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PUBLIC HEALTH EXPENDITURE EFFICIENCY AND INFANT SURVIVAL RATES IN THREE SELECTED SUB-SAHARAN AFRICAN COUNTRIES: A STOCHASTIC FRONTIER ANALYSIS FOR THE PERIOD 1998-2012

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Abstract

The study analysed the determinants of efficiency of government health expenditure in 3 selected Sub-Saharan African countries (Nigeria, Uganda and South Africa) with a view to identifying the health input most responsible for the inefficiency observed within their health sectors. It also examined the trend in efficiency change over the years in the countries and the effects of efficiency of government health expenditure on health outcomes within the study period. Secondary data were sourced from World Development Indicator (WDI) and from the officially released government budget documents of each country. The Stochastic Frontier Analysis (SFA) model with time-varying inefficiency effects technique was applied. The results showed that capital health expenditure efficiency in the 3 countries had improved significantly over the years while the recurrent health expenditure efficiency had not witnessed any significant improvement. It also showed that changes in infant survival rate were due to improvements in the capital health expenditure efficiency while the recurrent health expenditure efficiency had no statistically significant effect on changes in infant survival rate. The study therefore concluded that recurrent health expenditure compared to capital health expenditure has not resulted in improved health outcome of infant survival rate due to inefficiency in its usage; thus the governments in these 3 countries need to improve efficiency in its usage without

having to increase current spending levels. This could be achieved through effective and appropriate training of health workforce superintended by well-constituted health regulatory bodies. This process will ensure thoroughness in the training process and strict compliance to standards and job ethics for higher performance.

Keywords: Public Health Expenditure Efficiency, Infant Survival Rate, Stochastic Frontier Analysis (SFA), Recurrent Health Expenditure Efficiency, Capital health expenditure efficiency

INTRODUCTION

Governments in both developed and developing countries of the world seeking to improve health outcomes across the population could pursue two policy directions. They could either increase funds allocated to the health sector or improve efficiency of present spending levels. However, in the face of limited and sometimes shrinking government resources, as is the case in most sub-Saharan African (SSA) countries, pursuing efficiency in resources allocated to health care arises as a means of ensuring better health outcomes while maintaining present levels of spending (WHO, 2010; Jayasuriya and Wodon, 2003). In essence, despite the low levels of public health expenditure in SSA countries, there is still enough room to reduce wastage in the system arising from inefficiency in spending.

While there is a consensus in the literature that efficiency in government health spending is crucial to achieving better health outcomes, not much is known on the determinants of the (in)efficiency in spending observed. As a result, the findings of most country-specific and cross-country studies only reveal that health funds are being inefficiently utilized by most countries without pointing out to the major determinants of the inefficiency observed.

Moreover, studies at different times and in different regions of the world that have attempted to identify the determinants of the efficiency of government health expenditure have focused on the determinants arising from external environmental factors such as corruption and the quality of governance (Evans, Tandon, Murray and Lauer, 2001; Jayasuriya and Wodon, 2003; Afonso and Ayubin, 2005; Gupta, Verhoeven and Tiongson, 2002; Novignon, 2015; Novignion and Lawanson, 2014; Grigoli, and Kapsoli, 2013). However, studies that focus on the endogenously defined determinants of inefficiency (i.e. as a result of inputs used directly within a health system) are rare in the literature. To the best of our knowledge, there is no study that has considered the determinants of efficiency arising from the inputs used directly within health systems in both developed and developing countries of the world.

The study conducted by Chistom and Evans (2010) as a background paper for the 2006 world health report reveals that 9 out of the 10 determinants (sources) of inefficiencies relate to the inputs used directly within a health system namely health workers, medicines and infrastructure or hospitals. There is therefore the need for studies focusing on the determinants of inefficiencies endogenously determined within a health system assuming the absence of corruption or fraud. This study is therefore a significant departure from the approach of most studies that focused on identifying determinants arising from external environment factors alone notably corruption and quality of governance in a second stage tobit regression analysis.

Major inputs used in a health system are health human resources, medicines and infrastructure (Ichoku et al, 2011). Thus, a health system as a decision making unit (DMU) can be efficient in the use of an input while at the same time be inefficient in the use of others. It will therefore be misleading to only conclude that a health system has been inefficient in the use of its inputs without probing into the particular inputs most responsible for the observed inefficiency. As a result, the use of disaggregated input values will help to reveal hidden variation in inefficiency among the individual inputs namely expenditure on health workers, medicine and infrastructure. As noted by Mandl, Dierx, and Ilzkovitz (2008), disaggregating health inputs into its individual components makes room for an easier identification of the determinants of (in)efficiency arising from both within and outside a health system.

Past studies have mostly adopted aggregate values of inputs such as total public health expenditure, total private health expenditure and their per capita levels and have failed to disaggregate these expenditure items into their individual components. This has therefore made it practically impossible for an analysis of the variation in inefficiency across the individual components of health inputs as it only provides an overall assessment of the situation. However, the study by Chistom and Evans (2010), which identified the major inputs within a health system that accounted for varying levels of inefficiency, pointed out that human resources represented the major source of inefficiency in a health system ahead of other inputs. Moreover, the very few studies that have used disaggregated inputs values as explanatory variables such as that by Ichoku et al (2011); Sousa, Tandon, Dal poz, Prasad and Evans (2006). And that by Afonso and Ayubin (2005) were limited because they only adopted the numerical value of the inputs and not their monetary value. However, financial quantification of inputs used in a health system is necessary for an accurate economic evaluation of health sector efficiency (Novignon and Lawanson, 2014). Also, by adopting non-parametric measures, the studies by Ichoku et al (2011) and Afronso and Ayubin (2005) could not provide an analysis for the determinants of efficiency from within the health system.

The study by Sousa, Tandon, Dal poz, Prasad and Evans (2006) is the closest to this study as it used disaggregated health input values in a stochastic frontier analysis (SFA) study. They adopted total number of health workers to represent labour and the number of ambulatory units to represent capital. However, the focus of the study was not on the analysis on the endogenous determinants of efficiency as they also focused on the exogenous determinants in line with the practice in literature. Moreover, theirs was a cross-sectional and not panel data analysis of the efficiency of the health systems in the different municipalities in Brazil.

This present study attempts to fill this gap in the literature by applying a stochastic frontier panel data analysis to identify the endogenous determinants of the efficiency in health spending in 3 sub-Saharan African countries. The Battese and Coeli (1992) SFA model adopted in this study also makes it possible to identify the effects of efficiency of health expenditures on health outcomes, an objective that has thus far not been pursued by previous studies. In addition, the trend in efficiency change in the 3 countries since the MDG and Abuja declaration took effect in the 3 countries can also be investigated under the SFA methodology.

World Health Organization (2010) estimates that inefficiency in spending accounts for wastage of about 20% to 40% of funds allocated to health across the globe. The report also suggested that if these funds were efficiently utilized, universal coverage of health services (and in turn better health outcomes) could be easily achieved by countries while maintaining the same level of spending. Thus, while increasing budgetary health allocations should still be a policy pursued by governments in line with the Abuja declaration, identifying the sources of inefficiency in spending will help policy makers make wise decisions as to the use of their current resources. As identified in literature, more health spending might not lead to better health outcomes. Depending on the health system in place, countries achieve different health outcomes by spending similar amounts on health care.

Inefficiency in health expenditure can either be as a result of technical inefficiency with regards to input used (notably government spending on health) and as a result of external factors (such as corruption, not directly related to the heath system but which influences efficiency levels).

Thus, it is important to carry out a separate analysis of the efficiency in spending on the various inputs used within a health system. This would help in discovering the variation of inefficiency across inputs because certain inputs will account for the greater share of inefficiency observed. This is important because inefficiency can exist in spending even in the absence of external environmental factors such as corruption and external funds for health.

THEORETICAL FRAMEWORK AND EMPIRICAL LITERATURES

The study is rooted in the theory of Productive Efficiency which as a classical microeconomic theory is hinged on the proposition of the optimizing behaviour of firms based on the assumption that producers always operate efficiently. However, this assumption does not hold in practice as firms also experience inefficiency in their operations as they fail to use their resources optimally. In essence, firms always experience varying degrees of inefficiency in the process of transforming inputs to output. This deviation from the ideal can be explained by various factors both within and outside the control of the producer-both firm specific and industry related (Kokkinou, 2010).

A firm's performance is defined as the "ratio of outputs a production unit produces to the inputs it uses" (Kokkinou, 2010; Fried et al., 1993; Lovell, 1993). According to Kokkinou (2010) factors affecting the performance of firms include: differences in production technology, differences in efficiency of the production process and differences in the production environment.

While the differences in technology and in the production environment affect the performance of firms at the industry level, efficiency in production relates more to performance at the firm-level. This explains why firms adopting almost the same technology and operating under the same production or regulatory environment differ in terms of their performance due to the differences in their efficiency levels (Kokkinou, 2010, Korres, 2007).

This scenario therefore brings to the fore the need to measure how efficient firms have been in the use of their resource which is synonymous to measuring to what extent they have departed from the optimal use of resources at their disposal. The two basic was of measuring efficiency in literature are technical and allocative efficiency. Technical efficiency is a measure of a firm's ability to obtain the maximum output from given inputs while allocative efficiency measures the ability of a firm to use inputs in optimal proportions given their prices (Coelli, Prasada Rao, O'Donnell and Battese, 2005; Green, 2007).

Central to the discussion of how efficiency is measured is the concept of production frontiers. A firm regarded as a decision making unit (DMU) deviates from the optimal use of its resources (from technical and allocative efficiency) when it produces below the production frontier. Efficiency therefore occurs if firms produce as much outputs as they can (maximum outputs) from the inputs at their disposal or if they have done so at the minimal cost (Green, 2007). Measuring efficiency is therefore concerned with "estimating the unknown production frontier" (Coelli, Prasada Rao, O'Donnell and Battese, 2005). Both non parametric methods such as the Data Envelopment Analysis (DEA) and the Free Disposal Hall (FDH) analysis and

parametric methods such as the Stochastic Frontier Analysis (SFA) have been used in literature for the estimation of production frontiers.

EMPIRICAL REVIEW OF LITERATURE

Gupta and Verhoeven (2001) and Evans et al. (2001) were among the pioneers of efficiency studies in both developed and developing economies. Gupta and Verhoeven (2001) adopted the FDH technique, a non-parametric approach. Using panel data in a sample of 85 countries, they analyzed efficiency of government spending on education and health. The input used with regards to health was per capita public expenditure while output used was Life expectancy, infant mortality, and DPT immunizations. Their finding was that African countries were inefficient in health spending in relation to their Asian and Western Hemsiphere counterparts.

Evans, Tandon, Murray and Lauer (2001) estimated efficiency in inputs used in the health systems of 191 WHO countries between 1993 and 1997. Per capita health expenditure was the indicator of input while output was measured by life expectancy. Results show variation in efficiency scores among countries. Also, in a second stage analysis to identify the determinants of (in)efficiency, it was found that external factors such as prevalence if HIV/AIDS and civil unrest were found to be statistically significant in explaining the efficiency in a health system.

Afonso and Aubyn (2005) measured the efficiency of OECD countries in utilizing the inputs adopted within their health and education system in producing outcomes. Variation in efficiency scores were compared across countries using two non-parametric techniques, data envelopment analysis (DEA) and free disposal Hall (FDH) technique. Efficiency scores varied with the different techniques used, ranging from 0.859 to 0.886 in education and 0.832 and 0.946 in health. The difference between their study and others in the same line of enquiry is that they adopted a physical measurement of inputs instead of a monetary value. Their justification for this approach was that some countries could be wrongly classified as inefficient if the resources they used were expensive relative to others. On the other hand, those with access to cheaper resources could be wrongly classified as efficient.

In a later study, Gupta, Verhoeven and Tiongson (2008) improved on their previous study by adopting the DEA technique to analyze efficiency of health and education expenditure in 50 low-income countries. Input used was per capita health expenditure while outputs were those related to the health component of the MDGs- infant mortality, child mortality and maternal mortality. Their findings were that efficiency level varied with income levels as countries with low income occupied the bottom position in efficiency rankings. Furthermore, in a second-stage analysis to identify the determinants of efficiency, they authors found that external

environmental variables such as the quality of governance and fiscal institutions, improved educational levels and prevalence of HIV/AIDS were found to account for variation in efficiency levels.

Jayasuriya and Wodon (2003) studied the efficiency of public spending on education and health for 76 countries between 1990 and 1998 using the stochastic frontier technique with life expectancy and net enrolment in primary schools as proxies for outcome and per capita GDP, per capita expenditure son education or health, and adult literacy rate as indicators for inputs. Their study was a significant departure from or improvement on past studies as the determinants of efficiency was considered for the first time in literature. Most studies had only focused on determining whether a health DMUs across countries had utilized their inputs (in most cases government and private health spending) efficiently or not without proceeding to probe into the determinants or causes of the inefficiency observed. Their finding was that the quality of bureaucracy and urbanization are the major determinants of efficiency of government spending on education and health while corruption was not a significant determinant. The variables were also found to account for about half of the variation in efficiency across countries. Hsu (2013) in a study of 46 countries in Europe and Central Asia analyzed the efficiency of government spending on health using the DEA technique. Input used was health expenditure per capita, PPP (constant 2005 international dollars) while output used include life expectancy at birth, infant mortality rate (per 1,000 live births) and measles Immunization, (% of children ages 12–23 months). The study also went further to conduct a tobit regression on efficiency scores to account for the influence of environmental variables. The study adopted the following as measures of environmental variables: population density (people per sq. km of land area), per capita, PPP (constant 2005 international $), hospital beds (per 1000 people), average years of primary schooling, age 15+ and a regional dummy variable. The findings of the study show that countries in the region could have a 1.2% gain in health outcomes by maintaining the same level of spending. Hospital bed and primary schooling had strong effects on efficiency levels.

Grigoli and Kapsoli (2013) examined the efficiency of health expenditure in 80 emerging and developing economies for the period 2001-2010 using the stochastic frontier analysis (SFA) technique, a parametric technique. Their findings revealed that African countries were the least efficient in the use of their health resources with a potential for increasing life expectancy by 5 years while maintaining current spending levels. Western Hemisphere and Asian countries on the other hand were found to be more efficient in the use of their resources. The authors went on to perform a second stage regression analysis to identify the socioeconomic determinants of efficiency. Despite being a significant improvement over past studies, they however failed to provide an analysis for the determinants of efficiency arising directly from the inputs used within

a health system as their analysis was restricted to the significance of socioeconomic factors in explaining efficiency.

Gramani (2014) examined the inter-regional performance of the public health system in Brazil, a high-inequality country, using an integrated BSC-DEA model for four BSC perspectives. In line with the BSC model, the four perspectives that were associated with performance in national health systems in the study include: financial, customer, internal processes and learning & growth. After analyzing performance from all perspective, the study went on to identify the determinants of inefficiency in each region. Their results show that inefficiency varied across the different regions in the country and across different perspective used. For instance, the learning and growth perspective accounted for the major determinants of inefficiency in less efficient regions while the financial perspective was connected with the major determinants of efficiency in high efficient regions.

A major difference in their studies over previous ones was that they were able to identify the determinants of inefficiency across different regions in the country using different perspective. Thus, they were able to account for the influence of socioeconomic inequalities in explaining variation in inefficiencies. However, the study still failed to account for the endogenously determined sources of inefficiency in a health system (connected with inputs directly used in the health production process). Another limitation was that it was country-specific and did not account for variation in determinants of inefficiency across different regions of the world.

Novignon and Lawanson (2014) studied the efficiency of health systems in 45 Sub-Saharan African countries between 2005 and 2011 adopting the stochastic frontier technique, a parametric approach. Infant survival rate was adopted as a proxy for output while per capita health expenditure as the indicator for input. Their findings reveal large disparity in efficiency across health systems in the region. It also showed a lack of efficiency in the utilization of resources as about 20% of resources is being wasted. This is consistent with the findings of WHO (2010) that between 20 to 40% of funds allocated to health in the world is being wasted.

Novignon (2015) studied the importance of corruption and the quality of governance in explaining the efficiency of public health expenditure in 45 sub-Saharan African countries for the period 2005-2010 using the two-stage Data Envelopment Analysis technique. Inputs used were public health expenditure in PPP and average years of schooling while the following were used as outputs: life expectancy at birth, infant mortality rate, under-five mortality rate and crude death rate. The first stage analysis revealed that countries had the potential of improving their efficiency levels by 50% as efficiency scores stood at 0.5. In the second stage analysis which centered on the determinants of efficiency in health spending, corruption and public institutions

were associated with low efficiency levels. Thus, revealing that corruption and poor public institutions are important determinants of (in)efficiency of public health expenditure in sub-Saharan African countries. This is contrary to the findings of studies in other regions of the world, for instance that by Jayasuriya and Wodon (2003) that studied for countries in Asia, Europe and Central Asia, Latin America and Caribbean, and in industrialized nations where o corruption was found to have no significant impact on efficiency levels . The study also went further to consider the significance of other variables such as HIV/AIDS, immunization, urbanization, sanitation and population in explaining efficiency of health expenditures.

A pioneering work by Sousa, Tandon, Dal poz, Prasad and Evans (2006) measured the efficiency of human resources for health for attaining health outcomes, proxied by the coverage of antenatal care, across sub-national units in Brazil using stochastic frontier analysis (SFA). In the first stage analysis, inputs used were density of all types of health workers and the number of ambulatory units while the output was antenatal care coverage. In the second state analysis, the effects of the following inputs on antenatal care coverage were carried out individually: density of physicians, nurse professionals and nurse associates. Their findings show that the three inputs adopted all had a significant effect on the coverage of antenatal care in the country. In particular, a 1% increase in total health worker density would result in a 0.005% increase in the coverage of antenatal care.

Ichoku et al. (2011) are credited with the first known attempt at studying the efficiency of human resource for health on health outcomes in the African continent. Their study explored the technical and scale efficiency of national health systems (NHS) in utilizing human resources for health among 53 African countries in 2006 using the data envelopment analysis technique (DEA), a non-parametric approach. A total of 13 variables were adopted during their analysis, with 6 being outputs while 7 were inputs. Their findings revealed variation in efficiency levels across different country income classification, with countries exhibiting differences in constant returns scale technical efficiency (CRSTE), variable returns scale technical efficiency (VRSTE) and scale efficiency (SE).

While their study represents a significant attempt towards measuring (in)efficiency arising from the inputs used within a health system (as human resources are a major input in health systems) it however was limited by the methodology adopted and the unit of measurement of the inputs used. The DEA technique being a non-parametric approach without a functional form could not be used in assessing the determinants of inefficiency arising from within a model with accuracy. In addition, the inputs used were expressed in physical and not financial units hence not giving room for an accurate financial assessment of the determinants of efficiency.

METHODOLOGY

Techniques of Analysis

The technique of analysis applied in this paper is the stochastic frontier analytical technique (SFA). Its application depends largely on some underlying assumptions regarding the functional form of the production function on which the analysis is based Under SFA, a regression estimates are obtained by providing for a composite error term. The advantage of the SFA approach over non-parametric techniques such as the Free Disposal Hull (FDH) and Data Envelopment Analysis (DEA) is that the later techniques do not account for the presence of outliers and would tend to classify measurement errors as inefficiencies while the SFA takes care of measurement and randomness error. Moreover, a major merit of the SFA, is its ability to accommodate large number of inputs that affects health outcomes. This is a major limitation of the non-parametric methods (FDH and DEA) where efficiency scores are sensitive to large inputs.

Assuming a firm producing output q_i using a single input, x_i then a stochastic production frontier in its log-linear form is thus specified:

$$\ln q_i = \beta_o + \beta_1 \ln x_i + v_i - u_i \qquad \text{.....(1)}$$

$$\text{or } q_i = exp(\beta_o + \beta_1 \ln x_i + v_i - u_i) \qquad \text{.....(2)}$$

$$\text{or } q_i = \underbrace{exp(\beta_o + \beta_1 \ln x_i)}_{\text{deterministic component}} \times \underbrace{exp\,(v_i)}_{\text{noise}} \times \underbrace{exp(u_i)}_{\text{inefficiency}} \qquad \text{.....(3)}$$

Where; the composite error term, e has been decomposed into noise effect (v_i) and inefficiency effect (u_i).

Stochastic frontier analysis is mostly concerned with the prediction of technical inefficiency effects. This has to do with expressing technical efficiency as the ratio of observed output to the corresponding stochastic frontier output (Coelli, Prasada Rao, O'Donnell and Battese, 2005):

$$TE_i = \frac{q_i}{exp(X_i'\beta + v_i)} = \frac{exp(X_i'\beta + v_i - u_i)}{exp(X_i'\beta + v_i)} = exp(-u_i) \text{.....(5)}$$

Technical efficiency ranges between 0 and 1. It measures the output of the i-th firm in relation to the output that could be produced by a fully-efficient firm using the same input vector.

Sources of Data

Data for the study was obtained from the following sources: World Bank's World Development Indicators (WDI) 2014, Nigerian Central Bank statistical bulletin (2014); MOFPED, Uganda Drafts of budget estimates (recurrent and capital) for the selected period and from the National Budgets publication of South African Treasury for the selected period. The data will cover a 15

year period (1998 to 2012) due to unavailability of data and in order to capture efficiency in health spending during key health policy eras: the Millennium Development Goals that kicked off in 2000 and the Abuja declaration on health spending of 2001.

Model Specification

Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) were the first to develop a stochastic frontier analysis (SFA) technique. Their work was based on Maximum Likelihood (ML) estimation of a stochastic frontier model. The original specification was a production function specified for cross-sectional data with an error term which had two components, one to account for random effects and another to account for technical inefficiency. This model can be expressed in the following form:

$$Y_i = X_i\beta + (V_i - U_i) \qquad , i = 1, \dots, N, \dots\dots\dots\dots\dots(6)$$

where Y_i is the production (or the logarithm of the production) of the i-th firm; x_i is a k×1 vector of (transformations of the) input quantities of the i-th firm; β is a vector of unknown parameters; the V_i are random variables which are assumed to be iid $N(0,\sigma_V^2)$, and independent of the U_i which are non-negative random variables which are assumed to account for technical inefficiency in production and are often assumed to be iid. $|N(0,\sigma_U^2)|$.

The original specification has over the past 3 decades undergone series of re-specification and extended in various ways. These extensions include the specification of more general distributional assumptions for the U_i, such as the truncated normal or two-parameter gamma distributions; the consideration of panel data and time-varying technical efficiencies (Coelli, 1996).

The study adopted the Battese and Coelli (1992) that proposed a stochastic frontier production function for unbalanced panel data with firm effects which are assumed to be distributed as truncated normal random variables, also permitted to vary systematically with time.

The model may be expressed as:

$$Y_{it} = X_{it}\beta + (V_{it} - U_{it}) \qquad , i = 1, \dots, N, t = 1, \dots, T, \dots\dots\dots\dots(7)$$

where Y_{it} is (the logarithm of) the production of the i-th firm in the t-th time period; x_{it} is a k×1 vector of (transformations of the) input quantities of the i-th firm in the t-th time period; β is as defined earlier; the V_{it} are random variables which are assumed to be iid $N(0,\sigma_V^2)$, and independent of the $U_{it} = (U_i\exp(-\eta(t-T)))$, where the U_i are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be iid as truncations at zero of the $N(\mu,\sigma_U^2)$ distribution; η is a parameter to be estimated; and the panel

of data does not have to be complete (i.e. unbalanced panel data). The parameter, γ, must lie between 0 and 1.

Battese and Coelli (1992) proposed different models that allow for the estimation of time-varying technical inefficiency which takes the forms:

$u_{it} = f(t) \cdot u_i$

Where $f(t)$ is a function that determines how technical inefficiency varies over time:

$f(t) = exp[\eta(t - T)]$

Where α, β and η are unknown parameters to be estimated. The Battese and Coelli (1992) function is convex for all values of η.

According to Coelli, Prasada Rao, O'Donnell and Battese (2005), "in a fixed effects model, all terms involving t end up in the deterministic part of the frontier model irrespective of what they represent" while in a random effects model, "some terms involving t end up in the deterministic part of the frontier (these are associated with technological change) while others feature in the probability density function of u_{it} (these are associated with inefficiency)." Furthermore, unlike the cross-sectional models, Panel data models allow for an examination of changes in technical efficiencies and in the production technology adopted over time (Prasada Rao, O'Donnell and Battese, 2005). As a result, an advantage of the Battese and Coelli (1992) is that it also allows for a distinction between inefficiency and technology change.

Two models are used in this study to analyze the endogenous determinants of efficiency in the 3 countries. The above equation can therefore be further simplified in line with the works of Novignon and Lawanson (2014). The choice of the explanatory variables was also influenced by the works of Jayasuriya and Wodon (2003), Novignon and Lawanson (2014) and Sousa, Tandon, Dal poz, Prasad and Evans (2006). While Afonso and Ayubyn (2005) suggested the use of non-monetary values as input as this avoids the problem of accounting for differences in prices of inputs across countries, Novignon and Lawanson (2014) however proposed the use of monetary values as inputs as it permits for an accurate economic evaluation of a health system. Other studies such as that by Jayasuriya and Wodon (2003) have also adopted monetary values of inputs. Since this study is concerned with the economic evaluation of health systems, the choice of inputs is therefore in line with the works of Novignon and Lawanson (2014) and Jayasuriya and Wodon (2003). In particular, per capita health expenditure was included in order to capture other health expenditure items aside government health expenditure.

Model 1 is thus specified:

$$\ln ISR_{it} = \beta_0 + \beta_1 \ln RHE_{Xit} + \beta_2 \ln PHEX_{it} + \beta_3 \ln RGDP_{it} + v_{it} - u_{it} \ldots\ldots (8)$$

Model 2 is thus specified:

$$\ln ISR_{it} = \beta_0 + \beta_1 \ln CHEX_{it} + \beta_2 \ln PHEX_{it} + \beta_3 \ln RGDP_{it} + v_{it} - u_{it} \ldots\ldots\ldots\ldots\ldots \quad (9)$$

Where ISR_{it} is infant survival rate for the 3 countries at time t, $RHEX_{it}$ is government recurrent health expenditure for the 3 countries at time t, $CHEX_{it}$ is government capital health expenditure for the 3 countries at time t, $RGDP_{it}$ is real Gross Domestic Product per capita for 3 countries at time t and $PHEX_{it}$ is health expenditure per capita for the 3 countries at time t.

Definition and Measurements of Variables

Infant Mortality Rate (IMR): This is the probability of a child born in a specific year or period dying before reaching the age of one. It is the health system output used in this study. However, in line with the works of Afonso and Aubyn (2005), infant mortality rate (IMR) has been transformed into infant survival rate. This is done in order to ensure conformity with the best practices in literature where outputs of efficiency studies should show that "more is better".

Thus, infant mortality rate (IMR) was measured as [(number of children who died before 12 months)/(number of children born)] X 1000. This implies that an infant survival rate (ISR) can be computed as follows: *ISR*= 1000 - *IMR/ IMR.*

Recurrent Health Expenditure (RHEX**):** This refers to government's expenditure on human resources and on other non-wage expenditures. It has been used in this study as a proxy for government's expenditure on human resources which is a major health input used in this study. Recurrent expenditure of countries was converted from their local currencies to the international dollar values (in current years) in order to make possible for international comparison.

Real GDP per capita (RGDP): This refers to gross domestic capital per head in a country. It is a measure for the average income in a country. It is expected that as income increases, health outcomes should also increase because healthcare becomes more affordable.

Per capita Health Expenditure (PHEX): This is health expenditure per head in the population**.** It is a measure of the coverage of healthcare in the population and is calculated by dividing total health expenditures (both public and private) by total population in the country. it is used as control variable in this study to account for other forms of health expenditure that was not captured in the model.

Capital Health Expenditure (CHEX): This represents government expenditure on infrastructure and on other expenditure items such as medicines. It is a major health input used in any health system. Capital expenditure of countries was converted from their local currencies to the international dollar values (in current years) in order to make possible for international comparison.

EMPIRICAL RESULTS

Trend in Efficiency Change for Recurrent Health Expenditure (RHEX)

An examination of the trend in efficiency change for recurrent health expenditure model in the 3 countries reveals that efficiency change has not been significant over the years in the 3 countries. In essence, efficiency has been increasing but at an insignificant rate over the years. This explains why the efficiency change coefficient, η was found to be statistically insignificant in the MLE results for the RHEX model. This implies that the health systems in the 3 countries have not been able to improve the efficiency in the use of government recurrent health expenditure (which is a proxy to expenditure on human resource for health) over the years. This is consistent with the findings of Chistom and Evans (2010) where expenditure on human resource for health was found to have contributed to a large share of inefficiency in health systems.

Mean efficiency for the 3 countries increased slightly from 0.58190 in 1998 to 0.58198 in 2012. And in terms of the ranking of countries, Uganda had the highest efficiency score, followed by South Africa and Nigeria. This is however not consistent with the findings of Novignon and Lawanson (2014) where Nigeria took the second position. This could be because of the heterogeneity in health expenditure not accounted for by the large data set adopted by their study and due to the differences in choice of variables.

Table 1: Ranks and Trend in Efficiency Change for RHEX (1998-2005)

DMU	1998	1999	2000	2001	2002	2003	2004	2005
Uganda	0.72836	0.72837	0.72838	0.72839	0.72840	0.72841	0.72842	0.72843
S/Africa	0.62758	0.62759	0.62760	0.62762	0.62763	0.62764	0.62765	0.62766
Nigeria	0.38976	0.38977	0.38978	0.38980	0.38981	0.38983	0.38984	0.38986
Mean	0.58190	0.58191	0.58192	0.58194	0.58195	0.58196	0.58197	0.58198

Source: Computation by author from Frontier (Version 4.1c)

Table 2: Ranks and Trend in Efficiency Change for RHEX (2006-2012)

DMU	2006	2007	2008	2009	2010	2011	2012	Mean
Uganda	0.72844	0.72845	0.72845	0.72846	0.72847	0.72848	0.72849	0.72843
S/Africa	0.62767	0.62768	0.62769	0.62770	0.62771	0.62773	0.62774	0.62766
Nigeria	0.38987	0.38988	0.38990	0.38991	0.38993	0.38994	0.38996	0.38986
Mean	0.58199	0.58200	0.58201	0.58203	0.58204	0.58205	0.58206	0.58198

Source: Computation by authors from Frontier (Version 4.1c)

Trend in Efficiency Change for Capital Health Expenditure (CHEX)

An examination of the trend in efficiency change for the capital health expenditure model in the 3 countries reveals that efficiency change has been significant over the years. In essence, efficiency has been increasing at a significant rate over the years. This explains why the efficiency change coefficient, η was found to be statistically significant in the MLE results. This implies that the health systems of the 3 countries have been able to improve the efficiency in the use of government capital health expenditure (which is a proxy to expenditure on human resource for health) over the years. This result is consistent with the findings of the study of Chistom and Evans (2010) where governments were more found to be more efficient in the use of funds allocated to hospitals than they were for expenditure on human resource for health.

Mean efficiency for the 3 countries increased from 0.7178 in 1998 to 0.8425 in 2012. And in terms of the ranking of countries, Uganda had the highest efficiency score, followed by South Africa and Nigeria. This is however not consistent with the findings of Novignon and Lawanson (2014) where Nigeria took the second position. This could be because of the heterogeneity in health expenditure not accounted for by the large data set adopted by their study.

Table 3: Ranks and Trend in Efficiency Change (1998-2005)

DMU	1998	1999	2000	2001	2002	2003	2004	2005
Uganda	0.7933	0.8020	0.8104	0.8185	0.8262	0.8337	0.8408	0.8477
S/Africa	0.7852	0.7942	0.8029	0.8112	0.8192	0.8270	0.8344	0.8415
Nigeria	0.5749	0.5901	0.6049	0.6194	0.6336	0.6473	0.6607	0.6738
Mean	0.7178	0.7288	0.7394	0.7497	0.7597	0.7693	0.7787	0.7877

Source: Computation by author from Frontier (Version 4.1c)

Table 4: Ranks and Trend in Efficiency Change (2006-2012)

DMU	2006	2007	2008	2009	2010	2011	2012	Mean
Uganda	0.8543	0.8607	0.8668	0.8727	0.8783	0.8837	0.8888	0.8452
S/Africa	0.8484	0.8550	0.8613	0.8674	0.8732	0.8788	0.8842	0.8389
Nigeria	0.6864	0.6987	0.7106	0.7221	0.7333	0.7441	0.7545	0.6703
Mean	0.7964	0.8048	0.8129	0.8207	0.8283	0.8355	0.8425	0.7850

Source: Computation by authors from Frontier (Version 4.1c)

Estimates of Stochastic Production Function

Table 5: Model 1: Final Maximum Likelihood Estimates (MLE) of Stochastic Production Function with recurrent health expenditure (RHEX) as explanatory Variable

Variables	Parameters	ML function	St. Error	t-ratio
Constant	β_0	1.2166	0.2147	5.6677
LnRHEX	β_1	0.1555	0.0466	3.3389
LnPHEX	β_2	0.3779	0.0823	4.5912
LnRGDP	β_3	-0.1060	0.0810	-0.1309
	Variance Parameters			
Sigma squared	σ^2	0.0780	0.0300	2.6011
Gamma	γ	0.9089	0.0435	20.889
Meu	μ	0.5327	0.1674	3.1821
Eta	η	0.00003884	0.008029	0.00484
Log likelihood function	39.94			
LR test of the one-sided error	20.45			

Dependent Variable: infant survival rates (ISR) in natural logarithm

Source: computation by author from Frontier (Version 4.1c)

All the explanatory variables (RHEX, PHEX) are significant at 5% level of significance except for real GDP per capita. Furthermore, the fact that the variables are in their natural logarithm form implies that the coefficients can be treated as elasticities. Therefore, the estimated elasticities of infant survival rate due to recurrent health expenditure, per capita health expenditure and real GDP per capita are 0.16, 0.38 and 0.11 respectively.

There is also a positive relationship between all the explanatory variables and the dependent variable, infant survival rate, except for real GDP per capita with a negative relationship. A 1% increase in recurrent government health expenditure increased infant survival rate by 0.16 years. A 1% increase in per capita health expenditure increased infant survival rate by 0.38 years. However, a 1% increase in real GDP per capita reduced infant survival rate by 0.11 years. Suggesting that while income has increased in the 3 countries over the years, healthcare (provided majorly by the private sector) has however become very expensive, putting it out of the reach of a large share of the population. Also, while income has increased over the years in the 3 countries, the cost of living has also increased, making it more expensive to obtain nutritious food items. As a result, health outcomes have not improved significantly despite the increases in income witnessed over the years. This result is however not consistent

with the findings of the study of Novignon and Lawanson (2014) where the effect of real GDP per capita was found to be negative for the Battese and Coelli, 1992 model specification. This is probably due to the choice of variables used and to a large data set that might fall to account for heterogeneity in income levels across the 45 countries studied.

The estimate of γ at 90.89 is high and statistically significant, meaning that much of the variation in the composite error term is due to the inefficiency components. In essence, there is existence of high technical inefficiency in the dataset. This therefore shows that the model is a good predictor of technical inefficiency (Coelli, 1996, Novignon and Lawanson, 2014).

The estimate of η is positive, suggesting improvements in technical efficiency in the 3 countries over time. It is however very low at 0.00003884 and statically insignificant suggesting a very marginal improvement in technical efficiency over time in the 3 countries. In essence, technical efficiency has been improving but at a very marginal rate. Its statistical insignificance also shows that changes in infant survival rate have not been due to changes in the efficiency of recurrent health expenditure. Therefore, while the governments of the 3 countries have increased recurrent health expenditure over the years, it has not been used efficiently hence resulting to poor health outcomes witnessed over the years.

Table 6: Model 2: Final Maximum Likelihood Estimates (MLE) of Stochastic Production Function with capital health expenditure (CHEX) as explanatory Variable

Variables	Parameters	ML function	St. Error	t-ratio
Constant	β_0	2.3839	0.2245	10.618
lnCHEX	β_1	-0.0240	0.02113	-1.1364
LnPHEX	β_2	0.5727	0.1227	4.6662
lnRGDP	β_3	-0.3413	0.1147	-2.9757
Variance Parameters				
Sigma squared	σ^2	0.01459	0.00295	4.9384
Gamma	γ	0.42584	0.15002	2.8386
Meu	μ	0.15762	0.11691	1.3482
Eta	η	0.04830	0.02187	2.2208
Log likelihood function	36.81			
LR test of the one-sided error	4.156			

Dependent Variable: infant survival rates (ISR) in natural logarithm

Source: computation by author from FRONTIER (Version 4.1c)

All the variables (PHEX, RGDP) are significant at 5% level of significance except for capital health expenditure. Furthermore, the fact that the variables are in their natural logarithm form

implies that the coefficients can be treated as elasticities. Therefore, the estimated elasticity of infant survival rate due to capital health expenditure, per capita health expenditure and real GDP per capita is 0.024, 0.57 and 0.34 respectively.

There is also a positive relationship between all the explanatory variables and the dependent variable, infant survival rate, except for real GDP per capita and capital health expenditure (CHEX) with negative relationships. A 1% increase in capital government health expenditure will reduce infant survival rate by 0.024 years (although it is statistically insignificant). A 1% increase in per capita health expenditure will increase infant survival rate by 0.57 years. However, a 1% increase in real GDP per capita will reduce infant survival rate by 0.34 years.

This result is however not consistent with the findings of Novignon and Lawanson (2014) where the effect of real GDP per capita was found to be negative for the Battese and Coelli (1992) model specification. This is however probably due to the choice of variables used (as the aggregate value of government health expenditure was adopted) and to a large data set that might fail to account for heterogeneity in income levels across the 45 countries studied.

The estimate of γ at 42.58 is low and statistically significant, meaning that not much of the variation in the composite error term is due to the inefficiency components. In essence, there is existence of low technical inefficiency in the dataset. However as noted by Novignon and Lawanson (2014), the statistical significance of the variable is what is most important in the estimation process. This therefore shows that the model is a good predictor of technical inefficiency (Coelli, 1996, Novignon and Lawanson, 2014).

The estimate of η is positive, suggesting improvements in technical efficiency in the 3 countries over time. At 0.048, it is higher than that for the model with RHEX and statistically significant suggesting significant improvements in technical efficiency over time in the 3 countries. Its statistical significance also shows that changes in infant survival rate have been due to changes in the efficiency in the use of capital health expenditure.

The Battese and Coelli (1992) time varying efficiency model makes room for a distinction between changes in infant survival rate (ISR) due to changes in technology and changes in infant survival rate due to changes in technical efficiency. Annual percentage change in infant survival rate due to technological change is 2.4% although this change is not significant. However, annual percentage change in infant survival rate due to change in efficiency in the use of capital health expenditure is 4.8% and this is statistically significant. As a result, the change in infant survival rate has mostly been due to changes in efficiency in the use of capital health expenditure (a proxy for expenditure on the infrastructure) than to changes in technology within the health systems. This means that efficiency in expenditure on capital health expenditure has

contributed to improvements in infant survival over the years in the 3 countries. However, technology change with regard capital health expenditure has not been significant in explaining improvements in infant survival rate over the years in the 3 countries. This suggest that despite the low level of expenditure on technology in the 3 countries, funds allocated to infrastructural development have been used relatively efficiently; thus, the improvement in infant survival rate witnessed.

CONCLUSION AND POLICY PRESCRIPTIONS

This research work has examined the determinants of efficiency of government health expenditure in 3 selected sub-Saharan African (SSA) countries between 1998 and 2012. Having realised the lack of any empirical study on the endogenous determinants of efficiency in sub-Saharan African countries, this study was carried out to identify the determinants of efficiency that arise within a heath system in the absence of external environmental factors.

In order to achieve this, the study reviewed various theories on government health expenditure and outcomes. It also proceeded to review the various related literatures on the determinants of efficiency of government health expenditure from both the developing and developed nations included in the study area.

The study employed panel data to analyse the determinants of efficiency of government health expenditure using the stochastic frontier analysis (SFA) a parametric method instead of the non-parametric approaches such as DEA and FDH. The result of the finding showed that recurrent health expenditure is a greater determinant of government health expenditure inefficiency ahead of capital health expenditure.

Furthermore, it was discovered that changes in infant survival rate has not been due to changes in the efficiency in the use of recurrent health expenditure (a proxy for expenditure on health workers) while changes in infant survival rate has been due to changes in efficiency in the use of capital health expenditure (a proxy for expenditure on infrastructure). As a result, recurrent health expenditure has been used inefficiently in the 3 countries while capital health expenditure has been used more efficiently. In addition, change in efficiency over the years for recurrent health expenditure was insignificant while that for capital health expenditure was found to be statistically significant. And in terms of the rankings of the countries under the 2 models, Uganda came first followed by South Africa and Nigeria. This shows that Uganda has been more efficient in the use of its resources ahead of Nigeria and South Africa.

Based on the findings of the analysis, the following conclusions are made: First, it has been identified in this study that government spending on human resource for health input (proxied by government recurrent health expenditure) has been a greater determinant or source

of inefficiency ahead of expenditure on infrastructure (proxied by government capital health expenditure) in the 3 countries studied, as the mean efficiency of the recurrent health expenditure model was 58.20 compared to 78.50 for the capital health expenditure model. This is consistent with the findings of Chistom and Evans (2010) where it was estimated that inefficiency with regards human resource for health accounted for a greater share of inefficiency ahead of expenditure on hospitals.

Secondly, in terms of the trend in efficiency change over the years, it was discovered that efficiency in capital health expenditure has increased significantly over the years while efficiency in the use of recurrent health expenditure has not witnessed any significant increase. Thirdly, it was discovered that changes in infant survival rate has mostly been due to changes in technology with regards recurrent health expenditure and not due to changes in the efficiency of the usage of expenditure in recurrent expenditure. On the other hand, it was discovered that change in infant survival rate has mostly been due to changes in efficiency in the usage of capital health expenditure and not to technological change with regards capital health expenditure. As a result, efficiency of government capital health expenditure has contributed significantly to improvements in infant survival rate while efficiency of government recurrent health expenditure had no significant effect on improvements in infant survival rate.

Against the foregoing findings, it is therefore evident that the governments in the 3 countries should concern themselves more with increasing size of their budgetary allocations on capital health expenditure items (as they have been efficient in its usage to a large extent despite low spending levels) in order to achieve better health outcomes while they should focus more on increasing the efficiency in the use of recurrent health expenditure (as they have been inefficient in its use) in order to improve health outcomes across the population.

The result of the study indicates that increased expenditure on human resource for health (proxied as recurrent health expenditure) has not resulted in improved health outcomes due to inefficiency in its usage. As a result, government in the 3 countries need to improve efficiency in its usage without having to increase current spending levels. Since inefficiency could occur as a result of ineffective planning and inappropriate training of workers, government could ensure proper training of the health workforce. This could be done by ensuring that training institutions are well regulated to ensure thoroughness in the training process and strict compliance to standards and ethics set by the regulatory bodies.

In addition, since inefficiency could also occur as a result of poorly motivated workforce, government should create incentive packages to motivate health workers which could include creating a more conducive working environment. For instance, the working hours of health workers could either be reduced or made flexible to allow them work more efficiently. Maternity

leave for female health workers could also be extended or made flexible to prevent them from quitting their jobs after child delivery in order to raise their children. Furthermore, the government could also adopt health input mix policies by ensuring the optimal mix of human resource for health. This could include the training of casual health workers through short training courses to work as nurses and midwives alongside professionally trained workers.

The results also showed that the 3 countries have utilized capital health expenditure more efficiently with average efficiency scores for the CHEX model at 78.50 percent compared to 58.20 percent for recurrent health expenditure (RHEX) model. It also indicated that efficiency in the use of capital health expenditure over the years has brought about significant improvement in infant survival rate in the 3 countries. This therefore indicates that by placing more importance to capital health expenditure items in budgetary allocations, health outcomes could improve significantly in the 3 countries.

The rankings of countries in terms of their efficiency score for both models (recurrent and capital expenditure) also reveals that Uganda was the most efficient followed by South Africa and Nigeria. This reveals that Uganda has been able to utilize its recurrent and capital budgetary allocations more efficiently than South Africa and Nigeria. The Nigerian government should therefore study the health policies adopted by the Ugandan and South African governments in order to improve on the efficiency of its health system, especially at a time when resources are limited to pursue any expansion in budgetary allocations to the health sector.

In future empirical analysis, the scope of the study should be expanded to cover more countries within the sub-Saharan Africa. This will ensure more rigorous analysis and greatly obviate the limitations inherent in a panel data analysis covering only 3 countries.

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