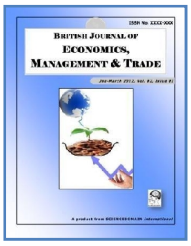

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AID-Growth Nexus Debates in Selected African Countries: A Methodological Exposition

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Authors' contributions

Author DAM designed the study, performed the econometric analyses, wrote the protocol, the first draft of the manuscript and eventually the final draft. Author HIM managed the analyses of the study and the final proofreading. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study examines the effectiveness of foreign aid in selected African countries. Also, it investigates the relevance of SEM system in gauging the relationship among multiple variables like foreign aid, economic growth, investment and human capital using multiple techniques such as SURE, 3SLS and OLS. This is to provide methodological exposition and contributions in aid-growth nexus debates, especially in the sample countries.
Study Design: Case Study.
Place and Duration of Study: Africa. Panel data ranging from 1987-2010.
Methodology: Simultaneous Equations Model (SEM) using balanced panel data approach was adopted and three techniques of estimation i.e. OLS, 3SLS and Seemingly Unrelated Regressions Estimate (SURE) were utilized. This adoption is in line with the dominant view in the literature that the best model for gauging the relationships among multiple variables like foreign aid, economic growth, investment and human capital as the case in this study is through SEM system.
Results: Our finding supports the popular view on aid effectiveness hypothesis in Africa. This is because our finding reveals that foreign aid impacts on economic growth through investment as a major transmission channel and it also impacts on human capital. Also, our findings indicate that SURE method proved to be the most efficient method for the estimation of SEM among the three techniques adopted; while OLS proved to be an

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appropriate technique for the estimation of SEM.
Conclusion: Essentially, the application of SURE method on SEM using Africa as a case study, is indeed a major empirical contribution from this study. Hence, due to our choice of appropriate model and estimation techniques, our finding becomes consistent with the leading view on aid effectiveness in Africa. We therefore recommend that more foreign aid should be allocated to investment and human capital. In the same vein, we suggest that subsequent studies on aid-growth nexus in Africa should take a clue from this study, especially in the area of methodological contributions.

Keywords: Foreign aid; SEM; economic growth; Africa; sure method; methodology.

1. INTRODUCTION

Easterly [1] and Abegaz [2] note that there seems to be a lot of interests in the study of aid-growth nexus but the results from the various studies and works (like [3,4,5]) are largely inconclusive and in some cases characterized with mixed findings. This scenario is especially true since the 1960s, 1970s, 1980s and even now, similar trends seem to be prevailing. In view of this development, considerable debates and studies about the specification and the mechanisms by which these two economic variables interact have continued till present time. Thus, Ali and Isse [6] did not mince words when they posited that the impact of foreign aid on economic growth is ultimately an empirical question. It is however important to state that the postulation that foreign aid increases and generates economic growth for LDCs and developing countries like the African continent is based on the Chenery and Strout's Dual Gap Model. Chenery and Strout [7] postulate that foreign aid promotes development thereby complementing domestic savings and foreign exchange availability. Thus, it assists in bridging the gap between savings and investment or the export-import gap. This postulation gave birth to the Financial Two Gap Model or the Double Deficits Model (DDM), which is regarded as an extension of the Harrod-Domar thesis [1,6,7]. The model assumes that a gap exists either between saving and investment or between exports and imports. And since LDCs and developing countries could not overcome these gaps on their own due to their limited resources; hence, foreign aid should fill these gaps. According to Ali and Isse [8], the proponents of foreign aid explicitly and implicitly are guided by three basic assumptions: (i) Capital formation is the key to development; (ii) LDCs are usually faced with the problem of capital shortage; and (iii) Government planning is a *sine qua non* for creating growth perspective in LDCs. As a matter of fact, the proponents of foreign aid as contributory to economic growth started with the first generation works of [8] to [6,9,10,11,12,13,14]; and now to more recent works like [15,16,17,18] and a host of others.

On the other hand, the alternative view that foreign aid does not positively contribute to economic growth dates back to the works of [19] to [1,20,21,22,23,24,25]. Also, Hansen and Tarp [26] as well as Brautigam and Knack [27] among others hold similar position on the issue. Despite these numerous studies on aid-growth nexus, the findings have been characterized by mixed results and inconclusiveness as noted by [1,12] as well as [4], which are largely due to methodological problems like incorrect model specification, choice of variables and methods of estimation among others. In this regard, Waheed [28] also identifies some plausible reasons for these discrepancies in the various studies to include: absence of lag structure for most models, open-endedness of theories (for instance, over 50 variables have been found to be significantly correlated with growth), simultaneous bias, parameter homogeneity, causality versus correlation, definition of variables and a host of others. Therefore, this study has taken the challenge of minimizing these methodological

problems. Hence, an appropriate model (i.e. SEM), model specification, choice of variables and estimation methods were cautiously and carefully selected in line with the general recommendations from previous studies.

In this connection therefore, a triangular SEM system was adapted in view of the three identified major variables (i.e. growth, investment and human capital) to be examined in our study. Thus, our SEM framework fulfilled the order and rank conditions as prescribed by Gujarati and Porter [29] as well as Wooldridge [30]. It satisfied the fundamental requirements for the robustness of the parameters in the SEM system. Also, three techniques of estimation were adopted for the purpose of enhancing the robustness and reliability of our findings. To this end, the main objective of this study is to examine the effectiveness of foreign aid in selected African countries. Also, the study investigates the relevance and suitability of SEM system in gauging the relationship among multiple variables like foreign aid, economic growth, investment and human capital using multiple techniques such as SURE, 3SLS and OLS.

1.1 Empirical Evidence

One of the most outstanding phenomena of post-second world war period is foreign aid, because it was meant to assist in the reconstruction of the war devastated and battered European economies like Germany. Later, the growth of concern on the part of developed countries with respect to the widening gap of living standards between the rich and poor countries, especially in Africa and Latin America. More particularly for the African continent, "it is clear that Africa has suffered a chronic failure of economic growth" [31]. Again, the assumption on the parts of developed countries to promote economic development in these poor countries became the major reasons for the administration of foreign aid to LDCs and other developing countries [32]. Hence, Africa started to witness aid inflows since the 1960s. Therefore, one of the questions which scholars and development analysts have started and continued to ask is: what is the impact of foreign aid on the economic growth of Africa? According to Easterly [33], Africa's growth is indeed a tragedy in view of the numerous problems that have continued to plague the continent like bad governance, corruption and mismanagement, political instability, poverty, conflicts and wars among others. Unfortunately, these problems have continued to make ineffective the impacts of foreign aid on the continent. Notwithstanding, Gyimah-Brempong [12] is of the view that foreign aid has positive and significant effect on the economic growth of Sub-Saharan Africa (SSA). His study on SSA used disaggregated cross-national time-series aid data and Least Squares Dummy Variables (LSDV) to estimate a Simultaneous Equations Model (SEM). He argued that aid affects growth directly and indirectly by augmenting the country's resources and that the most important and interesting issue is how to increase the efficiency of aid. Thus, if the effectiveness of aid in LDCs is to be maximized, the type of aid that has positive effects on growth needs to be promoted. The major finding of this study is that foreign aid impacts on growth via the investment channel. Also, a study by Burnside and Dollar [10] used a new database on foreign aid to investigate the relationships among foreign aid, economic policies and growth for 56 countries including 21 African countries. Their SEM framework of two equations was based on panel data of six four year time periods from 1970-73 until 1990-1993 and it was estimated using OLS and 2SLS techniques. Their finding indicates that aid has positive impacts in developing countries with good fiscal, monetary and trade policies.

In the same vein, Irandoust and Ericson [34] established in their study of some African countries from 1965-2000 using asymptotic theory of likelihood-based panel of cointegration that foreign aid and foreign direct investment positively enhanced economic growth for all the

countries in the sample. They concluded that foreign aid is not only additional domestic revenue to the recipient countries but also a supplement for domestic saving. This position is equally supported in a related finding by Kasuga [35] who posits that domestic saving significantly affects investment and by extension growth is also enhanced. Another study on African countries investigating aid-growth relationship for the period of 1960-2002 by Addison, Mavrotas and McGillivary [36] found that there is positive relationship existing between both economic variables and in fact, aid also impacts positively on poverty. In another related study by Gomanee, Girma and Morrisey [37] on aid-growth nexus in 25 SSA countries over a period of 28 years (i.e. 1970-1997) revealed a positive relationship. They argued that the poor record of growth in the African continent is not due to aid ineffectiveness but other factors like bad policy environment, corruption and bad governance among others. Again, a study by [15] on resource gaps and economic growth in Nigeria from 1970-1999 adopted SEM, which was estimated based on 2SLS method. The results arrived at supports the original hypothesis of [7] on the fact that countries at their pre-take-off stage of development needs to bridge the Investment-Savings gap predominance as the case with most African countries like Nigeria. A related study by Akpokodje and Omojimite [38] on the effects of aid flows on agricultural growth in Nigeria from 1970-2007 utilized SEM estimated with 2SLS method. Their findings show that foreign aid has positive and significant effects on agricultural growth in the country. Certainly, their finding implies that aid contributes to the development of the sector, which is the largest employment sector in the country and even in the whole of Africa. By extension, aid would contribute to poverty-reduction because the agricultural sector is a pro-poor sector with direct impacts on the rural people.

Again, a study by Helga [39] which also adopted SEM estimated with 3SLS technique to determine the correlation between foreign aid and FDI inflow in three heavily indebted African countries (i.e. Ghana, Malawi and Mozambique) for the period 1970-2004 suggest mixed findings. For instance, it was found that Ghana with higher GDP, aid and FDI are found to be substitute rather than complementary. However, when the other two countries were included and regressed for, the result indicates that aid and FDI are complementary. It could therefore be inferred that when HIPC countries experience a higher income per capita as the case with Ghana, it means that complementary effects tend to diminish at the cost of supplementary effects. Furthermore, [18] also examined the effectiveness of aid on economic growth in the African continent. Their findings revealed a positive and statistically significant relationship with the use of fixed effects growth model to estimate for 40 countries. They posited that it seems Africa's development is an aid-dependent one, which corroborates the position of Lancaster [40] and Goldsmith [41]. They observed that aid increases investment, which is a major transmission mechanism in the aid-growth nexus and that grant aid is more effective than other forms of aid. However, they noted that in order to avoid apparent donor aid-fatigue syndrome, strategy should be put in place to reduce future dependence on aid.

In the same vein, Malik [42] uses a cointegration analysis to examine the effectiveness of foreign aid on the economic growth of six poorest highly aid-dependent African countries i.e. Central African Republic, Malawi, Mali, Niger, Sierra-Leone and Togo. His findings discovered that a long-run relationship exists between per-capita real GDP, aid as percentage of GDP, investment as a percentage of GDP and openness. In this connection, the study established that the long-run effect of aid on growth was negative for all the countries except for Niger. Malik [42] posits that among the plausible explanation for the negative effect of aid on growth could be as a result of bad policy environment as pointed out by [10] and [37] in their studies. This explanation could be accepted as true in view of the prevalence of bad governance culture in most African countries. Also, Armah and Nelson

[43] in an empirical study on aid-growth link in 21 SSA countries spanning 1995-2003 utilized a 4-equation SEM system with a panel data approach of five years average. Their central argument is that foreign aid can potentially augment the inadequate domestic capital in LDCs like SSA countries in order to spur growth. At the same time, it can also upset the positive incentive and desire to build wealth in these countries thereby stalling growth. Notwithstanding, their findings revealed that foreign aid promotes growth in the face of good governance but their findings do not find any support for the good policy conditionality of [16]. However, their findings lend credence to the claim of Islam [44] that political stability is a necessary condition for aid effectiveness. Hence, they concluded that an increase in aid to SSA is a way of achieving MDGs; although, it is an insufficient medicine to solve the economic problems bedeviling the region.

A related study by Ndambendia and Njoupougnigni [45] examine the long-run relationship between foreign aid, foreign direct investment and economic growth in 36 Sub-Saharan African countries with the use of Mean Group (MG), Pooled Mean Group Estimator (PMG) and Dynamic Fixed Effect (DFE) proposed by [46]. Their findings revealed that strong evidence exists that there is positive impact of foreign aid and foreign direct investment on economic growth. However, the effect of foreign aid on growth for most SSA seems to be low. For example an increase of 1 percent of aid induces only 0.05 percent point of economic growth for PMG and 0.13 percent point for DFE. They concluded that human capital remains the key factor that can foster economic growth in SSA and as such improvement in the educational system should be considered as an effective way to enhance the quality of human capital. This result is consistent with earlier result by [17] as well as [18]. Furthermore, another study by Eregha, Sede and Ibidapo [47] on aid effectiveness in Africa focusing on 10 selected Economic Community of West African States (ECOWAS) countries for the period of 1970-2008 employed Pooled Panel Estimation Technique. Their findings revealed a negative and significant relationship between aid and growth in the region, which is at variance with the dominant view of aid effectiveness hypothesis in Africa. Although, their study found a positive and significant relationship between investment and growth, which concurs with similar finding by [12] and [18] but it found negative impacts of openness on growth. They noted that plausible explanations for aid ineffectiveness in the region could be due to poor policies, corruption, aid fungibility, uncertainty and weak institutions in the ECOWAS region. In fact, [40] had earlier confirmed that one of the reasons for aid ineffectiveness in Africa is due to aid fungibility, which according to Abuzeid [48] is a means of increasing the scope of corruption and rent-seeking syndrome. In particular [48] notes that significant amounts meant for the continent developmental activities were shipped to Swiss Banks and hence, he posited, “aid is a double-edged sword” [48].

Another study on Sierra Leone by Kargbo [49] examines the impact of foreign aid on the economic growth of the country for the period 1970-2007. He adopted ARDL model and Johansen maximum likelihood approach to cointegration for estimation. Generally, his finding revealed that aid effectiveness hypothesis exists in the country. He noted that the findings emanating from his study has lent supports only for the supplemental theories that aid is vital in the promotion of economic growth in LDCs like Sierra Leone. In this regard, it is discernable from the foregoing submissions of various studies that aid seems to have positive impact on Africa’s growth and it thus support the aid effectiveness hypothesis in Africa. Although, it is also evident that the results achieved are far less to expectations, which is due to myriad of problems confronting the continent, especially aid fungibility, bad governance and high level corruption among others. These problems have continued to make nonsense of aid administration in the continent. Therefore, if foreign aid must make any meaningful impact in the continent, a big push is required in various aspects of

development. Such aspects should include investment, human capital development, infrastructural development and most importantly, poverty reduction and good governance, which have been considered as the major socio-economic and political challenges confronting the continent.

2. METHODOLOGY

2.1 Model Specification and Statements of Hypotheses

The model for this study was based on Simultaneous Equations Model (SEM) using proxy variables according to Wooldridge [30] and Gujarati [50] to examine the relationships among multiple variables like foreign aid and growth as well as investment and human capital. This utilization of SEM system for this study is in line with previous studies (like [12,15,38,51]) as well as Sullivan, Tessman and Li [52]. These studies submitted that the best approach for understanding the interdependencies that exist among variables, which give feedback loops, is to use SEM because single equation overlooks these interdependencies. It adoption allows the simultaneous equations framework the possibilities of uncovering the interconnections that are not revealed by single equation method. This shortcoming has been identified by White [53] as one of the major problems confronting aid-growth analysis in most of the studies. In this connection, the main endogenous variable for this study is Growth (G) while the two proxy variables i.e. S_k (physical capital investment) and S_h (human capital investment) also served as endogenous-explanatory variables in the growth equation. According to [30], one of the means by which an omitted variable like foreign aid as the case in our study could be captured in the model specification and analysis is through the adoption of proxy variable. This recommendation is considered as a solution to the problem of endogeneity in the literature. Against this backdrop, the SEM framework is presented in the natural logarithm form and thus, it is specified as follows:

$$G_{it} = \beta_1 + \beta_2 \ln S_{k\,it} + \beta_3 \ln S_{h\,it} + \beta_4 \ln y_{0it} + \beta_5 \ln POV_{it} + \varepsilon_{it} \quad \ldots\ldots 1$$

$$\ln S_{K\,it} = \alpha_1 + \alpha_2 \ln AID_{it} + \alpha_3 \ln S_{h\,it} + \alpha_4 G_{it} + \alpha_5 \ln INF_{it} + u_{it} \quad \ldots\ldots 2$$

$$\ln S_{h\,it} = \gamma_1 + \gamma_2 \ln AID_{it} + \gamma_3 \ln S_{k\,it} + \gamma_4 G_{it} + \gamma_5 \ln EDU_{it} + v_{it} \quad \ldots\ldots 3$$

Here: G is the growth rate of GDP per capita, S_k is fraction of income invested in physical capital, S_h is fraction invested in human capital, y_o stands for the initial income and POV represents poverty. Also, AID implies foreign aid or development assistance, INF represents inflation and EDU means education (see Appendix B). Whereas $beta_1$- $beta_5$ are coefficients to be estimated ε_i μ_i and v_i are the stochastic terms which satisfy the classical assumptions of error terms. Thus, G, ln S_k and ln S_h are endogenous variables while ln y_0 , ln *POV*, ln *INF*, ln *AID* and ln *EDU* are exogenous variables.

Basically, according to [29] as well as [30], the most important and fundamental issue to be considered in a SEM system is the issue of identification. By identification, it means whether the parameters in the equation(s) can be estimated. In view of this position, there are two criteria for determining whether or not a particular equation is identified i.e. the order and rank conditions. The order condition is in the nature of a necessary condition, while the rank condition is in the nature of a necessary and sufficient condition. According to [30] when the numbers of excluded exogenous variables are more than the number of included endogenous variables, such equations are regarded as over-identification. Thus, since the

equations in our SEM framework satisfied this basic principle, we therefore conclude that our equations are over-identified and as such, the parameters in the model are fit for estimation. Importantly, the rank condition is superior to the order condition in determining whether or not a particular equation is identified, but the rank condition is quite difficult to state for a SEM involving more than two equations because it is very complex and more particularly it requires matrix algebra [54]. It was not surprising therefore that virtually all the articles reviewed on SEM like [15],[38],[39],[52],[53] and a host of others did not report their results on rank condition or worst still on identification at all. Notwithstanding, our SEM framework satisfied the rank condition because all the three equations fulfilled the requirements for the rank condition (see Appendix A). In view of these satisfactory results for all the equations, we hereby state that all the parameters in our SEM framework have satisfied the necessary condition of over identification and also, the necessary and sufficient conditions of rank identification. In view of these results, we therefore conclude that our SEM system is fit for estimation. To this end, the hypotheses to be tested in this study are:

H1: Foreign aid's impacts on economic growth, investment and human capital are better gauged through the use of SEM system.

H2: SURE method is an efficient estimator for SEM.

H3: OLS technique is an appropriate estimator for SEM.

2.2 Panel Data Approach

Panel data approach was adopted in view of its general recommendation from previous studies as a major way of solving some research problems like heterogeneity, outliers, model uncertainty, business cycle and endogeneity. Also, the panel estimation technique adopted for this study was in view of its advantages as noted by Greene [55]. He stated that a panel dataset possesses numerous advantages as compared to cross-sectional and time series data because it gives more informative data, more variability, less collinearity among the variables, more degrees of freedom and higher efficiency. Meanwhile, Mustafa and Abdul Razak [56] state that SEM applications using panel data are very powerful because they provide for the control of unobserved heterogeneity; while at the same time, it deals with simultaneity. All these highlighted methodological lacunas are potential interferences in arriving at a robust study on aid-growth nexus. In this connection therefore, the six years average panel method adopted in this study was also a move at eliminating some of the highlighted methodological problems. The panel method variant of six years average take a clue from [21] and [57] both used ten years average in their studies on foreign aid and growth. More especially, [21] made a combination of both five and 10 years average. Therefore, the balanced panel data for this study was based on six years average variant from 1987-2010 using the foreign aid's dataset of the Islamic Development Bank (IDB) for African Muslim Countries [see 56]. However, in view of the missing data problem encountered, 14 countries among the AMCs were classified as the "Base Sample" and we arrived at 336 observations (14x24) or panel observations of 56 (14x4).

2.3 Three Methods of Estimation for SEM

In order to have robust estimates and reliable findings, three methods of estimation (i.e. 3SLS, OLS and SURE) were adopted and utilized for the estimation of the SEM framework. This adoption of three methods is consistent with similar approach by [14] who used three

methods of estimation (i.e. 2SLS, 3SLS and GMM) for his SEM system. Also, Holzner [58] utilized GLS, 2SLS and SURE techniques for estimating her SEM framework. Importantly therefore, the SURE method for the estimation of SEM was recommended and first applied by Zellner and Theil [59] and it was equally noted in [60]. Other studies which utilized SURE method for the estimation of SEM include: AlDakhil [61] as well as Lundberg [62]. In fact, [60] notes that SURE technique guarantees improved hypothesis tests regarding regression coefficients and the values of other parameters in the SEM equations. As a matter of fact, this study gauged the AID-Growth impact as well as the AID-Investment and AID-Human capital impacts on the economies of the base sample. Therefore, the SEM approach using 3SLS, OLS and SURE methods were utilized for estimation and the results were later compared. Importantly, [29] recommend the need to compare the results of an applied OLS on SEM with other methods for the purpose of clarity and to ascertain whether OLS was appropriate or not. According to [29], the adoption of OLS as a method of estimation for SEM framework could be possible provided the following important requirement is fulfilled i.e. the SEM framework must be a triangular, recursive or causal model. Other related requirements include: (i) the model adopts proxy variable (s); and (ii) OLS is utilized for the purpose of comparing its result with other method (s) like 3SLS and SURE methods as the case in this study. It is however interesting to state that all these requirements have been fulfilled, especially the most important one i.e. the SEM framework for this study is both a triangular and causal model. This is because it is made-up of three equations, which makes it triangular and the three endogenous variables adopted are all causal in characteristics. In this connection therefore, EViews and Gretl Econometric Software packages were utilized to estimate our SEM system.

2.4 Population and Research Sample

It is necessary to state at this juncture that most studies on foreign aid and economic growth focus on LDCs or developing countries, which are mostly from Asia, Africa and Latin America continents. Therefore, since this research is on Africa and we observed that the studies available classified Africa into two broad regions i.e. Sub-Saharan Africa (SSA) and North or Tropical Africa [18,63]. This research therefore combined Muslim countries from these two broad regions (i.e. ten countries from SSA and four countries from North Africa) and thus referred to as African Muslim Countries-AMCs. This is in view of the fact that no specific study is seen by the authors on these Muslim countries, most especially as it relates to foreign aid and economic growth in the African continent. More importantly, all these sample countries are members of the IDB whose database on foreign aid to Africa was used for this study. The diagram below presents the methodological derivation of the sample countries utilized in this study.

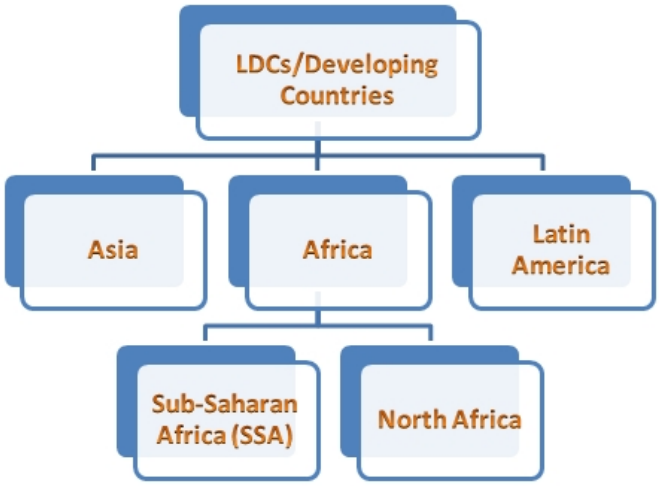

Fig. 1. The Methodological Derivation of the Research Sample

In this regard therefore, the 14 countries chosen for our study were selected based on the availability of data; and these countries are: Algeria, Burkina Faso, Chad, Comoros, Egypt, Gambia, Guinea, Mali, Mauritania, Morocco, Niger, Senegal, Sierra Leone and Tunisia.

3. RESULTS AND DISCUSSIONS

3.1 Results on the Three Methods of Estimation

Considering the view and position of [29] that one of the requirements or reasons that could necessitate the application of OLS on SEM framework should be to compare between the results of OLS and other methods of estimation and in this case, we have 3SLS and SURE methods. In view of this submission, we hereby present the comparative results for the three methods.

Table 1. Comparison of the Results for 3SLS, OLS and SURE Methods

Variables	3SLS	OLS	SURE
Regressors with significance levels (sl)	2	5	6
Regressor with consistent sl	Aid	Aid	Aid
Constant values	Fair	Better	Best
Standard errors	High	Low	Low
Adjusted r^2	Fair	Better	Better
P-values	Poor	Better	Best
Log determinant	-2.936	-3.756	-3.872
Over-identification test	1.210	-----	26.003***

From Table 1, it is evidently clear that the three methods of estimation adopted in our study have varying outcomes; although, the results for OLS and SURE methods seem to be very impressive and closely related. However, it is very interesting to state that the AID variable, which is of prime importance to our study has the most significant and impressive result across all the three methods of estimation. More importantly, the SURE method has the

highest number of regressors with significant and impressive values and also the lowest standard errors. Perhaps, another point of attraction in these results is that the over-identification tests of Hansen-Sargan for both 3SLS and SURE gives a clear picture between both methods. Moreover, the overall result on these three methods lends credence to the theoretical proposition of [29] about OLS being compared with other methods of estimation as presented in Table 1. Our finding on OLS as an appropriate estimator for SEM implies that as long as the guiding principles for the application of OLS are truly observed, then robust outcome is likely to be recorded as the case in our study. In view of the foregoing findings, we therefore conclude that SURE method proved to be an efficient estimator among all the three methods of estimation adopted in this study; and it thus lends supports to an earlier finding by [59] and [61]. Also, OLS technique proved to be an appropriate estimator for SEM system, which allays the apprehension from certain quarters on whether OLS could be an appropriate estimator for SEM. In this connection, we therefore state that henceforth the results of SURE method were adopted as the main reference point and basis for subsequent discussions in this study, because it proved to be the most efficient.

3.2 SEM Estimates for the Three Endogenous Variables

In view of the fact that the variables of interest in this study are AID-Growth, AID-Investment and AID-Human capital relationships; it is important to state that literatures on aid-growth nexus suggest that the best model to estimate these relationships is Simultaneous Equations Model (SEM). Therefore, the three endogenous variables of interest in this study are economic growth, investment and human capital. In this connection, it could be seen as in Table 2 that investment positively and significantly impact on economic growth at 1 percent significance level. This implies that every percentage increase in the Investment-GDP ratio results in 0.02 percent increase in the economic growth rate of GDP. Thus, our finding that investment impacts positively on economic growth is consistent with earlier findings by [6], [12,18]. This finding also lend supports to our theoretical framework, which holds that investment is a transmission channel and also a proxy variable for foreign aid through which it impacts on economic growth could be gauged. On the other hand, the human capital variable which is often regarded as a significant determinant of economic growth like investment carries a negative sign due to the indicator used but with no significance level. This finding is at variance with an earlier finding by [54] who found that human capital and FDI exerts strong positive effect on economic growth in developing countries.

Table 2. Panel Result with Economic Growth as Dependent Variable using SURE method

Variable	Coefficient	T-Ratio	P-value
Investment	2.290	3.479	0.001***
	(0.658)		
Human capital	-0.101	-0.121	0.904
	(0.832)		
Poverty	21.883	6.347	0.000***
	(3.448)		
Initial income	-22.667	-6.763	0.000***
	(3.351)		

Mean = 1.738; SD = 2.569; S.E. = 1.701; Adj. R^2 = 0.518; Observations = 56

*Notes: The standard errors are reported in parentheses. With the exception of human capital, which was insignificant, all the parameters for other variables are significant at 1% significance level (i.e. ***).*

Furthermore, variable like initial income shows the anticipated negative sign and also significant at the highest level of 1 percent. This finding is consistent with the theoretical expectation and empirical findings of scholars like [6] and [10], which is indeed a validation of the income convergence thesis as noted in their studies. In the same vein, the results emanating from Table 3 establish that growth impact on investment at 5 percent significant level which suggests a symbiotic relationship between growth and investment as well as bidirectional causality. On the other hand, the result of human capital proxy by infant mortality carries the expected negative sign but with no significant impact on investment even at 10 percent significance level. In the same regard, the coefficient of inflation also has negative sign but with no significance on investment. However, the impact of foreign aid (i.e. AID) on investment indicates positive and significance at the best significance level of 1 percent, which is highly commendable. This finding is consistent with earlier findings by [26] on the positive and significant impact of foreign aid on investment. Notwithstanding the positive impact of foreign aid on investment, it is still not significant enough due to the high level corruption and fiscal recklessness on the part of most African leaders. And as such, resources meant for productive investments in physical and human development are diverted to unproductive areas. This position is supported by [17], when he posited that corruption decreases economic growth directly and indirectly through investment in physical capital. Nonetheless, our result that foreign aid positively impact on the investment drive of African countries is consistent with the findings of [12] as well as [18].

Table 3. Panel Result with Investment as Dependent Variable using SURE method

Variable	Coefficient	T-Ratio	P-Value
Growth	0.038 (0.017)	2.288	0.026**
Human capital	-0.159 (0.105)	-1.514	0.136
Inflation	-0.013 (0.041)	-0.180	0.758
Aid	0.115 (0.040)	2.888	0.006***

Mean = 2.924; SD = 0.394; S.E. = 0.297; Adj. R^2 = 0.375; Observations = 56

Notes: The standard errors are reported in parentheses. With the exception of growth, all the regressors are in natural logarithm. The parameters of growth and AID are both significant at 5% (**) and 1% (***) significance levels respectively.

The results in Table 4 present the impacts of the various variables utilized in regressing human capital in the SEM framework. The growth variable shows a positive sign with no significant impact on human capital even at the 10 percent significance level. Also, investment carries negative sign with no significant impact on human capital, which is similar to our earlier result in Table 3 i.e. human capital also does not have impact on investment, which is at variance with theoretical expectation and empirical findings. Notwithstanding, the education variable which is the proxy for primary school enrolment indicates a negative sign at a strong significance level of 1 percent. In fact, the coefficient and parameter of this variable show the best result with respect to human capital proxy by infant mortality. Thus, the result implies that the higher the level of primary school enrolment the lower the rate of infant mortality in AMCs. This finding is consistent with conventional economic wisdom that high level of literacy impacts positively on the well-being of the society, especially in terms of health matters, which corroborates the view of [50]. This result supports the empirical findings of [17] as well as [21] that foreign aid contributes to human capital development.

Table 4. Panel Result with Human Capital as Dependent Variable using SURE method

Variable	Coefficient	T-Ratio	P-Value
Growth	0.024	1.400	0.168
	(0.017)		
Investment	-0.177	-1.261	0.213
	(0.141)		
Edu	-0.555	-4.718	0.000***
	(0.118)		
Aid	-0.149	-3.686	0.001***
	(0.041)		

Mean = 4.281; SD = 0.516; S.E. = 0.314; Adj. R^2 = 0.592; Observations = 56

*Notes: The standard errors are reported in parentheses. With the exception of growth, all the regressors are in natural logarithm. The parameters for EDU and AID are both significant at 1% significance level (i.e. ***).*

Basically, the most important variable to human capital in this SEM framework is AID and it shows the anticipated negative sign with strong significant impact on infant mortality. This result is consistent with the findings of [18] and [44]. The implication of this result for AMCs is that for a one-unit increase of AID/GDP ratio, it results in an average of 0.15 percent decrease in infant mortality. Previous studies like [17] have shown that investment in human capital and by extension on growth is promoted when there is decline in mortality, especially infant mortality. This is because of its endemic nature in most African countries, in view of the rampage of HIV or AIDS in the continent. Therefore, the dimension of the relationship among health improvement, human capital investments and economic growth is very significant for African countries, which are among the poorest and most backward countries in the world.

4. CONCLUSION

Among the identifiable reasons why the various studies on aid-growth nexus have been characterized with mixed results and inconclusiveness as noted by [1] and [12] among others, are due to methodological problems like choice of model, its specification, methods of estimation and a host of others. Therefore, this study has taken the challenge of minimizing these methodological problems by cautiously and carefully selecting an appropriate model (i.e. SEM) with correct specification and estimation methods. Thus, our triangular SEM system satisfied the order and rank conditions as recommended by [29] as well as [30]. It therefore satisfied the fundamental requirements for the robustness of the parameters in our SEM framework. In this connection, three methods of estimation techniques were adopted for the purpose of minimizing the methodological loopholes, which previous studies suffered from. It is interesting to state that among the three methods adopted, the SURE method performed more efficiently than 3SLS and OLS. Hence, the validity for the adoption of SURE method as an efficient estimation technique for SEM framework has been supported by our finding. Similarly, OLS as an appropriate technique of estimation for SEM is also supported in view of the proposition of [29]. Moreover, our findings support the aid effectiveness hypothesis in Africa, which seems to be the dominant view on aid-growth nexus debate in Africa as noted in the studies of [12,37] as well as [18]. In this regard, this study is perhaps the first study on aid-growth nexus in AMCs, which also utilized SEM system and SURE method in the same study. Furthermore, this study also compares OLS with other methods of estimation. Thus, we have empirically provided support for the relevance of the proposition of [29] that comparing the results of OLS with any other method for the estimation of SEM could assist in knowing more how OLS badly performs when it is wrongly applied. To this end, since our findings are consistent with previous findings by various scholars and writers, it does indicate that our study adopted appropriate and reliable methodology in terms of choice of model, its specification and methods of estimation. We therefore recommend that more

foreign aid should be allocated to both investment and human capital in order to promote sustainable growth in the selected countries. Also, we suggest that subsequent studies on aid-growth nexus should take a clue from this study. This is to avoid or minimize the methodological lacunas, which have been identified as responsible for the mixed results and inconclusiveness in aid-growth nexus studies in Africa.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Appendix A

Application of the Rank Condition

The rank condition in SEM analysis states that an equation is identified if and only if at least one nonzero determinant of order (M-1) (M-1) can be constructed from the coefficients of all variables excluded from that equation but included in the other equations of the model (Wooldridge, 2009). This condition is therefore regarded as the necessary and sufficient condition upon which basis identifiability of the SEM system for estimation could be confirmed as adequate and appropriate. Considering our SEM framework with triangular simultaneous equations, we hereby present the entire model as follows:

$$G_i = \beta_1 + \beta_2 \ln S_{ki} + \beta_3 \ln S_{hi} + \beta_4 \ln y_{0i} + \beta_5 \ln POV_i + \varepsilon_i \quad (1)$$

$$\ln S_{Ki} = \alpha_1 + \alpha_2 \ln AID_i + \alpha_3 \ln S_{hi} + \alpha_4 G_i + \alpha_5 \ln INF_i + u_i \quad (2)$$

$$\ln S_{hi} = \gamma_1 + \gamma_2 \ln AID_i + \gamma_3 \ln S_{ki} + \gamma_4 G_i + \gamma_5 \ln EDU_i + v_i \quad (3)$$

We now transform our model to ordinary equation format and thus, the following equations emerged from our three system equations.

$$Y_{1i} = \beta_{10} + \beta_{12} Y_{2i} + \beta_{13} Y_{3i} + \gamma_{12} X_{2i} + \gamma_{13} X_{3i} + u_{1i} \quad (4)$$

$$Y_{2i} = \beta_{20} + \beta_{21} Y_{1i} + \beta_{23} Y_{3i} + \gamma_{21} X_{1i} + \gamma_{24} X_{4i} + u_{2i} \quad (5)$$

$$Y_{3i} = \beta_{30} + \beta_{31} Y_{1i} + \beta_{32} Y_{2i} + \gamma_{31} X_{1i} + \gamma_{35} X_{5i} + u_{3i} \quad (6)$$

Here $Y_1 \equiv G$, $Y_2 \equiv \ln S_k$, $Y_3 \equiv \ln S_h$, $X_1 \equiv \ln AID$, $X_2 \equiv \ln y_0$, $X_3 \equiv \ln POV$, $X_4 \equiv \ln INF$ and $X_5 \equiv \ln EDU$ (other notations are standard).

$$Y_{1i} - \beta_{10} - \beta_{12} Y_{2i} - \beta_{13} Y_{3i} - \gamma_{12} X_{2i} - \gamma_{13} X_{3i} = u_{1i} \quad (7)$$

$$Y_{2i} - \beta_{20} - \beta_{21} Y_{1i} - \beta_{23} Y_{3i} - \gamma_{21} X_{1i} - \gamma_{24} X_{4i} = u_{2i} \quad (8)$$

$$Y_{3i} - \beta_{30} - \beta_{31} Y_{1i} - \beta_{32} Y_{2i} - \gamma_{31} X_{1i} - \gamma_{35} X_{5i} = u_{3i} \quad (9)$$

We hereby rearrange the terms in each of the above equations in the following order: constant, Y_{1i}, Y_{2i}, Y_{3i}, X_{1i}, X_{2i}, X_{3i}, X_{4i}, and X_{5i}. Hence, we have the following equations:

$$-\beta_{10} + Y_{1i} - \beta_{12} Y_{2i} - \beta_{13} Y_{3i} - \gamma_{12} X_{2i} - \gamma_{13} X_{3i} = u_{1i} \quad (10)$$

$$-\beta_{20} - \beta_{21} Y_{1i} + Y_{2i} - \beta_{23} Y_{3i} - \gamma_{21} X_{1i} - \gamma_{24} X_{4i} = u_{2i} \quad (11)$$

$$-\beta_{30} - \beta_{31} Y_{1i} - \beta_{32} Y_{2i} + Y_{3i} - \gamma_{31} X_{1i} - \gamma_{35} X_{5i} = u_{3i} \quad (12)$$

There is the need to convert the above equations into the matrix format. For brevity, this study focused on the 3×9 matrix of coefficients only:

$$\begin{array}{c} 1 \quad Y_1 \quad Y_2 \quad Y_3 \quad X_1 \quad X_2 \quad X_3 \quad X_4 \quad X_5 \\ \hline \end{array}$$
$$\begin{bmatrix} -\beta_{10} & 1 & -\beta_{12} & -\beta_{13} & 0 & -\gamma_{12} & -\gamma_{13} & 0 & 0 \\ -\beta_{20} & -\beta_{21} & 1 & -\beta_{23} & -\gamma_{21} & 0 & 0 & -\gamma_{24} & 0 \\ -\beta_{30} & -\beta_{31} & -\beta_{32} & 1 & -\gamma_{31} & 0 & 0 & 0 & -\gamma_{35} \end{bmatrix}$$

Now we consider Eq. 1 for the rank condition analysis, which requires that we must obtain at least one nonzero 2×2 determinant from the coefficients of the variables excluded from Eq. 1but included in other equations; i.e. X_1, X_4 and X_5 (as indicated by 0's in the first row of the 3×9 matrix of coefficients). To obtain the determinant, there are a few steps involved. First, we obtain the relevant matrix of coefficients of variables X_1, X_4 and X_5 included in the other equations. Mechanically, this is done by retaining the columns corresponding to X_1, X_4 and X_5 only and deleting the first row. Doing so results in exactly one 2×3 matrix, which we will call E and its associated determinant. However, in order to derive determinant of at least a nonzero of 2x2 matrix from 2x3 matrix, we need to construct it. Hence, we arrived at the following sets of 2x2 matrices:

$$E = \begin{bmatrix} -\gamma_{21} & -\gamma_{24} & 0 \\ -\gamma_{31} & 0 & -\gamma_{35} \end{bmatrix}$$

$$|E_1| = \begin{vmatrix} -\gamma_{21} & -\gamma_{24} \\ -\gamma_{31} & 0 \end{vmatrix} = -\gamma_{24}\gamma_{31} \neq 0$$

$$|E_2| = \begin{vmatrix} -\gamma_{24} & 0 \\ 0 & -\gamma_{35} \end{vmatrix} = \gamma_{24}\gamma_{35} \neq 0$$

$$|E_3| = \begin{vmatrix} -\gamma_{21} & 0 \\ -\gamma_{31} & -\gamma_{35} \end{vmatrix} = \gamma_{21}\gamma_{35} \neq 0$$

In view of the above results for matrix E, we conclude that Eq. 1 satisfies the rank condition because all the determinants resulted in nonzero outcome. Similar procedures were also followed for the determining for Eq. 2. However, we must construct 2x2 matrices from the 2x3 matrix in order to derive our determinant of at least a nonzero and hence, we arrived at the following:

$$F = \begin{bmatrix} -\gamma_{12} & -\gamma_{13} & 0 \\ 0 & 0 & -\gamma_{35} \end{bmatrix}$$

$$|F_1| = \begin{vmatrix} -\gamma_{12} & -\gamma_{13} \\ 0 & 0 \end{vmatrix} = 0$$

$$|F_2| = \begin{vmatrix} -\gamma_{13} & 0 \\ 0 & -\gamma_{35} \end{vmatrix} = \gamma_{13}\gamma_{35} \neq 0$$

$$|F_3| = \begin{vmatrix} -\gamma_{12} & 0 \\ 0 & -\gamma_{35} \end{vmatrix} = \gamma_{12}\gamma_{35} \neq 0$$

Similarly, in view of the result obtained from matrix F, we conclude that Eq. 2 also satisfies the rank condition because two of our determinants resulted in nonzero outcome. Finally, we consider Eq. 3 to verify for the satisfaction of the rank condition and this requires that we must obtain at least one nonzero 2×2 determinant from the coefficients of the variables excluded from Eq. 3 but included in other equations; i.e. X_2, X_3 and X_4 . Similar procedure must be followed as done for matrix F in order to arrive at least a nonzero outcome among the 2x2.

$$G = \begin{bmatrix} -\gamma_{12} & -\gamma_{13} & 0 \\ 0 & 0 & -\gamma_{24} \end{bmatrix}$$

$$|G_1| = \begin{vmatrix} -\gamma_{21} & -\gamma_{13} \\ 0 & 0 \end{vmatrix} = 0$$

$$|G_2| = \begin{vmatrix} -\gamma_{13} & 0 \\ 0 & -\gamma_{24} \end{vmatrix} = \gamma_{13}\gamma_{24} \neq 0$$

$$|G_3| = \begin{vmatrix} -\gamma_{21} & 0 \\ 0 & -\gamma_{24} \end{vmatrix} = \gamma_{21}\gamma_{24} \neq 0$$

Sequel to the result obtained from matrix G above, we also conclude that Eq. 3 also satisfies the rank condition since two of the determinants for our constructed 2x2 resulted in nonzero outcome. From the foregoing analyses of the rank condition we conducted, it is clear that all the three equations in our SEM framework fulfilled the rank condition of identifiability.

APPENDIX B

Definition of Variables and Sources of Data

S/N	VARIABLE	INDICATOR	TYPE OF VARIABLE	SOURCE
1.	GROWTH	GDP PER CAPITA GROWTH (ANNUAL %)	ENDOGENOUS (MAIN REGRESSAND)	WORLD BANK & IMF
2.	INVESTMENT	GROSS FIXED CAPITAL FORMATION (% OF GDP)	ENDOGENOUS	WORLD BANK, IMF & CBN
3.	HUMAN CAPITAL	MORTALITY RATE, INFANT (PER 1000 LIVE BIRTHS)	ENDOGENOUS	WORLD BANK & IMF
4.	INITIAL INCOME	GDP PER CAPITA (FIRST YEAR OF EVERY AVERAGE PERIOD)	EXPLANATORY	WORLD BANK & IMF
5.	EDUCATION	PRIMARY SCHOOL ENROLMENT, (% GROSS)	EXPLANATORY	WORLD BANK & IMF
6.	AID	THE FOUR MAJOR CATEGORIZATION OF DA IN IDB	EXOGENOUS	IDB
7.	INFLATION	INFLATION, CONSUMER PRICES INDEX (ANNUAL %)	EXOGENOUS	WORLD BANK & IMF
8.	POVERTY	GDP PER CAPITA	EXPLANATORY	WORLD BANK, IMF & AFDB

Source: Mustafa and Abdul-Razak 2012 [54].

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