HIV/AIDS Scourge and Economic Growth in Sub-Sahara Africa

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Abstract This study examines the impact of HIV/ AIDS scourge on economic growth of some selected Sub-Sahara African countries. The three sub-Sahara African regions (Southern, West and Eastern) are categorized into lowest and highest HIV prevalence rate, using the global report of the UNAIDS 2012 data. In each region, the lowest and the highest HIV prevalence rate countries are selected respectively. Thus, we consider a panel of three countries in each category over a period from 1995 – 2012. We used these data to estimate the cross-country level regressions of these two categories, using panel data models. Thus, our results are in twofold: For lowest HIV prevalence rate category, the pooled OLS model was the “best” model. This pooled OLS model indicated that, for one unit increase in HIV prevalence rate, the gross domestic product per capita of countries is expected to decrease by US\$23.46, holding all other variables constant. Again for highest HIV prevalence rate category, the fixed effect model was the “best” model. The fixed effect model revealed that, one unit increase in HIV prevalence rate will cause the gross domestic product per capita of countries to decrease by US\$9.98, holding all other variables constant. Generally, for a unit increase in HIV prevalence rate, the impact of HIV on the economy is two-thirds larger in lowest HIV prevalence rate countries than that of the highest HIV prevalence rate countries.

Keywords HIV/ AIDS, GDP, Panel Data Models

contain only 11% of the earth’s population ^[4]. This has attracted the concern of many researchers from different fields to investigate various aspects of the HIV/AIDS scourge.

AIDS is no longer only a health issue but also a significant threat to economic growth and development of affected countries. Many studies have attempted to assess AIDS impact on economic growth and development. According to IMF ^[5], AIDS affect all levels of an economy and society, from individuals and households to small and large businesses to the different levels and activities of government. Early empirical studies, for instance, Over ^[7], Cuddington et.al. ^[1], and Dixon et.al. ^[3] concluded that the epidemic would have an appreciable impact on economic performance.

In most of these Sub-Saharan countries, HIV/AIDS scourge has grown to the extent that its effect on their economies and societies is evident and very serious. One can easily connect HIV/ AIDS effect on an economy. For instance, one can expect that when labour supply is reduced, due to declining life expectancy, this will have a negative effect on output; and this will eventually affect a lot of macroeconomic indicators of an economy.

Thus, the objective of this study is to examine the impact of HIV/AIDS on economic growth in both highest and lowest HIV prevalence rate countries in the Sub-Sahara region.

1. Introduction

In 2013, more than 35 million people were living with HIV ^[9]. In specific, more than two-thirds (which is 70%) of these people living with HIV, that is 24.7 million, live in Sub-Sahara Africa ^[10]. The current trend of new AIDS cases with respect to Sub-Saharan countries seems not to be getting better. In 2013, an estimated 1.5 million people in the region became newly infected and 1.1 million adults and children died of AIDS (accounting for 73% of the world’s AIDS death). The alarming point is that, Sub-Saharan region

2. Materials and Methods

Selection of Variables

In line with Cuddington ^[1], Delacruz ^[2], and Maijama et. al. ^[6], this paper adopted the Solow neoclassical growth model and considered GDP per capita to be a function of HIV/AIDS prevalence rate and health expenditure per capita in level, while controlling for other variables that influence economic growth.

Selection of Countries

The Sub-Sahara Africa countries are in three (3) regions

(i.e.; west, eastern and southern). In each category, we select two countries with respect to the highest and lowest HIV prevalence rate. Thus, the whole study is categorized into countries with highest and lowest HIV prevalence rate. According to UNAIDS [10], the highest HIV prevalence rate countries are Swaziland, Cameroon and Uganda from the southern African, west Africa and east Africa respectively. Also, the lowest HIV prevalence rate countries are South Africa, Senegal and Tanzania from the southern Africa, west Africa and eastern Africa respectively.

Data Source

Secondary data on GDP per capita, HIV prevalence rate and health expenditure per capita spanning from 1995 to 2012 were obtained from the World Bank website.

Pooled OLS Model

A pooled model is one where the data on different individuals are simply pooled together with no provision for individual differences that might lead to different coefficients.

$$y_{it} = \beta_1 + \beta_2 X_{2it} + \dots + \beta_k X_{kit} + e_{it} \quad (1)$$

Where i^{th} denote individual units, t is the time period and y_{it} represents the t^{th} observation in the dependent variable for i^{th} individual unit.

The coefficients ($\beta_1, \beta_2, \beta_3$) do not have i or t subscripts, they are assumed to be constant for all individuals in all time periods, and do not allow for possible individual heterogeneity. It is this characteristic that leads to equation (1) being called a pooled model.

Fixed Effect Models

When we assume that the intercepts are different for different individual units but the slope coefficients β_2 and β_3 are assumed to be constant for all individual units; equation (1) becomes:

$$y_{it} = \beta_{1i} + \beta_2 X_{2it} + \dots + \beta_k X_{kit} + e_{it} \quad (2)$$

An i subscript has been added to the intercept, implying that (β_{1i}) can be different for each individual unit. All behavioral differences between individuals, referred to as individual heterogeneity, are assumed to be captured by the intercept.

An appropriate way to estimate the model in equation (2) is to include an intercept dummy variable (indicator variable) for each individual unit. Thus, equation (2) becomes:

$$y_{it} = \beta_{11} D_{1i} + \beta_{12} D_{2i} + \dots + \beta_{1,10} D_{10,i} + X_{2it} + \dots + \beta_k X_{kit} + e_{it} \quad (3)$$

In a panel data context, equation (3) is called the least squares dummy variable estimator for fixed effect models.

Random Effect Model

Random individual unit differences can be included in our model by specifying the intercept parameters β_{1i} to consist of a fixed part that represents the population average, $\bar{\beta}_1$, and

random individual differences from the population average, u_i . The random effect model is given as:

$$\begin{aligned} y_{it} &= \bar{\beta}_1 + \beta_2 X_{2it} + \dots + \beta_k X_{kit} + (e_{it} + u_i) \\ y_{it} &= \bar{\beta}_1 + \beta_2 X_{2it} + \dots + \beta_k X_{kit} + v_{it} \end{aligned} \quad (4)$$

where now $\bar{\beta}_1$ is the intercept parameter and the error term v_{it} is composed of a component u_i that represents a random individual effect and the component e_{it} which is the usual regression random error.

Testing Fixed and Random Effects

We have to conduct formal statistical test to know the presence of fixed and/or random effects in our panel data. A fixed effect is tested by F-test, while a random effect is examined by Breusch and Pagan's Lagrange multiplier (LM) test. The former compares a fixed effect model and OLS to see how much the fixed effect model can improve the goodness-of-fit, whereas the latter contrast a random effect model with OLS. The similarity between random and fixed effect estimators is tested by a Hausman test.

F-test for Fixed Effects

In a regression equation (3), the null hypothesis is that all dummy parameters except for one for the dropped are all zero. The alternative hypothesis is that at least one dummy parameter is not zero. This hypothesis is tested by an F test, and it's given below:

$$F_{(n-1, nT-n-k)} = \frac{(R_{LSDV}^2 - R_{pooled}^2) / (n-1)}{(1 - R_{LSDV}^2) / (nT - n - k)} \quad (5)$$

If the null hypothesis is rejected (at least one group/time specific intercept u_i is not zero), you may conclude that there is a significant fixed effect and therefore, the fixed effect model is better than the pooled OLS.

Breusch-Pagan LM Test for Random Effects

Breusch and Pagan's Lagrange multiplier (LM) test examines if individual (or time) specific variance components are zero. The LM statistic follows the chi-squared distribution with one degree of freedom.

$$LM_u = \frac{nT}{2(T-1)} \left[\frac{T^2 \bar{e} \bar{e}}{e'e} - 1 \right]^2 \square \chi_{(1)}^2 \quad (6)$$

If the null hypothesis is rejected, you can conclude that there is a significant random effect in the panel data, and that the random effect model is able to deal with heterogeneity better than the pooled OLS.

Hausman Test for Comparing Fixed and Random Effects

The Hausman specification test compares fixed and random effect models under the null hypothesis that individual effects are uncorrelated with any regressor in the model.

$$LM = (b_{LSDV} - b_{random})' \hat{W}^{-1} (b_{LSDV} - b_{random}) \square \chi^2_{(k)} \quad (7)$$

If the null hypothesis of no correlation is rejected, you may conclude that a fixed effect model is appropriate than the random effect model.

Chow Test for Poolability

Poolability asks if slopes are the same across group or over time. The null hypothesis of this Chow test is the slope of a regressor is the same regardless of individual for all k regressors, and the statistic is given below:

$$F[(n-1)(k+1), n(T-k-1)] = \frac{(e'e - \sum e_i' e_i) / (n-1)(k+1)}{\sum e_i' e_i / n(T-k-1)} \quad (8)$$

where $e'e$ is the SSE of the pooled OLS and $e_i' e_i$ is the SSE of the pooled OLS for group i . If the null hypothesis is rejected, the panel data are not poolable; each individual has its own slopes for all regressors. Under this circumstance, the random coefficient model or hierarchical regression model will be appropriate.

3. Results and Discussion

In panel data modeling, we evaluate different types of models in order to select the “best” model for this study. The models are the pooled OLS model, fixed effect model and the random effect model.

3.1. Highest HIV Prevalence Rate

We estimate different models and examine their respective goodness-of-fit measures to identify the model that fits the data well. Table 1 contrasts the outputs of the pooled OLS, fixed effect and random effect models. Here, the parameter estimates and standard errors of the health expenditure variable are relatively the same across methods.

Table 1. Comparison of OLS, Fixed Effect and Random Effect Models in Highest Prevalence Rate

	Pooled OLS	Fixed Effect Model	Random Effect Model
Prevalence Rate	-7.78 (6.09)	-9.98 (6.41)	12.27 (5.52)
Health Expenditure	10.06 (0.35)	10.08 (0.36)	11.17 (0.72)
Intercept (baseline)	497.46 (189.46)	493.42 (35.85)	175.3 (49.62)
Swaziland(dummy)		439.39 (116.73)	
Cameroon(dummy)+		-	
Uganda (dummy)		-349.7 (39.04)	
F-Test (Model)	812.93 **	1023.33**	844.08**
R ²	0.94	0.99	0.96
N	54	54	54

+Cameroon dummy is omitted to prevent collinearity and brackets are standard errors

The F statistics of these models are significant at the .05

significance level, and their respective R² are very high. These high goodness-of-fit measures indicate that these models fit the data very well.

Although each of these models fits the data well, we suspect that each country may have its own initial GDP, which is significantly different from those of other countries. Thus, we need to probe further to know which model is appropriate for our data. We do this by conducting statistical tests to identify the “best” model.

Testing Fixed and Random Effects

We need to examine if fixed and/or random effects exist in panel data. In other words, we perform series of tests in order to select the “best” model in Table 1. Here, we use the F-test to compare a fixed effect model and OLS, while Breusch and Pagan’s Lagrange multiplier (LM) test is used to contrast a random effect model with OLS. The similarity between random and fixed effect estimators is tested by a Hausman test.

F-test for Fixed Effects

The null hypothesis that all dummy parameters except for one for the dropped are all zero was rejected [$F(2,49) = 93.51$; P-value <0.00]. We conclude that there is a significant fixed effect or significant increase in goodness-of-fit in the fixed effect model. Therefore, the fixed effect model is better than the pooled OLS.

Breusch-Pagan LM Test for Random Effects

The null hypothesis that individual (or time) specific variance components are zero was rejected [$\chi^2 = 163.52$; p-value <0.00]. We conclude that there is a significant random effect in the panel data. Therefore, the random effect model is able to deal with heterogeneity better than the pooled OLS.

Hausman Test for Comparing Fixed and Random Effects

The null hypothesis that the random effect model is appropriate was rejected [$\chi^2 = 33.05$; p-value <0.000]. Therefore the fixed effect model is appropriate and better than the random effect model.

Poolability Test

We conducted the test of poolability to identify whether heterogeneity entails slopes (parameter estimates of regressors) varying across individual and/or time. The null hypothesis that the panel data are poolable with respect to countries was not rejected [$F = 5.53$, p-value = <0.42]. Thus, the “best” model is the fixed effect model according to the Hausman test.

We have concluded that the “best” model for the highest HIV prevalence rate countries is the fixed effect model. This fixed effect model posits that each country has its own intercept but shares the same slopes of regressors (i.e.; HIV prevalence rate and health expenditure). Firstly, we will interpret the intercept of each country. Thus, the output of the “best” model is given below:

$$GDP_{Swaziland} = 932.81 - 9.98 * Prevalence\ Rate + 10.08 * Health\ Expenditure$$

$$(s.e) \quad (116.7) \quad (4.2) \quad (0.36)$$

The intercept of Swaziland is 932.81, which is 439.39 larger than that of baseline intercept (i.e., Cameroon) 493.42, and this deviation is statistically significant at the .05 significance level ($p < .000$).

$$GDP_{Cameroon} = 493.42 - 9.98 * Prevalence\ Rate + 10.08 * Health\ Expenditure$$

$$(s.e) \quad (35.85) \quad (4.2) \quad (0.36)$$

Cameroon's intercept is 493.42, which is the baseline intercept and it is statistically significant at the .05 significance level ($p < .000$).

$$GDP_{Uganda} = 143.72 - 9.98 * Prevalence\ Rate + 10.08 * Health\ Expenditure$$

$$(s.e) \quad (39.0) \quad (4.2) \quad (0.36)$$

The intercept of Uganda is 143.72, which means it is 349.7 smaller than that of baseline intercept (i.e., Cameroon) 493.42, and this deviation is statistically significant at the .05 significance level ($p < .000$).

Generally, the fixed effect model has R^2 of 0.99, and this means the model accounts for 99 percent of the total variation in the gross domestic product per capita of the highest HIV prevalence rate countries in the sub-Sahara Africa. The two explanatory variables (HIV prevalence rate and health expenditure) are statistically significant. For one unit increase in HIV prevalence rate, the gross domestic product per capita of countries is expected to decrease by US\$9.98, holding all other variables constant. Whenever health expenditure increases by one unit, the gross domestic product per capita of countries will increase by US\$10.08, holding all other variables constant.

Table 2. Comparison of OLS, Fixed Effect and Random Effect Models in Lowest Prevalence Rate

	Pooled OLS	Fixed Effect Model	Random Effect Model
Prevalence Rate	-23.46 (0.73)	-28.95 (8.61)	-22.16 (5.14)
Health Expenditure	12.15 (0.03)	11.69 (0.27)	12 (0.18)
Intercept (baseline)	316.45 (3.61)	335.96 (33.77)	327.85 (30.46)
Senegal + (dummy)		-	
South Africa(dummy)		244.39 (119.36)	
Tanzania (dummy)		27.57 (75.15)	
F-Test (Model)	6078.4 **	3234.83**	12156.85**
R^2	0.99	0.99	0.99
N	54	54	54

+Senegal dummy is omitted to prevent collinearity and brackets are

standard errors

3.2 Lowest HIV Prevalence Rate Countries

The outputs of the OLS, fixed effect and random effect models are contrasted in Table 2.

The F statistics of these models are significant at the .05 significance level, and their respective R^2 are very high. These high goodness-of-fit measures indicate that these models fit the data very well.

Testing Fixed and Random Effects

We need to examine if fixed and/or random effects exist in panel data.

F-test for Fixed Effects

The null hypothesis that all dummy parameters except for one for the dropped are all zero was not rejected [$F(2,49) = 2.63$; $P\text{-value} < 0.082$]. We conclude that the pooled OLS model is better than the fixed effect.

Breusch-Pagan LM Test for Random Effects

The null hypothesis that individual (or time) specific variance components are zero was not rejected [$\chi^2 = 0.75$; $p\text{-value} < 0.39$]. We conclude that the pooled OLS model is better than the random effect model.

Poolability Test

The null hypothesis that the panel data are poolable with respect to countries was not rejected [$F = 2.56$, $p\text{-value} = < 0.23$]. Therefore, we conclude that the pooled OLS model is the "best" model.

Thus, the "best" model for lowest HIV prevalence rate countries is given below:

$$GDP = 316.45 - 23.46 * Prevalence\ Rate + 12.15 * Health\ Expenditure$$

$$(s.e) \quad (3.6) \quad (0.73) \quad (0.03)$$

$$R^2 = 0.99$$

This pooled OLS model fits the data well at the .05 significance level ($F = 6078.4$ and $p < .0000$). The R^2 of 0.99 says that this model accounts for 99 percent of the total variation in the gross domestic product per capita of lowest HIV prevalence rate countries in the sub-Sahara Africa. The two explanatory variables (HIV prevalence rate and health expenditure) are statistically significant.

Even in case of zero HIV prevalence rates, zero health expenditure, each country is expected to have US\$316.45 of gross domestic product per capita.

For one unit increase in HIV prevalence rate, the gross domestic product per capita of countries is expected to decrease by US\$23.46, holding all other variables constant.

Whenever health expenditure increases by one unit, the gross domestic product per capita of countries will increase by US\$12.15, holding all other variables constant.

4. Conclusions

This paper uses HIV/ AIDS prevalence rate across a panel of countries to investigate the impact of the epidemic on gross domestic product. Our findings are in two folds: Firstly, for lowest HIV prevalence rate category, the pooled OLS model was the “best” model. This pooled OLS model indicated that, for one unit increase in HIV prevalence rate, the gross domestic product per capita of countries is expected to decrease by US\$23.46, holding all other variables constant. Whenever health expenditure increases by one unit, the gross domestic product per capita of countries will increase by US\$12.15, holding all other variables constant.

Secondly, for highest HIV prevalence rate category, the fixed effect model was the “best” model. Here, countries have difference intercept but the same slope. The fixed effect model revealed that, one unit increase in HIV prevalence rate will cause the gross domestic product per capita of countries to decrease by US\$9.98, holding all other variables constant. Whenever health expenditure increases by one unit, the gross domestic product per capita of countries will increase by US\$10.08, holding all other variables constant.

Generally, for a unit increase in HIV prevalence rate, the

impact of HIV on the economy is two-thirds larger in lowest HIV prevalence rate countries than that of the highest HIV prevalence rate countries.

The limitation of this study is that, the AIDS epidemic is still an evolving phenomenon and as new data become available, the effect of the epidemic on GDP can be appropriately detected. However, our findings indicate a strong negative relationship between HIV/ AIDS and GDP; and positive relation between health expenditure and GDP.

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