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ASSESSING UNIVERSITY OF EDUCATION, WINNEBA PRODUCTION ECONOMIES OF SCALE AND SCOPE: A FURTHER DECOMPOSITION

Isaac Addai
Department of Accounting Education, University of Education, Winneba

ABSTRACT: *The study, paper empirically estimates University of Education, Winneba (UEW) multi-product costs using the flexible quadratic cost function. Statistical results suggest that there are both economies of scale and scope in UEW multi-production. Furthermore, there exist product-specific diseconomies of scope for Fulltime output suggesting that it is more costly or cost disadvantage for UEW producing that output in isolation from other outputs. There exist product-specific economies of scope for Distance and Sandwich outputs respectively suggesting cheaper joint production of each output.*

KEYWORDS: economies of scale, economies of scope, multi-product, cost function

INTRODUCTION

Higher Education Institutions (HEIs) are complex organisations, characterised as they are by their multi-product nature. HEIs as multi-product firms are generally agreed to produce two main outputs, namely teaching and research, Cohn and Cooper (2004). Verry and Layard (1975) also as far back recognised what they referred to as the third leg output encompassing *inter alia*, the provision of advice and other services to businesses, the storage and preservation of knowledge, and the provision of a source of independent comment on public issues. The academic literature in recent times also pointed out that HEIs could contribute to the economic growth of the territories in which they operate, Huggins, Johnston and Stride (2012). This paper also opines that in developing countries, HEIs also serve as a 'stopping gap' of holding on to the teaming unemployed. For example with an estimated 320,000 HEIs students in 2015, majority of these potential job seekers will not participate in the job market for at least the next three years sparing the Government of Ghana (GOG) which is the largest employer of these teaming formal job-seekers for non-existent jobs.

Although much attention has been given since the 1990s after the seminal work by Cohn, Rhine and Santos (1989) to related issues of costs in the delivery of higher education in many western countries, most African countries and Ghana being no exception have very limited understanding or have not researched much about the costs of production of its various public (wholly owned by the GOG) HEIs. The paper seeks to overcome these shortcomings and initiate the analysis of the multiproduct cost structure of the University of Education Winneba (UEW), a public university in Ghana. The structure of the paper is now outlined. The next section reviews the background of UEW, followed by the literature on the HEI multi-product costs analysis. The methodology section follows. The data description section immediately follows and the model specification section is next. The empirical results section follows. The penultimate section is for the discussion while the last section concludes and set the agenda for future research.

UEW Background

On 14th May, 2004 the University of Education Act, Act 672 was enacted to upgrade the status of the University College of Education of Winneba to the status of a full University and to

provide for related matters. The University of Education, Winneba (UEW) was established in September, 1992 as a University College under PNDC Law 322. UEW brought together seven diploma awarding colleges namely; the Advanced Teacher Training College, the Specialist Training College and the National Academy of Music all at Winneba; the School of Ghana Languages, Ajumako; College of Special Education, Akwapim-Mampong; the Advanced Technical Training College, Kumasi; and the St. Andrews Agricultural College, Mampong-Ashanti. The Winneba campus is the seat of the Vice-Chancellor with satellite campuses at Kumasi, Mampong and Ajumako. The total staffing position is 2,077 while the student population is over 51,000 UEW (2015) *20th Congregation Handbook.* UEW is one of the ten GOG owned universities in Ghana.

LITERATURE REVIEW

HEIs cost analysis was first researched by Bagley in 1925. Cost functions provide important information for producers to achieve efficiency in production. HEIs multi-product cost analyses was initiated in the very recent times by the seminal paper of Cohn, Rhine and Santos (1989). The seminal Cohn *et al.* (1989) paper, which introduce HEIs as multi-product organizations and hence focus upon more sophisticated measures of economies of scale and scope occurred only 28 years ago in the United States of America (US). By using flexible quadratic cost function (FQCF) and employing data from a 1981-82 sample of 1,887 U.S. universities computed a multi-output cost function measuring both teaching and research outputs. Their study measures full-time-equivalent (FTE) enrolments as teaching output, and uses measures of research grant income as a proxy for research output. There have been an intensive empirical studies on the economies of scale and scope of HEIs since which so far have adopted the FQCF (Lewis & Dundar, 1995; Koshal & Koshal 2001; Laband & Lentz, 2003; Sav, 2004, 2011; Cesar, 2006; Hou & Min, 2009, and it still remains researchers favourite with only a few exceptions adopting the CES (Johnes, 1997; Izadi Johnnes, Oskrochi, Crouchley, 2002) and the HTCF (de Groot et al., 1991; Glass, McKillop, & Hyndman, 1995; Nelson & Hevert, 1992; Stevens, 2005), while in the more recent literature stochastic frontier analysis (SFA) has been adopted (Johnes, 1996; Stevens, 2005; Johnes, Johnes, & Thanassoulis, 2008, Mamun 2012). There is not a single empirical paper to the best of the author's knowledge that has been published on the multi-product cost structure on or of any of the public HEIs and privately-owned HEIs in Ghana necessitating a pioneering research by this paper in that direction. The primary objective of this paper is to study the economies of scale and scope of UEW as a multiproduct organisation rather than to compare the advantages and disadvantages of the various functions mentioned above. In furtherance to this point, this paper also adopts the quadratic cost function due to its wider application in the literature.

Data

The data for the study was obtained from the National Council for Tertiary Education (NCTE), and University of Education, Winneba. The 2010-2015 compensation (salary and emoluments) and Book and Research expenditures were obtained from the NCTE Research Department, while the 2010-2015 full-time students enrolments was obtained from UEW (2015) *20th Congregation Basic Statistics Brochure*.

Model Specification

The general structure of the model for this study is:

$$y_{kt} = \alpha + \beta x_{kt} + \mu_{kt} \qquad [4]$$

where $\mu_{ktt} \sim \text{IID}(0, \sigma^2)$ and i = 1, UEW individual-level observations, and t = 1,.....6 time series observations.

A multi-product flexible quadratic cost function (FQCF) for the paper is modelled as:

$$TC_N = \alpha_0 + \sum_i \beta_i output_{ik} + 1/2 \sum_i \sum_j \delta_{ij} output_{ik} output_{jk} + \varepsilon . \quad [5]$$

Where TC_N is the total cost of producing *N* products at UEW. α_0 is a fixed cost, and the $output_i$ mix includes Full-time programme, Distance programme and Sandwich Programme. β_i, δ_{ij} are output-specific coefficients to be estimated and ε is a stochastic term. Using research income as a proxy for output is quite problematic. It is argued that it is an input into the research process and not an output of the process. This could potentially involve misspecification in that the output affects the level of inputs, Worthington and Higgs (2011) hence, the paper did not consider UEW research expenditure as an output.

With panel data estimation, fixed effects approach allows the unobserved individual effects to be correlated with the included regressors. For this paper, the time dimension of the panel and most of the variation in the dependent and independent variables is across observations and introduction of fixed effects estimations is very short and it therefore introduces severe multicolinearity and diminish the precision of coefficient estimates. Thus, it is clear that the model will inevitably have multicollinearity as the regressors contain linear outputs together with squared variants and cross-product terms for such a short time period observation, Johnes, Johnes and Thanassoulis (2008). As a result, panel estimation is not pursued. An Ordinary Least Squares (OLS) of the cross-products are rather estimated. In the empirical estimation, FQCF output cross-product specification for the paper is estimated using the STATA data and statistical analysis software as:

$$\text{TC} = \beta_0 + \beta_1 \text{FulDist}_i + \beta_2 \text{FulSand}_i + \beta_3 \text{SandDist}_i + \mu_k \quad [5.1]$$

where i = 1, …..6, and μ_k is an error term.

Following Baumol *et al*. (1988), Cohn *et al*. (1990), Koshal and Koshal, (2001), Sav (2011), Worthington and Higgs (2011) the following models for the UEW scale and scope economies are specified.

Average Incremental Cost

The average incremental cost $AIC(y_i)$ for producing output y_i is defined as:

$$AIC(y_i) = \frac{c(y) - c(y_{N-i})}{y_i} \quad [6]$$

Where $C(y)$ is the total cost of producing the three outputs $C(y_{N-i})$ is the total cost of producing zero units of the *i*th output. In the case of a single product, the economies of scale are measured by the average incremental cost divided by the marginal cost.

Ray Economies of Scale

Ray economies of scale exist when the quantities of the product are increased proportionately and are presented as follows: $E(ray) = \frac{\text{C}(y)}{\sum y_i \times \text{MC}(y_i)}$ [7]

Product-Specific Economies of Scale

Product-specific economies (or diseconomies) of scale are the cost savings (or dissavings) which occur when the level of one product increases while the levels of the rest of the outputs remain fixed. The product-specific economies of scale for y_i , $E(y_i)$ are specified as:

$$E(y_i) = \frac{\mathrm{AIC}(y_i)}{\mathrm{MC}(y_i)} \quad [8]$$

Where $MC(y_i) = \partial \mathrm{TC}/\partial y_i$ is the marginal cost of producing y_i units of output.

Economies of Scope

Economies of scope measure the cost savings (or otherwise) 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. In higher education, for example, two types of economies of scope can arise: the economies from the production of all the outputs (eg teaching, research and third mission) using shared inputs, and the economies from the production of different disciplines using shared inputs. Global economies of scope arise if the cost of producing all outputs together in one firm is less than the cost of producing each output in a separate firm.

Global economies of scope are defined as:

$$GES(y_i) = \frac{\sum C(y_i) - C(y)}{\mathrm{C}(y)} \quad [9]$$

If $GES(y_i) > 0$ (< 0) then global economies (diseconomies) of scope exist for producing the outputs jointly rather than in separate firms.

Product-Specific Economies of Scope

And the product-specific economies of scope are calculated as:

$$PES(y_i) = \frac{C(y_i) + C(y_{N-i}) - C(y)}{\mathrm{C}(y)} \quad [10]$$

If $PES(y_i) > 0$ then there are complementarities from producing output i with the other outputs and $PES(y_i) < 0$ then the converse is the case.

Summary descriptive statistics

Table 1 presents a summary descriptive statistics for annual costs and outputs of UEW which covers the period of 2010-2015 academic years. Sample means, median, maximum, minimums and standard deviations are reported. Between 2010 and 2015, an average annual total cost of GH₵ 4.5707 million was incurred. The three broadly UEW outputs, Fulltime, Distance and Sandwich between 2010 and 2015 variously graduated an average of 18996, 17366, and 8534 students.

Table 1. Definition of Variable and Summary Statistics

Variable	Description	Mean	Median	SD	Min	Max
TC	Total Cost	4.5707	4.4307	2.2007	2.0507	7.3907
Ful	Fulltime FTE	18996.67	17558.5	4288.657	14623	26823
Dist	Distance FTE	17366.83	16282.5	3944.954	13256	23746
Sand	Sandwich FTE	8534	9409	2367.919	4582	10447
Ful2	Ful squared	3.7608	3.0808	1.8108	2.1408	7.1908
Dist2	Dist squared	3.1508	2.6608	1.4708	1.7608	5.6408
Sand2	Sand squared	7.7507	8.9107	3.6607	2.1007	1.0908
Ful x Dist		3.2308	3.0608	6.9407	2.4908	4.1908
Ful x Sand		1.6808	1.6708	7.4307	6.7007	2.8008
Sand x Dist		1.4508	1.4608	4.1407	7.7907	2.0508
n = 6						

Notes: total cost is in millions of Ghana cedis.

Empirical Results

The estimated coefficients, standard errors and t-values of the cost function are presented in Table 2. The R^2 for the cost function in Eq. 5.1 is 0.97 and this is similar to measures of predictability of higher education institutions elsewhere. Producing Fulltime and Sandwich crosss-outputs by UEW is significant at the conventional five percent level of significance, but there is no cost complementarity. There are cost complementarities for the production of Fulltime and Distance, and Sandwich and Fulltime cross-outputs but they are however, not significant at the conventional five percent level of significance.

Table 2 Estimated Quadratic Cost Function

	Coefficient	Standard Error	t-Value
β_0	3.0707	1.3507	2.27
β_1	-.0941969	.061102	-1.54
β_2	.3170531	.0421861	7.52
β_2	-.0539848	.1052022	-0.51
R^2	0.97		

The estimated quadratic cost function in Table 2 is used to estimate the MC and AIC at the mean levels. The UEW marginal cost of producing Fulltime outputs have decreased by on average and *ceteris paribus* GH₵14, 796 between 2010-2015. The UEW marginal cost of producing

Distance outputs have decreased by on average and *ceteris paribus* GH₵1250 between 2010-2015 academic years. The UEW marginal cost of producing Sandwich outputs have increased by on average and *ceteris paribus* by GH₵15359 between 2010-2015. These are presented in Table 3.

Table 3

Full Time MC	Distance MC	Sandwich MC	Full Time AIC	Distance AIC	Sandwich AIC
-14796.28	-1250.127	15359.45	2324.063	2923.991	5195.291

The production of average Sandwich outputs between 2010 to 2015 cost GH₵5195 making Sandwich production the most costly, followed by Distance output average incremental cost of GH₵ 2923 and Fulltime output average incremental cost of GH₵ 2324 at UEW *ceteris paribus*, between 2010 to 2015.

The UEW Product Specific Economies of scale (PSEscale) and Global Economies of Scale of their three outputs at the mean levels are presented in Table 4.

Table 4

Full Time PSEscale	Distance PSEscale	Sandwich PSEscale	Global Economies of Scale
-.1965389	4.911296	.1663014	1005.887

The UEW Economies of Scope (PSEscope) and Global Economies of Scope of their outputs at the mean levels are also presented Table 5.

Table 5

Full Time PSEscope	Distance PSEscope	Sandwich PSEscope	Global Economies of Scope
-.1965389	4.911296	.1663014	9384.219

DISCUSSION

The input included in the analysis are full-time equivalent academic and non-academic staff and non-labour expenditure, referred to as the total cost, and the outputs are Fulltime, Distance, and Sandwich. Product-specific and ray economies of scale and product-specific and global economies of scope at the mean output are calculated using estimates from a quadratic cost function. The main findings are as follows:

Between 2010-2015 academic years, The UEW MCs of producing Fulltime equivalent output and Distance equivalent output decrease on average and *ceteris paribus* while the MC of producing Sandwich equivalent outputs increase on average and *ceteris paribus*.

There is evidence of ray economies of scale at the mean output between 2010-2015 academic years at UEW assuming the compositions of output remains unchanged. The findings suggest that UEW multi-production is experiencing economies of scale and there exist the incentives to expand all its outputs to take advantage of the potential scale economies from 2015 onwards. There is product-specific diseconomies of scale for Fulltime output suggesting that there is no incentive to continue to increasing the Fulltime output between the 2010-2015 academic years. There exist product-specific economies of scale for the production of Distance and Sandwich outputs. There is also empirical evidence of global economies of scope for UEW outputs. This indicates that scope economies can be more exploited as scale increases as there are material

benefits for the joint production of Fulltime, Distance and Sandwich outputs. There exist product-specific diseconomies of scope for Fulltime output suggesting that it is more costly or cost disadvantage for UEW producing that output in isolation from its other outputs. There exist product-specific economies of scope for Distance and Sandwich outputs respectively suggesting cheaper joint production of each output.

CONCLUSION

Using the available data for six academic years from the NCTE, the study has pioneered the empirical estimation and analysis of the economies of scale and scope in the Ghanaian HEIs sector using the UEW as the unit of analysis. Overall, the results empirically establish the existence of economies of scale and scope for UEW multi-production for the period for which there exist data. In terms of future research, a key limitation of this analysis has been the unavailability of enough data for parametric statistical inference. There is a trade-off as a pace-setter study however, by analysing the available data using the standard methodologies in the Social Studies literature of analysing HEIs multi-product cost structure. This paper serves as an overview and with the availability of more refined data this major limitation of this study could be overcome and the estimation of the existence of economies of scale and scope in the whole public Ghanaian HEIs sector will be pursued in future.

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Isaac Addai is a Social Scientist, and a Lecturer at the Department of Accounting Studies, University of Education, Winneba.