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Size and Economies of Scale in Higher Education and the Implications for Mergers

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Abstract

This paper carries out a meta regression analysis to estimate the optimal size of higher education institutions (HEI) and identify its implications for strategies of mergers in higher education. This study finds an optimal institutional size of 24,954 students. We find potential opportunities for merging different HEIs relative to their mean sample size: public universities by nearly 190 per cent, private universities by 131 per cent, small colleges by around 952 per cent, and non-US HEIs by about 118 per cent. However, if we compare with actual sizes of top ranked universities we find that in some parts of the world top ranked universities seem to be below optimal size, while in others they appear above optimal size. We urge caution in the interpretation of the findings due to the limited data. We recommend further research and that policymakers around the world refer to their own cost structures to determine the optimal size for efficiency.

JEL Classification: I23, I21, I22
Keywords: Size, economies of scale, higher education, mergers, optimal size

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1. Introduction

In higher education, universities and colleges make decisions on how to efficiently use resources in order to enhance and maintain a sustainable competitive position (Bonaccorsi et al. 2007). Consequently, management of higher education institutions (HEIs) have a strong interest in cost minimization (Laband and Lentz 2003). Elements affecting decisions on cost minimization include quantity and quality of output, whether to specialize or produce multiple outputs or whether the institution should be small or large in either student enrolment or research (Laband and Lentz 2003). Mergers are often perceived as a means to achieve cost savings through increased economies of scale and a means to reduce competition in the market.

It is within this context that the education literature includes many econometric studies that analyse economies of scale in HEIs by identifying the optimal size for a HEI or attempt to justify the need for mergers of institutions (Patterson 2000). In most of the analyses of economies of scale, the focus is to establish if larger institutions incur lower costs than small institutions and thus determine at what size a HEI functions at optimum efficiency (Patterson 2000). Size is usually measured in terms of student enrolment and economies of scale arise when the cost of providing education falls as the student enrolment increases (Lloyd et al. 1993). Student enrolment is the most common measure used for teaching output and an essential contributor to institutional costs (Cohn et al. 1989; de Groot et al. 1991). In the short-term an HEI can achieve economies of scale by lowering quality and boosting quantity (student enrolment), but in the long term the quality of instruction and research output also influence the HEI cost structure and are vital determinants of economies of scale in higher education (Fu et al. 2008).

Many empirical studies have been carried out to determine if there are economies of scale in higher education. The size-cost relationship has been presented in many ways including through estimations of cost functions, calculations of the overall and product specific economies of scale and illustrations of the shape of the average or marginal cost curves. In the USA, a seminal review of studies conducted in the previous 50 years was carried out by Brinkman and Leslie (1986). Their review focused on the size-cost relationship in US higher education and concluded that economies of scale are most likely to occur at the low end of student enrolment range i.e. 1000 full time equivalent (fte) students in two year colleges and 1500-2000 fte students in four year colleges (Brinkman and Leslie 1986, Patterson 2000). However, they also determined that nature and strength of the economies of scale were not only influenced by size, but also by type of institution, type of costs (administrative vs instructional), input prices like salaries paid and breadth of curriculum (Patterson 2000, Brinkman and Leslie 1986).

A popular strategy for cost minimization and boosting competitiveness in higher education has been the merger of HEIs. In Europe, USA, Australia and China, there have been comprehensive mergers of HEIs (Lloyd et al. 1993, Mao et al. 2009, Paterson 2000). One of the main reasons and arguments for the mergers is the expected increase in size and scope of the institution and ultimately economies of scale which would provide an economic benefit and could free resources to improve quality of output (Patterson 2000). There is however limited empirical literature on the economic benefits of such mergers and whether mergers directly result in lower education costs or savings. However, there exist several studies that have generally sought to establish the size-cost relationship and prove the existence of economies of scale in HEIs (Patterson 2000, Cohn et al. 1989, de Groot et al. 1991).

This paper's main interest is to derive from the empirical literature a "standard" optimal HEI size, show how it varies by characteristics of the HEIs and each study, and to discuss the implications on strategies of mergers in higher education. The paper employs a systematic review approach in collating the relevant empirical literature. The empirical studies reviewed, use a variety of estimation techniques, models and data in determining economies of scale in higher education institutions. Hence in order to make the estimates comparable meta regression analysis will be used (Stanley and Jarrell 1989). To our knowledge this is the first study to utilize meta regression analysis to compute a base estimate of the optimal HEI size. We adapt the meta regression analysis guidelines laid out by Stanley and Jarell (1989) and the approach utilized by Colegrave and Giles (2008) to compute a "standard" estimate of an optimal school size and how independent variables increased or decreased the "standard".

The paper is organized as follows, section II details the methodology used in the literature search and the meta regression analysis. Section III presents the findings of the meta regression analysis. Section IV discusses the results and their strategic implications on mergers in higher education. The paper concludes by providing suggestions for further research.

2. Methodology

2.1 Background on Meta Regression Analysis

Meta regression analysis (MRA) is an approach used in meta analysis. It is especially useful when the control and experimental groups required in a comprehensive meta analysis are not available (Stanley and Jarell 1989). MRA's design allows for the control of biases found in non-experimental studies. The steps to conducting an MRA include a) searching and documenting all relevant studies, b) choosing the summary statistic for the dependent variable, c) selecting meta-independent variables pertaining to the study design and conduct, d) carrying out the MRA and finally e) conducting specification tests (Stanley 2001).

2.2 Search for Relevant Studies

We initially searched for the existing literature and systematic reviews on the subject matter. We identified two literature reviews; Patterson (2000) and Brinkman and Leslie (1986). We selected keywords based on our reading of these earlier literature reviews. The keywords that were chosen are "economies of scale", "cost structure" and "cost function". The keywords were used in combination with the terms "higher education", "colleges" and "universities" and a requirement that each study contain an exact term "ray economies of scale". We then searched for relevant published empirical articles, books, book chapters and working papers during the period October 2011 to April 2014. The following electronic databases and search engines were searched: ERIC, PsycINFO, Science Direct, SAGE, JSTOR, Social Science Research Network, Economic Papers, Wiley, Taylor and Francis, Springer and Google Scholar.

Our initial search yielded 155 studies with estimates of economies of scale including about 7 references from Brinkman and Leslie (1986). Relevant studies had to meet the following inclusion criteria:

1) Studies analyse economies of scale by estimating institutional cost functions. The general methodology involves estimating total costs as a function of outputs S (e.g. student enrolments and research), exogenous inputs and input quality measures, X_i (e.g. institutional characteristics, student-faculty ratio), output quality, Q_i (e.g.

entrance scores, academic reputation), and input prices, p_i (e.g. faculty compensation). Hence the total cost of an institution i can be expressed as follows:

$$TC_i = f\,(S, X_i, Q_i, p_i) \tag{1}$$

Functional forms for estimating economies of scale considered in this study include the earlier linear cost functions, constant elasticity substitution cost functions, and hybrid translog cost functions and the most common, quadratic cost function (Longlong et al 2009). The quadratic cost function, another way of presenting equation (1) is shown in equation (2):

$$\alpha_0 + \sum_{i=1}^{n} \alpha_i S_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} S_{ij} + \sum_{i=1}^{n} \gamma_i X_i + \sum_{i=1}^{n} \delta_i Q_i + \theta_1 p_i + \varepsilon_i \tag{2}$$

Where TC is the total cost of producing *n* outputs/products, α_0 is a constant, α_i and β_{ij} are coefficients for the various output variables. *Si* represents the outputs; γ_i, δ_i and θ_1 are the coefficients of inputs/ input quality X_i, output quality Q_i and input price p_i . ε_i is a random error term.

2) Studies that estimated economies of scale for the whole institution. We excluded studies that estimated economies of scale for departments or courses (Lenton 2008, Lloyd et al. 1993, Dundar and Lewis 1995).

3) Studies that used total student enrolment (or graduate and undergraduate student enrolments) as a measure of teaching output in the cost functions. Studies that estimated economies of scale using measures such as student completion rates or

student credit hours were excluded from the study (Worthington and Higgs 2011, Sav 2011).

4) Studies that were published after 1960. Brinkman and Leslie (1986) clearly show that most studies published earlier than 1960 were mostly based on smaller samples, descriptive statistics and institutions that were on average smaller than contemporary higher education institutions today.

The inclusion criteria confer some uniformity between the reviewed studies, ensuring relevance (Colegrave and Giles 2008). After applying our inclusion criteria, we identified 21 studies. Our literature search was thorough; however it is possible that some studies have been excluded due to unavailability in libraries or online. Studies such as Heaton (1996) and Heaton and Throsby (1997) were referenced in Patterson (2000), but could not be found anywhere online or in libraries.

2.3 Dependent variable

In meta analyses, the effect size is the key variable of interest. In our study we looked at various articles that employed diverse estimation techniques in determining the economies of scale at higher education institutes and the optimal size at which average costs are lowest. The studies employed estimation methods such as linear regression, hybrid translog cost functions and quadratic multi-product cost functions. Consequently, choosing an effect size from the coefficients was problematic as they were difficult to standardize. In this paper we use optimal institutional size estimates as the dependent variable of our meta regression analysis. These estimates correspond to the institutional student enrolment where the minimum ray economies of scale are achieved. This is normally demonstrated on an average cost curve showing a minimum point after which, costs start rising again. Ray economies of scale refer to the reduction in average costs relative to marginal costs when a composition of output is assumed to remain fixed while its size is allowed to vary (Dundar and Lewis 1995). Hence, ray economies of scale are overall economies of scale over an output set. Ray economies of scale often indicate a decline or increase in total education costs as HEIs alter the levels of their outputs.

As mentioned earlier, the most common outputs featured in economies of scale studies are student enrolment and research. For purposes of standardization, we selected total student enrolment as the main indicator for optimal institutional size[4]. In instances where the optimal size was given as an interval, we calculated the midpoint and used it instead in our analysis. After checking for the presence of our parameter of interest, we reduced our tally of studies from 21 to 12. We excluded studies that did not have optimal institutional size estimates or did not explicitly indicate the minimum ray average costs corresponding to the output mix (Lyell 1979, Sav 2011, Koshal et al. 2001, Dougherty 1990, Goudriaan and de Groot 1991, Hashimoto and Cohn 1997, Laband and Lentz 2003, Longlong et al. 2009, Worthington and Higgs 2011).

Some of the 12 remaining studies provided more than one set of estimations based on either different functional forms (single product vs. multi product cost functions) or different subgroups (e.g. public vs. private universities). Multiple estimates of optimal institutional size (OIS) were treated as separate observations if they were based on separate models or subgroups of HEIs. Hence, the 12 studies on which our analysis is based on, produced 30 observations of OIS (see appendix A for complete list).

[4] Where enrolment was split into undergraduate (UG) and graduate (G) numbers, we simply added the two numbers. Research output was excluded as an indicator as the indicators for the variable were too diverse ranging from publications, federal research grant money, general research grant money etc.

2.4 Meta-Independent Variables

Twelve meta-independent or predictor variables were considered in the MRA. Ten of these are binary variables compared to two continuous variables. These variables were selected based on key feature variables described in Brinkman and Leslie (1986) and Colegrave and Giles (2008). The binary predictor variables describe type of data (non-US data, subgroup sample) and they also reflect the presence or absence of the following variables in the studies; input quality and price variables (i.e. student–faculty ratio, faculty salaries), an output quality variable (i.e. entrance test scores, academic reputation or rankings), exogenous input variables (i.e. institutional type e.g. public or private university). The continuous variables are sample size and year of data. Table 1 shows the definitions of meta-independent variables.

Table 1 Meta-Independent Variables

Code	Definition
A. Institutional Type	
Public	=1 if public university
Private	=1 if private university
College	=1if small college/liberal arts/post secondary school
Mixed	=1 if mixed sample HEIs (all institutional types)
Mixed2	=1 if mixed sample of public and private universities only
B. Quality Indicators	
InputQ	=1 if omitted input quality and price variables e.g. student-faculty ratio, faculty salaries
OutputQ	=1 if omitted output quality variables e.g. entrance test scores, academic reputation
C. Datasets	
Non-US	=1 if based on non-US data
Subgroup	=1 if based on a subsample
Sample	Sample size
Year	Year of data
D. Model Specification	
MP	=1 if study used a multi-product cost function
Form	=1 if study specified a quadratic cost function
Totalcost	=1 if total educational expenditures used as dependent variable in cost function (vs.variable costs)
HC	=1 if study tested for heteroscedasticity
E. Publication characteristics	
Peer	=1 if study published in peer-reviewed outlets

Table 2 lists the 30 OIS estimates with their corresponding meta-independent variables.

Table 2 OIS and corresponding meta-independent variables

OIS	Public	Private	College	Mixed	Mixed2	InputQ	OutputQ	MP	Form	Totalcost	HC	Pub	non-US	Subgroup	Sample	Year
1750	0	0	1	0	0	0	1	0	0	1	0	2	0	0	119	1977.5
3500	0	0	1	0	0	0	1	0	0	1	0	2	0	0	585	1977.5
5120	0	0	0	1	0	0	1	0	1	1	0	1	0	0	692	1981.5
4842	0	0	0	1	0	0	1	1	1	1	0	1	0	0	692	1981.5
2110	0	0	0	1	0	0	1	0	1	1	0	1	0	0	1195	1981.5
45000	0	0	0	0	1	1	0	1	0	0	0	1	0	0	86	1982.5
17000	0	1	0	0	0	1	0	1	0	0	0	1	0	1	61	1982.5
1600	0	0	1	0	0	0	0	0	1	1	0	1	1	0	65	1991.5
10481	1	0	0	0	0	0	1	1	0	1	0	1	1	0	13	2000
18141	0	0	0	0	1	0	1	1	0	1	0	1	1	0	33	2000
1100	0	0	1	0	0	1	1	0	1	1	0	2	0	1	72	1987.5
1600	0	0	1	0	0	1	1	0	1	1	0	2	0	0	129	1987.5
20227	0	1	0	0	0	1	1	0	1	1	0	2	0	0	24	1987.5
2150	0	0	1	0	0	1	1	0	1	1	0	2	0	0	331	1987.5
18934	0	1	0	0	0	1	1	0	1	1	0	2	0	1	21	1987.5
1115	0	0	1	0	0	1	1	0	1	1	0	1	0	1	72	1987.5
2153	0	0	1	0	0	1	1	0	1	1	0	1	0	0	331	1987.5
1584	0	0	1	0	0	1	1	0	1	1	0	1	0	0	129	1987.5
30957	0	0	0	0	1	0	0	0	1	1	1	1	0	1	66	1990.5
11758	0	0	0	0	1	0	0	0	1	1	1	1	0	1	51	1990.5
16112	0	0	0	0	1	0	0	0	1	1	1	1	0	1	44	1990.5
22174	0	0	0	0	1	0	0	0	1	1	1	1	0	1	33	1990.5
2472	0	0	1	0	0	0	0	1	1	1	1	1	0	0	295	1994.5
19800	0	0	0	1	0	0	1	1	1	1	0	1	0	0	1450	1995.5
19800	0	0	0	1	0	0	1	1	1	1	0	1	0	0	1316	1995.5
5300	0	0	0	1	0	1	1	0	0	1	0	2	0	0	123	1967.5
13000	1	0	0	0	0	0	1	0	1	1	1	1	1		19	1980
9800	0	0	0	1	0	0	0	1	1	0	1	2	0	1	730	1994.5
16000	0	0	0	1	0	0	0	1	1	0	1	2	0	0	820	1994.5
7720	0	0	0	1	0	0	0	1	1	0	1	2	0	1	384	1994.5

Notes. Year was calculated as a midpoint for data obtained between two years e.g. 1987/1988 becomes 1987.5

Table 3 presents the descriptive statistics. The mean OIS across the literature is around 11,110 students. Mean OIS refers to the average of the OIS estimates. The average institutional sizes from the study samples are presented in appendix B. However a closer look at OIS by institutional type indicates that estimates based on public and private university samples have a higher mean OIS of 11,740 and 18,720 students respectively, while for college samples the OIS is very low at 1,902, possibly pulling down the OIS into the mid-range OIS for all literature. Nearly 37 per cent of the estimates omitted input quality and price variables (e.g. student-faculty ratio, faculty salaries), compared to 63 per cent who omitted output quality variables (e.g. entrance test scores, academic reputation, rankings). About 63 per cent of the estimates were in peer-reviewed articles, 13 per cent are based on non-US data and 37 per cent of are based on multi-product cost functions, while only 30 per cent tested for heteroscedasticity.

Table 3 Descriptive Statistics (n=30)

	Mean	Std. Dev.
Optimal Institutional Size		
Full sample	11,110	10,427.36
Public (n=3)	11,740.5	1,781.20
Private (n=3)	18,720.33	1,624.08
College (n=10)	1,902.4	712.758
Mixed (n=9)	10,054.67	6,782.82
Mixed2 (n=5)	24,023.67	12,158.5
Rest of variables		
Public	0.067	0.254
Private	0.100	0.305
College	0.333	0.479
Mixed	0.300	0.466
Mixed2	0.200	0.407
InputQ	0.367	0.490
OutputQ	0.633	0.490
MP	0.367	0.490
Form	0.767	0.430
Totalcost	0.833	0.379
HC	0.300	0.466
Pub	0.633	0.490
Non-US	0.133	0.346
Subgroup	0.345	0.484

Sample	332.700	415.288
Year	1987.817	7.191

Table 4 presents the correlation matrix of the OIS estimates and predictor variables. As seen from Table 4, a number of correlations are significant at the 1 per cent and 5 per cent levels. Notable high positive correlations are "non-US data" and public universities at about 0.68, studies based on mixed public and private universities and OIS at around 0.63, and "total costs (use of total costs in estimations)" and studies that omitted output quality variables at 0.58. Negative correlations include "total costs (use of total costs in estimations)" and studies that used multi-product cost functions at around 0.59, "small colleges" and OIS at around 0.64. Interestingly studies that tested for heteroscedasticity are positively correlated with "mixed samples of public and private universities" at 0.4, but negatively correlated with studies that omitted input quality and price variables in their estimations at around 0.5 and studies that omitted output quality variables in their estimates at around 0.71. Year of data is positively correlated with studies that used multiple product cost functions at around 0.48, an indication that these cost functions have become commonplace or more popular in recent years.

Table 4 Correlation Matrix

	OIS	Public	Private	College	Mixed	Mixed2	InputQ	OutputQ	MP	Form	Totalcost	HC	Pub	non-US	Subgroup	sample	Year
OIS	1																
Public	0.016	1															
Private	0.247	-0.089	1														
College	-0.635***	-0.189	-0.236	1													
Mixed	-0.067	-0.175	-0.218	-0.463**	1												
Mixed2	0.630**	-0.134	-0.167	-0.354	-0.327	1											
InputQ	-0.041	-0.203	0.438**	0.342	-0.347	-0.208	1										
OutputQ	-0.393**	0.203	0.023	0.245	0.045	-0.484***	0.292	1									
MP	0.33	0.074	-0.023	-0.391**	0.408**	-0.035	-0.292	-0.282	1								
Form	-0.18	-0.169	-0.079	0.056	0.189	-0.118	-0.071	-0.093	-0.234	1							
Totalcosts	-0.349	0.120	-0.149	0.316	-0.293	-0.00001	-0.031	0.588***	-0.588***	0.176	1						
HC	0.213	0.117	-0.218	-0.309	0.048	0.400**	-0.498***	-0.709***	0.106	0.361**	-0.293	1					
Pub	-0.23	-0.203	0.208	0.196	0.106	-0.380**	0.282	0.148	-0.148	-0.071	-0.217	-0.045	1				
non-US	-0.012	0.681***	-0.131	-0.069	-0.257	0.049	-0.298	0.095	0.109	-0.247	0.175	-0.043	-0.298	1			
Subgroup	0.176	-0.189	0.236	-0.200	-0.154	0.354	0.049	-0.489***	-0.098	0.223	-0.253	0.463**	0.049	-0.277	1		
sample	-0.055	-0.207	-0.243	-0.208	0.785***	-0.344	-0.386**	0.174	0.376**	0.253	-0.092	-0.098	-0.055	-0.288	-0.311	1	
Year	0.199	0.083	-0.094	-0.122	-0.040	0.207	-0.327	-0.299	0.484***	0.303	-0.119	0.305	-0.22	0.281	0.178	0.117	1

Notes: *** and ** denote significance at the 1 per cent and 5 per cent levels, respectively.

2.5 Meta regression model

We estimated a MRA model based on the guidelines suggested by Stanley and Jarrell (1989) and the application by Colegrave and Giles (2008) to finding optimal school size. The MRA model is expressed in equation 3.

$$\mathrm{OIS}_i = \alpha + \sum_{m=1}^{m} \alpha_m Z_{im} + \varepsilon_i$$

for i =1, 2,...,n (3)

OIS denotes the dependent variable optimal institutional size for the i_{th} study in n studies. However n refers to the 30 estimations produced since some of the 12 studies computed more than one OIS estimate. Z_{ik} represents the meta-independent variables described earlier in table 1 The constant term, α denotes the mean OIS predicted by the MRA model if all other predictor variables Z_{ik} are zero. Hence this is used in this study as the base estimate or predicted "standard" OIS (Colegrave and Giles 2008). α_m denotes the mean deviation from the constant term and standard OIS, α. ε_i is a random error term.

We are concerned about heteroscedasticity especially since the estimates are based on different sample sizes. To ensure that our MRA estimates are BLUE, we carry out tests for heteroscedasticity (Breusch-Pagan test) and multicollinearity (Variance Inflation Factor-VIF), and if necessary use robust standard errors to counter heteroscedasticity. We also check for omitted variable bias and misspecification using the Ramsey RESET test.

3. Results

Table 5 presents the results of our MRA model (equation 3, n=30). OIS represents our dependent variable and parameter of interest for the study. From the original 15 meta-independent variables, we only include 13 variables, excluding sample size and year of data.

This is because these two variables substantially contribute to heteroscedasticity in the model[5]. After excluding these variables, we estimated our model using OLS.

Table 5 MRA results (n=30)

Dependent Variable-OIS		Model 1 (OLS)	Model 2 (Robust SE)
	Coefficient	**t**	**t**
Constant	24,954.45	3.07***	4.36***
Institutional Type			
Public	7,615.22	0.72	0.81
College	-14,657.84	-3.16***	-5.02***
Mixed	-10,809.22	-1.87*	-3.50***
Mixed2	13,337.35	2.17**	2.46***
Referent-Private			
Other independent variables			
InputQ	-428.33	-0.10	-0.18
OutputQ	-3,823.91	-0.61	-0.77
MP	4,403.65	1.19	1.17
Form	6,071.67	1.43	2.18**
Totalcost	-6,803.55	-0.88	-1.15
HC	-8,987.01	-1.34	-1.60
Pub	-2.706.69	-0.75	-1.03
non-US	-8,959.18	-1.56	-1.87*
Subgroup	-5,721.37	-1.73	-2.62**
	R^2=0.65		R^2=0.80
	$F_{13,16}$=5.10*** BP=3.10* Ramsey RESET=1.67 ($F_{3,13}$ P=0.222)		$F_{13,16}$=8.53***

Notes: ***, ** and * denote significance at the 1 per cent, 5 per cent and 10 per cent levels, respectively. BP is Breusch-Pagan test.

The model is significant at 1 per cent level and has an adjusted R^2 of 0.65. Our specification tests show that the variance inflation factor of independent variables is below 10 (rule of thumb) suggesting reason not to be concerned about multicollinearity (see Appendix C). The Ramsey RESET test indicates that the model neither has omitted variable bias nor is it mis-specified (p=0.222). However the Breusch-Pagan Test is still significant at 10 per cent level, suggesting we should still be concerned about heteroscedasticity in the model. In order to

[5] With these variables in the model, the Breusch-Pagan test is 3.68 (p=0.055)

counter this, a second estimation of the model was done with robust standard errors (model 2). Since the coefficients of the meta-independent variables do not change, we report only the t-values from the second estimation with robust standard errors. The model with robust standard errors has an R^2 of 0.80. Our interpretation of results is based on the second model.

The results show that the intercept (our standard model estimate of OIS) is 24,954 full time equivalent student enrolment ($p<0.01$). This is the base model when all the meta-independent variables are all equal to zero. The reference category for institutional type is the private university variable, which corresponds to the standard model estimate of 24,954 students. The public university variable is not significant, an indication that estimates based on public universities samples, on average are not significantly different from the intercept (which is also our reference variable private university). Several meta-independent variables significantly affect our OIS estimate. Studies which based their estimates on small colleges on average reduce the standard model estimate by 14,657 students ($p<0.01$) while studies which based their estimates on mixed samples of HEIs, on average reduce the standard model estimate by 10,809 students. Studies which based their estimates on mixed samples of public and private universities increase the standard model estimate by 13, 337 students ($p<0.01$).

Other significant variables concern the type of data and sample used and the functional form of model used. Studies based on subgroups, on average reduce the standard model estimate by 5,721 students, while studies based on non-US data[6], on average reduce the standard model estimate by 8,959 students. Studies that used quadratic cost functions, on average increase the standard model estimate by 6,071 students. Omitting input quality, price variables or output quality variables in a study does not significantly affect our standard

[6] Non-US data is based on four estimates from three studies from Australia, Turkey and Taiwan.

model estimate; neither does publishing in peer reviewed outlets nor testing for heteroscedasticity. Studies that used multi-product cost functions (vs. single product) or studies that used total costs as their dependent variable (vs. variable costs) also do not significantly change our standard model estimate.

4. Discussion

4.1 Policy implications

The standard estimate of OIS and how meta-independent variables affect it have possible implications on strategies for HEI mergers. For interpretation, we add the coefficients of significant institutional type variables to the standard model estimate to get the predicted OIS for each type of institution.

In our analysis, public universities are predicted to have an OIS which is the same as the standard model estimate of 24,954 students. Average institutional size for public university samples in the reviewed literature is about 8,608 students. This probably indicates or justifies an argument for mergers. Hence, public universities of average sample size can increase student enrolment by about 190 per cent as they experience declining average costs until they reach 24,954 students, the optimal point. Our analysis predicts the OIS for private universities to be equivalent to the standard model OIS of 24,954 students. The average size for private universities in our sample is 10,784 students. Hence, there is room or justification for increasing private university size by 131 per cent of the sample mean to reach the optimal point. However, there are caveats to these findings. Since the average institutional size and predicted OIS are based on two non-US studies (Australia and Taiwan), where public universities could be smaller than US public universities), the implied expansion path is likely more applicable to non-US countries than the US. Moreover, in the US, the cost-size relationship of public universities is influenced or obscured by the financing structure, where funding is dependent on enrolments (Laband and Lentz 2004, Getz and Siegfried 1991). The small sample of public university estimates also warrants caution in our interpretation. In addition, private university estimates in our sample are all based on US studies and might be less applicable to non-US contexts where private universities could be much smaller in size and may be less common.

A cursory comparative analysis of our predicted optimum with actual sizes of top three universities based on Times Higher Education World University Rankings[7] from each region shows varying opportunities for expansion (see appendix D). The top three universities in North America are all private universities with sizes in the range of 2,012 to 21,000 total students, indicating room for expansion in the range of 19 per cent to 1140 per cent. The top public university in North America is larger than the predicted optimum, and hence would need to contract by 31 per cent. In Europe the top three universities are all public with sizes ranging from 13,964 to 21,872 students, indicating expansions in the range of 14 per cent - 79 per cent. In Asia, the top three universities are public institutions, with sizes ranging from 22, 260 to 37, 304 students. However, based on our optimum, only one university has room for expansion (12 per cent) while the other two would face contraction in the range of 14 per cent and 33 per cent respectively. In Oceania, the top three universities are all Australian and publicly controlled with sizes ranging from 16,719 to 49,020 students. This would indicate room for expansion for one university by around 49 per cent, while the other two universities would need to contract by about 32 per cent and 49 per cent respectively. In South America, two of the top institutions are public universities and the third ranked institution is a private

[7] http://www.timeshighereducation.co.uk/world-university-rankings/

university. They have sizes in the range of 22,848 (private) to 88,962 students. Comparing with our optimum, the two public universities would need to contract by 44 per cent and 72 per cent respectively, while the private university can expand by 9 per cent. In Africa, the top three universities are public institutions with sizes ranging from 25,532 to 28,442 students. This would indicate that these institutions are slightly larger than our predicted optimum and would face contraction in the range of 2 per cent-12 per cent.

The variable “colleges” is predicted to have a lower OIS than the standard estimate, about 10,296 students. Considering that average “college” size in the reviewed literature is about 979 students, this finding suggests room for average size colleges to expand by around 952 per cent. This variable is based on studies that used samples of community colleges, liberal arts colleges and vocational schools. Predicted OIS for non-US HEIs is about 15,995 students. Average non-US HEI size in the reviewed literature is 7,338 students. This would suggest expansion in size of non-US HEIs by about 118 per cent of the sample mean. However only four studies looked at non-US institutions suggesting a heavy bias in the literature towards US institutions. This bias maybe due to the ease of data availability or data reliability of HEI costs in the US. Hence caution is warranted in interpreting non-US data.

While omitting input quality and output quality variables does not seem to influence study’s OIS estimate, what this study cannot dismiss is the potential effect of the input price on potential mergers. Our study faces shortcomings, one of them being that our sample size for the MRA is quite small. Previous studies have indicated that student-faculty ratio and the complexity of curriculum accounted for greater variation in institutional costs than enrolment size (Brinkman and Leslie 1986; McLaughlin et al. 1980). Hence, expanding institutional size, as mergers do, could also increase costs especially from higher faculty salaries or increased curricula potentially negating any economies of scale (Brinkman and Leslie 1986).

Our analytical findings seem to suggest a justification for the potential expansion or merging of HEIs. Yet, there are several reasons to be cautious. First, institutional characteristics and location of HEIs appear to influence the cost –size relationship. Second, our preliminary comparisons with actual sizes of top ranked institutions show a varied picture on expansion or contraction. Third, there are shortcomings of our data, in particular the limited sample. Hence, we recommend policymakers in US or non-US locations to refer to their own cost structures to determine the optimal size for efficiency (Colegrave and Giles 2008).

4.2 Research implications

Our findings also have implications on current and future research in this area. Our analysis produced several important insights on how empirical methodology influences OIS estimates. The type of functional form used in cost functions seems to matter. For instance, estimates based on quadratic cost functions increase the standard model OIS by about 6,071 students. The use of quadratic or cubic cost functions in estimating economies of scale for HEIs became the norm starting in the mid-1980s in articles by Throsby (1986) and Cohn et al. (1989), unlike earlier studies where linear functional forms where commonplace. Hence, one may argue that functional form acts as an indirect indicator of a time trend in the methodology and may influence estimates.

However as expected and earlier illustrated, our limited sample size is a major shortcoming. This makes it difficult for us to draw firm conclusions on our findings. Furthermore, our sample distribution is skewed towards smaller colleges (10 estimates) or estimates from mixed HEIs (9 estimates), for a total of 19 out of 30 estimates. Thus, studies determining the cost-size relationship of small colleges or estimating economies of scale based on mixed samples of universities and colleges (which have different sizes and costs) currently dominate the literature. While, our efforts in searching for the relevant studies were rigorous, there is a small possibility that we missed unpublished articles which might have increased our sample size. In addition, we identified many other studies that estimated economies of scale but did not specifically reveal the optimal institutional size in their estimates. We hope that this MRA will encourage future researchers to produce OIS estimates when estimating cost functions.

5. Conclusion

This paper used the meta-regression analysis method to determine a standard OIS in higher education. Our findings indicate a standard OIS of 24,954 students. The meta-regression analysis shows that the predicted standard OIS is negatively influenced by; studies based on small college samples and samples of mixed HEIs, the use of subsamples, studies based on non-US data. The standard OIS is positively influenced by studies based on samples of mixed public and private universities and the use of quadratic or cubic cost functions. The OIS for public universities is not significantly different from the standard OIS estimate (also private university estimate). We find a potential for HEIs to expand their size by different magnitudes; public universities by about 190 per cent of the sample mean size, private universities by 131 per cent of the sample mean size, small colleges by around 952 per cent of the sample mean size, and non-US HEIs by about 118 per cent of the sample mean. However, if we compare optimum sizes with actual sizes of top ranked universities in the

Times Higher Education World University Rankings a more mixed impression emerges: in some parts of the world top ranked universities seem to be below optimal size, while in others they appear above optimal size. However, we urge caution in the interpretation of the findings due to the still limited sample of studies producing optimal institutional size estimates and the dominance of optimal institutional size estimates of small colleges in the literature. We therefore recommend further research in this area. We also recommend policymakers in US or non-US locations to refer to their own cost structures to determine the optimal size for efficiency.

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Appendix A

Studies included in the MRA

Author	Country	Pub Yr	OIS	Public	Private	College	Mixed	Mixed2
Brinkman	USA	1981	1750	0	0	1	0	0
Brinkman	USA	1981	3500	0	0	1	0	0
Cohn et al	USA	1989	5120	0	0	0	1	0
Cohn et al	USA	1989	4842	0	0	0	1	0
Cohn et al	USA	1989	2110	0	0	0	1	0
DeGroot et al	USA	1991	45000	0	0	0	0	1
DeGroot et al	USA	1991	17000	0	1	0	0	0
Lewis & Dundar	Turkey	1995	1600	0	0	1	0	0
Fu et al	Taiwan	2008	10481	1	0	0	0	0
Fu et al	Taiwan	2008	18141	0	0	0	0	1
Getz and Siegfried	USA	1991	1100	0	0	1	0	0
Getz and Siegfried	USA	1991	1600	0	0	1	0	0
Getz and Siegfried	USA	1991	20227	0	1	0	0	0
Getz and Siegfried	USA	1991	2150	0	0	1	0	0
Getz and Siegfried	USA	1991	18934	0	1	0	0	0
Getz et al	USA	1991	1115	0	0	1	0	0
Getz et al	USA	1991	2153	0	0	1	0	0
Getz et al	USA	1991	1584	0	0	1	0	0
Koshal and Koshal	USA	1995	30957	0	0	0	0	1
Koshal and Koshal	USA	1995	11758	0	0	0	0	1
Koshal and Koshal	USA	1995	16112	0	0	0	0	1
Koshal and Koshal	USA	1995	22174	0	0	0	0	1
Koshal and Koshal	USA	2000	2472	0	0	1	0	0
Laband and Lentz	USA	2004	19800	0	0	0	1	0
Laband and Lentz	USA	2004	19800	0	0	0	1	0
Maynard	USA	1971	5300	0	0	0	1	0
Throsby	Aus	1986	13000	1	0	0	0	0
Varadi	USA	2001	9800	0	0	0	1	0
Varadi	USA	2001	16000	0	0	0	1	0
Varadi	USA	2001	7720	0	0	0	1	0

Appendix B

Average Institutional Size, n=22

	Mean	Std. Dev.
Full sample	8,013.23	5,840.35
Public (n=3)	8,608.5	1,501.19
Private (n=3)	10,784	807.14
College (n=3)	979.39	355.80
Mixed (n=8)	4,343.1	2,217.44
Mixed2 (n=5)	14,839.83	4,868.98

Appendix C

Test for Multicollinearity

Variable	VIF	1/VIF
HC	7.39	0.135
OutputQ	7.21	0.139
Mixed	5.51	0.182
Public	5.39	0.185
Totalcost	5.19	0.193
Mixed2	4.71	0.212
College	3.74	0.268
InputQ	3.47	0.288
Non-US	2.99	0.335
Form	2.52	0.397
MP	2.5	0.400
Pub	2.34	0.428
Subgroup	1.91	0.524
Mean VIF	**4.22**	

Notes: VIF denotes variance inflation factor

Appendix D

Actual Sizes of Top-Ranked Universities from World Regions

Institution	Size	Public	Private	Country	Expansion (Contraction)
North America					
California Institute of Technology	2,231		√	USA	1119%
Harvard University	21,000		√	USA	119%
Stanford University	19,945		√	USA	125%
University of California Berkeley	36,142	√		USA	(31%)
Europe					
University of Oxford	21,872	√		UK	114%
University of Cambridge	18,306	√		UK	136%
Imperial College of London	13,964	√		UK	179%
Oceania					
University of Melbourne	36,626	√		Australia	(32%)
Australia National University	16,719	√		Australia	149%
University of Sydney	49,020	√		Australia	(49%)
Asia					
University of Tokyo	28,978	√		Japan	(14%)
University of Hong Kong	22,260	√		Hong Kong	112%
National University of Singapore	37,304	√		Singapore	(33%)
South America					
University of Sao Paulo	88,962	√		Brazil	(72%)
State University of Campinas	44,519	√		Brazil	(44%)
Pontifical Catholic University of Chile	22,848		√	Chile	109%
Africa					
University of Cape Town	25,352	√		South Africa	(2%)
Stellenbosch University	28,193	√		South Africa	(11%)
University of Witwatersrand	28,442	√		South Africa	(12%)

Notes: Rankings based on Times Higher Education World University Rankings. Actual institutional sizes are from each university's website. Magnitude of expansion or contraction is relative to the optimum of 24,954 students. Expansion is by multiplication and contraction by subtraction.

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