

Investigation of developmental relationship between west and east African regions using socio-economic indicators

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Abstract:

Advances in studying the Developmental Relationship that exist between some African countries have necessitated the collection of many variables about Regions. Detection of important variables as predictors and outcomes among them, without applying an appropriate statistical method is a very challenging task. Because of recurrent nature of the Socio-economic Indicators of each regions that are under study. There are usually more than one variable in the outcome set. For the prevention of this problem that causes multi-collinearity, a statistical method named canonical correlation analysis (CCA) is a good solution. In this paper, Canonical Correlation Analysis (CCA) was applied to socio-economic data of West and East African regions to examine the existence and strengths of relationships between the two regions in terms of their socio-economic development. The results of the analysis revealed that, the strongest correlation of (.9999) is associated with Somalia in East Africa as well as Ghana in West Africa. This is followed by Mauritius and Zambia in East Africa as well as Guinea Bissau and Niger in West Africa. The last strongest correlation of (0.8425) is associated with Burundi, Madagascar and Zimbabwe in East Africa as well as Benin and Gambia in West Africa. The study recommends using the canonical correlation to evaluate socio-economic development between countries. Consequently, the countries associated with such kind of correlations were those countries shared socio-economic indicators for the period under study.

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1. Introduction

West and East African regions have diverse ethnic, cultural and social groups. Each of the regions has countries as its member states. The regions are also believed to share some common features in terms of their socio-economic development. It is in view of this that the paper carried out an investigation using Canonical Correlation analysis method and determines the area and extent of relationship among member countries of these regions using socio-economic indicators [1, 2, 3].

The Conference of African Ministers of Finance, Planning and Economic Development analyzed the economic and social indicators for West and East African regions and come up with the economic and social conditions of these regions [4]. Mai, *et al.* [5] and Hotelling [6] used socio-economic indicators and classified East and West African regions in terms of their socio-economic levels. Mardia, *et al.* [7] and Weenink [8] Report indicated that, the performance in social development of the two regions exhibits significant disparities across countries. While many countries are experiencing worsening social conditions and several have made progress toward meeting the MDGs. This paper will explored the application of Canonical Correlation Analysis on socio-economic data of East and

West African regions and determine the existence and strength of relationships between the two regions.

Specifically, growth factors in Eastern Africa included expansion in agriculture, horticulture and services, especially finance, telecommunications and construction. The sub region also benefited from healthy inflows of aid and strong growth in tourism and FDI. However, growth in some Eastern African countries such as Uganda remains constrained by infrastructure bottlenecks, especially energy and transportation. While in West Africa, GDP growth was strong in most countries, due to accelerated recovery in Liberia (8.0 per cent), increased oil production and prices and growth in non-oil sectors in Nigeria (6.1 percent each), high FDI inflows and remittances in Cape Verde (5.8 percent), and expansion in mining activity in Sierra Leone (5.8 per cent), Ghana (6.0 percent) and Burkina Faso (4.3 percent). Growth in construction and tourism together with high public spending underpinned a high GDP growth rate in the Gambia (5.8 per cent). Growth also remained high in Benin (4.7 percent), with a recovery in re-export activity and cotton production and strong growth in construction [9, 10, 11].

In 1999, the socio-economic situation of the countries of the sub region, evolved in quite a contrasted manner,

according to the main sectors. On whole, economic growth rate which stood at 3.3%, was not enough to attain the objective of eradicating poverty by the year 2015. Such rate, which was already very modest, dropped to 2.6% in the year 2000, whereas the growth slowdown in the developed countries only portends a slight recovery of 3.6% in the UEMOA countries on which there are information. The three factors constituting the annual performance index (GDP per capita, rate of inflation and ratio of the deficit of the current operating account to GDP) experienced some simultaneous improvement only in two countries (Senegal and Guinea) [10, 12, 13].

Udofia, *et al.* [14] and Tien [15] reports stated that despite the slowdown in economic activity throughout West Africa, government revenue continued to grow more rapidly than expenditure leading to an improvement in the principal budget balances. The increase in revenues continued in 2004 albeit at a slower pace than in the previous year. The revenues increased by 27.6 % in 2004 as against 25.2 % in 2003. This development results from the improvement of Nigeria's revenue situation as boosted by the oil sector and stronger revenue collection initiatives in many countries. In ratio to GDP, revenues stood at 29.5 % in 2004 overall compared with 28.9 % in 2003. This performance is attributable mainly to Nigeria, the only country to register a rate higher than the average for the zone (39.7%). Guinea (10%) and Niger (11.4%) registered an extremely weak performance.

With these indicators of development in the regions, there are several measures of correlations to express the relationships between the two regions in terms of their development. However, a multivariate approach otherwise known as Canonical Correlation Analysis is ideal if one is interested in finding out the existence and strength of relationships between the regions. Canonical Correlation Analysis is a multivariate statistical model that facilitates the study of interrelationships among sets of multiple dependent and multiple independent variables, the analysis will go further in determining the relative importance of each variable. According to Udoh [16], the model was developed by many researchers where they analyzed how arithmetic speed and arithmetic power are related to reading speed and reading power.

Canonical Analysis has been applied to a variety of research problems. For instance, Udoh [16] also seek to determine whether a relationship exists between information technology (IT) investment and the strategic and economic performance of the firm using canonical correlation Analysis. The analysis was performed with a sample of 100 firms. The result indicates a significant relationship in the organizational performance measure explained by IT investment. Weenink [8], examined the potential applications of CCA in regional science by describing its algorithm in a regional or spatial context. The author applied CCA to explore the mutually interdependent relationship between transport and development in China's Zhujiang Delta. The results highlighted the utility of CCA in revealing the structural and spatial patterns of two dominant and four subdominant transport development relationships in this growing region of China [17, 18, 21, 22].

In Goebel and David, Canonical correlation Analysis was used to examine the interrelatedness among forest strata using CCA axis scores. The results revealed several trends and strong relationship between the canopy and seedling strata, as well as between the sapling and seedling strata.

In the context of this paper, West and East African regions were considered as our data sets consisting of member countries as our multiple variables which also constituted two data sets, P and Q for the purpose of analysis. The analysis then derived number of canonical functions in $\min. (P, Q)$ i. e., in number of variables in the smaller set. These functions gave the canonical correlations of the canonical variables starting with the strongest, the second strongest and subsequently to the weakest ones.

An interpretation of derived canonical functions requires examination of the derived canonical loadings in relation to the tested significant functions [21, 22, 23, 24, 25 and 26]. This approach was however employed in this study, and the results revealed that, there are strong relationships between the West and East African regions and the countries that have contributed to each different kind of relationships were identified.

1.1 Canonical Correlation Model

Canonical correlation Analysis developed by [5, 28 and 29] is a statistical model to identify and quantify the association between two sets of variables. Canonical Correlation Analysis focuses on the correlation between linear combination of the variables in one set and a linear combination of variables in another set. The idea is first to form a linear combination of variables of the two sets under consideration and then determine the pair of linear combination having the largest correlation. Next we determine the pair of linear combination having the largest correlation among all pairs uncorrelated with the initially selected pair. Thus, let the two linear combination be:

$$V = a'X \quad \text{and} \quad U = b'Y \quad (1)$$

note that from equation (1.1)

$$\text{var.}(V) = a' \text{var}(X) a = a' \Sigma_{XX} a \quad (2)$$

$$\text{var}(U) = b' \text{var}(Y) b = b' \Sigma_{YY} b \quad (3)$$

And

$$\text{cov}(V, U) = a' \text{cov}(X, Y) b = a' \Sigma_{XY} b \quad (4)$$

We shall seek the coefficient vectors a and b so that

$$\text{Corr.}(V, U) = \frac{\text{cov.}(V, U)}{\sqrt{\text{var}(V)} \sqrt{\text{var}(U)}} = \frac{a' \Sigma_{XY} b}{\sqrt{a' \Sigma_{XX} a} \sqrt{b' \Sigma_{YY} b}} \quad (5)$$

Is as large as possible [27, 29 and 30].

The first pair of canonical variables is the pair of linear combinations V_1, U_1 having unit variance which maximizes the correlation in equation (5). Generally, the k th pair of

canonical variates is therefore the pair of linear combinations V_k, U_k having unit variance, which maximize the correlation in equation (5) among all choices uncorrelated with the previous $k-1$ canonical variates [30 and 31].

Thus, the first pair of canonical variates is:

$$V_1 = a'_1 X = a_{11}X_1 + a_{12}X_2 + \dots + a_{1p}X_p \quad (6)$$

$$U_1 = b'_1 Y = b_{11}Y_1 + b_{12}Y_2 + \dots + b_{1q}Y_q \quad (7)$$

With correlation

$$\rho_1(V_1, U_1) = \frac{a'_1 \Sigma_{12} b_1}{\sqrt{a'_1 \Sigma_{11} a_1} \sqrt{b'_1 \Sigma_{22} b_1}} \quad (8)$$

Subsequently,

V_2, U_2 are the 2nd pair of canonical variates,

V_3, U_3 are the 3rd pair of canonical variates,

V_i, U_i are the i th pair of canonical variates

Where $i = \min. (p, q)$.

With correlation $Corr(V_i, U_i) = \rho_i$

2. Material and Methods

The data used for this investigation was obtained from African Development [32] which reports on socio-economic data. Average of five years data for forty variables principally as Socio-economic indicators in percentages and corresponding countries of West and East African Regions for the period of five years ie. (1999-2003) were considered. These variables are Urban population, Female Population, Labor Participation Rate, Labor Participation Rate-Female, Labor Participation Rate –Male, Population Growth Rate, Urban Population Growth Rate, Female Population Growth Rate, Life Expectancy at Birth Male, Life Expectancy at Birth-Female, Infant Mortality Rate, Crude Death Rate, Total Fertility Rate, Gross Primary Enrolment Ratio, Gross Primary Enrolment Ratio-Female, Gross Secondary Enrolment Ratio, Gross Secondary Enrolment Ratio-Female, Adult Literacy Rate, Adult Literacy Rate-Male, Adult Literacy Rate-Female, GDP Growth Rate, Real Per Capita, Gross Capital Formation, Public Capital Formation, Private Capital Formation, Gross National Savings, Consumer Price Index, Real Exchange Rate Index, Monetary Growth, Income Velocity, Total Revenue and Grants, Total Expenditure and Net Lending, Overall Deficit/Surplus, Export Volume Growth, Import Volume Growth, Term of Trade Growth, Current Account Balance, External Reserve, Debt Service and External Debt

The method of analysis adopted was multivariate approach. The variables are drawn together in the application of Canonical Correlation analysis to investigate the relationship between East African member countries and West African member countries. In particular it examines the relationship between seventeen (17) countries as

dependent variables and sixteen (16) countries as independent variables.

The aim of canonical correlation analysis is to investigate the relationship between a linear combination of dependent variables $U(Y_1, Y_2, \dots, Y_p)$ and a linear combination of independent variables $V(X_1, X_2, \dots, X_q)$.

The analysis estimates a number of such relationships where the number of dependent or independent variables, whichever is smaller, determine the maximum number of correlation coefficients required beginning with the strongest to the weakest one. The relationship is such that the correlation between each pair of U and V is maximized.

The researcher will be constrained on the approach to interpretation of the results of the analysis, because the output depends on the software used for the analysis. Giving a choice on the approach, Kamla [33], Ombeni [34], Ricks [35] and Sheriff, *et. al.* [36] stated that, interpretation of canonical functions is based on weights, canonical loadings or canonical cross loadings whichever will give the required results depending on the software use for the analysis. The analysis was carried out using Genstat statistical software which provides weights and loadings. Therefore the interpretation was using loadings which are stronger than weights.

The issue of important is whether all the correlation coefficients are significant. Taiwo [37] However, provided an approximation for large n in multivariate test of significant of canonical correlation coefficients. If the canonical correlations coefficient(s) are statistically significant, we still need to make substantive interpretation of the results. These interpretations involved examining the canonical loadings in conjunction with significant canonical functions to determine the relative importance of each of the original variables in the canonical correlation. In this paper we employed the use of loadings in the interpretation of result as proposed by [38 and 39]. Canonical loadings measure the correlation of each variable in a set with the linear combination of variables (canonical variates) in the set. This process was applied to socioeconomic data of West and East African regions data and the results are presented in Table 1 and 2.

3. Results

The number of dependent variables sixteen (16) or the number of independent variables seventeen (17) whichever is smaller, determines the maximum number of canonical function. Thus the analysis is based upon the derivation of sixteen (16) canonical functions.

The first canonical correlation is 0.9999 with corresponding Bartlett's statistic of 873. Similarly, the second to the sixteen canonical correlations with their corresponding Bartlett's statistics of the regions are presented in the Table 1. The canonical functions with bolded numbers 1 through 9 in the first column of Table 1 are the significant functions since their Bartlett tests values are greater than the critical chi square values, while the function with unfolded numbers 10, 11, 12, 13, 14, 15, and 16 were insignificant. The insignificant canonical functions are therefore disregarded for further interpretation.

Table 1: Canonical correlations coefficients and significant tests for West and East Africa

Canonical Function	Canonical Correlation (r_c)	Eigen values (r_c^2)	% of shared variance	Bartlett's Test	Approximate χ^2 Values
1	0.9999	0.9998	9.29	873.4	311.47 = χ_{272}^2
2	0.9992	0.9984	9.28	(s=1), 687.28	277.14 = χ_{240}^2
3	0.9974	0.9948	9.24	(s=2), 545.64	244.81 = χ_{210}^2
4	0.996	0.9920	9.22	(s=3), 429.91	214.48 = χ_{182}^2
5	0.9811	0.9626	8.94	(s=4), 323.64	186.15 = χ_{156}^2
6	0.9645	0.9303	8.64	(s=5), 251.38	159.81 = χ_{132}^2
7	0.9471	0.8970	8.33	(s=6), 192.79	135.48 = χ_{110}^2
8	0.9343	0.8729	8.11	(s=7), 142.80	113.15 = χ_{90}^2
9	0.8425	0.7098	6.59	(s=8), 97.42	92.81 = χ_{72}^2
10	0.7765	0.6030	5.60	(s=9), 70.20	74.42 = χ_{56}^2
11	0.7048	0.4967	4.61	(s=10), 49.88	58.12 = χ_{42}^2
12	0.6568	0.4314	4.00	(s=11), 34.77	43.77 = χ_{30}^2
13	0.5739	0.3294	3.06	(s=12), 22.35	31.41 = χ_{20}^2
14	0.5414	0.2931	2.72	(s=13), 13.58	21.03 = χ_{12}^2
15	0.3917	0.1534	1.43	(s=14), 5.9	12.59 = χ_6^2
16	0.3141	0.0987	0.92	(s=15), 2.29	5.99 = χ_2^2

Table 2: Loadings for West and East African Regions

Country/Function	1	2	3	4	5	6
P set(East Africa)						
Burundi	-0.000174	0.017151	-0.003646	-0.008815	0.010941	-0.000653
Comoros	-0.003295	-0.005049	0.004844	0.001597	0.005416	-0.003222
Djibouti	-0.001565	0.003646	0.002636	-0.000380	-0.007435	-0.008387
Eritrea	0.001809	0.000930	-0.001911	-0.001408	0.004595	0.004426
Ethiopia	-0.002681	-0.004729	0.013977	0.003955	-0.009907	0.000466
Kenya	0.007582	-0.015149	0.022494	0.025386	0.000555	-0.030361
Madagascar	-0.004922	0.012239	-0.004085	0.011318	-0.021873	-0.000849
Malawi	-0.001715	-0.009884	-0.005575	-0.002655	-0.010537	0.001011
Mauritius	0.000916	0.008014	-0.008823	-0.009218	0.002952	-0.008570
Mozambique	-0.000350	0.003361	-0.000621	0.000920	0.004473	-0.005012
Rwanda	0.000475	0.006845	0.010590	-0.019794	0.005854	-0.015525
Seychelles	-0.000402	0.001211	0.000734	-0.001235	-0.001566	0.002091
Somali	0.004635	0.002681	0.003981	-0.003593	-0.007565	-0.001565
Uganda	0.001878	0.000082	-0.005463	0.000307	-0.000772	0.006601
Tanzania	-0.000935	-0.018850	-0.038977	0.000482	0.021251	0.009054
Zambia	-0.000048	-0.007782	0.009390	0.005526	0.006687	0.005602
Zimbabwe	0.002159	0.006330	0.001348	-0.000534	0.000301	-0.015095
Q set (West Africa)						
Benin	-0.020740	0.011183	-0.028268	-0.020847	-0.009712	-0.022056
Burkina Faso	0.018078	-0.024533	0.042881	0.011737	0.039975	0.048537
Cape Verde	-0.000816	0.001766	0.006611	-0.002934	0.003944	0.001690
Cote-d-voire	0.002824	0.000349	0.020617	0.002982	-0.000898	-0.014972
Ghana	0.003895	0.001519	-0.002612	0.003079	-0.000013	-0.021548
Guinea	0.002152	-0.006130	0.005597	0.003576	0.007097	0.002526
Guinea-Bissau	-0.003203	0.002527	0.000644	0.003676	0.001755	-0.006007
Liberia	0.005533	-0.005149	0.014555	0.006470	-0.000497	-0.002627
Mali	0.001289	-0.002487	-0.004918	0.001637	0.002269	-0.004185
Mauritania	0.005608	-0.021682	0.017694	0.000418	0.003942	0.031991
Niger	-0.013572	0.012607	-0.018574	-0.017816	-0.016532	-0.026147
Nigeria	-0.001094	-0.002909	0.002044	-0.002346	0.000626	0.000504
Senegal	-0.002830	0.020150	0.032742	0.031433	-0.016904	-0.008946
Sierra-Leone	0.002608	0.006177	-0.013478	-0.003656	-0.006065	0.006372
Gambia	0.003654	-0.016276	-0.003908	-0.013569	-0.010190	0.001773
Togo	0.000137	-0.009044	-0.006664	-0.001429	0.00372	0.011745

Table 2: Loadings for West and East African Regions (Continued)

Country/Function	7	8	9	10	11	12
p Set (East Africa)						
Burundi	0.009200	0.005174	0.023924	0.004478	0.006400	0.000783
Comoros	-0.006864	0.000338	-0.001078	0.001764	-0.000940	0.000121
Djibouti	0.017621	0.004708	-0.000153	-0.001154	-0.002386	-0.002984
Eritrea	0.003668	-0.007430	-0.001801	0.001820	0.003067	0.001242
Ethiopia	-0.010504	-0.006493	-0.013249	-0.005295	-0.008073	-0.004080
Kenya	-0.037036	-0.019275	0.020185	0.003060	-0.003487	0.002018
Madagascar	0.012163	-0.005234	0.012890	-0.005502	-0.003255	-0.002560
Malawi	-0.002468	-0.018032	-0.008594	-0.000498	-0.001209	0.000369
Mauritius	0.005475	-0.008581	-0.009861	0.004987	0.003243	0.000134
Mozambique	-0.011254	0.014533	0.007924	0.003988	-0.001529	-0.000424
Rwanda	0.013603	0.026209	0.007349	0.004304	0.001440	-0.000426
Seychelles	-0.003785	0.001802	0.001473	-0.000061	0.000191	0.000071
Somali	0.002206	-0.000701	0.000185	0.000518	0.003992	0.001109
Uganda	0.006366	-0.004107	-0.010229	-0.000636	0.000805	-0.000065
Tanzania	-0.002180	-0.009885	-0.025825	-0.012889	-0.001323	-0.000380
Zambia	0.007764	0.005543	-0.012766	0.003083	0.005309	0.000187
Zimbabwe	0.004150	0.005224	0.010608	-0.000826	-0.002067	-0.000302
Q set (West Africa)						
Benin	-0.024948	-0.022876	0.013288	-0.006766	-0.008236	-0.002132
Burkina Faso	-0.019503	0.002806	0.037478	0.003110	0.003747	-0.002057
Capa-Verde	-0.003773	0.002675	-0.003751	0.005470	0.001573	0.000468
Cote-d-Ivoire	-0.040928	-0.001898	-0.017399	-0.006273	-0.001080	-0.002005
Ghana	-0.004003	-0.018756	-0.001645	0.000084	0.002741	0.001820
Guinea	-0.007688	-0.007239	0.000603	-0.000517	0.000230	-0.000392
Guinea-Bissau	0.000345	0.000873	0.001923	0.001884	0.001697	0.000101
Liberia	0.007552	0.014258	0.012075	0.004241	-0.000314	0.000496
Mali	0.002764	0.023756	-0.014564	-0.001262	0.000473	0.000650
Mauritania	-0.001906	0.006509	0.013577	-0.000832	-0.000074	-0.001172
Niger	0.010051	-0.021701	-0.025638	0.000093	-0.000425	0.001798
Nigeria	0.016591	-0.005348	-0.000984	0.007369	-0.001421	0.001222
Senegal	-0.042863	0.002280	-0.020936	-0.006316	-0.002569	-0.003702
Sierra-Leone	0.011714	-0.003637	0.002494	-0.004096	0.003250	-0.000831
Gambia	-0.017214	0.011217	0.012945	0.005707	0.000454	0.000016
Togo	-0.004638	-0.001856	-0.009618	-0.000934	-0.000077	0.000511

Table 2: Loadings for West and East African Regions Continued

Country/Function	13	14	15	16
P Set (East Africa)				
Burundi	0.002282	0.031846	0.002603	-0.012765
Comoros	-0.005103	0.006486	0.009605	0.009988
Djibouti	-0.000518	0.005022	-0.000297	-0.004760
Eritrea	-0.003932	-0.001473	-0.002324	0.005972
Ethiopia	0.017545	-0.030146	-0.004146	0.003219
Kenya	-0.035566	-0.010340	-0.005585	-0.005990
Madagascar	0.030618	-0.018832	-0.011086	0.013893
Malawi	-0.019909	-0.000917	-0.011007	0.000475
Mauritius	0.001825	0.014078	-0.006250	-0.004695
Mozambique	-0.024192	0.005779	0.002343	-0.001826
Rwanda	0.024179	0.010652	0.001832	0.009449
Seychelles	0.005655	-0.002489	0.003309	0.002390
Somali	-0.006872	0.002608	0.001436	0.009843
Uganda	-0.007623	0.001324	0.012939	-0.003847
Tanzania	0.009472	0.000420	-0.002616	-0.013952
Zambia	0.002470	-0.013154	0.003913	-0.005305
Zimbabwe	0.011703	0.001211	0.008060	-0.001467

The loadings for East and West Africa for the sixteen canonical functions are presented in Table 2, but only the significant functions 1 through 9 are retained for interpretations. The bolded values in the table represent the

largest loadings of the canonical functions with corresponding countries. Each value in the Table was obtained using the socio-economic indicators in the regions

Table 2: Loadings for West and East African Regions (continued)

Country/Function	13	14	15	16
Q set (West Africa)				
Benin	-0.037500	0.032290	0.023919	0.019164
Burkina Faso	0.023279	0.013434	0.022846	0.009977
Cape-Verde	0.003368	0.012000	0.014090	0.004620
Cote-d'Ivoire	-0.000880	-0.004625	0.003039	0.016842
Ghana	-0.011297	0.008411	-0.025695	-0.011851
Guinea	0.012044	0.003178	0.009112	0.000046
Guinea-Bissau	-0.002869	0.000007	-0.003856	0.014812
Liberia	0.004899	0.003703	-0.003315	-0.000570
Mali	-0.011494	-0.009234	-0.013948	-0.012955
Mauritania	0.016933	0.000857	0.023061	-0.030643
Niger	0.003926	0.025567	-0.006560	-0.011298
Nigeria	-0.008258	-0.019689	0.001825	0.001832
Senegal	-0.003906	-0.013608	-0.032715	0.014762
Sierra-Leone	-0.006650	0.004323	-0.001037	0.000510
Gambia	-0.001406	-0.016715	0.004947	-0.013027
Togo	0.018680	-0.001293	-0.017269	-0.003122

4. Discussion of Result

In Table 1, Canonical correlations were derived for the set of West and East African countries. Nine canonical functions in the Table emerged as being statistically significant for interpretation and accounted for 78% of the variance shared between the variates; the remaining non-significant function accounted for only 22% of the shared variance between the variates. The significant functions are used in the interpretations of the loadings in Table 2, while the remaining functions 10, 11, 12, 13, 14, 15, and 16 are non-significant and therefore not used for interpretation.

The results in Table 2 shows the loadings for each canonical function and corresponding countries, the bolded entries indicated the largest loading explained by the corresponding countries among the significant canonical functions which shows the strength of the country's contribution to the canonical correlation. The results show that the strongest correlations (.9999) is associated with Somalia in East Africa as well as Ghana in West Africa; the second strongest correlation (0.9992) is associated with Mauritius and Zambia in East Africa as well as Guinea Bissau and Niger in West Africa; the third strongest correlation (0.9974) is associated with Ethiopia and Zambia in East Africa as well as Cape-Verde, Cote D-Ivoire and Liberia in West Africa; the fourth strongest correlation (0.9960) is associated with Kenya in East Africa as well as Senegal in West Africa; the fifth strongest correlations (0.9811) are associated with Comoros, Eritrea and Tanzania in East Africa as well as Guinea in West Africa; the sixth strongest correlation (0.9645) is associated with Malawi, Seychelles and Uganda in East Africa as well as Burkina-Faso, Mauritania and Togo in West Africa; The seventh strongest correlation (.9471) is associated with Djibouti in East Africa as well as Nigeria and Sierra Leone in West Africa; the eighth strongest correlation (0.9343) is associated with Mozambique and Rwanda in East Africa as well as Mali in West Africa and the last strongest correlation (0.8425) is associated with Burundi, Madagascar and Zimbabwe in East Africa as well as Benin and Gambia in West Africa.

This has reveals that, there are significant correlations between East and West Africa regions in terms of their

socio-economic development for the period under study, and these correlations are due to the strong relationships between the countries of the regions as categorized above. This established that there are similarities among some member countries in the regions in terms of their socio-economic indicators. For instance, Somalia in East Africa region is in the same canonical function with Ghana in West Africa, and therefore is similar in their socio-economic development.

5. Summary and Conclusion

In this study, I considered member countries of West and East African regions as dependent and independent variables respectively and forty socio-economic indicators for the analysis. The technique of multivariate statistics otherwise called canonical correlation analysis was employed to determine the relationships of the two African regions in terms of their socio-economic development. Canonical correlations, eigenvalues and canonical loadings in number of the smaller set of the two sets were derived. The results of the analysis revealed that, there are relationships in similarities between countries in the two in terms of their socio-economic development. Consequently, the countries associated with such kind of correlations were highlighted, which implies that, those countries shared something in common in their associated socio-economic indicators for the period under study.

References

- [1]. World Bank (2005). African Development Indicators database. Washington, DC. The World Bank.
- [2]. UNDP (2005) Human Development Report. United Nations Development Program, United Nation, New York. <http://www.undphdp.org>
- [3]. UNECA (2006). Economic Report on Africa. United Nations Economic Commission for Africa Addis Ababa. <http://www.unecareport.org>.
- [4]. NEPAD (New Economic Partnership for Africa's Development). (2004). Rapport Annual 2003/2004. New Economic Partnership for Africa's Development, <http://www.nepadforum.com/PDF->

- documents/rapport_annuel/NEPADFrench.pdf
http://www.nepadforum.com/PDFdocuments/rapport_annuel/NEPADFrench.pdf
- [5]. Mai, L. W. and Ness M. R., (1999). Canonical correlation analysis of customer satisfaction and future purchase of mail-order specialty food: *British food Journal*, 101(11), 857-870.
 - [6]. Hotelling, H., (1936). Relations between two sets of Variate. *Biometrika*, 28, 312-377.
 - [7]. Mardia, K. V., Kent, J. T. and Bibby J. M., (1979). *Multivariate Analysis* Academic press, London.
 - [8]. Weenink, D., (2003). Canonical Correlation Analysis. Institute of Phonetic Sciences, University of Amsterdam, IFA Proceedings 25 (2003), 81–99.
 - [9]. Hansen, C.W. and Lønstrup, L., 2015. The Rise in Life Expectancy and Economic Growth in the 20th Century. *The Economic Journal*, 125(584), 838-52. <https://doi.org/10.1111/eoj.12261>
 - [10]. Johnston, M., 2021. Controlling Corruption: Institutional Strategies. In Andreas Bågenholm and others Eds. *The Oxford Handbook of the Quality of Government*, Oxford: Oxford Academics. <https://doi.org/10.1093/oxfordhb/9780198858218.013.25>.
 - [11]. Bag, S. and Omrane, A., (2022). Effective linkages between women empowerment and economic development in India. *International Journal of Business Excellence*, 28(4), 430-450.
 - [12]. Oyekale, A. S., 2015. Non-monetary assessment of pro-poor growth in Nigeria: Evidence from demographic and health surveys. *The Journal of Developing Areas*, 49(1), 107-132. <https://doi.org/10.1353/jda.2015.0017>
 - [13]. Pelinescu, E., 2015. The impact of human capital on economic growth. *Procedia Economics and Finance*, 22, 184-190. [https://doi.org/10.1016/S2212-5671\(15\)00258-0](https://doi.org/10.1016/S2212-5671(15)00258-0).
 - [14]. Udofia, E. P., Atser, J. and Ikurekong, E. E., (2013). Linear Discriminant Analysis of Multiple Groups in Rural Settlements of Akwa Ibom State, Nigeria. *Journal of Rural Development*, 32 (2), 121-138
 - [15]. Tien, N.H., 2021. Relationship between inflation and economic growth in Vietnam. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, 12(14), 5134-39.
 - [16]. Udoh, E. O., (2015). Integration and Politics among West African states: The Nigerian experience. *Pearl Journal of Management, Social Science and Humanities*, 1(1), 30-41.
 - [17]. UN Economic Commission for Africa, African Union & African Development Bank Group. (2016). *Assessing Regional Integration in Africa (ARIA VII): Innovation, Competitiveness and Regional Integration*. Addis Ababa, Ethiopia: Economic Commission for Africa.
 - [18]. UN Economic Commission for Africa, African Union and African Development Bank. (2010). *Assessing Regional Integration in Africa IV: Enhancing Intra-African Trade*. Addis Ababa: UN Economic Commission for Africa. Retrieved from www.uneca.org/aria4/ARIA4Full.pdf.
 - [19]. United Nations Development Programme (2018). *Summary Human Development Indices and Indicators 2018 Statistical Update*. USA: UNDP.
 - [20]. United Nations Development Programme (2019). *Human Development Report 2019 beyond income, beyond averages, beyond today: Inequalities in human Development in the 21st century*. USA: UNDP.
 - [21]. United Nations Economic Commission for Africa, African Union, African Development Bank, United Nations Conference on Trade and Development. (2019). *Assessing Regional Integration In Africa IX*. Addis Ababa: Economic Commission for Africa.
 - [22]. World Bank. (2018). *Infrastructure Development in Sub-Saharan Africa: A Scorecard*. Policy Research Working Paper 8425, 1-45.
 - [23]. AfDB, OECD & UNDP. (2017). *African Economic Outlook 2017*. Paris Cedex: OECD.
 - [24]. African Development Bank (2016). *Africa Visa Openness Report 2016*. Abidjan: African Development Bank.
 - [25]. African Development Bank (2020). *African Economic Outlook 2020 Supplement Amid Covid-19 Africa's Economic Performance and Outlook Amid Covid-19–19*. Abidjan: African Development Bank Group.
 - [26]. African Union (2002). *Treaty Establishing the African Economic Community*, Article 43. African Union. Retrieved 1219, 2016, from www.au2002.gov.za/docs/key_oau/aectreat1.htm
 - [27]. Aning, K., and Abdallah, M., (2016). Confronting hybrid threats in Africa: improving multidimensional responses. In C. d. Coning, L. Gelot, & J. Karlsrud, *The future of African peace operations From the Janjaweed to Boko Haram* (pp. 20-38). London: Zed Books.
 - [28]. Butu, A. W., (2013). Impact Of ECOWAS Protocols on Political And Economic Integration of the West African Sub Region, *International Journal of Physical and Human Geography*, 1(2) Pg. 47-58.
 - [29]. Hosny, A. S., (2013). Theories of Economic Integration: A Survey of the Economic and Political Literature *International Journal of Economy, Management and Social Sciences*, 2(5), 133-155.
 - [30]. Ibrahim, S. G., and Obiageli, N. L., (2015). Bi-Regional Integration in Africa: An Evaluation of the Major Challenges of the Common Market for Eastern and Southern Africa (COMESA). *International Journal of Multidisciplinary Research and Modern Education*, 1(1), 446-460.
 - [31]. Institute for Economics and Peace. (2020). *Global Terrorism Index 2020: Measuring the Impact of Terrorism*. Sydney: Institute for Economics & Peace.
 - [32]. ADB (2006). *Selected Socio-Economic Data on Regional Member Countries*, African Development Bank Pocket Statistics. <http://www.afdb.org/portal/pag>

- [33]. Kamla Foundation. (2018). World Poverty Clock. Retrieved 10 2, 2020, from <https://kamlafoundation.org/wpcontent/uploads/2019/01/World-Poverty-Clock.pdf>
- [34]. Ombeni, M. N., (2015). The Benefits of Regional Economic Integration for Developing Countries in Africa: A Case of East African Community (EAC). Korea Review of International Studies.
- [35]. Ricks, T., (2017). From the Abuja Treaty to the Sustainable Development Goals: Realizing Economic Integration in Africa. Retrieved from ncilj.org/wpcontent/uploads/2017/03/Ricks.pdf
- [36]. Sheriff, G. I., David, O. and Adams, J. W., (2015). An Inter-governmentalist Approach to Regional Integration in Africa: The Efficacy of the African Union (AU). *International Journal of Multidisciplinary Research and Modern Education*, 1(1), 461-479.
- [37]. Taiwo, O. and Moyo, N., (2012). Eliminating Barriers to Internal Commerce to Facilitate Intraregional Trade. In B. A. Initiative, *Accelerating Growth through Improved Intra-African Trade* (pp. 8-12). Washington, D.C: Brookings Africa Growth Initiative.