

ECONOMIES OF SCALE AND SCOPE IN NIGERIAN UNIVERSITIES

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Abstract

The study was carried out to estimate the cost function of universities in Nigeria. Specifically, economies of scale and scope in the production of undergraduates, postgraduates and research outputs in the universities were examined. Stratified random sampling technique was used to sample 30 out of the 79 public universities in Nigeria. The stratification was based on geographical location, state, federal, conventional and specialized universities. Stochastic Cost Frontier Estimator (SCFE) was adopted in the estimation of university's costs. The results of data analysis indicated that there was cost-efficiency for the universities to expand the production of undergraduate, postgraduate and research output, while there was cost-inefficiency for the universities to expand the production of either undergraduate or postgraduate or research output. Furthermore, the results showed that universities would enjoy synergy if they produced undergraduate, postgraduate and research output together and there was cost saving arising from producing either undergraduate or postgraduate or postgraduate or research output in conjunction with all other output of the universities. The study concludes that universities should explore ways of benefiting from economies of scale and scope in the production of multiple outputs.

Keywords: Economies of scale, Economies of scope, Cost function, Multi-product.

Introduction

Universities are complex organizations because they produced multiple outputs from multiple inputs. It therefore becomes difficult to estimate the performance of such institution. Cost functions provide important information for producers to achieve efficiency in production. Moreover, an estimation of marginal cost, average cost and economies of scale and scope in

the university system has not attracted the attention of many researchers in Nigeria. This might be due to the lack of awareness of the availability of the alternative methods of analysis. Any analysis of cost in the Universities must acknowledge and explicitly take into account the estimation technique and the complex nature of production. The two main functions of an institution of the Universities are generally agreed to be production of knowledge through research and dissemination of knowledge through teaching (Cohn and Copper, 2004). In addition, universities also produce a third output, which comes under the heading of public service, or social output. Such activities that fall into this category include storing and preserving knowledge and providing a source of independent comment (Very & Layard, 1975).

The treatment of cost analysis of universities as a multi-product rather than single output firm has been a subject of discourse over a long period. The definition of appropriate measure of multiple outputs of universities however is by no means clear-cut. In addition, measure for inputs and exogenous factor, choice of technique and specific function are also unresolved issues confronting the researcher who wishes to estimate cost functions in the universities (Johnes, Johnes, Thanassoulis, Lenton & Emrouznejad 2004)).

The issue of economies of scale and scope in the universities is an issue of ongoing research which plays vital role in the formulation of sound policy. The university is a place where the evaluation of efficiency and the estimation of cost usually take place. This is because first, there has been a clamour for performance indicators in the universities in many countries (Johnes & Johnes, 2005). Secondly, data are publicly available on cost and outputs of universities and thirdly, the multi-product character of universities render them an ideal subject of analysis.

In today's economic and financial environment, the issue of cost and efficiency of universities is becoming increasingly sensitive even in countries where traditionally universities have been relatively well funded with respect to number of students. This is because, weighing the huge amount of public funds committed to university education and the quality of products from the universities the government is highly concerned about the efficiency of these institutions. This is to identify the extent to which resources accrued to universities are utilized in order to achieve the objectives for which they were established and from which a number of decision can be made regarding the institutions that are not efficient in the use of resources. The study explores different dimensions of economies of scale and scope by estimating a multiple-product cost function for universities in Nigeria.

Economies of Scale

There would be economies of scale if long-term average costs are decreasing. In universities, there would be economies or diseconomies of scale if an expansion of output results in a decrease or increase in average cost (Johnes, Johnes, Thanassoulis, Lenton & Emrouznejad 2004). The economies of scale of university cost function are defined as the inverse cost elasticity of the quality adjusted output (Fu et al. 2004). Economies of scale can be assessed in the single output situation by calculating the marginal and average cost of producing output as follows and comparing the two:

$$\text{Marginal costs; } MC = \partial C(y) / \partial y \text{ ----- (1)}$$

$$\text{Average cost; } AC = C(y) / y \text{ ----- (2)}$$

If marginal cost is less than the average cost (or equivalently if $MC/AC < 1$) then there are economies of scale since the university is operating to the left of the minimum point of average cost curve.

In the multi-product case, the concept of average cost and economies of scale are not as straightforward as in the single output case (Johnes et al. 2004). Economies of scale are replaced by two concepts. Ray economies or diseconomies of scale are the cost saving or dissavings arising when the size of aggregate output expands but the composition of output remains constant. Product specific economies or diseconomies of scale are the cost saving or dissavings, which occur when the output of one product increases while quantities of the other output remain fixed. The calculation of each of these from estimated cost function is presented below;

Ray Economies of Scale

The size of the ray economies of scale (S_R) is calculated in the general case as follows;

$$S_R = \frac{C(y)}{\sum_i y_i C_i(y)} \text{ ----- (3)}$$

Where $C_i(y) = \partial C(y) / \partial y_i = MC_i$ and represents the marginal cost of producing the i th output. For example, in the case where there are just three outputs of the higher education production function, i, j and k (representing, say, teaching, research and community service respectively), then the measure of ray economies of scale is given by:

If $S_R > 1$ then there is economies of scale. If, however $S_R < 1$, then there is diseconomies of scale.

$$S_R = \frac{C(y_i y_j y_k)}{y_i MC_i + y_j MC_j + y_k MC_k} \text{ ----- (4)}$$

Product-Specific Economies of Scale

Often, the researchers are interested in the impact of costs on increasing the output of the product (for example undergraduate teaching) while holding output of the other product constant. In this case, the estimate of product-specific economies of scale is the relevant measure, (Johnes et al. 2004). In this case, the product specific economies of scale may be measured as the ratio of average incremental cost to marginal cost. This provides an indication of how costs respond to a change in the output of one product type, holding output of all other goods constant (Johnes 1997). In order to define the incremental cost of producing output $i(IC(y_i))$ in the general case the following formulae can be written:

$$IC(y_i) = C(y_N) - C(y_{N-i}) \text{-----} (5)$$

Where $C(y_N)$ is the total cost of producing all the multi-product output; and $C(y_{N-i})$ is the total cost of producing all the output except output i (i.e. output i is zero). The average incremental cost of product i due to the additional output product i (where product i is one of N product in the multi- product firm) can therefore be defined in general case as:

$$AIC(y_i) = [C(y_N) - C(y_{N-i})] / y_i = IC(y_i) / y_i \text{-----} (6)$$

Thus, in situation where there are just three products i, j and k , then the average incremental cost for product i are given by:

$$AIC(y_i) = [C(y_i, y_j, y_k) - C(0, y_j, y_k)] / y_i \text{-----} (7)$$

Product- specific economies of scale for product $i(S_i(y))$ are then calculated as the ratio of average incremental cost to the marginal cost of product i . specifically

$$S_i(y) = AIC(y_i) / C_i(y) \text{-----} (8)$$

If $S_i(y) > 1 (S_i(y) < 1)$ then there are product- specific economies (diseconomies) of scale for product i .

Economics of Scope

In addition to economies of scale, a multi-product cost function allows the measure of overall economies of scope. In any production process, economies of scope are present when there are cost efficiencies to be gained by joint production of multiple products, rather than being produced separately. Economies of **scope** exist **between** outputs, if the total cost of joint production is less than the cost of separate production (Johnes et al 2004). Economy of scope thus implies the presence of complementarities between the diversified output of undergraduate teaching and research. According to Johnes et al. (2004), Economies of scope measure the cost savings arising from producing two or more products jointly in a multi-

product firm rather than in a firm specializing in the production of one output. Thus by producing two or more products in one firm, there may derive cost advantages compared to producing each output in separate firms. In higher education, for example, two types of economies of scope arise; economies of scope arising from production of teaching (undergraduates and postgraduates), research and knowledge transfer using shared inputs such as academic and support staff, library and equipment, and buildings. Economies of scope arising from the production of different discipline using share inputs such as students, library facilities, equipment, building and administrative staff.

Economies of scope thus imply the presence of complementarities between diversified output of undergraduate teaching and research. The complementarities may be as a result of sharing and joint utilization of faculty, staff and equipment. For a university engaging in both undergraduate and graduate program, the conventional measures of economic of scope compares the costs of separate and joint productions that are evaluated at the quality adjusted level. (Fu et al. 2004). Economies of scope can be defined as global or product specific.

Global Economies of Scope

Global economies of scope measure the degree to which it is cheaper to produce two or more outputs together rather than separately. If there are complementarities in the production of university's many output, then there are global economics of scope; and the cost of producing all outputs together is less than the cost of producing each output separately i.e.

$$C(y) < \sum_i C(y_i) \text{-----} (9)$$

Where $C(y)$ is the cost of producing all N output together, and $C(y_i)$ is the cost of producing the i th output only, in a specialized firm. Thus, the degree of economies of scope are measured by S_G where

$$S_G [\sum_i C(y_i) - C(y)] / C(y) \text{-----} (10)$$

In a situation where a university produces three outputs i, j and k , then global economics of scope are measured by:

$$S_G = [C(y_i, 0, 0) + C(0, 0, y_k) - C(y_i, y_j, y_k)] / C(y_i, y_j, y_k) \text{-----} (11)$$

If $S_G > 0$ or < 0 then global economies or diseconomies of scope exists for producing the output jointly rather than in separate firms. Therefore the separation of a multi-disciplines university into single-discipline University leads to higher cost as the cost efficiencies in the joint production are no longer exploited.

Product-Specific Economies of Scope

The researcher may be particularly interested in the complementarities arising from

producing one specific output in conjunction with all other outputs. For example, the relevant question may be; are there cost advantages from producing undergraduate degrees with all other university outputs such as master's degree, PhDs, research and knowledge transfer, compared to producing undergraduate degrees in a university specializing only in that output? Alternatively, he may wish to examine whether there are costs advantages from producing arts output jointly with science output compared to producing the output of different subject in specialized institutions. Thus product specific economics of scope for the product i (SC_i) measure the proportional costs increase or decrease from producing all output except the i th one. In general case

$$SC_i = [C(y_i) + C(y_{N-i}) - C(y)] / C(y) \text{-----} (12)$$

Where $C(y_{N-i})$ is the cost of producing all input jointly except the i th one? Again in the context of three-output firm, product – specific economies of scope are measured by:

$$SC_i = [C(y_i, 0, 0) + C(0, y_j, y_k) - C(y_i, y_j, y_k)] / C(y_i, y_j, y_k) \text{-----} (13)$$

If $SC_i > 0$ then there are complementarities from producing output i with the other outputs. If $SC_i < 0$ then the converse is the case.

Methodology

In order to analyse the cost structure of universities; the cost function is formulated. This is to relate the total cost which is the dependent variable to the number of undergraduates, number of postgraduates and research outputs proxied by the number of Ph.D degrees awarded by each university which are the independent variables. Number of Ph.D. degrees awarded is chosen as a measure of research output based on Carnegie classification of universities reported by Filippini and Lepori, (2006). This in effect, is to estimate the cost of undergraduate programme, cost of postgraduate programmes and cost of research outputs. Also the total teaching cost, marginal cost, unit cost and economies of scale and scope in the production of multiple outputs were also estimated.

In the cost function, the total cost consisted of capital and recurrent costs. The capital cost comprised of cost of building and equipment, maintenance and library costs. The recurrent cost on the other hand includes salary and allowances of academic and non- academic staff, stationeries cost etc.

Where C is the total cost, y_1 is the vector of the number of undergraduates, y_2 is the vector of the number of postgraduates and y_3 is the vector of the number of PhD degrees conferred. Specifically, the cost function is expressed as follow:

$$\text{The cost function is defined as: } C = f(y_1, y_2, y_3) \text{-----} (14)$$

Therefore the total cost at university j , y denotes the i th number of students. The form of cost function explored in this study

$$C = \beta_0 + \beta_1 y_1 + \beta_2 y_2 + \beta_3 y_3 + \beta_4 y_1^2 + \beta_6 y_3^2 + \beta_7 y_1 y_2 + \beta_8 y_1 y_3 + \beta_9 y_2 y_3 + \varepsilon \text{ -----(15)}$$

and ε is the error term. The associated marginal cost of undergraduate teaching, postgraduate programmes, research outputs and unit cost are given in equations 17, 18, 19 and 20 respectively.

$$C = \beta_0 + \sum \beta_i y_i + \sum_{i=1, j=1}^{33} \beta_{ij} y_j + \varepsilon \text{ -----(16)}$$

$$\frac{dc}{dy_1} = \beta_1 + 2\beta_4 y_1 + \beta_7 y_2 + \beta_8 y_3 \text{ -----(17)}$$

$$\frac{dc}{dy_2} = \beta_2 + 2\beta_5 y_2 + \beta_7 y_1 + \beta_9 y_3 \text{ -----(18)}$$

$$\frac{dc}{dy_3} = \beta_3 + 2\beta_6 y_3 + \beta_8 y_1 + \beta_9 y_2 \text{ -----(19)}$$

$$AC = \frac{C_j}{\sum y_{ij}} \text{ -----(20)}$$

Presentation of Results

Cost Function Results

In this study, a cost function was estimated for 30 universities in Nigeria. These universities comprised of federal, states, conventional and specialized universities. The total cost is the dependent variable and it consisted of capital and labour costs. The capital cost included building, equipment and library expenses while the labour cost includes wages and salaries of academic and non-academic staff. Three outputs variables were identified in the cost function and these are the independent variables. They are the number of undergraduates, number of postgraduates and research Outputs proxied by number of PhD degrees conferred. In the cost function, the total cost (dependent variable) was regressed against the number of undergraduates, number of postgraduates and the number of PhD degrees awarded (independent variables). The estimated coefficient of the quadratic cost model is presented in table 1.

Table 1: Analysis of the Quadratic Cost Model

Model	R	R	Adjusted R square	Std. Error of the Estimate
1	.906	.820	.739	780140260

The coefficient of determination of the model (R^2) is satisfying, and showed that the model is significant. This means that the cost function fits the data well (R^2 is 0.820 for all the universities). This means that 82% of the variation in the total cost is accounted for by the number of undergraduates students, number of postgraduates students and the volume of research carried out.

Table 2: Results of the Contribution of the Independent Variables to the Total Cost

Model	R	R	Ajusted R Square	Contribution of the Independent Variable
Y2	.789 ^a	.622	.609	62%
Y1	.858 ^b	.736	.716	12%
Y3	.882 ^c	.778	.753	4%

For the linear specification of the cost function, table 2 showed that the model is adequate and significant. The R^2 0.778. In terms of the individual contribution to the total cost, number of undergraduates contributed about 12%, number of postgraduates 62% and research outputs contributed about 4% to the total cost. However, 22% are due to unexplained variations.

Table 3: Analysis of Economies of scale

Economies of scale	Evaluated at:
Ray Economies of scale (S_R)	42
Product – specific economies of scale	
Undergraduate	1.2×10^{-1}
Postgraduate	9.6×10^{-3}
Research	7.9×10^{-3}

Table 3 shows that there are ray economies of scale for all the universities outputs. This is because the value of ray economies of scale (S_R) is greater than one, that is, $S_R = 42$; $S_R > 1$. This suggests that there is cost efficiency arising from expanding the aggregate number of undergraduate, postgraduate and research outputs in the selected universities but the composition of these outputs remain constant.

In terms of product-specific economics of scale, the results of data analysis show that the value of product-specific economies of scale is less than one for the cost undergraduate programme with $S_{y1} 0.012 < 1$, cost of postgraduate programme with $S_{y2} 0.0096 < 1$ and cost of research with $S_{y3} 0.0079 < 1$. This means that it will be cost inefficient for universities to increase the production of either the number of undergraduate or postgraduate or research output, while holding any of the number of undergraduate, number of postgraduate or research output constant.

Table 4: Analysis of Economies of Scope

Economies of Scope	Evaluated at:
Ray Economies of Scope (S_R)	0.55
Product – Specific Economies of scope	
Undergraduate	0.21
Postgraduate	0.21
Research	0.21

Table 4 showed that the value of economies of scope was 0.55 which is greater than zero. The results also show that product-specific economies of scope exist for the production of undergraduate, postgraduate and research output. This is because the value of product-specific economies of scope was 0.21 and this was greater than zero.

Discussion of Findings

In this study, an attempt has been made to examine the existence of economies of scale and scope in Nigerian universities. In the empirical analysis based on simple indicators, the findings of the study indicated that cost differences between outputs were greater than the cost differences between universities. In terms of the unit cost, the unit cost of postgraduate was found to be the highest while the marginal cost of research was the highest. However, in the linear specification of the cost function, the cost of postgraduate programmes had the highest contribution to the total cost.

The study showed that there was cost-efficiency arising from the expansion of the aggregate number of undergraduates, postgraduates and research outputs but the composition of these outputs remained constant. This means universities will save cost if they increase the number of undergraduates, postgraduates and research outputs. That is, they will enjoy economies of scale.

There was cost-inefficiency for the universities to increase only the production of either undergraduates or postgraduates or research outputs while holding any of the outputs constant. This result is very interesting and has a clear policy implication. This implies that most Nigeria universities are too small in size and that they have not exhausted their scale economies and are experiencing diseconomies of scale due to their size. For universities to benefit from economies of scale arising from production of multiple outputs, there is an urgent need to expand the university sector. This could be done by the expansion of the existing institutions. This will bring down the unit cost to the barest minimum and the universities will operate at the optimum scale. This finding agrees with the findings of Johnes and Johnes, (2005) in the United Kingdom universities, when they observed that if the current levels of efficiency are considered, any further expansion of higher education in the U.K. should be effected within the existing institutions. If the efficiency could be increased, overhead cost would fall and hence opening of new institutions would become a viable option.

The finding indicated that there was cost-efficiency arising from the production of undergraduates, postgraduates and research outputs together rather than producing them separately in one university specialized in the production of such output. This means that there is cost saving arising from the production of undergraduate, postgraduate and research output together in one university rather than producing it separately in one university specialized in the production of undergraduate, postgraduate or research output. This

implied that universities will save cost if they produce undergraduate, postgraduate and research output together rather than producing them separately in one university specialized in the production of any of these outputs.

The finding also showed that there was cost advantage derived from producing undergraduates, postgraduates and research outputs jointly with all other university's output compared to producing any of these separately in a university specializing only in the production of any of these outputs. This means that there will be cost advantages from producing undergraduate, postgraduates and research output jointly with all other university's output compared to producing any of these outputs separately in one university specializing only in the producing of any of these outputs.

This therefore showed that universities will enjoy synergy if they produced undergraduate, postgraduate and research output together and produced either undergraduate or postgraduate or research output in conjunction with other outputs of the universities. The implication of this is that there is an interaction between teaching and research and has been considered in this study within the universities. This interaction is of great importance in considering teaching and research as individual academic's job. Findings of this study have shown that to a great extent, synergies can be achieved between teaching and research in Nigeria universities. But the source of these synergies is yet to be understood. Is the economies of scope arose between teaching and research or the production of different disciplines using shared inputs. Johnes (1997) study on cost in UK higher education found that synergies can be observed between teaching and research in British universities. But he observed that these synergies may arise from complementarities in the production of multiple outputs. This implies that the teachers and researcher have to share the same resources; it may also arise from complementarities which occur at the level of individual academic. Johnes also noted further that this therefore relates to the issues of how the individual academic's job should be defined, should all academics be required to teach and carry out research or would some degree of specialization bring about more efficiency?

Conclusion

The results of this study showed that the university system is characterised by the existence of economies of scale scope. This implies that Nigerian universities are characterised by excessive capacity to expand and that a separation of a conventional (multi-discipline) university into specialised (single discipline) university leads to higher cost as the interactions in the joint production of outputs are no longer exploited. Overall, the results suggest that universities in Nigeria can greatly benefit from both scale and scope economies. Big universities seem to be more cost efficient in their operation. Thus for universities to remain financially worthwhile, there is an urgent need for the expansion of the university system in

order to benefit from economies of scale and scope arising from the production of multiple outputs.

References

- Cohn, E., & Cooper, S.T. (2004). Mult-product cost functions for universities: Economies of scale and scope. In G. Johnes & J. Johnes (Eds.), *The International handbook on the economics of education*. Cheltenham: Edward Elgar.
- Johnes, G., Johnes, J., Thanassoulis, E., Lenton, P., & Emrouznejad, A. (2004). An exploratory analysis of cost structure of higher education in England. Lancaster University Management School working paper retrieve on December 8, 2014 from <http://webarchive.nationalarchives.gov.uk/20130401151715/http://www.education.gov.uk/publications/eOrderingDownload/RR641.pdf>
- Johes, G. and Johnes, J. (2005). *Higher education institutions' cost and efficiency: taking the decomposition of further step*. Online at: www.hw.ac.uk/ecoWWW/cert/certhp.htm
- Johnes, G. (1997). *Costs in UK Higher Education: A System-Wide Perspective*. Research Report. Centre for Economic Reform and Transformation (CERT). Department of Economics, Heriot-Watt University, Edinburgh, UK. Online at: www.hw.ac.uk/ecoWWW/cert/certhp.htm
- Filippini M., Lepori B. (2006) Cost structure, economies of capacity utilization and scope in Swiss higher education institutions
- Verry, D. W. and P. R. G. Layard (1975). 'Cost functions for university teaching and research.' *Economic Journal* 85: 55-74.