.				

Source: Calculations done by authors based on the Eviews 9 software