THE PRIVATE VERSUS PUBLIC INFRASTRUCTURE IN SUB-SAHARAN AFRICA: AN EMPIRICAL VALIDATION

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Abstract: The macro-economics of the relationship between the private and public infrastructure in sub-Saharan Africa has been very unpredictable due to the region's ineffective planning and policy formulation for infrastructure and service delivery. This paper examines the relationship between public and private infrastructure in sub-Saharan Africa. It also demonstrates that sub-Saharan Africa consumes more and invests less when compared to the industrialised world and that the present domestic investments in sub-Saharan Africa is actually more in the hands of the private sector. Lastly, an inference relationship for measuring and comparing economic stability between countries and regions was formulated, with the industrialised countries as reference value.

Keywords: Infrastructure, Private sector, Public sector, sub-Saharan Africa Investments, Macro-economics.

1. INTRODUCTION

In many developing countries, particularly countries within sub-Saharan Africa, public ownership is considered one means of avoiding the degradation of infrastructure services and the effects of market fluctuation (Nwoye, 2002; World Bank, 2002; World Bank, 2004). This has encouraged policies hostile to private ownership of national infrastructure and service delivery, policies which sometimes result in outright nationalization of some infrastructure enterprises (World Bank, 2002). These policies notwithstanding, the performance evaluation of public infrastructure in sub-Saharan Africa have shown that the public infrastructure services often used by the poor are of low quality, inadequate and sometimes exhibit very severe low percentage cost recovery and poor spin-off for social economic development (World Bank, 1994; World Bank, 2000; World Bank, 2002; World Bank, 2004).

It has also been observed that there are some deficiencies in the performance evaluation criteria used to assess the public sector in the region. Among these is an inability to quantify social objectives, or to separate them from the economic objectives set for public enterprises (Alexander, 2002; Nwoye 2002; Fischer et al., 2003). Thus, it is intrinsically wrong to assess the public sector by criteria relating to profitability alone (Independent policy group, 2003). The performance of the private sector has even been used as a major indicator of confidence in the economy and of the effectiveness of public policy (Nwoye, 2002; Independent Policy Group, 2003). Thus, a comparative assessment of the effects of each sector on the domestic economy subject to these constraints would be very difficult. Therefore, the need to critically examine this problem is overwhelming. Nonetheless, the authors are of the view that such study can be critically analysed from two dimensions namely: the quantum of investments in the region and the quantum of social objectives. It is the primary aim of this paper to empirically investigate partly this major concern from the perspective of the quantum

of investments from both sectors in the domestic economy in order to ascertain the dominant sector. Such an investigation might provide an insight into the macro-economics of the region's infrastructure and more specifically a new direction to policies underpinning infrastructure. However, it would be useful to precede such a critical evaluation with an overview of the private and public sectors in sub-Saharan Africa.

It is important to note that private sector performance in any economy is usually monitored by actual and potential shareholders (Fischer et al., 2003). If poor performance is reflected in the stock market, share prices will be lower than they might have been, inviting buyers who will eventually install better management for capital gains when share prices subsequently rise (Fischer et al., 2003). Where this threat is not strong enough, shareholders can force managers to pay more attention to profit maximisation and cost reduction. Therefore, private sector managers are constrained by market forces through the performance of the stock market. (Fischer et al., 2003).

Conversely, the public sector faces no market pressures, because it tends to be dependent on the government's role as a watch dog. However, nationalisation in most cases results in poor management of the resulting enterprise, causing the government problems (Fischer et al., 2003). It appears that such political initiatives or policies are born from the need to serve effectively those for whom such services were intended. The sacrifice usually paid for fulfilling these needs could be enormous, as it is in sub-Saharan Africa, whereas, the fundamental reason for this sacrifice is the ease with which policy makers exercise power – an ease that could under-price public services. However, such under-pricing results in a pricing system that might exclude essential cost elements in production (Alexander, 2002). If services are under-priced, more of them will be consumed than if they were available at market cost (Alexander, 2002; Nwoye, 2002; Fischer et al., 2003), leading to an increase in demand that would be virtually impossible to meet (Alexander, 2002). It is thus one of the aims of this paper to also validate empirically the true extent of the region's increasing consumption capacity.

One reason often given for public involvement in infrastructure and service provisions is the fear of foreign dominance in the economy: multinationals could dominate key sectors of the economy if government does not participate in establishing business ventures in those areas (Nwoye, 2002). Others are to impede foreign dominance, to establish key industries crucial to the development of other sectors, to diversify the economy, and to satisfy the need to check the excesses of the private sector, especially in the welfare services sector (Nwoye, 2002; Fischer et al., 2003).

2. METHODOLOGY

The modified "adhoc conventional approach" model (Wang, 2002), based on the conventional neoclassical one sector aggregate production function in which public infrastructure constitutes a direct input to the production function, was employed for this study. It takes this form:

$$Y_t = f\left(L_t, W_t, X_t\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where Y_t is GDP per capita, W_t is public sector gross capital formation (Public Investments) and X_t, L_t private sector gross capital formation (Private Investments) and labor services respectively. The subscript *t* denotes time series. The application of this model is based on the assumption that L_t is of negligible effect on GDP in this function. Moreover, the primary concern of this investigation, to test the effect of public investments (X_t) on private investments (W_t) and that of private investments (W_t) on public investments (X_t), resulted in the exclusion of the variable "labour services" (L_t).

Data was collected from the Africa statistics year book (2003) and International Monetary Fund (IMF) (2003). The data collected from the latter was extracted from the International Financial Statistics. It was used to show the huge difference between the consumption and investments pattern in the sub-Saharan Africa (see Table 1, 2, 3 and 4) by means of some descriptive analysis and a bar chart plot showing both the sub-Saharan Africa and industrialized countries' gross capital formation as a percentage of GDP and final consumption expenditure as a percentage of GDP (see figs.1 and 2). The other data for sub-Saharan African countries, showing their average GDP per capita (1995-2000) in US$ tagged variable *Y* and public investment (1995-2000) tagged variable *X* (on proxy for public infrastructure) and private investments (1995-2000) tagged variable *W* (on proxy for private infrastructure) were empirically evaluated by regression analysis to develop an acceptable model. The average GDP per capita was the dependent variable while public investment and private investment were the independent variables (see Table 5).

To test the extent to which the independent variable predicts the dependent variable in the statistical model, several measures of variation were developed as illustrated in the works of Levine et al. (1999). The first measure is the total sum of squares (*SST*). The second is the explained variation or regression sum of squares (*SSR*), and the unexplained variation or error sum of squares (*SSE*). These measure of variation were used to develop the coefficient of determination (r^2) and correlation coefficient (r) . The coefficient of multiple determination r^2 represents the proportion of the variation in *Y* that is explained by the set of explanatory variables selected (Levine et al., 1999). The coefficient of correlation *r* to test the strength of the relationship or association between two variables was carried out. (Levine et al., 1999).

Residual analysis was then carried out to be sure if the multiple linear regression model is appropriate for the available data. To determine whether there is a significant relationship between the dependent variable and a set of explanatory variables the F-test was also carried out. However, the F test as explained below was used to test the null hypothesis as it is the case for simple linear regression (Levine et al., 1999). Since there was more than one explanatory variable, the null (H_0) and the alternative hypotheses (H_1) were set up as follows: $H_0 : \beta_1 = \beta_0 = 0$

This means that the null hypothesis be accepted if $\beta_1 = \beta_0 = 0$ i.e. there is no linear relationship between the dependent variable and the explanatory variables. Where: β_0 is the intercept of the dependent variable and β_1 or precisely β_j is the slope of the dependent variable with one of the independent variables while holding the other

constant. If H_1 : At least one $\beta_j \neq 0$ (reject the null hypothesis if $\beta_j \neq 0$ i.e. there is a linear relationship between the dependent variable and at least one of the explanatory variables).

In order to determine the contribution of each of the explanatory variable, the Partial *F test* criterion was applied. It involves determining the contribution to the regression sum of squares made by each explanatory variable after the other explanatory variable has been included in the model (Levine et al., 1999).

Moreover, to have a better understanding of the statistics of the numerical data for gross capital formation and final consumption expenditure for sub-Saharan Africa and the Industrial countries, the central tendency, variation and shape of the data were computed and examined for each set. For the central tendency the mean, median were of relevance while mode, midrange and mid-hinge were not necessary for this investigation.

To understand the variation within the data, the following computations were made: The first quartile, Q_1 , is a value such that 25% of the observations are smaller and 75% of the observations are larger. The third quartile, Q_3, is a value such that 75% of the observations are smaller and 25% of the observations are larger. The range, inter-quartile range, variance and standard deviations were also included in the computation, but the coefficient of variation was left out because it was not necessary for the investigation. All analysis carried out was through the use of a PH statistical software.

3. DISCUSSION OF RESULTS

The gross capital formation and final consumption expenditure data for sub-Saharan Africa and the industrial countries revealed a more concentrated or homogeneous data because the range, inter-quartile range, the sample variance and the standard deviation were relatively small. Despite the homogenous tendency in the data for sub-Saharan Africa and the industrial countries, the data showed that the final consumption expenditure for the former was more dispersed than that of the latter. For reasons of space the descriptive statistical result table for the data was not included in the result tables displayed. Furthermore, the shape, which reflects the manner in which the data is distributed (skewness), showed from computed values that both the gross capital formation and final consumption expenditure for sub-Saharan Africa is negative or left skewed. This has pulled the mean down so that the median becomes greater than the mean. The reverse is the case for the industrial countries as the manner of distribution is positive or right skewed, resulting in the mean being greater than the median. However, the homogeneity of the data had actually given credence to its reliability and use.

The first bar chart plot (see fig.1) shows sub Saharan Africa's gross capital formation and the final consumption expenditure over a period of time, and Table 1 revealed that the mean final consumption expenditure as a percentage of GDP is 4.4 times larger than the gross capital formation in sub-Saharan Africa. The second bar chart plot (see fig.2) shows the industrial countries' gross capital formation and the final consumption expenditure over a period of time, and Table 2 revealed that the mean final consumption expenditure as a percentage of GDP for industrial countries is 3.8 times larger than the gross capital formation for the industrial countries. By implication, sub-

Saharan Africa's final consumption expenditure over gross capital formation is 1.15 times larger than the final consumption expenditure over gross capital formation for the industrialised countries (see Tables 3 and 4).

The following multiple linear regression model for the data in Table 5 was developed for sub-Saharan Africa:

$$Y = 3.37X + 3.22W - 169.85 \quad (2)$$

Testing the linear relationship between the dependent variable and the explanatory variables with the F test, the null hypothesis H_0 was rejected since $F > F_U$ (critical value). Therefore, a linear relationship exists between the dependent variable and the explanatory variables in the model. The coefficient of multiple determination r^2 and the coefficient of multiple correlations computed for the model above were considered satisfactory. To provide an additional check on the validity of the model, the residual plots were examined and we observe from the residual plots that there appear to be little or no pattern in the relationship between the residual and the values of X; public investments (public gross fixed capital formation) and W; private investments (private gross fixed capital formation). Thus, it was concluded that the multiple regression model was appropriate.

In determining the contribution of the explanatory variable, the partial F-test criterion was used, and the stages employed are as follows:

- Two simple linear regression model partial outputs (see Tables 6 and 7) in each of which one of the mentioned explanatory variables was computed.
- To determine whether X significantly improves the model after W has been included:

$$SSR(X/W) = 80568662.6 - 78949647 = 1619015.6$$

$$F = \frac{1619015.6}{141999.4} = 11.40 > F_{critical}$$

Therefore the addition of variable X after W has been included significantly improves the model.

- To determine whether W significantly improves the model after X has been included:

$$SSR(W/X) = 80568662.6 - 68933355 = 11635307.6$$

$$F = \frac{11635307.6}{141999.4} = 82 > F_{critical}$$

In addition, variable W significantly improves the model after variable X has been included.

Thus, we have been able to show that each of the explanatory variables significantly improves the model. However, the proportion of W *(private gross fixed capital formation)* was significantly greater (since 82 > 11.40) by the ratio $\left(\frac{82}{11.4} = 7.1\right)$.

Further, with some assumptions, we were able to deduce an inference relation for measuring and comparing the economic stability of any country or region. These assumptions are as follows: we assumed a negative sign for final consumption expenditure as a percentage of GDP (*FCE*) and a positive sign for gross capital formation as a percentage of GDP (*GCF*). The inference relationship for economic stability is $S_E = GCF + FCE.....(3)$

S_E is the inference relationship for economic stability, and the higher its value in comparison to that of the industrialized countries (reference value) the higher the economic stability of that region or country. The following examples should suffice to show this:

Industrialized countries:
$S_E = 20.8 - 79 = -58.2\%$
Sub-Saharan Africa:
$S_E = 18.7 - 81.5 = -62.8\%$
Since: -58.2 > -62.8
$\Rightarrow$ The Industrial countries are economically more stable than the sub-Saharan Africa with a 4.6% margin of stability.

4. CONCLUSION

This investigation was able to show empirically that private fixed capital formation (*W*) has a greater effect on GDP than the public fixed capital formation (*X*) in sub-Saharan Africa. The most striking revelation was that the effect of *W* was seven times greater than the effect of X on GDP. The implication of this finding is that the private sector invests seven times more heavily in domestic gross capital formation than does the public sector because $\left(\frac{82}{11.4} = 7.1\right)$. It inescapably follows that the private sector is more likely to have invested more in infrastructure. This no doubt contradicts the widespread notion that the region's domestic economy is in public hands. Further, our earlier findings using the descriptive analysis have shown that the sub-Saharan African region consumes much and invests little since sub-Saharan Africa's final consumption expenditure over gross capital formation is 1.15 times larger than the final consumption expenditure over gross capital formation for the industrialised countries.

Table 1: Gross capital formation and final consumption expenditure (1991-2001) for sub-Saharan Africa

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Gross capital formation as a % GDP	19.6	18.8	19.1	20	19.2	18.4	18.1	19.1	18.4	17.1	17.5
Final consumption expenditure as % of GDP	80.6	83.3	83.7	83.6	83.2	82.1	82.7	85.6	79.2	75.2	77.1

Source: International Financial statistics (2003)

Table 2: Gross capital formation and final consumption expenditure (1991-2001) for Industrial countries

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Gross capital formation as a % GDP	21.1	20.4	19.7	20.3	20.5	20.5	20.9	21.2	21.5	21.8	20.5
Final consumption expenditure as % of GDP	78.7	79.2	79.5	79	78.7	78.7	78.1	78.1	78.8	78.9	80

Source: International Financial statistics (2003)

Table 3: Industrial countries and the sub-Saharan Africa gross capital formation comparison

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Gross capital formation as a % GDP(industrial countries)	21.1	20.4	19.7	20.3	20.5	20.5	20.9	21.2	21.5	21.8	20.5
Gross capital formation as a % GDP(sub-Saharan Africa)	19.6	18.8	19.1	20	19.2	18.4	18.1	19.1	18.4	17.1	17.5

Source: International Financial statistics (2003)

Table 4: Industrial countries and the sub-Saharan Africa final consumption expenditure comparison

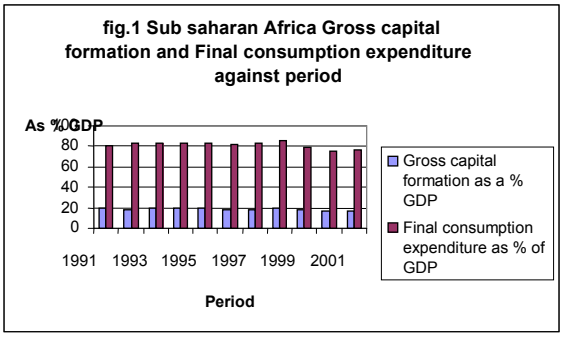
Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Final consumption expenditure as % GDP(industrial countries)	78.7	79.2	79.5	79	78.7	78.7	78.1	78.1	78.8	78.9	80
Final consumption expenditure as a % GDP(sub-Saharan Africa)	80.6	83.3	83.7	83.6	83.2	82.1	82.7	85.6	79.2	75.2	77.1

Source: International Financial statistics (2003)

Table 5: Average GDP per capita, gross public and private capital formation (1995-2000)

	Mean US$ GDP Per capita (1995-2000)(dollars)	**Public investment(1995-2000)(dollars)**	**Private investment(1995-2000)(dollars)**
COUNTRY	Y	X	W
Angola	498.7295495	41.39455261	122.1887396
Benin	392.0419387	28.61906153	41.94848745
Botswana	3206.614173	407.24	490.6119685
Burkina-faso	228.1555545	31.94177763	34.67964429
Burundi	151.1881268	10.88554513	3.32613879
Cameroun	638.8752103	8.944252944	95.83128155
Cape verde	1460.800529	132.9328482	235.1888852
Central Afr.Rep	345.185009	18.9851755	15.87851042
Chad	213.3588554	19.84237355	18.34886156
Comoros	357.6585873	21.10185665	28.97034557
Congo	810.5642496	51.06554772	176.7030064
Congo Dem.Rep	106.6730811	12.48075049	3.626884759
Cote d' Ivoire	817.1347746	39.22246918	69.45645584
Djibouti	1004.478554	41.18362073	70.31349881
Egypt	1071.46475	58.93056125	182.1490075
Equatorial Guinea	938.2704839	37.53081936	643.653552
Eritrea	160.571239	45.60223188	2.408568585
Ethiopia	112.7334717	10.3714794	8.229543435
Gabon	4396.137814	232.9953041	936.3773543
Gambia	354.5107735	24.81575414	36.86912044
Ghana	395.9858239	46.72632721	41.97449733
Guinea	527.1375906	39.0081817	80.65205136
Guinea Bissau	249.7976772	28.22713752	17.98543276
Kenya	329.0192881	21.38625372	38.4952567
Lesotho	521.9091828	174.8395762	84.02737843
Madagascar	232.457986	17.20189097	14.41239513
Malawi	160.1518682	13.93321253	7.84744154
Mali	259.8414207	23.9054107	32.74001901
Mauritania	175.6929618	23.54285688	12.82558621
Mauritius	4100.296766	299.3216639	815.9590564
Mozambique	163.3217786	19.59861343	25.47819746
Namibia	2305.613727	182.1434844	357.3701277
Niger	202.3215308	11.53232726	8.699825826
Nigeria	286.4141664	24.91803248	30.93272997
Rowanda	320.9098328	24.06823746	24.71005713
Sao T&Principe	364.1778007	94.68622818	83.03253856
Senegal	584.2628967	37.97708829	65.43744443
Seychelles	6630.44978	570.2186811	1604.568847
Sierra Leone	193.6179921	6.38939374	0.387235984
South Africa	3901.41724	101.4368482	554.0012481
Sudan	289.5349388	4.63255902	50.95814922
Swaziland	1703.922583	95.41966463	252.1805422
Tanzania	176.2188055	5.815220582	23.96575755
Togo	341	10.912	45.012
Uganda	322.2061964	18.68795939	37.37591879
Zambia	370.2680443	35.17546421	22.95661875
Zimbabwe	616.2899051	59.16383089	41.90771355

Source: African statistical Yearbook (2003)



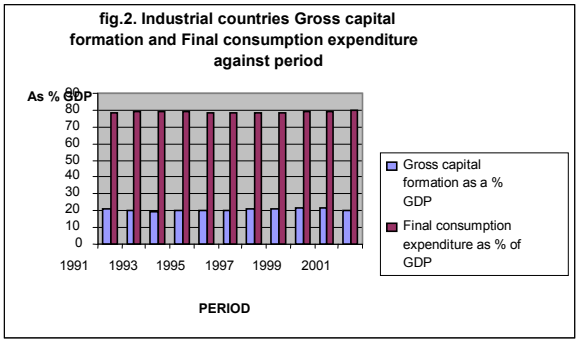


Table 6: Summary output of a linear regression with variable W as the only explanatory variable

Regression Statistics								
Multiple R	0.951285							
R Square	0.904943							
Adjusted R Square	0.902963							
Standard Error	415.6568							
Observations	50							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	78949647	78949647	456.9622	3.56E-26			
Residual	48	8292989	172770.6					
Total	49	87242636						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	229.1154	68.0185	3.368427	0.001498	92.3551	365.8757	92.3551	365.875653
W	4.253019	0.198956	21.37668	3.56E-26	3.852992	4.653047	3.852992	4.653047039

Table 7: Summary output of a linear regression with variable X as the only explanatory variable

Regression Statistics								
Multiple R	0.88889471							
R Square	0.7901338							
Adjusted R Square	0.78576158							
Standard Error	617.611002							
Observations	50							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	68933355.33	68933355	180.7172	6.83202E-18			
Residual	48	18309280.8	381443.4					
Total	49	87242636.14						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	175.402985	105.0758948	1.669298	0.101569	-35.86613706	386.6721	-35.86613706	386.672108
X	11.1399765	0.828675669	13.44311	6.83E-18	9.473813328	12.80614	9.473813328	12.80613958

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