An Analysis of the Technical Efficiency of Cameroonian Public Universities

R. Nguemkap Kouamo(✉) and G. Tchoffo Tameko

University of Dschang, Dschang, Cameroon
romualdnguemkap95@gmail.com

Abstract. The objective of this research is to evaluate the technical efficiency of Cameroon's 8 public universities (i.e., their ability to use a minimum of resources to produce a maximum of results). The data used come from the National Institute of Statistics (INS) and cover the period from 2013 to 2018. Based on the literature, the numbers of students and teachers per university are taken as inputs; and the numbers of graduates and research licenses issued are taken as outputs. The data envelopment analysis (DEA) method and the Malmquist index are used. More specifically, the first step consists of calculating the level of technical efficiency of universities using the DEA, while the second step analyzes the changes in productivity over the period 2013 to 2018 using the Malmquist index. The results show that Cameroonian public universities are inefficient and do not make optimal use of the resources at their disposal. The main recommendation of this study is that the capacity of Cameroonian universities be improved in order to make efficient use of the resources at their disposal.

Research Contribution: This paper researches the percentage improvement of human capital produced by universities and universities with the best practices in terms of management and management. The calculation of productivity allows us to understand that the technical efficiency of universities has improved during the period 2014–2018.

Keywords: Public universities · DEA · Malmquist Index · technical efficiency

1 Introduction

The theory of human capital developed by [1, 2] allows us to understand that the skills acquired in the educational system (school, college, high school, university, technical and vocational education and training, etc.) improve the productivity of individuals and stimulate economic growth. In the same way, from the theory of endogenous growth, a current economics of education was born which is particularly interested in the functioning of educational systems and the optimal conditions of production of education [3]. In recent decades, the focus of educational research has been on the study of the functioning of educational systems, and more specifically on the analysis of the technical efficiency of schools [4]. In this perspective, the most recent works such as those of [5] and [6] place particular emphasis on the quality of education and economic growth. In most of

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the studies carried out in the context of African countries, a strong positive relationship between investment in the education system and economic growth emerges [7–10].

According to [11] Sub-Saharan Africa lags far behind the rest of the world in higher education. His study contradicts the myth that higher education has little impact on economic growth and poverty reduction, calling on African governments to place greater emphasis on education. With the emergence of a knowledge-based economy, the role of higher education is becoming increasingly important. It can help countries catch up with technologically advanced societies. In this respect, the evaluation of the technical efficiency of universities is inevitable as they tend to be more autonomous.

Higher education is of crucial importance in modern societies, insofar as it is considered to perform many functions: training for citizenship, factor of social promotion, vector of social justice and national cohesion, engine of economic growth. In this regard, it should be emphasized that, since time immemorial, the missions of the University have always been those of knowledge production through research, aggregation and transmission of this knowledge, in order to prepare learners for professional life. In coherence with this idea, the State of Cameroon assigns to higher education "a fundamental mission of production, organization and dissemination of scientific, cultural, professional and ethical knowledge for the development of the nation and the progress of humanity.

In Cameroon, studies on school efficiency are mainly focused on primary education [12] and secondary education [13]. To our knowledge, there is no study on school efficiency in higher education in Cameroon. The level of technical efficiency of Cameroonian public universities and the evolution of their productivity remain unknown, which prevents the establishment of appropriate policies and the optimal allocation of resources. This article aims to answer the following questions. What is the level of technical efficiency of Cameroonian public universities? How is their productivity evolving over the period 2014, 2018?

In this study, an output-oriented DEA model to determine the technical efficiency of Cameroonian public universities and the Malmquist index to evaluate the change in productivity between is used.

The results show that overall Cameroonian public universities waste the resources made available to them, they can increase by 21% the number of graduates and research authorization obtained. Of the 8 universities, over the period 2014–2018, the average productivity growth rates are 7.5% for total factor productivity, 16.30% for technical efficiency, 94.68% for technical progress. An important finding is that total productivity is explained more by technical efficiency than by technical progress. These results have led to economic policy recommendations to improve the productivity of the higher education sector in Cameroon.

Following this introduction, a review of the literature follows in Sect. 2. The methodology and data are presented in Sect. 3. Section 4 presents the results and their discussion and Sect. 5 is devoted to the conclusion and recommendations.

2 Review of the Literature

The notion of technical efficiency took on its initial meaning and was accompanied by the first measurement efforts through the work of [14] which provided the definition and

conceptual framework for the measurement of efficiency. The modern measurement of producer efficiency appeared with the pioneering work of [15] and those of [16]. This work is part of a purely neo-classical framework.

The literature on the application of the DEA method to higher education had a major turning point with the publication of the work [17] and [18]. The most recent studies [19–23] use the DEA method not only for efficiency and productivity measurement, but also for university ranking. Many studies on the application of DEA in the education sector have used Malmquist indices.

[24] used panel data from 45 British universities to assess the change in the sector's total factor productivity (TFP) between the academic years 1980–81 and 1992–93. This period was chosen because it corresponds to significant changes in public funding. The authors found an increase in productivity of up to 51.5 percent over the study period. Using both decompositions of the Malmquist productivity index, they suggested that this increase was primarily due to technological progress rather than to improvements in technical efficiency. Specifically, the results show that the technological frontier improved by 39.1 percent, while technical efficiency improved by only 8.8 percent.

In Australia, [25] examined the productivity growth, technical efficiency and scale efficiency of 35 universities between 1996 and 2000. They found that the average productivity growth of the universities was 1.8% per year, due to a positive technology change of 2.1%, a decrease in technical efficiency of 0.7% and an improvement in scale efficiency of 0.4%. It should be noted that the productivity change results presented in this study are only average values.

The study by [26] on the efficiency of private universities using the DEA model with the Malmquist productivity index over a period of 2004–2007, indicates variability among the units studied. The number of research outputs and the number of graduates show different variability. [27] also applied the Malmquist indices to assess the productivity growth of state universities and colleges in the Philippines, using panel data from 59 universities for the period 1999–2003. An average productivity change score obtained of 1.002 indicates a very slight growth in total productivity. The main origin of this increase is improvements in technical efficiency, unrelated to technological innovation. In fact, there was a technological regression of 5.2 percent over the period studied. Therefore, the authors suggest that the Philippine government should focus on providing modern teaching and learning structures to state higher education institutions to improve their technological performance.

[28] applied the DEA method and Malmquist indices to study the change in efficiency and productivity of 133 doctoral-level universities in the United States over the period 2005–2009. The total index was decomposed into technology change and technical efficiency change. The latter was then split into "pure" technical efficiency change and scale efficiency change. The average total Malmquist index obtained, 0.987, shows a slight regression in average university productivity over the four academic years studied. However, this decrease was only for the years 2006–2007 and 2007–2008, while a significant increase in productivity for the academic year 2008–2009 was observed (with an average index of 1.015). Furthermore, looking at the results of the decomposed Malmquist indices, the author concludes that a trend towards productivity gains was achieved through technological change, with a positive change observed for 50% of the

universities examined. In contrast, 62% of the universities showed a deterioration in technical efficiency. From the detailed indices, the decrease in pure technical efficiency is more important than the decrease in scale efficiency.

In view of this dense literature, it is important to note that most of the work on academic efficiency in higher education and productivity change has been done in Europe and the United States. In the Cameroonian context, to our knowledge, no research exists. This study therefore contributes to filling the gap in the Cameroonian literature on school efficiency in higher education.

3 Methodology and Data

3.1 Methodology

A dynamic DEA (Data Envelopment Analysis) approach and the Malmquist index allow for the study of variations in the overall productivity of factors of production, a highlighting of management efficiency on the one hand and technical progress on the other. The methodology used is that of the DEA. Following the notation used by [29] the efficiency is obtained as follows:

$$TE_K = \frac{\sum_{r=1}^{s} U_{rk} Y_{rk}}{\sum_{i=1}^{m} V_i X_{ik}} \tag{1}$$

Where TE_k is the technical efficiency of organization k using m inputs to produce s outputs; Y_{rk} is the quantity of output r produced by organization k; X_{ik} is the quantity of input i consumed by organization k; U_r is the weight of output r; V_i is the weight of input i; s is the number of outputs; and m is the number of inputs.

This measure of technical efficiency is a relative measure (compared to all other EDRs in the data set). According to [29] the technical efficiency of organization k is maximized under two constraints. First, the weights applied to the outputs and inputs of organization k cannot generate an efficiency score greater than 1 when applied to every organization in the sample. Second, the weights applied to outputs and inputs are strictly positive.

The following linear programming problem must be solved for each organization:

$$Max \begin{cases} \dfrac{\sum_{r=1}^{s} V_i X_{ik}}{\sum_{i=1}^{m} V_i X_{ik}} \\ sc \dfrac{\sum_{r=1}^{s} U_{rk} Y_{rj}}{\sum_{i=1}^{m} V_i X_{ik}} \leq 1 \end{cases} \tag{2}$$

With j = 1,…,n ∀ i; ur ≤ 0 and ∀ r = 1,…,s; i = 1,…,m.

The Malmquist index is an index of the change in total factor productivity calculated by comparing the data for a current year with the previous one. It is the geometric mean of an efficiency index and a technical progress index. The efficiency index is an index of the ratio of observed output to potential output given the available technology. The technical progress index is an index of the change in potential output that can be measured from the shift in the current year's production frontier relative to the base year. Then the calculation of the Malmquist index is based on ratios of distances, and their average implies a calculation of geometric means.

A more succinct but equivalent description of this index can be found in [30]. The Malmquist productivity index measures the change in productivity (TFP) between two observations, by calculating the ratio of the distances of each data item from a common technology. The Malmquist FPR change index (input oriented) between period 0 (the base period) and period 1 (using period 1 technology as the reference technology) is defined by:

$$TFP_1/TFP_0 = D_1(Y_0, X_0)/D_1(Y_1, X_1)$$

Where the notation: $D_t(X_s, Y_S)$ represents the distance between the observation of the period S and the technology of period t and X_s and Y_s are respectively the input and output of the period S. A value of this ratio in (3) greater than 1 will mean an improvement in total factor productivity."

With reference to the work of [31] the Malmquist productivity index is defined as "The geometric mean of two indices: one index evaluated in relation to the technology of period 1 and another in relation to the technology of period 0".

3.2 The Data

The data are collected from the Ministry of Higher Education and the Ministry of Research and Scientific Innovation and come from the National Institute of Statistics (INS) (year). They cover all 8 public universities in Cameroon (Bamenda, Buea, Maroua, Ngaoundéré, Douala, Dschang, Yaoundé 1 and Yaoundé 2) over the period 2013 to 2018. Based on the literature and available data, the selected inputs are as follows:

- The number of students enrolled in the university, this number takes into account all students enrolled in each cycle.
- The number of teachers per university; this variable takes into account all teachers regardless of rank.

The product of education is embodied in the person and therefore immaterial [32]. As an output, the number of graduates and the number of research authorizations issued by the Ministry of Scientific Research and Innovation are used, regardless of the nationality of the researcher. Table 1 presents the averages for the 8 universities of the selected inputs and outputs.

Table 1. Descriptive statistics of variables

		Inputs		Outputs	
Year	Number of universities	Number of students	Number of teachers	Number of diplomas	Number of research authorizations
2014	8	25541	445	4694	10
2015	8	26815	479	4985	12
2016	8	29321	555	5246	12
2017	8	30562	588	5738	15
2018	8	34384	713	5900	19

Source: Authors based on INS data

Table 2. Efficiency Score Results

Year	Number of universities	Number of efficient universities	Technical efficiency (Average)	Organizational efficiency (Average)	Scale efficiency (Average)
2014	8	1	0.61	0.94	0.65
2015	8	1	0.69	0.96	0.70
2016	8	2	0.74	0.92	0.80
2017	8	1	0.83	0.98	0.84
2018	8	6	0.96	1	0.96
2014–2018	8	5	0.71	0.95	0.74

Source: Authors

4 Results of the Estimates

The results are presented in two steps. In a first step the results of the efficiency scores calculation and in a second step the results of the change in productivities.

Since the resources available to universities are limited, we opt for an output-oriented DEA model. The efficiency scores over the period 2014–2018 are presented in Table 2.

Over the 4 years of study, the average technical efficiency of Cameroon's public universities is 0.71% which translates into an average increase of 29% in the number of graduates and the number of research permits. The technical efficiency of universities has been growing steadily since 2014, the highest efficiency score is recorded in 2018, this is 96%. The efficiency frontier between 2014 and 2018 is given by the University of Bamenda, it is the only one that shows a technical efficiency score of 100%. It was joined in 2016 by the University of Ngaoundéré. In 2018, only the universities of Douala and Yaoundé 1 are not technically efficient.

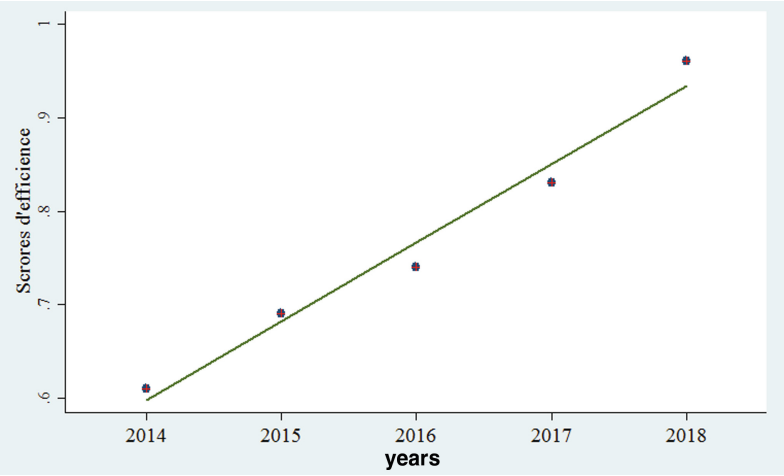

Fig. 1. Evolution of technical efficiency between 2014 and 2018. Source: Authors

Other universities must follow their example if they want to have the best practices. The University of Douala and Yaoundé 1 remain the only universities that were not efficient between 2014 and 2018. They still show a decreasing efficiency of scale, reflecting the fact that they do not operate at an optimal size. They could increase their academic output (number of graduates, number of research permits) by 19% and 9% respectively.

The technical efficiency of the universities has continued to grow since 2014 as shown in Fig. 1. The frontier of efficiency between 2014 and 2018 is given by the University of Bamenda, it is the only one that displays a technical efficiency score of 100%, thus translating an optimality in the use of resources made available to it. It was joined in 2016 by the University of Ngaoundéré. In 2018, only the universities of Douala and Yaoundé 1 are not technically efficient. The University of Bamenda observes good practice. It recruits students according to its infrastructural capacities and its teaching staff. It operates with increasing efficiency of scale, producing at an optimal size.

In terms of ranking, the University of Bamenda remains a pioneer, followed by the University of Buea and Dschang. The universities of Douala, Yaoundé 1 and 2, Maroua and Ngaoundéré must take the example and copy the practices of the University of Bamenda if they want to see their level of technical efficiency improve. The University of Douala and Yaoundé 1 remain the only universities that were not efficient between 2014 and 2018. They still show a decreasing efficiency of scale, reflecting the fact that they do not operate at an optimal size. They could increase their academic output (number of graduates, number of research permits) by 19% and 9% respectively.

Due to the lack of information on the price of resources available to public universities, organizational efficiency cannot be interpreted. The efficiency of scale is 74%, which globally reflects that universities suffer from a size problem. Their operational size is not optimal. This result can be explained by a very large number of students in some fields and a small number in others (Table 3).

Table 3. Results of the Malmquist Index

Years	Malmquist Index	Technical efficiency	Change in productivity
2014–2015	1.068	1.150	0.952
2015–2016	1.039	1.147	0.941
2016–2017	1.084	1.146	0.967
2017–2018	1.108	1.211	0.926
2014–2018	1.075	1.163	0.946

Source: Authors

The Malmquist productivity index and its two components for the 8 universities are presented and analyzed.

A relevant observation emerges from these results. It should be noted that Cameroonian public universities did not perform equally well during the 2014–2018 period in terms of both technical efficiency and technical progress. However, the universities in the sample experienced positive growth rates for technical efficiency. On average, total factor productivity across the sample grew at an average annual rate of 94% from 2014 to 2018. The highest annual growth in total productivity is observed in 2017 with a rate of 96.7%. The higher education sector can increase its productivity either by improving the level of efficiency in production or by technological diffusion. Thus, the improvement in productivity is attributable to technical efficiency, which has experienced an average annual growth rate of 7.5%.

Technical progress has improved by an average of 16.36% per year during the same period. This may be due to the introduction of new educational policies in higher education such as the application of the LMD (Licence-Master-Doctorat) system[1] in Cameroonian public universities. Globally, Cameroonian public universities have not experienced technical efficiency gains. They perform poorly in terms of technical progress in terms of growth rate (-12.83%) over the study period. This leads to the conclusion that the improvement in the total productivity of the 8 universities during the five academic years from 2013–2014 to 2017–2018 is the result of technological innovation, not the improvement in their technical efficiency. However, total productivity did not improve throughout this period.

Using the Malmquist indices, it is found that technological change has a determining influence on the change in total factor productivity in Cameroonian public universities. This is revealed by a change in the same direction of both indices over the period examined (2014–2018). Thus, higher education reform policies in recent years have had

[1] At the initiative of the Heads of State of the Economic and Monetary Community of Central African States (CEMAC), Cameroon signed up in March 2006 for the application of the LMD system (Bachelor's, Master's, and Doctorate) in the universities and higher education establishments of the CEMAC region. This reform was in line with the Bologna process "conducted in a hurry" (Charlier et al., 2009, summary section). However, it is through Order N° 18/00035/MINESUP/SG/DDES of January 28, 2018, ten (10) years later, that this reform is organized in Cameroon.

a positive influence on this. But this change is not identical across all universities and periods.

5 Conclusion

The objective of this paper was to evaluate the technical efficiency of the 8 public universities in Cameroon. The data used come from the National Institute of Statistics (INS) and cover the period from 2013 to 2018. Two complementary estimation techniques are used: the DEA approach and the Malmquist index. The DEA econometric analysis was carried out under the assumption of variable and constant returns to scale depending on the output orientation. Over the period considered, only the University of Bamenda remained technically efficient. It should therefore be taken as a model by other universities because of its very good practices. Cameroon's public universities are wasting the resources made available to them, they can increase their number of graduates and research authorization by 21%.

Using the Malmquist indices to estimate their impacts in terms of measuring productivity change shows that over the period 2014–2018 the average productivity growth rates, are 94.68% for total factor productivity, 16.30% for technical efficiency, 94.68% for technical progress in all 8 universities. An important conclusion is that total productivity is explained more by technical efficiency than by technical progress. Given that universities have more autonomy, they should assume more responsibility towards the state, society and students. In view of these results, the main recommendations are: to establish programs to support governance; and to evaluate the technical efficiency of universities on an annual basis. Institute work to evaluate the relevance of current educational policies on the evolution of universities' educational output and changes in productivity over time. In terms of development, the government should strive to increase technological innovations in teaching and learning techniques and investments in the higher education sector to boost the productivity of universities.

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