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RESEARCH ARTICLE

PRODUCTIVITY ANALYSIS OF PUBLIC HOSPITALS IN CAMEROON: A MALMQUIST PRODUCTIVITY INDEX APPROACH.

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Abstract

The study employed the Malmquist Productivity Index to analyze the productivity of public hospitals in Cameroon. The main advantage of this approach is that it does not impose any specification on the production technique and does not require input prices like other techniques. Productivity was decomposed into its usual constituents of productivity growth: technological change and efficiency change. The results show on average that Cameroonian hospitals did not experience productivity growth during the period analyzed and this was due to technical regress. Integrated health centres were more productive than Sub Divisional Medical Centres and District Hospitals respectively while hospitals located in Urban areas achieved higher productivity scores than those in Semi-urban and Rural areas respectively. Productivity can be improved by providing more training courses to employees and also improving the working conditions of the personnel, designing good reward and punishment systems for employees since most of them tend to take jobs in multiple health facilities due to low pay and tend to focus less in their public hospitals.

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Introduction: -

The concepts of healthcare provision and healthcare production have gained much attention in recent empirical literature. According to Weisbrod (1991) as cited in Roos, (1997), these services are much talked about because they involve the preservation of life or they at least have an impact on the quality of life. Monitoring hospital productivity and how it varies over time has become significant because it helps policy analysts to evaluate the impact of health policies on service deliveries and health outcomes. Given the scarce nature of healthcare resources, it is important that the resources be put into their optimal use to translate the inputs to outputs so that the healthcare services can be delivered to as many people as technically feasible (Kirigia, et al., 2011).

As cited in Murray & Frenk (2002), there are three main goals for any health system as stipulated by the World Health Organisation; “to improve health as a primary goal, to provide financial protection for people through fair financial contribution, and to respond to people’s expectations as regards to non-health issues which include to respect people’s dignity, autonomy and confidentiality of information”. These three intrinsic goals should be monitored by all countries and should form the bases for the assessment of health systems performance facilitated by WHO. The World Health Assembly (2000) has also emphasized that “people’s health and well-being depend essentially on the performance of the health systems that serve them”(Nazgul, 2011). However, healthcare systems are faced with the challenge of resource scarcity and often have insufficient resources to respond to all health problems and target groups simultaneously (Molem & Beri, 2016).

Marie Koumate recently made the headlines when she tried saving the twins inside her dead and pregnant aunt [Monique Koumate] at the Laquantine hospital in Douala who was denied medical care because of the lack of money and died at the gate of the hospital. It was then reported that Marie who accompanied the aunt to the hospital bought a razor blade at a nearby pharmacy and sliced the womb of the deceased in which one of the twins came out dead while the other who came out breathing gave up the ghost minutes later (Bada, 2016). This is just one of the multiple challenges faced by developing nations especially in their public health delivery systems. Such tragic incidents may not happen if health systems are properly organized and managed.

Further, resource scarcity is a major challenge faced by many health facilities in Cameroon and government lays special emphasis on increasing budgetary allocations to the health sector. However, an increase in the allocation of resources for healthcare often come at the expense of other national priorities including education, housing, water, national defence etc. Proper management of these resources then becomes fundamental if the system has to meet up with its goals especially in a developing country like Cameroon where little emphasis is placed on assessing whether health expenditures actually translate into expected outcomes (Molem & Beri, 2016), Njong & Ngantcha, (2013) have shown in their studies in Cameroon that public health spending may have insignificant impact on the population's health status; because of the failure of health resources to translate into improved services.

Every government has as priority to ensure good health to its citizens, consistent with the fundamental human right of life. Hernandez & Miguel (2014) suggested that "improving the performance of health systems in low- and middle-income countries (LMIC) can help redress health inequities and make the right to health a reality for vulnerable populations". However, significant differences have been found in healthcare provision, funding and outcomes across different countries at similar income levels some of which Murray & Frank (2002) and Marsha et al., (2008) attributed them to differences in health systems performance. Many countries therefore seek to measure the productivity of their health systems through performance measurement in order to compare their relative performance given the need to ensure the best use of scarce resources (Roh, Changsuh, & Moon, 2007). It is for this reason that the current study has sought to determine the productivity level of public hospitals in Cameroon and how productivity vary by type of health facility (Sub Divisional Medical Centres, Integrated Health Centres, District Hospitals) and location (Urban, Semi-Urban and Rural). The remainder of this paper is organized as follows: Section 2 reviews the literature. Section 3 details the methodology. Section 4 presents the results and Section 5 concludes the study.

Literature Review: -

Recently, much empirical literature has been done to establish the efficiency levels of hospitals. Hollingsworth (2008) did a comprehensive review of published works on frontier efficiency measurement techniques in healthcare and found a total of 317 studies between the years 1980-2006, 80 per cent of which made use of Data Envelopment Analysis (DEA) while the rest used parametric stochastic Frontier Analysis. A majority of these studies were however aimed at estimating technical efficiency and very few of them studied hospitals productivity growth. Linna (2000) employed the Malmquist Productivity Index and used a panel dataset comprising of 43 acute care hospitals in Finland to estimate the productivity of hospitals for the periods 1988-1994. He used net operating costs, total number of beds, average hourly wages of labour, annual price index for local government healthcare expenditures, teaching status, and readmission rate for admission as input variables and the total number of emergency visits, the total sum of follow-up visits, the DRG-weighted number of total admissions, the total bed days, the number of residents, the total number of on-the-job training weeks of nurses, and the total number of impact-weighted scientific publications as output values (Chul-Young, Moon, & Jung, 2013). He found productivity growth in the 1992-93 and 1993-94 periods which was mostly attributed to technological change. Rosko, and Valdmanis (2006) examined 170 hospitals in Pennsylvania in 2002 employing output-oriented DEA and found that the existing inefficiency was due to pure technical inefficiency. Chu (2011) also used data extracted from Guangdong Province's Health Statistical Yearbooks for the years 2004-2008 to estimate the productive efficiency of 463 Chinese hospitals and found using the Malmquist Productivity Index that hospitals had experienced productivity growth between 2004 and 2008 and this was mostly accounted for by technological progress. Chu, (2011) reviewed hospitals efficiency studies in the western context in which he found the works of Harrison and Sexton (2006), and Harrison, Coppola, & Wakefield (2004) who analysed hospitals nationwide in the 1990s using input-based data envelopment analysis (DEA) yielding efficiency scores of 0.68 to 0.79. Ferrier, Chen, Hwang, & Shao (2005) also estimated productivity of hospitals and concluded that there was a declining trend in overall technical efficiency for the 89 included acute care hospitals in California for the period 1992-97 which was mostly attributed to a deterioration in pure technical efficiency.

Most of the works use the Malmquist productivity Index(MPI), The Index is used to calculate productivity growth between two time periods. A change in total productivity occurs either by a change in relative technical efficiency of a Decision Making Unit(DMU) or by a change in technology (Meryem, 2000). The index was introduced by Caves et al., (1982), later Fare et al. (1994) showed the potentials of the approach and demonstrated how the values of the distance functions needed in the approach could be captured by applying linear programming techniques used in DEA (Luoma&Jarvio, 2000). The approach has a major advantage of not imposing any specification on the production technique or the efficiency distribution law (Hollingsworth et al, 1999). The choice of a non-parametric technique in the assessment of efficiency in the health domain has the advantage of taking into consideration the specificities of health sectors, such as; (i) the complexity of multiproduct/multifactor technology, (ii) it does not require input and output prices (iii) the uncertainty related to the behaviour and objectives of actors engaged in the health sector. The main idea of the Malmquist Productivity Index(MPI) is to measure total factor productivity change. Just like in any other productivity measurement, an index of output is divided by an index of inputs. The MPI has as advantage the fact that price information is not needed for weighting in its methodology which makes it an invaluable property especially in public sector applications where reliable price information is often missing

An important advantage of applying MPI to panel data is that one can decompose productivity change into two components: efficiency change (catching-up effect) and technical change (shift of the efficiency frontier) (Fare, Grosskopf, Norris, & Zhang, 1994). This kind of information is useful since productivity improving policy measures depend on the pattern of productivity change. The appropriate policy responses will be different for productivity slowdown due to the catching up being modest and when the slowdown is due to the lack of change of the frontier technology (Luoma&Jarvio, 2000). Malmquist index is constructed from distance functions, allowing explicit calculation and isolation of changes in inefficiency. Fare et al. (1994) calculated distance functions directly in “goods” space by means of linear programming. Their calculations exploit the fact that the output distance functions used to construct the Malmquist index are reciprocal to Farrel (1957) output-oriented technical-efficiency measures. They therefore bear a close relationship to the standard output-oriented DEA-model. This link to efficiency allows us to decompose productivity changes into changes in efficiency and the best-practice frontier (technical change) (Fare et al., 1994).

Methodology: -

The study employed the Malmquist Productivity Index to estimate productivity levels of public hospitals in Cameroon. Its mathematical formulation is specified as below

$$M_0^{t+1}(X^{t+1}, Y^{t+1}, X^t, Y^t) = \frac{D_0^{t+1}(X^{t+1}, Y^{t+1})}{D_0^t(X^t, Y^t)} \left[\frac{D_0^t(X^{t+1}, Y^{t+1})}{D_0^{t+1}(X^{t+1}, Y^{t+1})} \frac{D_0^t(X^t, Y^t)}{D_0^{t+1}(X^t, Y^t)} \right]^{\frac{1}{2}} \quad (1)$$

Or $M = E * T$

Where Y = Index of outputs and X = Index of Inputs

A value for equation (1) of M_0 greater than 1 indicates positive TFP growth from period t to period $t+1$. A value for M_0 of less than 1 indicates TFP decline between the two periods while $M_0=1$ implies no change in TFP between the two time periods under consideration (Jacobs et al., 2006).

E (the ratio outside the brackets) represents the change in the output-oriented Farrell technical efficiency levels between periods t and $t+1$.

$$E = \frac{D_0^{t+1}(X^{t+1}, Y^{t+1})}{D_0^t(X^t, Y^t)} \quad (2)$$

A value of 1 for E means the hospital has the same distance from the frontier in both periods. A value greater than 1 means the hospital has improved its efficiency in period $t+1$ compared to period t in that it has moved closer to the frontier. When the value is less than 1 the hospital has moved further away from the frontier.

T reflects the changes in productivity levels due to technical progress for the hospital sector. It is the geometric mean of the shift in technology between the two periods, evaluated at X^{t+1} and X^t

$$T = \left[\frac{D_0^t(X^{t+1}, Y^{t+1})}{D_0^{t+1}(X^{t+1}, Y^{t+1})} \frac{D_0^t(X^t, Y^t)}{D_0^{t+1}(X^t, Y^t)} \right]^{\frac{1}{2}} \quad (3)$$

A value of greater than 1 for T means the industry produces more outputs in period $t+1$ compared to period t , controlling for input levels (given that the output orientation is being used). In other words, the hospital sector has experienced productivity gains over time. A frontier shifts of less than 1 would equivalently represent productivity loss by the industry. When $T=1$ the industry has made neither productivity gains nor loss.

The Malmquist productivity index is an advancement of DEA to estimate the productivity of DMUs. Unlike in other productivity indices such as Laspeyres, Paasche, Fisher and Tornqvist which require quantity and price information

as well as assumptions about the structure of technology and the behaviour of producers, The Malmquist index has an advantage over such indices since it does not require information on the prices of inputs and outputs or technological and behavioural assumptions. This makes the Malmquist index a particularly suitable tool for the analysis of productivity change in the public sector, where output prices are not in general available (Jacobs, Smith, & Street, 2006). A further advantage of applying MPI to panel data is that one can decompose productivity change into two components: efficiency change (catching-up effect) and technical change (shift of the efficiency frontier). This kind of information is useful since productivity improving policy measures depend on the pattern of productivity change.

A number of iterations were performed to investigate how sensitive productivity scores are to an increasing number of hospital activities. Secondly, the difference in productivity levels of Sub Divisional Medical Centres(CMA), Integrated Health Centres(CSI) and District Hospitals(HD) as well as the difference in productivity levels between Urban, Semi-urban and Rural health facilities were carried out using One-way analysis of variance (ANOVA) method with post hoc comparisons. DEAPv2.1 developed by Coelli (1996) was used to estimate the productivity of public health facilities and SPSSv21 was used to perform the analysis of variance.

Analyses in the study employed secondary data based on the first Public Expenditure Tracking Survey (PETS1) jointly carried out in Cameroon by the World Bank and the National institute of Statistics. The current study utilises Panel data for 109 health facilities observed for two time periods i.e. 2002-2003. There exist a lot of controversy regarding the choice of the appropriate input and output variables because of the special characteristics of health industry and the difficulties in measuring the final output of healthcare provision, the final production outcome of this industry, that is “health improvements”, is heterogeneous, multiple and it does not occur in discrete units. Thus, it is difficult to measure and at the same time take into account the quality of the healthcare service output (Molem & Beri, 2016). Consequently, a significant proportion of variability exists in the chosen inputs and outputs of hospitals between different studies” (Maniadakis et al., 2009). However, the inputs and output variables included for this study were selected based on what has been widely used in most empirical works.

Table 1.1 Definition of Variables

Variable	Description
<i>Output variables(Y)</i>	
Admissions	# of inpatients or hospitalizations
Total number of consultations	General medical Consultations
length of stay	Days stayed by inpatients in hospital
Medical Tests	Includes HIV/AIDS, Urine analysis, other STDs, etc.
Births	Sum of deliveries for each hospital
Maternal & Childcare Services	# of children less than 5 years consulted and prenatal consultations
Transfers out	Referrals out of the health facility
Transfers in	Referrals into the health facility
Follow up cases	
<i>Input Variables(X)</i>	
Administrative Staff	
Medical Staff	Include number of active doctors, Nurses, assistance nurses, care givers and other qualified medical personnel
Laboratory Technicians	Includes both laboratory and radiology technicians
Beds	# of available beds
Other Staff	# of active workers other than doctors and nurses

Source: Molem& Beri (2016), # = Number

Two key output variables need more attention i.e., transfers out of a health facility and transfers into another health facility. If patients end their care in one hospital with a transfer to another hospital, it is assumed that this represents an inability on the part of the first hospital to meet the patient’s treatment needs. Transfers into a hospital are likely to represent complex patients referred from less capable institutions. These variables capture an aspect of case mix and patient severity (Jacobs, Smith, & Street, 2006).

Further, DEA formulation requires that the input and output variables be positive. Marek (2009) reported that if the variable is not positive, a positive value is added to the negative value so that the particular input or output variable becomes positive. This same adjustment must be made to the same input or output value for all decision making units included in the data set in order not to alter the efficiency frontier. A number of hospitals in our sample reported zero values for some input and output variables and the DEAP developed by Coelli (1996b) does not accept zero input and output values, in order to overcome this situation and proceed with the analysis, a value of 2 was added for input and output values in order to transform them into positive values.

Results: -

This section report findings based on solutions to the Malmquist productivity index, worthy of note here is that the Malmquist index would be less than one if there is a productivity decline, more than one if there is productivity growth and if there is no change in productivity, the Malmquist index will be equal to one. As earlier noted, the Malmquist productivity index was decomposed into its various components of efficiency due to the existence of returns to scale.

Table1.2:-Malmquist Index Summary of Annual Mean

Mode 1	Year	Efficiency Change	Technical Change	Pure Change	Efficiency Scale Change	MPI
1	1					
	2	1.305	0.544	1.25	1.044	0.71
	Means	1.305	0.544	1.25	1.044	0.71
2	1					
	2	1.305	0.541	1.193	1.094	0.706
	Means	1.305	0.541	1.193	1.094	0.706
3	1					
	2	1.298	0.537	1.232	1.053	0.696
	Means	1.298	0.537	1.232	1.053	0.696
4	1					
	2	1.295	0.536	1.221	1.061	0.694
	Means	1.295	0.536	1.221	1.061	0.694
5	1					
	2	1.024	0.696	1.085	0.944	0.713
	Means	1.024	0.696	1.085	0.944	0.713
6	1					
	2	0.98	0.726	1.025	0.956	0.711
	Means	0.98	0.726	1.025	0.956	0.711
7	1					
	2	1.04	0.679	1.033	1.007	0.707
	Means	1.04	0.679	1.033	1.007	0.707

Source: (By Author, 2016), Malmquist Index Averages Are Geometric Means

Table 1.2 presents Malmquist index averages for efficiency change, technical change, pure efficiency change, scale efficiency change and the malmquist productivity index (total factor productivity score) for models 1 to 7. Turning to model 4, we can observe that the malmquist score for the health facilities was 0.694 implying that there was a productivity decline of 30.6 per cent from 2002-2003. By analysing decomposition of the Malmquist Index, it can be observed that the negative change was on average due to technical regress (decrease by 30.4 per cent). 19 of the 109 health facilities realised productivity growths between the two time periods. It can further be observed that efficiency change, pure efficiency change and scale efficiency change experience growths between the two years under consideration.

Table 1.3:-Summary of Productivity Scores by type and Location of Health Facility

TYP E		Y	Efficiency Change	Technical Change	Pure Change	Efficiency Scale Change	Efficiency Scale Change	MPI
	SDMC	1						
		2	1.1667	0.5806	1.1369	1.0262		0.6775
	IHC							
		1						
		2	1.4845	0.5086	1.2895	1.1512		0.7553
	DH							
		1						
		2	1.1343	0.5681	1.0759	1.0543		0.6443
LOCATION								
	Urban							
		1						
		2	1.4769	0.5476	1.1713	1.2609		0.8089
	SU							
		1						
		2	1.1314	0.5503	1.1269	1.0038		0.6224
	Rural							
		1						
		2	1.3012	0.5336	1.2313	1.0568		0.6946

Source (By Authors, 2016) Model 4 only: Malmquist Index Averages are Geometric Means, SU= Semi-urban; SDMC= Sub Divisional Medical Centre, IHC=Integrated Health Centre, DH=District Hospital

Table 1.3 presents a summary of the Malmquist productivity scores and its decomposition by type and location of health facility. It can be observed that there was a productivity decline (decrease in MPI) from 2002-2003 to 0.6775(declined by 32.25 per cent) for Sub Divisional Hospitals, 0.7553(decline by 24.47 per cent) for Integrated Health Centres and 0.6443(declined by 35.57 per cent) for District Hospitals. This decline was greatly accounted for by the technical regress (41.94 per cent for Sub Divisional Hospitals, 49.14 per cent for Integrated Health Centres and 43.19 per cent for District Hospitals. However, Integrated Health Centres were generally more productive than Sub Divisional Hospitals and District Hospitals. Efficiency change, pure efficiency change and scale efficiency change experienced growths between the two time periods.

Analysis based on the location of the health facility show that urban health facilities obtained a total factor productivity score of 0.8089(decline by 19.11 per cent); Semi urban health facilities obtained a productivity score of 0.6224(decline by 37.76 per cent) and rural health facilities obtained a total factor productivity score of 0.6946(30.54 per cent). The decline in total factor productivity score was also accounted for by technical regress (45.24 per cent for Sub Divisional Hospitals; 44.97 per cent for Integrated Health Centres and 46.64 per cent for District Hospitals). Efficiency change, pure efficiency change and scale efficiency change also experienced growths between the two time periods.

Table 1.4: - Analysis of variance in Productivity by Type of health facility

		Summary statistics of ANOVA			
Type of Health Facility	Mean Productivity	Standard Deviation	Frequency		
CMA	3.35	14.097	27		
CSI	1.26	2.235	54		
HD	1.04	2.2	28		
Total	1.72	7.239	109		
Analysis of Variance					
Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Prob> F
Between Groups	96.342	2	48.171	0.918	0.402
Within Groups	5562.547	106	52.477		
Total	5658.889	108			

Source (By Authors, 2016)

A one-way between-groups analysis of variance was conducted to explore the impact of type of health facility on productivity. Health facilities were divided into three groups (Group 1: CMA; Group 2: CSI; Group 3: HD). Test for differences in mean productivity levels by type of health facility did not produce significant results [$F(2, 106) = 0.918, p = 0.402$]; as shown on table 1.4. The actual difference in mean scores between the groups was quite small, as guided by the calculated eta squared (effect size) of .02 [Cohen, 1988]

Table 1.5: - Analysis of variance in Productivity by location of health facility

Type of Health Facility	Mean Productivity	Summary statistics of ANOVA			
		Standard Deviation	Frequency		
Urban	1.3	2.524	28		
Semi-urban	0.75	0.43	23		
Rural	2.32	9.765	58		
Total	1.72	7.239	109		
Analysis of Variance					
Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Prob> F
Between Groups	47.26	2	23.63	0.446	0.641
Within Groups	5611.629	106	52.94		
Total	5658.889	108			

Source (By Authors, 2016)

Similarly, test difference in mean productivity levels by location of health facilities did not produce significant results, as shown on table 1.5. The actual difference in mean scores between the groups was quite small, as guided by the calculated eta squared (effect size) of .01 [Cohen, 1988]

Conclusion:-

This paper explored the productivity of public hospitals in Cameroon using the Malmquist productivity Index. The MPI method was considered appropriate because it allows multiple input and output variables and it does not require price information which is problematic in public health delivery systems. Three hospital types were used i.e., Sub Divisional Medical Centres, Integrated health centres and District Hospitals. Our results showed that there was a decline in productivity over the two time periods which was accounted for by technical regress. Hospitals located in Urban centres obtained higher productivity scores than those located in Semi-urban and Rural Health centres respectively. Analysis of Variance results did not produce any significant differences in productivity by type and location of health facility. The study was perhaps the first in measuring productivity of public hospitals in Cameroon.

Our findings suggest that much attention needs to be directed towards improving the overall productivity of public hospitals in Cameroon since there was a decline in productivity between the time periods included. Productivity improvement should be considered as one of the strategies for mobilizing more domestic resources for healthcare. Besides, if productivity level is improving, it implies greater availability of health services. Furthermore, it can entail improvement in the quality of services. Therefore, monitoring productivity of public hospitals should be considered paramount and this can only be possible if appropriate input, input prices and output data is collected from health facilities. The ministry of public health should therefore ensure that this information is collected and made available for the analysis. Productivity can be improved by providing more training courses to employees and also improving the working conditions of the personnel, designing good reward and punishment systems for employees since most of them tend to take jobs in multiple health facilities due to low pay and tend to focus less in their public hospitals.

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