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Liang-Cheng Zhang and Andrew C Worthington

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Abstract

Numerous studies have investigated economies of scale and scope in higher education as a means of providing public and private providers of college and university teaching and research and their stakeholders with knowledge of the cost structures that underpin provision in this economically and socially important sector. However, debate continues on the precise nature of these economies of scale and scope given the mixed findings, largely because of the significant institutional and other differences in the chosen context. To address this, we employ meta-regression analysis to explore not only the overall level of scale and scope economies across nearly 50 international studies conducted in Australia, the US, the UK, Italy, China, and others since the early 1980s, but also those factors that potentially affect their presence in the higher education sector. Our findings suggest that functional form, allowances for managerial efficiency, and the specification of teaching outputs have a significant impact on the estimated scale economies. In contrast, for scope economies, the key factors appear to be when the age of the analysis, the diversity of the sample, and the national level of economic development in the chosen context.

Key words: Economies of scale; economies of scope; meta-regression analysis; higher education

JEL Codes: C21; I23; D29

1. Introduction

Ever since Baumol, Panzar, & Willig (1982) developed the seminal theory in industrial economics underpinning multiple-output, multiple-input economies of scale and scope, interest in investigating cost structures in a variety of industries has continued to grow. Cohn, Rhine, & Santos (1989) represent the first attempt to apply this theory to higher education and their model has since encouraged others to follow their lead in examining higher education cost structures across a range of contexts and time periods.

These studies contribute to our better understanding of the future of higher education in terms of an appropriate if not optimal size and scope. If there is evidence of economies of scale, it suggests that increasing the operational size of higher education, for both institutions and industries, can yield benefits in the form of lower unit costs. In contrast, evidence of economies of scope would suggest that the joint production of different outputs carries with it cost savings. Therefore, by investigating scale and scope economies, existing studies have imagined the future *optimal* structure for sustainable delivery using estimates of these critical cost economies. Regrettably, the chosen institutional, regulatory and market contexts within which existing results have been derived vary so markedly that generalization for informing government policy and industry practice is difficult.

We believe we could more appropriately sort existing findings on the economics of scale and scope in higher education with meta-regression analysis (MRA). MRA is a tool used in meta-analysis to examine the impact of moderator variables on study effect size using regression-based techniques. Unlike a mere literature review with its reliance on possibly subjective qualitative discussion [see Cohn & Cooper (2004) for a recent qualitative review of scale and scope economies in higher education], MRA is able to shed greater light on both the general outcomes of a large body of existing work and possible reasons for the differences in these results. MRA is also more effective at this task than standard meta-analytic techniques. We use economies of scale and economies of scope as the effect sizes and investigate the factors that exert a significant impact on these effect sizes, namely, the scale elasticity and cost savings from joint production, both commonly considered as good effect sizes in economics (Stanley & Doucouliagos, 2012).

The purpose of this study is therefore to analyze potential factors affecting economies of scale and scope in higher education through conducting an MRA. The remainder of this paper is structured as follows. Section 2 discusses the potential factors affecting scale and scope economies. Section 3 outlines the method of constructing the meta-regression models. Section 4 details the results of the analysis and most importantly reveals the significant impact factors, from the perspective of both their theoretical and practical importance. Section provides some brief concluding remarks and some practical suggestions for future research in the area.

2. Literature review

The theory of scale economies dates at least to Adam Smith's *Wealth of Nations* explanation of them as a source of wealth differences between countries. In brief, if there are economies of scale, all else constant, unit costs are lower in larger firms, resulting from the spreading of

fixed costs over additional units of production. Subsequently applied to many economic activities, but mostly limited to single-output production, Baumol (1975) and Panzar & Willig (1975) extended the idea to multi-output production and added discussion on the economies of scope resulting from the cost savings of joint production. Multi-product estimation, as introduced by Baumol, Panzar, & Willig (1982), further accelerate the spread of these premise of economies of scale and scope to a variety of multi-output production contexts including, as here, higher education.

Cohn et al. (1989) first applied Baumol's et al. (1982) theory of scale and scope economies to higher education. Using quadratic cost functional (QCF, or flexible fixed cost quadratic) forms, Cohn et al. (1989) estimated scale and scope economies using a sample of 1,195 public and 692 private higher education institutions in the US. As this seminal work directed subsequent inquiry, it is useful to highlight some key features of their analysis. First, while there are any number of other possible functional forms, including constant elasticity of substitution (CES) (Johnes, 1997; Izadi et al., 2002) and hybrid translog (TL) (De Groot et al., 1991; Glass et al. 1995a, 1995b, 1996) functions, quadratic cost functional forms have dominated, even though Baumol et al (1982) suggested these alternatives. Given the probably impact of the functional form on the estimated scale and scope economies, this choice remains critical.

Second, Cohn et al. (1989) included both public and private institutions in their analysis. Again, this is an important consideration because the funding of public institutions tends to constrain their enrolments and programs relative to their counterparts. Cohn et al. (1989) understood this potential impact and therefore split the sample into public and private institutions. They then estimated the cost economies for each type of institution and identified significant differences between them. Several subsequent studies followed this approach, especially in the US, including Chavas (2012), Laband (2003) and Sav (2004). As an alternative, if the public and/or private institution subsamples are relatively small, others, including Johnes, Johnes, & Thanassoulis (2008) and Johnes & Salas-Velasco (2007) employ an ownership dummy variable.

Besides these factors, accounting for the managerial efficiency of an institution may also be another important factor affecting scale and scope economies. For example, government regulation and the characters of not-for-profit organizations may invoke inefficient outcomes through the setting of additional social and other organizational objectives. In fact, as the cost economies derived from regression models are from an *average* cost function, they implicitly assume that at least some institutions are less than perfectly efficient. Johnes (1998) first noted this and suggested the use of a stochastic frontier model or alternative, as did Izadi et al. (2002), Maripani (2007), and Johnes & Johnes (2009) later.

Another potential factor is the role of teaching outputs in estimation economies of scale and scope in higher education. If we were to consider students as the most important teaching output, the question follows as to how we measure this quantitatively. For instance, at the beginning of the teaching process, each institution counts enrolled students; during the teaching process, students decide when, how many, and what courses they undertake to fulfill set graduation requirements; at the end of the teaching process, students successfully passing

all requirements graduate. Each of these teaching (production) processes has its own teaching outputs: at its simplest, enrolments, credits, and completions, and each are evident in the existing literature. Of these, enrolments are the most common choice, invariably because of data availability. Nevertheless, as each type of output actually represents a different teaching process, this specification choice can have marked impacts on the estimated economies of scale and scope. Unfortunately, most past studies did not provide a reason for the choice of specific teaching output, though Agasisti (2016) recently specified both enrollments and completions as the teaching outputs and compared the results.

The potential factors above naturally raise a simple question: how do they affect the economies of scale and scope in higher education? This question might be answered by using a sample from a country like previous studies did. It could be easy to include the factors above but it is impossible to comprehensively contain some important control variables such as sample size and data source. MRA is built for solving this question by borrowing the characteristics of previous studies to investigate whether some characteristics might be the important factors to affect effect size. We will give more details about MRA in the next section.

3. Methodology

Following Stanley & Jarrell (1989; 2005), our MRA model for a sample of S studies has the following form:

$$b_i = \beta + \sum_{k=1}^K \alpha_k Z_{ik} + \varepsilon_i \quad \text{for } i = 1, 2, \dots, S \quad (1)$$

where b_i is the reported effect size estimate of the i -th empirical study, β is the true value of b_i , Z_{ik} are the meta-independent (or study-level) variables used for representing the important characteristics of a study, α_k are the coefficients corresponding to the meta-independent variables, and ε_i is the meta-regression error term used for accounting for any unexplained disturbance in Z_{ik} .

The purpose of the meta-regression model in (1) is to identify the potential factors influencing the effect size, such that statistically significant estimated coefficients for the meta-independent variables indicate that the characteristics of the study have a significant relationship with the results and vice versa.

In this study, the effect size, b_i , is the estimates of the cost economies (scale and scope). More specifically, we are interested in factors affecting two cost economies: ray (or overall) scale economies (SRAY) and global (or total) scope economies (GSE). To ensure comparability, we only consider studies whose results are consistent with the multi-output production theory in Baumol et al. (1982). We first introduce the estimate of scale economies for multi-product production:

$$SRAY(y) = \frac{C(y)}{\sum_{i=1}^n y_i \frac{\partial C}{\partial y_i}} \quad (2)$$

where $C(y)$ is the total cost of producing all outputs given the different output values $(y_1, \dots, y_n)$ and other control variables such as mean prices, institution characteristics (for simplicity, they are omitted in the equations), such that $\partial C / \partial y_i$ is the marginal cost of producing product y_i .

Note that this measure calculates the effect of a simultaneous and proportional increase of *all* output scales along a ray in output space while holding the composition of each institution's outputs constant. Hence, ray economies of scale. If there are economies of scale, the estimated measure is greater than unity, implying aggregate output increases while the composition of output remains constant.

An estimate of scale economies can help institutions decide how large they should be. In contrast, the estimate of global scope economies is the percentage of cost savings from joint production relative to fully integrated costs (or alternatively, the percentage increase in costs from specialized production):

$$GSE(y) = \frac{\sum_{i=1}^n C(y_i) - C(y)}{C(y)} \quad (3)$$

where $\sum_{i=1}^n C(y_i)$ is the cost of producing product i in n separated specialized institutions, and $C(y)$ is the cost of producing all n products jointly within an institution.

Scope economies typically result from the sharing of inputs across different outputs. Therefore, input prices and the available technology greatly affect their presence (Bailey & Friedlaender, 1982). Using (3), if the estimate of $GSE(y)$ is greater than zero, scope economies are present, implying that the cost of producing different types of products within a single production unit is less than the cost of producing them separately.

From equations (2) and (3), we can clearly see that both estimates vary with the level of output y . Most previous studies evaluate these estimates at the mean (average) output level for the industry. We follow this approach in our MRA by assuming that the higher education sector in a specific country will have point estimates of scale and scope economies on average. We can also use these estimates to indicate the mere presence of scale and scope economies, by specifying binary dependent variables as follows:

- $D.SRAY$: one for estimates of scale economies evaluated at a mean output level larger than zero, otherwise zero
- $D.GSE$: one for estimates of scope economies evaluated at a mean output level larger than zero, otherwise zero

The meta-independent variables Z_{ik} consist of continuous variables and the dummy variables. Following Stanley et al. (2013) and the literature, we include the following continuous explanatory variables:

- *Year*: the year the data were collected
- *Sample size*: the number of institutions included in the sample
- and dummy variables:
- *Public*: one for public institutions, otherwise zero
- *OECD*: one for OECD (2016) member-countries, otherwise zero
- *QCF*: one for QCF functional form, otherwise zero
- *Efficiency*: one for (in)efficiency control, otherwise zero
- *Enrolments*: one for enrolments as teaching outputs, otherwise zero
- *Panel*: one for longitudinal study, otherwise zero
- *Journal*: one for refereed journal, otherwise zero

One limitation of our paper is that we cannot offset the potential publication bias (Doucouliagos, 2005) arising from the relatively studies that report standard errors. In fact, in our sample, just two (Fu, Huang, & Tien, 2008; Nemoto & Furumatsu, 2014) reported the standard errors of the estimates of scale and scope economies using the delta method (Zhang & Worthington, 2015). Unfortunately, as all studies use different functional forms and/or independent variables for calculating the cost economies, it is almost impossible to calculate the standard errors retrospectively. This limitation is not uncommon and is shared with most other meta-regression analyses (Colegrave & Giles, 2008; Velickovski & Pugh, 2010; Bel & Warner, 2016)

4. Sampling procedure and study characteristics

The selection of publications is key to conducting a proper meta-analysis. It is especially important to include as many different types of publications as possible to reduce publication bias, with Stanley & Doucouliagos (2012) suggesting that meta-analysis should not only include published works but also incorporate unpublished sources, including theses, dissertations, working and conference papers and commercial research reports.

We employ two phases in our literature search. The first phase involves the searching of major education, economics, and social science databases, including ERIC, ProQuest Dissertations & Theses Global, Science Direct, JSTOR, Google Scholar, SCOPUS, and EconPapers. As we already know the seminal work in the area (Cohn et al., 1989) dates from 1989, we narrow the literature search to English language peer reviewed journal articles from 1989 onwards including the keywords ‘higher education’, ‘university’, ‘economies of scale’, and/or ‘economies of scope’.

In the second phase, we remove duplicate studies and those that are not empirical, do not specify multiple outputs, those not reporting estimates evaluated at the sample means, not specific to higher education, and not conducted at the institutional level. For example, in some higher education studies (Dundar & Lewis, 1995; Gana, 1996; Lewis & Dundar, 1995) data is collected at the departmental or faculty level. For consistency, we include only those studies

in our sample reporting estimates evaluated at the mean output level, not the median (Filippini & Lepori, 2007).

summarizes the 39 publications identified using this process. Note some studies report more than a single estimate for economies of scale and/or scope given the use of alternative methods, functional form, the use of subsamples, etc. In these cases, we list all estimates, but categorize them as a single study, as indicated by including ‘Yes’ in the column headed *Multiple* in

. Overall, our sample comprises 39 studies with 49 observations for scale economies and 34 observations for scope economies.

Table 1. Studies included in the meta-regression analysis, by country.

Author(s)	No. of institutions	Ownership	Data year	Country context	Functional forma	Efficiency control	Teaching specific
Worthington & Higgs (2011)	36	Public	2006	Australia	QCF	No	Comple
Zhang & Worthington (2016)	37	Public	2012	Australia	QCF	No	Comple
Mamun (2012)	18	Public	2007	Bangladesh	TL	Yes	Enrolm
Maripani (2007)	22	Public and private	2004	Chile	TL	Yes	Enrolm
Cheng & Wu (2008)	68	Public and private	2004	China	QCF	No	Enrolm
Longlong et al. (2009)	74	Public	2001	China	QCF	No	Enrolm
Li & Chen (2012)	75	Public	2009	China	QCF	No	Enrolm
Li (2016)	62	Public	2009	China	QCF	No	Enrolm
Johnes & Schwarzenberger (2011)	79	Public	2005	Germany	QCF	Yes	Enrolm
Olivares & Wetzel (2014)	154	Public	2007	Germany	Nonparametric	Yes	Enrolm
Agasisti & Dal Bianco (2007)	58	Public	2002	Italy	QCF	No	Enrolm
Agasisti & Johnes (2010)	57	Public	2004	Italy	QCF	Yes	Enrolm
Agasisti (2016)	55	Public	2011	Italy	QCF	Yes	Enrolm
Hashimoto & Cohn (1997)	94	Private	1991	Japan	QCF	No	Enrolm
Nemoto & Furumatsu (2014)	218	Private	2005	Japan	Nonparametric	Yes	Enrolm
Rufino (2006)	29	Public and private	2002	Philippines	QCF	No	Enrolm
Johnes & Salas-Velasco (2007)	26	Public and private	2004	Spain	QCF	Yes	Enrolm
Fu et al. (2008)	33	Public and private	2001	Taiwan	TL	Yes	Enrolm
Fu et al. (2011)	56	Public and private	2003	Taiwan	QCF	No	Enrolm
Glass et al. (1995b)	61	Public	1990	UK	TL	No	Enrolm
Glass et al.(1995a)	61	Public	1992	UK	TL	No	Enrolm
Johnes (1996)	50	Public	1990	UK	QCF	No	Enrolm
Johnes (1997)	99	Public	1995	UK	CES	No	Enrolm
Johnes (1998)	50	Public	1990	UK	QCF	Yes	Enrolm
Izadi et al.(2002)	99	Public	1995	UK	CES	Yes	Enrolm
Johnes et al.(2008)	121	Public	2003	UK	QCF	Yes	Enrolm
Johnes & Johnes (2009)	121	Public	2003	UK	QCF	Yes	Enrolm
Cohn et al. (1989)	1,887	Public and private	1982	US	QCF	No	Enrolm
Foltz et al. (2007)	96	Public and private	1998	US	QCF	No	Enrolm
de Groot et al. (1991)	147	Public and private	1983	US	TL	No	Enrolm
Koshal & Koshal (1999)	329	Public and private	1991	US	QCF	No	Enrolm
Koshal & Koshal (2000)	295	Private	1995	US	QCF	No	Enrolm
Koshal et al. (2001)	184	Private	1995	US	QCF	No	Enrolm
Laband & Lentz (2003)	2,942	Public and private	1996	US	QCF	No	Enrolm
Sav (2004)	2,189	Public and private	1996	US	QCF	No	Credit h
Sav (2010)	457	Public	2007	US	QCF	No	Credit h
Sav (2011)	321	Public	2007	US	QCF	No	Credit h
Chavas et al. (2012)	92	Public and private	1998	US	Nonparametric	Yes	Comple
Agasisti & Johnes (2015)	954	Public and private	2007	US	QCF	Yes	Comple

Note: ^a QCF is quadratic cost functional form, TL is hybrid translog function, CES is constant elasticity of substitution function, and nonparametric means the study did not use a specific functional form for estimating scale and scope economies.

Most studies reported both estimates of economies of scale and economies of scope. Some studies even report more than one estimate for scale economies of scope economies. However, there are still some publications reporting either one of the estimate. **Error! Reference source not found.** shows the final sample used in our meta-regression analysis. Notice that almost all publications are published in a journal and only one publication (Maripani, 2007) is published in the form of thesis.

In this paper, there are 49 observations could be used for analyzing factor affecting estimates and presence of economies of scale. The mean for estimate of scale economies (SRAY) is 1.170 but the maximum is up to 4.37. The mean for presence of scale economies (D.SRAY) shows 67.4 % of estimates indicating presence of scale economies. The data span using for previous studies is quite wide, spreading more than three decades (from 1982 to 2012). There is also significant variation in the sample size. For instance, Mamun (2012) uses a sample of just 18 institutions while Laband & Lentz (2003) includes some 1,492 institutions.

The other statistics also indicate some interesting facts. Most estimates for scale economies are using samples from public institutions (63.3%) and OECD countries (85.7%). As for the methodology adopted by previous studies, 73.5% of estimates are from using the quadratic cost function with 44.9% of estimates using a panel sample. However, only 34.7% of estimates account for efficiency.

The last two columns of Table 2 provide the observations on scope economies used in the meta-regression analysis. There are 34 observations, fewer than for the analysis of scale economies. While the mean estimate for scope economies (GSE) is just -0.001, the presence estimate (D.GSE) suggests another story by indicating that 64.71% of estimates imply the presence of positive scope economies. The lower mean estimate of scope economies could be the result of a single very low outlier (-8.27) (Cheng & Wu, 2008). These results suggest the necessity of considering the presence of cost economies, not just their magnitude, as a dependent variable. That said, the characteristics of the independent variables are quite similar to those found in the extant studies of scale economies.

Table 2. Descriptive statistics of literature on scale economies (n = 49) and scope economies (n = 34)

	Scale economies		Scope economies	
	Mean	Std. dev.	Mean	Std. dev.
Dependent variables				
SRAY / GSE	1.170	0.592	-0.001	1.609
D.SRAY / D.GSE	0.674	0.474	0.647	0.485
Independent variables				
Year	1999.714	7.670	1998.647	7.603
Sample size	241.755	390.005	163.382	261.901
Public	0.633	0.487	0.588	0.500
OECD	0.857	0.354	0.824	0.387
QCF	0.735	0.446	0.677	0.475
Efficiency	0.347	0.481	0.412	0.500
Enrolments	0.714	0.456	0.853	0.360
Panel	0.449	0.503	0.471	0.507
Journal	0.980	0.143	0.971	0.172

Notes: (i) n is the number of estimates included; (ii) the minimum and maximum SRAY are 0.18 and 4.37 respectively, the minimum and maximum sample size for SRAY studies are 18 and 1,492 respectively; the minimum and maximum GSE are -8.27 and 2.82 respectively, the minimum and maximum sample size for GSE studies are 18 and 1,195 respectively

served with the scale economies.

Table 3. Correlation matrix for literature on scale economies (n = 49) and scope economies (n = 34)

Variables	SRAY/ GSE	D.SRAY/D. GSE	Year	Sample size	Public	OECD	QCF	Efficiency	Enrolmen ts	Panel	Journal
SRAY/GSE	1.000	0.466***	-0.178	0.014	0.236	0.227	-0.203	0.039	-0.068	-0.225	0.072
D.SRAY/ D.GSE	0.455**	1.000	-0.109	-0.058	0.007	-0.180	0.147	-0.257	-0.307*	-0.167	0.236
Year	0.014	-0.376***	1.000	-0.377**	0.008	-0.403**	0.043	0.343**	-0.308*	0.634***	-0.124
Sample size	-0.004	0.087	-0.312**	1.000	-0.153	0.194	0.242	-0.092	-0.097	-0.145	0.095
Public	0.012	0.011	0.217	-0.125	1.000	-0.074	-0.068	-0.150	-0.010	-0.289*	0.208
OECD	-0.293**	-0.036	-0.207	0.210	0.052	1.000	0.010	0.074	-0.192	-0.027	-0.081
QCF	-0.139	-0.123	0.160	0.244*	0.022	0.019	1.000	-0.316*	0.068	-0.104	0.252
Efficiency	0.010	-0.407***	0.327**	-0.217	-0.067	0.053	-0.339**	1.000	-0.159	0.648***	-0.208
Enrolments	0.265*	0.234	-0.417***	-0.089	-0.201	-0.258*	-0.175	0.081	1.000	-0.440***	-0.072
Panel	-0.055	-0.421***	0.618***	-0.294**	-0.078	0.017	-0.108	0.635***	-0.247*	1.000	-0.185

Notes: (i) Correlations coefficients for scale (scope) economies below (above) diagonal; (ii) *, **, and *** denote two-sided significance at the 0.1, 0.05, and 0.01 level, respectively

The above initial findings indicate some potential correlations between dependent and independent variables. In the following section, we should model all variables with meta-regression analysis.

5. Meta-regression results

In this section, we regress our meta-independent variables on both estimates of cost economies and the presence of cost economies. The former aims to identify those factors affecting the magnitude of the scale and scope economies while the latter aims to find the factors affecting the likelihood of scale or scope economies.

5.1 Results for the magnitude of scale and scope economies

For the first meta-regression analysis, we regress the magnitude of the scale and scope economies on the independent variables. Several regression models are potential candidates especially for analyzing the magnitude of scale economies. Some might consider Tobit regression as the magnitude of the scale economies is usually greater than zero. However, this estimate is usually not equal to zero (i.e. not censored at zero). Of course, theoretically, economies of scale are never zero as total cost is always positive. Another candidate model is truncated regression. However, given the small number of observations, we do not truncate our data. For additional discussions of modeling censored or truncated dependent variables, see Long (1997) for details. We therefore follow similar MRA studies (Carvalho et al., 2012) and employ ordinary least squares (OLS).

To test the assumption of OLS, we conduct a Breusch–Pagan chi-square test (BP test) for heteroscedasticity. As shown in **Error! Reference source not found.**, the statistics for both dependent variables are insignificant, indicating the constant variance of error terms is not violated. However, the results for both dependent variables show not all coefficients of independent variables are significant. The insignificant F-test and low R2 further confirm these variables do not contribute to explaining the variance of SRAY and GSE.

These results may appear confusing given the independent variables are usual in the literature estimating the magnitude of scale and scope economies. However, with reported estimates closer either one for SRAY or zero for GSE, it might not be surprising about the insignificant results. In fact, Carvalho et al. (2012) also found insignificant results when they applied a meta-regression analysis to scale and scope economies for water utilities.

Table 1: MRA results: dependent variables SRAY and GSE

Variables	Magnitude of scale economies (SRAY)		Magnitude of scope economies (GSE)	
	Coefficients	<i>t-values</i>	Coefficients	<i>t-values</i>
Intercept	-37.817	-0.991	-46.294	-0.344
Year	0.019	1.011	0.023	0.343

Sample size	0.000	0.936	0.000	0.027
Public	0.017	0.085	0.388	0.591
OECD	-0.292	-1.018	0.943	1.000
QCF	-0.306	-1.322	-0.622	-0.842
Efficiency	-0.095	-0.364	0.813	0.964
Enrolments	0.408	1.655	-0.648	-0.621
Panel	-0.034	-0.121	-1.539	-1.434
Journal	0.733	1.134	0.725	0.388
Number of estimates	49		34	
BP test	12.408		12.398	
F-test	1.025		0.807	
R2	0.191		0.232	

Note: BP test is Breusch–Pagan chi-square statistics.

5.2 Results for the presence of scale and scope economies

In this section, we will analyze factors explaining the presence of scale (D.SRAY) and scope economies (D.GSE). Notice that D.SRAY and D.GSE are dummy variables whose outcomes are dichotomous or binary (either 1 for cost economies or 0 for cost diseconomies). We follow the suggestion of Bel & Fageda (2009) and use probit regression to conduct a meta-regression analysis for these dependent variables.

This time, the results are very different from those in **Error! Reference source not found..** The significant LR test statistic, which has the same function with F-test in Table 5 shows at least one of the meta-independent coefficients, is not equal to zero. We can observe that there are three coefficients are significantly different zero in both models; however, the significant factors vary.

For the model with presence of scale economies, QCF and Efficiency have negative impacts on the presence of scale economies. This implies that studies using the quadratic cost function or accounting for efficiency are more likely to conclude the presence of scale diseconomies. This is not surprising as accounting for efficiency usually leads to lower estimates of scale economies. One interesting finding is that using enrolments as teaching outputs has significant and positive impacts on the presence of scale economies, indicating studies using this output are more likely to get the results of scale economies than studies using completions or credit hours. This strengthens the view of Agasisti (2016) that different types of teaching outputs represent different goals for stakeholders and decision-makers.

On the other hand, the results of the presence of scope economies point to another direction. The above factors (functional forms, whether accounting for efficiency and using enrolments) have no significant effects on the presence of scope economies. Instead, data collected year,

the number of institutions (sample size), and whether the collected sample is from OECD countries have significant relationships with scope economies. These negative relationship results further imply that studies using a sample of older data set or fewer institutions or non-OECD countries are more likely to conclude the presence of scope economies.

Table 2: MRA results: dependent variables D.SRAY and D.GSE

Variables	Presence of scale economies (D.SRAY)		Presence of scope economies (D.GSE)	
	Coefficients	<i>z-values</i>	Coefficients	<i>z-values</i>
Intercept	23.244	0.059	643.760	0.242
Year	-0.014	-0.266	-0.316	-1.900*
Sample size	0.000	-0.062	-0.007	-1.920*
Public	0.103	0.188	0.371	0.399
OECD	0.825	1.038	-3.341	-2.232**
QCF	-1.884	-2.173**	2.345	1.599
Efficiency	-1.993	-2.457**	0.884	0.791
Enrolments	1.201	1.713*	-13.305	-0.018
Panel	-0.166	-0.241	-0.613	-0.573
Journal	6.373	0.017	2.871	0.001
Number of estimates	49		34	
LR test	21.786***		22.701***	
McFadden Pseudo R2	0.352		0.514	
AIC	60.120		41.448	
Log pseudo likelihood	-20.060		-10.724	

Notes: (i) LR test is the log likelihood ratio chi-square statistic; (ii) *, **, and *** denote two-sided significance at the 0.1, 0.05, and 0.01 level, respectively.

6. Concluding remarks

In this paper, we investigate the factors affecting economies of scale and scope in higher education. Since Cohn's et al. (1989) seminal work published in 1989, the number of investigations of scale and scope economies in higher education has grown rapidly. However, the mixed results serve as a source of some confusion for industry practitioners, policy makers and stakeholders. This makes application of the findings to actual practice and policy exceedingly difficult. This paper is the first attempt to address this problem with a meta-regression analysis proposed by Stanley & Jarrell (1989). This analysis is widely used to investigate the factors affecting the interested effect size. In our analysis, the effect sizes are the magnitude and presence of scale and scope economies.

Although previous studies suggest several factors that potentially affect scale and scope economies, our results suggest that these potential factors do not have significant relationship with the *magnitude* of scale and scope economies. This finding is consistent with previous work (Carvalho et al., 2012) using MRA to evaluate the degree of scale and scope economies in the water sector. We argue that the degrees of cost (scale and scope) economies might not be a good effect size estimator as these are naturally closer to their thresholds (one for scale economies and zero for scope economies). However, our contribution to the literature is that our investigated factors indeed affect the *presence* of these cost economies. That is, these factors will affect the probability of passing these thresholds.

Our results suggest that the presence of scale economies tends to be affected by model specification, including functional form, whether departures from managerial efficiency are included, and specifying enrolments as teaching outputs. In particular, studies employing a quadratic cost function tend to find the presence of scale *diseconomies*. This means the choice of functional form is no longer neutral when estimating scale economies. Future studies then need to justify why they choose a particular functional form rather than simply following precedent. Allowing for (in)efficiency also has significant and negative relationship with the presence of scale economies. This implies that studies accounting for efficiency are likely to conclude *diseconomies* of scale.

This is not surprising since the costs estimated by such studies usually are less than the costs estimated by a common regression model given the adjustment of efficiency. As total and marginal costs decline, the output level remains constant, and we expect the magnitude of any scale economies to fall. The interesting part is that this does not affect the magnitude of the scale economy, rather its presence. Another factor that significantly affects the presence of scale economies is whether studies use enrolments as teaching outputs. Our results imply that studies using enrolments tend to conclude the presence of scale economies. This suggests that the choice of teaching outputs plays an important role in the estimation and supports Agasisti's (2016) view of different dimensions in maximizing outputs.

The significant factors affecting presence of scope economies are quite different from those affecting the presence of scale economies. This suggests that the presence of scope economies is free from many model-specification related biases. However, a more likely

scenario is the data selected by most studies. Our findings indicate that the data year, sample size, and OECD-sourced samples are significant factors affecting the presence of scope economies. The negative signs of the estimated coefficients further imply that studies using older data sets, smaller sample sizes or developing country samples are more likely to conclude the presence of scope economies. These findings therefore help us conceptualize the potential ways of realizing scope economies the world over. For example, there should be cost savings from the recent trend toward institutional specialization in developed countries, but from joint production in developing countries, and from a smaller number of institutions rather than a larger number of institutions in a country.

As a final point, while collecting the sample, we found most studies did not report the variance or standard deviation for the cost economies. While this does not affect the conduct of meta-regression analysis, they would be very helpful in diagnosing any potential publication bias. We suggest further studies provide such estimates using the delta method.

details the correlations between the variables. The correlation coefficients, including the level of statistical significance, for the scale economy studies are below the diagonal while those for the scope economy studies are above the diagonal. Unsurprisingly, there is a positive correlation (0.455, significant at the .05 level) between the magnitude of the scale economies and its presence. However, the correlations between these two dependent variables and the independent variables differ markedly. For example, the magnitudes of the scale economies significantly only relate to developed country studies (OECD), and whether enrolments serve as a measure of teaching output.

In contrast, the presence of scale economies significantly negatively correlates with three independent variables: the data year, the inclusion of efficiency, and the use of panel data, suggesting older studies, those omitting efficiency, and cross-sectional and time-series only studies are more likely to conclude the presence of scale economies. The correlation coefficients above the diagonal in served with the scale economies.

Table 3. Correlation matrix for literature on scale economies (n = 49) and scope economies (n = 34)

Variables	SRAY/ GSE	D.SRAY/D. GSE	Year	Sample size	Public	OECD	QCF	Efficiency	Enrolmen ts	Panel	Journal
SRAY/GSE	1.000	0.466***	-0.178	0.014	0.236	0.227	-0.203	0.039	-0.068	-0.225	0.072
D.SRAY/ D.GSE	0.455**	1.000	-0.109	-0.058	0.007	-0.180	0.147	-0.257	-0.307*	-0.167	0.236
Year	0.014	-0.376***	1.000	-0.377**	0.008	-0.403**	0.043	0.343**	-0.308*	0.634***	-0.124
Sample size	-0.004	0.087	-0.312**	1.000	-0.153	0.194	0.242	-0.092	-0.097	-0.145	0.095
Public	0.012	0.011	0.217	-0.125	1.000	-0.074	-0.068	-0.150	-0.010	-0.289*	0.208
OECD	-0.293**	-0.036	-0.207	0.210	0.052	1.000	0.010	0.074	-0.192	-0.027	-0.081
QCF	-0.139	-0.123	0.160	0.244*	0.022	0.019	1.000	-0.316*	0.068	-0.104	0.252
Efficiency	0.010	-0.407***	0.327**	-0.217	-0.067	0.053	-0.339**	1.000	-0.159	0.648***	-0.208
Enrolments	0.265*	0.234	-0.417***	-0.089	-0.201	-0.258*	-0.175	0.081	1.000	-0.440***	-0.072
Panel	-0.055	-0.421***	0.618***	-0.294**	-0.078	0.017	-0.108	0.635***	-0.247*	1.000	-0.185
Journal	0.118	0.207	-0.081	0.082	0.189	-0.059	0.240*	-0.198	-0.091	-0.160	1.000

Notes: (i) Correlations coefficients for scale (scope) economies below (above) diagonal; (ii) *, **, and *** denote two-sided significance at the 0.1, 0.05, and 0.01 level, respectively

The above initial findings indicate some potential correlations between dependent and independent variables. In the following section, we should model all variables with meta-regression analysis.

7. Meta-regression results

In this section, we regress our meta-independent variables on both estimates of cost economies and the presence of cost economies. The former aims to identify those factors

affecting the magnitude of the scale and scope economies while the latter aims to find the factors affecting the likelihood of scale or scope economies.

7.1 Results for the magnitude of scale and scope economies

For the first meta-regression analysis, we regress the magnitude of the scale and scope economies on the independent variables. Several regression models are potential candidates especially for analyzing the magnitude of scale economies. Some might consider Tobit regression as the magnitude of the scale economies is usually greater than zero. However, this estimate is usually not equal to zero (i.e. not censored at zero). Of course, theoretically, economies of scale are never zero as total cost is always positive. Another candidate model is truncated regression. However, given the small number of observations, we do not truncate our data. For additional discussions of modeling censored or truncated dependent variables, see Long (1997) for details. We therefore follow similar MRA studies (Carvalho et al., 2012) and employ ordinary least squares (OLS).

To test the assumption of OLS, we conduct a Breusch–Pagan chi-square test (BP test) for heteroscedasticity. As shown in **Error! Reference source not found.**, the statistics for both dependent variables are insignificant, indicating the constant variance of error terms is not violated. However, the results for both dependent variables show not all coefficients of independent variables are significant. The insignificant F-test and low R² further confirm these variables do not contribute to explaining the variance of SRAY and GSE.

These results may appear confusing given the independent variables are usual in the literature estimating the magnitude of scale and scope economies. However, with reported estimates closer either one for SRAY or zero for GSE, it might not be surprising about the insignificant results. In fact, Carvalho et al. (2012) also found insignificant results when they applied a meta-regression analysis to scale and scope economies for water utilities.

Table 1: MRA results: dependent variables SRAY and GSE

Variables	Magnitude of scale economies (SRAY)		Magnitude of scope economies (GSE)	
	Coefficients	<i>t-values</i>	Coefficients	<i>t-values</i>
Intercept	-37.817	-0.991	-46.294	-0.344
Year	0.019	1.011	0.023	0.343
Sample size	0.000	0.936	0.000	0.027
Public	0.017	0.085	0.388	0.591
OECD	-0.292	-1.018	0.943	1.000
QCF	-0.306	-1.322	-0.622	-0.842
Efficiency	-0.095	-0.364	0.813	0.964
Enrolments	0.408	1.655	-0.648	-0.621
Panel	-0.034	-0.121	-1.539	-1.434
Journal	0.733	1.134	0.725	0.388

Number of estimates	49	34
BP test	12.408	12.398
F-test	1.025	0.807
R2	0.191	0.232

Note: BP test is Breusch–Pagan chi-square statistics.

7.2 Results for the presence of scale and scope economies

In this section, we will analyze factors explaining the presence of scale (D.SRAY) and scope economies (D.GSE). Notice that D.SRAY and D.GSE are dummy variables whose outcomes are dichotomous or binary (either 1 for cost economies or 0 for cost diseconomies). We follow the suggestion of Bel & Fageda (2009) and use probit regression to conduct a meta-regression analysis for these dependent variables.

This time, the results are very different from those in **Error! Reference source not found.** The significant LR test statistic, which has the same function with F-test in Table 5 shows at least one of the meta-independent coefficients, is not equal to zero. We can observe that there are three coefficients are significantly different zero in both models; however, the significant factors vary.

For the model with presence of scale economies, QCF and Efficiency have negative impacts on the presence of scale economies. This implies that studies using the quadratic cost function or accounting for efficiency are more likely to conclude the presence of scale diseconomies. This is not surprising as accounting for efficiency usually leads to lower estimates of scale economies. One interesting finding is that using enrolments as teaching outputs has significant and positive impacts on the presence of scale economies, indicating studies using this output are more likely to get the results of scale economies than studies using completions or credit hours. This strengthens the view of Agasisti (2016) that different types of teaching outputs represent different goals for stakeholders and decision-makers.

On the other hand, the results of the presence of scope economies point to another direction. The above factors (functional forms, whether accounting for efficiency and using enrolments) have no significant effects on the presence of scope economies. Instead, data collected year, the number of institutions (sample size), and whether the collected sample is from OECD countries have significant relationships with scope economies. These negative relationship results further imply that studies using a sample of older data set or fewer institutions or non-OECD countries are more likely to conclude the presence of scope economies.

Table 2: MRA results: dependent variables D.SRAY and D.GSE

Variables	Presence of scale economies (D.SRAY)		Presence of scope economies (D.GSE)	
	Coefficients	<i>z-values</i>	Coefficients	<i>z-values</i>
Intercept	23.244	0.059	643.760	0.242
Year	-0.014	-0.266	-0.316	-1.900*
Sample size	0.000	-0.062	-0.007	-1.920*

Public	0.103	0.188	0.371	0.399
OECD	0.825	1.038	-3.341	-2.232**
QCF	-1.884	-2.173**	2.345	1.599
Efficiency	-1.993	-2.457**	0.884	0.791
Enrolments	1.201	1.713*	-13.305	-0.018
Panel	-0.166	-0.241	-0.613	-0.573
Journal	6.373	0.017	2.871	0.001
Number of estimates	49		34	
LR test	21.786***		22.701***	
McFadden Pseudo R2	0.352		0.514	
AIC	60.120		41.448	
Log pseudo likelihood	-20.060		-10.724	

Notes: (i) LR test is the log likelihood ratio chi-square statistic; (ii) *, **, and *** denote two-sided significance at the 0.1, 0.05, and 0.01 level, respectively.

8. Concluding remarks

In this paper, we investigate the factors affecting economies of scale and scope in higher education. Since Cohn's et al. (1989) seminal work published in 1989, the number of investigations of scale and scope economies in higher education has grown rapidly. However, the mixed results serve as a source of some confusion for industry practitioners, policy makers and stakeholders. This makes application of the findings to actual practice and policy exceedingly difficult. This paper is the first attempt to address this problem with a meta-regression analysis proposed by Stanley & Jarrell (1989). This analysis is widely used to investigate the factors affecting the interested effect size. In our analysis, the effect sizes are the magnitude and presence of scale and scope economies.

Although previous studies suggest several factors that potentially affect scale and scope economies, our results suggest that these potential factors do not have significant relationship with the *magnitude* of scale and scope economies. This finding is consistent with previous work (Carvalho et al., 2012) using MRA to evaluate the degree of scale and scope economies in the water sector. We argue that the degrees of cost (scale and scope) economies might not be a good effect size estimator as these are naturally closer to their thresholds (one for scale economies and zero for scope economies). However, our contribution to the literature is that our investigated factors indeed affect the *presence* of these cost economies. That is, these factors will affect the probability of passing these thresholds.

Our results suggest that the presence of scale economies tends to be affected by model specification, including functional form, whether departures from managerial efficiency are included, and specifying enrolments as teaching outputs. In particular, studies employing a quadratic cost function tend to find the presence of scale *diseconomies*. This means the choice of functional form is no longer neutral when estimating scale economies. Future studies then need to justify why they choose a particular functional form rather than simply following precedent. Allowing for (in)efficiency also has significant and negative relationship with the presence of scale economies. This implies that studies accounting for efficiency are likely to conclude *diseconomies* of scale.

This is not surprising since the costs estimated by such studies usually are less than the costs estimated by a common regression model given the adjustment of efficiency. As total and marginal costs decline, the output level remains constant, and we expect the magnitude of any scale economies to fall. The interesting part is that this does not affect the magnitude of the scale economy, rather its presence. Another factor that significantly affects the presence of scale economies is whether studies use enrolments as teaching outputs. Our results imply that studies using enrolments tend to conclude the presence of scale economies. This suggests that the choice of teaching outputs plays an important role in the estimation and supports Agasisti's (2016) view of different dimensions in maximizing outputs.

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concern the literature on scope economies. However, none of the variable correlations with the magnitude of the scope economies are significant and only enrolments significantly correlates with the presence of scope economies. These are very similar results to those observed with the scale economies.

Table 3. Correlation matrix for literature on scale economies (n = 49) and scope economies (n = 34)

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D.SRAY/ D.GSE	0.455**	1.000	-0.109	-0.058	0.007	-0.180	0.147	-0.257	-0.307*	-0.167	0.236
Year	0.014	-0.376***	1.000	-0.377**	0.008	-0.403**	0.043	0.343**	-0.308*	0.634***	-0.124
Sample size	-0.004	0.087	-0.312**	1.000	-0.153	0.194	0.242	-0.092	-0.097	-0.145	0.095
Public	0.012	0.011	0.217	-0.125	1.000	-0.074	-0.068	-0.150	-0.010	-0.289*	0.208
OECD	-0.293**	-0.036	-0.207	0.210	0.052	1.000	0.010	0.074	-0.192	-0.027	-0.081
QCF	-0.139	-0.123	0.160	0.244*	0.022	0.019	1.000	-0.316*	0.068	-0.104	0.252
Efficiency	0.010	-0.407***	0.327**	-0.217	-0.067	0.053	-0.339**	1.000	-0.159	0.648***	-0.208
Enrolments	0.265*	0.234	-0.417***	-0.089	-0.201	-0.258*	-0.175	0.081	1.000	-0.440***	-0.072
Panel	-0.055	-0.421***	0.618***	-0.294**	-0.078	0.017	-0.108	0.635***	-0.247*	1.000	-0.185
Journal	0.118	0.207	-0.081	0.082	0.189	-0.059	0.240*	-0.198	-0.091	-0.160	1.000

Notes: (i) Correlations coefficients for scale (scope) economies below (above) diagonal; (ii) *, **, and *** denote two-sided significance at the 0.1, 0.05, and 0.01 level, respectively

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Sample size	0.000	0.936	0.000	0.027
Public	0.017	0.085	0.388	0.591
OECD	-0.292	-1.018	0.943	1.000
QCF	-0.306	-1.322	-0.622	-0.842
Efficiency	-0.095	-0.364	0.813	0.964
Enrolments	0.408	1.655	-0.648	-0.621
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Journal	0.733	1.134	0.725	0.388
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Table 2: MRA results: dependent variables D.SRAY and D.GSE

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	Coefficients	z-values	Coefficients	z-values
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As a final point, while collecting the sample, we found most studies did not report the variance or standard deviation for the cost economies. While this does not affect the conduct of meta-regression analysis, they would be very helpful in diagnosing any potential publication bias. We suggest further studies provide such estimates using the delta method.

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