Cost economies in the provision of higher education for international students: Australian evidence

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Introduction

The global higher education market has grown exponentially in volume, scope, and complexity over the past two decades, with students, faculty, programs, and even institutions, moving across national and regional borders (Knight 2013). Student mobility, the traditional internationalisation strategy, continues to provide momentum for this global higher education market expansion, with the number of students worldwide pursuing higher education overseas doubling from 2 million in 2000 to 4.2 million in 2012, a rate of growth expected to continue in the foreseeable future (OECD 2014). Likewise, in Australia, education services have represented the country's largest service export since 2013, with A$15.7 billion earned in 2014 alone, accounting for about 27.5% of all service exports (ABS 2015a; DFAT 2015). But apart from generating tremendous economic benefits to individual providers, international education, especially in the higher education sector, is well regarded as "…a key enabler of productivity and growth for virtually every part of an economy" (Australian Government 2015a, p. 8), producing positive effects in the social, cultural, and intellectual life of the exporting country.

Nonetheless, the financial incentives associated with international education have often led Australian universities to compete aggressively for international students without considering the associated costs and risks (Australian Government 2015a). As a result, international education suffers recurrent quality issues such as accusations of degree mills, poor academic performance, and the misconduct of international students, and occasional surface-level negative interactions between international and domestic students (Four Corners 2015). This counters the expectations of higher education providers and the government, along with other stakeholders, that the education of international students will generate positive benefits for both international and domestic students. Therefore, there is an urgent need for closer examination of the institutional costs of international education, i.e., providing higher education for international students, to inform policy and practice.

Unfortunately, no recent studies in this area empirically consider the cost structure of higher education in the provision for international students. This study addresses this gap in the literature by particularly focusing on the following three research questions. First, is the unit cost of international students higher than that of domestic students? Second, is it possible to gain cost economies by increasing (or even decreasing) the number of international students and by how much? Lastly, what is the nature of the cost savings between domestic and international higher education?

The responses to these questions will provide useful advice for the future development of international higher education, in both Australia and elsewhere. The response to the first question will directly provide guidance in price setting for international students. The responses to the second and third questions will help us better understand whether there are economies of scale and scope in the provision of international higher education. Our study will thus identify the potential for efficiency improvements to institutions to reflect the true cost of education and subsequently operate at an efficient scale. Such discussions about cost economies will also help institutions construct a more sustainable environment for their operations (Ilieva et al. 2014).

In fact, estimating the scale and scope economies of higher education has been a primary focus of the literature (e.g. Cohn et al. (1989); Johnes and Johnes (2009); Johnes and Schwarzenberger (2011); Li and Chen (2012); Agasisti and Johnes (2015)). Unfortunately, little of this considers the cost economies in international higher education. In considering the potential cost economies, we explore the scale and scope economies of another possible form of instructional output, namely, international higher education in higher education institutions (HEIs). The next section discusses the debate on the costs and potential cost economies of higher education provision for international students. The section following defines our method, including the dataset and model specification. We then discuss our results. The final section presents the conclusion of this paper.

Cost economies of higher education provision for international students

In most developed countries, including Australia, higher education is highly subsidised, which means that domestic students usually pay less than the full cost of education (currently about 40 percent of costs across all programs). When international higher education first emerged, international students usually enjoyed the same tuition and other fees as domestic students (Knight & de Wit 1995). However, as the number of international students grew, concerns emerged about whether these students were paying enough to cover the costs of provision. As a result, after the 1980s, there was considerable interest in how to assess tuition charges for international students.

Two pricing rules have been consistently used (Throsby 1991), namely, average cost and marginal cost pricing. For example, in 1980, the British government decided to remove subsidised fees for overseas students. Instead, overseas students were to pay full-cost fees, as calculated by the average cost of instructional budgets divided by total student enrolments (Blaug 1981). In contrast, marginal cost pricing employs an econometric model to estimate the marginal costs of incremental enrolments. This type of cost is important because it provides information about whether universities should enrol more overseas students, or instead direct funds toward other investments (Hoenack et al. 1986).

However, estimating the cost of international education is difficult because of the entanglement of this type of service with other services provided by HEIs. For example, apart from providing academic courses/programs to international students, the Australian Government (n.d.) requires Australian HEIs to offer specialist services to help international students adjust to life and study in Australia. These support services to international students include language and academic support, designated international student advisers, on-arrival reception and orientation programs, childcare, health and counselling, student accommodation, employment services, prayer and worships rooms, banking, shopping and food outlets, and clubs, societies, sport and fitness facilities. Nonetheless, it is obvious that domestic students in Australia will also enjoy some or most of these listed support services offered by the HEIs. That is to say, few of the support services provided by Australian HEIs are reserved exclusively for international students.

One of the biggest debates on the costs of international education relates to the common assumption that international students need substantive language and academic support, which would result in additional costs compared with domestic students who are believed to be more prepared linguistically and academically, and thus do not require such services. Such an assumption may certainly hold during the early stages of international education development when HEIs need to invest generously to initially establish facilities, organisational structures, operational mechanisms, and human resources to provide their first groups of international students with appropriate linguistic and academic support. However, as the international education system matures in individual HEIs, these will become routine, incurring smaller additional operational costs from the perspective of the HEI.

Another possible factor to affect the costs of teaching international students is completion time. For instance, Hoenack and Davidson (1987) found that the completion time of US international students is significantly lower than that of domestic students. In addition, given the recently increasing numbers of transnational or offshore programs on offer in Australia, as shown in Table 1, a considerable number of Australian international (undergraduate) students may study only offshore or attend Australian HEIs for only one or two years, rather than four years as nearly all domestic students do. This means the costs of providing education for these international students can be much less than that for domestic students because the former actually spend less time studying in Australia.

<INSERT TABLE 1 HERE>

All the scenarios discussed make it very difficult (if not impossible) to distinguish the costs of providing higher education for international students from those for domestic students. For example, all enrolled students, regardless of their residency or citizenship, use services provided by a university library. Most previous cost studies estimated the average and marginal costs of *all* students, and assumed the costs of international education were the same as previous estimates (Chishti 1984; Heaton and Throsby, 1998; Winkler 1984a; Winkler 1984b). However, this assumption is only appropriate if domestic and overseas students are equally distributed across the same fields and at the same level, which is unreasonable given more than half of overseas student enrolments at Australian HEIs during the last five years have enrolled in science, technology, engineering and mathematics (STEM) courses (Australian Government 2015b). Table 2 provides further details.

<INSERT TABLE 2 HERE>

Fortunately, Baumol et al. (1982) developed an econometric technique to overcome these difficulties, by specifying a multi-output cost function. In a multi-output scenario, such as higher education, we cannot directly calculate the average costs for particular outputs. However, we can indirectly estimate them by calculating the average incremental cost. One advantage of this approach is that once we obtain the average and marginal costs, we can calculate the economies of scale of international education by dividing the average cost by the marginal cost. If the estimate is larger than one, this implies the existence of economies of scale for international education. In this case, enrolling more overseas students would benefit the exporting (host) institutions (and by association, the funding country) by creating lower average costs.

International higher education could also generate cost savings from the joint production of international education and other domestic education outputs. Thus, another measure used to determine the cost benefits of international higher education is to estimate its economies of scope. For example, there are potential scope economies between international and domestic education because the same academic staff can teach the same courses to both types of students. In addition, while providing international higher education requires more diversified teaching and administrative staff, and more qualified faculties to support teaching and research activities (Park 2004), these could subsequently reduce the costs of producing international teaching and research.

Specification and Methodology

To estimate economies of scale and scope, we need to first specify a cost functional form. In the past thirty years, the flexible fixed cost quadratic (FFCQ) function proposed by Mayo (1984) dominates the estimation of scale and scope economies in higher education. This cost function permits an output to have zero value without further transformation. Mayo (1984, pp 216-217) further divides FFCQ into two kinds of functional form based on input prices entering either additively (FFCQ-A) or multiplicatively (FFCQ-M). The FFCQ-A function is as follows:

$$C^{FFCQ-A}(\boldsymbol{y},\boldsymbol{w};\boldsymbol{\beta}) = F(\boldsymbol{y};\boldsymbol{\beta}) + A(\boldsymbol{w};\boldsymbol{\beta})$$
$$= \left(\beta_0 + \sum_{i=1}\beta_{0i}F_i + \sum_{i=1}\beta_i y_i + 0.5\sum_{i=1}\sum_{j=1}\beta_{ij}y_i y_j\right) + \sum_{l=1}\beta_{wl}w_l \quad (1)$$

where $F(\cdot)$ is a quadratic form in output vector **y** and $A(\cdot)$ is an linear form in input price vector **w**, subscripts *i* denotes the output, y_i is the *i*-th type of output (out of *n* types of output), $w_l$is the *l*-th input price, β_0 is the fixed cost, β_{0i} is for adjusting fixed cost if some output y is zero and $\beta_{wl}'s, \beta_i's, \beta_{ij}'s$ are scalars of unknown parameters.

The FFCQ-M function is $F(\cdot)$ multiplied by $M(\cdot)$ then

$$C^{FFCQ-M}(\boldsymbol{y}, \boldsymbol{w}; \boldsymbol{\beta}) = F(\boldsymbol{y}; \boldsymbol{\beta}) \cdot M(\boldsymbol{w}; \boldsymbol{\beta})$$

$$= \left(\beta_0 + \sum_{i=1} \beta_{0i} F_i + \sum_{i=1} \beta_i y_i + 0.5 \sum_{i=1} \sum_{j=1} \beta_{ij} y_i y_j \right) \cdot \prod_{l=1} w_l^{\beta_{wl}} \tag{2}$$

where $M(\cdot)$ is a linearly homogeneous function of input price vector **w** and other notations are consistent with equation (1).

In the estimation of scale and scope economies in higher education, the FFCQ-A function has been the most popular form since first adopted by Cohn et al. (1989). Of most appeal is its linear nature, which makes it easier to account for the heterogeneity unobserved at the institution level when panel data is available. However, the FFCQ-A function also brings with its several unsolved issues. First, because of a limitation of the linear functional form, it is almost impossible to match all cost function regularity conditions, which could lead to model misspecification. For example, to impose linear homogeneity, we could omit the numeraire price by dividing total cost and the other factor prices by this price (Martínez-Budría et al. 2003). However, there is no guidance available to select the numeraire price. Troublingly, the results are not invariant to this choice (Triebs et al. 2016). Most studies (Agasisti & Johnes 2015; Izadi et al. 2002; Johnes 1996, 1997, 1998; Johnes & Johnes 2009; Johnes & Schwarzenberger 2011) implicitly bypass this regularity condition by assuming input prices are constant across institutions given their highly regulated contexts. However, we note that most of these studies have used sample data before 2003. As the competition among universities is now much more intense, and most (including in

Australia) now operate in more deregulated contexts, this assumption should now be weaker.

In contrast, the FFCQ-M function is theoretically more appealing than the FFCQ-A because it easily conforms to all of the cost function regularity conditions, as proven by Greer (2003, 2008, 2010). For example, we impose the symmetry condition with $\beta_{ij} = \beta_{ji}$, and ensure linear homogeneity by letting all input-price coefficients sum to one ($\sum_{l=1} \beta_{wl} = 1$). Zhang and Worthington (2016) have also already tested this with Australian higher education data. For the above reasons, we believe it is necessary to employ the FFCQ-M function to avoid model misspecification. As this functional form remains novel, we specify the same cost and control variables as Zhang and Worthington (2016), but provide additional tools for testing the function. Note that in all other respects, not least purpose and main research questions, the present analysis is very different.

This study employs a balanced panel dataset comprising 37 Australian public universities from the Department of Industry, Innovation, Science, Research, and Tertiary Education over the period from 2003 to 2012. The dependent variable is total operating expenditure. In order to estimate the cost economies of international higher education, we specify the teaching outputs (students) according to graduate residency status. We refer to these students as international (or overseas) students, in contrast to domestic students, which may include, for example, students who are Australian citizens, New Zealand citizens, or the holders of a permanent residence visa.

However, one problem is how we further disaggregate these students. Two common ways are to classify them based on the field of education (science and non-science) and the level of education (undergraduate and postgraduate). Although it is attractive to use both in our study, there would be too many outputs as we already disaggregate students based on graduate residency status. Therefore, we disaggregate the teaching outputs in both ways and allow the data itself to decide which better fits and matches all model assumptions. This results in five outputs and three input prices in the cost function. We convert all monetary variables (costs and input prices) to their real values (2003 = 100) using the consumer price index from the Australian Bureau of Statistics (ABS 2015b).

Following previous studies, several control variables (**z**) are also included. To start, we include the attrition rate (z_q) as a teaching quality-adjusted indicator (Aina 2013; Zhang and Worthington 2016). We also include time-invariant dummy variables for each of the eight regions (states and territories) and four alliance groups, which is a common practice used to account for any heterogeneity when using a nonlinear functional form (e.g. Delgado et al. 2015 and Zhang and Worthington 2016). The four alliance groups comprise the Australian Technology Network (ATN, z_{a1}), the Group of Eight (Go8, z_{a2}), the Innovative Research Universities (IRU, z_{a3}), and the Regional Universities Network (RUN, z_{a4}). We specify institutions not belonging to any of these groups (z_{a5}) as the reference group. The eight Australian regions are New South Wales (NSW, z_{g1}), Victoria (VIC, z_{g2}), Queensland (QLD, z_{g3}), Western Australia (WA, z_{g4}), South Australia (SA, z_{g5}), the Australian Capital Territory (ACT, z_{g6}), Tasmania (TAS, z_{g7}), and the Northern Territory (NT, z_{g8}) Institutions without a main campus and located in more than one state (z_{g9}) are the reference group. Table 3 provides the means, standard deviations, minimums, and maximums for each of the variables from 2003 to 2012.

<INSERT TABLE 3 HERE>

We use a regression model to link actual total costs, c, with our assumed cost function (2) by incorporating a multiplicative normal error, $\varepsilon \sim N(0, \sigma^2)$:

$$c = C^{FFCQ-M}(\boldsymbol{y}, \boldsymbol{w}; \boldsymbol{\beta}) \cdot exp\left(\sum_{m=1}^{13} \beta_{zm} z_m\right) \cdot exp(\varepsilon)$$

$$= C^{FFCQ-M}(\boldsymbol{y}, \boldsymbol{w}, \boldsymbol{z}; \boldsymbol{\beta}) \cdot exp(\varepsilon) \quad (3)$$

Here, exp denotes the base of the natural logarithm. Note that $\boldsymbol{z}$ is a vector of institutional characteristics, including attrition rates, and two categorical indicators for the region and alliance group. Those categorical indicators are dummy variables with a value of one for positive amounts of the output $\boldsymbol{y}$ but zero otherwise. With some transformations by taking logarithms of both sides, we create linearity (3) in the parameters of the input prices and control variables:

$$ln(c) = ln\left(C^{FFCQ-M}(\boldsymbol{y}, \boldsymbol{w}, \boldsymbol{z}; \boldsymbol{\beta})\right) + \varepsilon$$

$$= ln\left(\beta_0 + \sum_{i=1}^{5} \beta_i y_i + 0.5 \sum_{i=1}^{5} \beta_{ii} \, (y_i)^2 + \sum_{i,j=1;\, i \neq j}^{10} \beta_{ij} y_i y_j\right) \qquad (4)$$

$$+ \sum_{l=1}^{3} \beta_{wl} ln(w_l) + \sum_{m=1}^{13} \beta_{zm} z_m + \varepsilon$$

We use least squares to derive the coefficient estimators by minimising the sum of squares $\sum\left(\ln(c) - ln\left(C^{FFCQ-M}(\boldsymbol{y}, \boldsymbol{w}, \boldsymbol{z}; \boldsymbol{\beta})\right)\right)^2$ subject to a linear homogeneity constraint ($\sum_{l=1}^{3} \beta_{wl} = 1$).

Note that as we employ a panel dataset, biased findings could result from not clustering. That is, the institutions are observed repeatedly over time (2003 to 2012 in our analysis) and therefore there is potential dependence in the model residuals. The assumption of independent and identically distributed residuals may then not hold, leading to biased standard errors, for which we correct using a clustering-robust method (Petersen 2009) at the institution level. This corrected covariance-matrix (usually known as the cluster-robust variance matrix) is used for calculating the cluster-robust coefficient standard errors.

To infer the existence of scale and scope economies and the cost differences between domestic and overseas completion, we employ the delta method (Zhang and Worthington 2015) to estimate the standard error of the estimates with the cluster-robust variance matrix. Finally, we construct 95% confidence intervals to conduct significance tests the existence of scale and scope economies. If their intervals do *not* include one for scale economies or zero for the scope economies, it suggests that these estimates are significantly different from the thresholds (one and zero, respectively) at the 5% significance level. Thus, there is evidence for the existence of scale and scope economies (if their intervals are higher than the threshold) or *dis*economies (if their intervals are lower than the threshold). For results with their intervals including the thresholds, the tests suggest neither cost economies nor *dis*economies but indicate that institutions have been cost efficient and that they could not increase efficiency by further changing the quantities of outputs.

Empirical Results

Table 4 details the estimates of the two five-output multiplicatively separable cost functions. Each cost function uses different outputs, as shown in Table 3. The appearance of cost complementarity indicates the potential cost savings when producing both types of outputs together. In practice, given all students with either form of residency share much the same resources, we expect cost complementarity between domestic and overseas teaching, at least at the same field of study or level of education (β_{13} and β_{24}). Unfortunately, we cannot find evidence of cost complementarity in the field of education nor at the level of education. Estimates of β_{13} and β_{24} in the level of education are negative, but they are not significantly different from zero at the 5% significance level. However, the above finding is not surprising as the multicollinearity resulting from the inclusion of interaction terms could interfere with the significance of cost complementarity (Worthington and Higgs 2011). Whether there are economies of scope requires further investigation.

For model diagnostics, we provide four indicators, namely, the residual standard error (RSE), the Akaike information criterion (AIC), the Shapiro-Wilk (SW) normality test, and the Runs test (Baty et. al. 2015). We use the first two for the model comparisons: the lower the value, the better the model. We use the second two to test the assumption of a nonlinear regression. The SW normality test will test whether the residuals have a normal distribution. The final test statistics show whether the residuals in our models follow the randomness condition. We can see that the model using the level of education data has better fit than the model using the field of education. Both models do not violate the assumption of residual randomness, as their runs test statistics are not significant. However, the model using the level of education fails to follow the normality of residuals given its significance at the 0.05 level. This indicates that this model could produce biased estimates for the coefficients. On the contrary, albeit with slightly less model fit, the model including field of education easily passes all of the tests. We therefore use this model to calculate the following cost estimates.

<INSERT TABLE 4 HERE>

By considering the descriptive statistics in Table 3 and the cost function estimates in Table 4, we calculate the costs, scale and scope economies of higher education provision for international students using the formula in Baumol et al. (1982). The analysis follows common empirical practice—that is, instead of presenting the estimates of costs and economies with specific output values, we standardised the results with different percentages of existing mean output (from 25% to 200%), representing the costs for institutions with different sizes (i.e. from one-quarter to double the average size). Therefore, all cost economies estimates are functions of mean output, representing the costs for institutions with different sizes. That is, in the following equations for calculating the cost economies estimates, output **y** will be replaced with its respective *p* % of mean output (y_{ip}). That said, all control variables are set to their respective means.

Tables 5 presents comparisons of the annual average incremental costs of *i*-th output evaluated at *p* % of mean output ($\text{AIC}(y_{ip})$). Notice that this is calculated with the difference between total cost and the cost of *i*-th type of output ($\text{IC}y_{ip}$) and then be divided by *i*-th output. With our functional form in equation (3), we write the annual average incremental cost as

$$\text{AIC}(y_{ip}) = \frac{\text{IC}y_{ip}}{y_{ip}} = \left(\beta_i y_{ip} + 0.5\beta_{ii} y_{ip}^2 + \sum_{j=1;\, i\neq j}^{5} y_{ip} y_{jp}\right) \cdot \prod_{l=1}^{3} w_l^{\beta_{wl}} \cdot exp\left(\sum_{m=1}^{13} \beta_{zm} z_m\right) / y_{ip} \tag{5}$$

<INSERT TABLE 5 HERE>

Note that we use $\text{AIC}(y_{ip})$ as a proxy for the average costs of international and domestic students. We observe that $\text{AIC}(y_{ip})$ for domestic science completions are significantly higher than the costs of their overseas counterparts, at least up to 75% of mean output. However, nothing suggests that there is significant cost difference between domestic and overseas non-science completions. Our findings therefore disagree with those in earlier studies (Blaug 1981), which asserted that international students could be responsible for institutions incurring higher costs than with their domestic counterparts because some require remedial teaching in English speaking and writing and additional assistance with course and laboratory work. This implies diversity in the costs of providing international higher education, rather than simply higher costs for international students.

Marginal cost represents the additional costs of producing one additional output unit. The calculation of the cost is from taking the first derivative of the cost function (equation (3)) with respect to output *i*:

$$\text{MC}(y_{ip}) = \frac{\partial C^{FFCQ-M}(\boldsymbol{y_p}, \boldsymbol{w}, \boldsymbol{z}; \boldsymbol{\beta})}{\partial y_{ip}} = \left(\beta_i y_{ip} + \beta_{ii} y_{ip}^2 + \sum_{j=1;\, i\neq j}^{5} \beta_{ij} y_{jp}\right) \cdot \prod_{l=1}^{3} w_l^{\beta_{wl}} \cdot exp\left(\sum_{m=1}^{13} \beta_{zm} z_m\right) \quad (6)$$

where $\boldsymbol{y_p}$ is a output vector at p % of mean output; that is, $\boldsymbol{y_p}=[y_{1p}, \dots, y_{5p}]$.

As shown in Table 6, the findings suggest that these depend on both the field of education and the percentage of mean output. For example, at 100% of mean output, we can see that producing one additional overseas science completion is much cheaper than producing one additional domestic undergraduate completion (A$20,090 vs. A$68,950). Interestingly, this difference is decreasing with the increase in mean output. However, we do not obtain similar results for non-science completions, as there is no significant difference between domestic and international students at any indexed percentage of mean output. The marginal cost differences between domestic and overseas science completions are also in line with the average incremental cost results, but the significance remains up to 150% of mean output.

It may be of some surprise that the AIC and MC for overseas science completions are much lower. To obtain some insight, we return to Table 3. Note that overseas science completions only occupy a relatively small portion of full completions with 688 annual graduates as against 1661 annual domestic graduates. One institution even has only three graduates each year. Another possible reason is the short completion time we discussed earlier. This effect ought to have more influence on more expensive courses like the science field subjects in our study. Our model may reflect these differences in the lower AIC and MC for overseas science completions. However, from our results, these cost advantages only apply to smallish institutions (those less than 75% of mean output for AIC and 125% of mean output for MC).

<INSERT TABLE 6 HERE>

To observe the effect of size expansion and contraction on the estimates of scale and scope economies, Tables 7 and 8 summarise these estimates and indicate whether the Australian university sector as a whole is experiencing economies of scale (significantly greater than one) or economies of scope (significantly greater than zero).

Economies of scale indicate the situation in which average costs per student (as measured by completions) fall as fixed costs spread over increasing numbers of students, calculated by dividing the AIC by the MC. When all outputs change proportionally, we can estimate ray economies of scale (SRAY) as the proxy scale for the economies:

$$\mathrm{SRAY}(\boldsymbol{y_p}) = \frac{C^{FFCQ-M}(\boldsymbol{y_p}, \boldsymbol{w}, \boldsymbol{z}; \boldsymbol{\beta})}{\sum_{i=1}^{5} y_{ip} \cdot \mathrm{MC}(y_{ip})} \tag{7}$$

As shown in Table 7, SRAY exist up to 200% of mean output. This implies that we could achieve improvements in cost efficiency by expanding all outputs up to at least 200% of the current mean output. This finding is consistent with Zhang and Worthington (2016) using the same period of data, but slightly different from Worthington and Higgs (2011) using older data from 1998 to 2006, which indicated scale economies up to only 100% of mean output. This again confirms that the Australian university sector is currently experiencing economies of scale.

When not all outputs change proportionally, product-specific scale economies can reveal whether there are scale economies in which only one type of output varies at a time. These estimates ($\mathrm{PSCE}(y_{ip})$) are calculated by dividing $\mathrm{AIC}(y_{ip})$ in Table 5 by $\mathrm{MC}(y_{ip})$ in Table 6 at their corresponding p % of mean output. For example, the estimate of product-specific scale economies at 25% of mean output for domestic science completions is 1.10 (i.e. 88.77 is divided by 80.99). We observe consistent results regarding economies of scale. When considering completions as teaching outputs, there are economies of scale for overseas non-science completions up to 200% of output mean level. Another interesting finding is that the estimates of scale economies for the other three teaching outputs are not significant. This suggests that the current number of completions for these three outputs have achieved their cost efficient level and that universities could not increase efficiency further by increasing completions across these outputs.

<INSERT TABLE 7 HERE>

Investigating economies of scope provides further insights into possible strategy for future structural change. We calculate the estimate of global scope economies (GSE) as the percentage of cost savings from joint production relative to fully integrated costs or as the percentage increase in costs from specialised production:

$$\text{GSE}(\boldsymbol{y_p}) = \frac{\sum_{i=1;\, i\neq j}^{5} C^{FFCQ-M}(y_{ip}, y_{jp}=0, \boldsymbol{w}, \boldsymbol{z}; \boldsymbol{\beta}) - C^{FFCQ-M}(\boldsymbol{y_p}, \boldsymbol{w}, \boldsymbol{z}; \boldsymbol{\beta})}{C^{FFCQ-M}(\boldsymbol{y_p}, \boldsymbol{w}, \boldsymbol{z}; \boldsymbol{\beta})} \; for\; j = 1 \dots 5 \; but \; j \neq i. \qquad (8)$$

Overall, estimates of GSE in Table 8 support the joint production of all types of output, but at only 25% of mean output. The value of 0.34 indicated at least a 34% reduction in total costs from joint production at 25% of mean output. The negative estimates appear once the mean output exceeds 50%. This finding is slightly different from Zhang and Worthington (2016) and Worthington and Higgs (2011) as GSE are evident at least up to 125%. However, as both these analyses did not provide any significance test, we favour the more conservative level suggested here.

Similar to scale economies, the concept of scope economies can also apply to product-specific measures. The degree of product-specific scope economies (PSOE) for *i*-th type of product at p % of output mean could be denoted as:

$$\text{PSOE}(y_{\text{ip}}) = \frac{[C^{FFCQ-M}(y_{ip}, y_{jp} = 0, \boldsymbol{w}, \boldsymbol{z}; \boldsymbol{\beta}) + C^{FFCQ-M}(y_{ip} = 0, y_{jp}, \boldsymbol{w}, \boldsymbol{z}; \boldsymbol{\beta})] - C^{FFCQ-M}(\boldsymbol{y_p}, \boldsymbol{w}, \boldsymbol{z}; \boldsymbol{\beta})}{C^{FFCQ-M}(\boldsymbol{y_p}, \boldsymbol{w}, \boldsymbol{z}; \boldsymbol{\beta})} \qquad (9)$$

$for\; j = 1 \dots 5 \; but \; j \neq i$

Product-specific economies (diseconomies) of scope exist when $\text{PSOE}(y_{\text{ip}})$ is significantly larger (less) than zero. The presence of product-specific scope economies implies that the cost of producing a specific type of product jointly with the other types of products is *less* than that to produce it separately. Similar to the GSE results, the product-specific scope economies exist at only 25% of mean output except for domestic science. As the remaining estimates are not significant, it reflects that these quantities of outputs are cost efficient.

<INSERT TABLE 8 HERE>

Concluding Remarks

The significant and growing revenue streams made possible by international higher education have dominated the decisions of universities in providing this form of education. However, few studies have investigated its cost structure, let alone the possible benefits that may arise associated with these costs from economies of scale and scope that could also benefit domestic student services. Therefore, this study offers a comprehensive review of the costs and economies of providing higher education for overseas students using a sample of 37 Australian public universities over the period from 2003 to 2012. Most importantly, instead of inferring significance purely based on the estimates, as in most previous studies, we test all results using a two-sided t-test. Our main conclusions as follows correspond to the research questions initially proposed. We draw the conclusion from our estimation results and this should be especially useful for future study.

First, the unit and marginal costs for overseas students are not necessarily higher than are those for their domestic counterparts. In fact, our findings show that the costs of overseas students are lower or not significantly different to domestic students in that the costs mainly depend on the field of education and the quantity of output. In the non-science field of education, despite the observed differences, there is no significant difference in unit or marginal costs between domestic and overseas completions. On the other hand, in the science field of education, the marginal costs of overseas students are significantly lower than the costs of domestic students up to 125% of mean output. As discussed, this could be because of the typically shorter degree completion time of international students. From our findings, this effect has a stronger influence on lowering the costs of overseas science completions. The above findings provide a solid cost-side rationale for directing resources to international students other than the potentially higher revenues.

Second, our findings suggest two possible strategies for HEIs to achieve cost economies by adjusting their number of teaching outputs. For HEIs that wish to change only one output level at a time, we suggest an increase in the output of overseas non-science completions up to 200% of current mean output because there are only product-specific scale economies with this output. Note that our findings indicate that the other three types of outputs have already achieved their optimal number of completions and so Australian HEIs could seek to maintain their current number of domestic science and non-science and overseas science completions.

On the other hand, if HEIs wish to make all their outputs change together, the presence of economies of scale for Australian higher education suggest that they could increase all output levels proportionally up to 200% of the mean output. This implies that existing larger institutions have benefitted substantially from these cost advantages, while smaller Australian HEIs should seek to expand all their entire outputs proportionally in order to achieve the proven cost savings. In contrast, the cost saving (of between 8–9%) between domestic and international teaching is only found in very small institutions (less than 25% of mean output). Fortunately, there is no evidence of diseconomies of scope between these two outputs and therefore our results indicate that universities should maintain their current joint production of domestic and international students.

Finally, in contrast to most previous studies that did not provide tests of significance for their estimates of cost economies, our study clearly highlight the importance of these tests. From Tables 7 and 8, we can clearly observe that the wider confidence intervals (or larger standard errors) for these estimates increase with the percentage of mean output, implying less precision. This is not surprising as there are fewer large-size observations, leading to larger standard deviations for the estimates. In addition, we can see that estimates closer to the critical point are usually not significantly different from that point. These findings suggest that previous studies should not assert the presence of scale and scope (dis)economies simply because their estimates are (lower) higher than some critical point. In other words, for future studies, it is necessary to provide significance tests whenever inferring the existence of scale and scope economies.

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Tables

Table 1

Higher education delivery to international students in Australia

	Student number			% Growth	
	2011	2012	2013	2012	2013
International students in Australia	224,914	215,592	218,286	-4.1%	1.2%
Students at offshore campuses	80,458	82,468	84,785	2.5%	2.8%
Distance education students offshore [a]	27,205	25,552	25,331	-6.1%	-0.9%
Total	332,577	323,612	328,402	-2.7%	1.5%

Note: [a] Includes online learning and correspondence students studying award courses.

Source: Australian Government (2014)

Table 2

International student enrolments in Australian higher education: STEM fields by level of study, 2014

Broad field of education	Level of study				International student proportion of total students in post-graduate research
	Undergraduate	Postgraduate (Research)	Postgraduate (Other)	Total	
Engineering & related technologies	15,050	4,320	7,038	26,408	54.2%
Information technology	9,045	780	11,387	21,212	51.6%
Agriculture, environmental & related studies	1,332	617	792	2,741	45.6%
Natural & physical sciences	7,464	3,926	1,889	13,279	38.1%
Mathematics related	202	201	205	608	36.2%
All other broad fields of education	105,954	8,607	70,413	184,974	21.6%
Total	139,047	18,451	91,724	249,222	31.5%

Source: Australian Government (2015b)

Table 3

Selected Variable Statistics, 2003–2012

Variable	Description	Mean	Std dev.	Min.	Max.
Specific to the model with broad field of education					
y_1	Domestic science completions	1660.81	1099.60	179.00	4954.00
y_2	Domestic non-science completions	2985.09	1608.41	348.00	7795.00
y_3	Overseas science completions	668.35	485.54	3.00	2264.00
y_4	Overseas non-science completions	1499.12	1089.37	23.00	7044.00
Specific to the model with educational levels					
y_1	Domestic undergraduate completions	2,964.99	1,604.64	414.00	7,709.00
y_2	Domestic postgraduate completions	1,481.98	932.00	42.00	5,907.00
y_3	Overseas undergraduate completions	1,105.26	984.52	11.00	7,143.00
y_4	Overseas postgraduate completions	1,049.37	673.81	10.00	3,276.00
Shared variables in both models					
c	Total operating expenditure [a]	400,671.26	280,775.63	34,355.00	1,327,777.62
y_5	Number of publications	1,222.31	1,086.73	60.76	5,118.15
w_1	Price of academic labour [a]	76.82	15.67	52.22	131.99
w_2	Price of non-academic labour [a]	56.77	13.07	38.83	121.97
w_3	Price of non-labour [a]	8.58	4.18	3.30	28.98
z_q	Attrition rate (%)	18.07	6.10	6.21	38.83
z_{a1}	ATN institutions	0.14	-	0.00	1.00
z_{a2}	Go8 institutions	0.22	-	0.00	1.00
z_{a3}	IRU institutions	0.16	-	0.00	1.00
z_{a4}	RUN institutions	0.16	-	0.00	1.00
z_{a5}	Non-alliance group institutions	0.32	-	0.00	0.00
z_{g1}	Institutions located in NSW	0.27	-	0.00	1.00
z_{g2}	Institutions located in VIC	0.22	-	0.00	1.00
z_{g3}	Institutions located in QLD	0.19	-	0.00	1.00
z_{g4}	Institutions located in WA	0.11	-	0.00	1.00
z_{g5}	Institutions located in SA	0.08	-	0.00	1.00
z_{g6}	Institutions located in ACT	0.05	-	0.00	1.00
z_{g7}	Institutions located in TAS	0.03	-	0.00	1.00
z_{g8}	Institutions located in NT	0.03	-	0.00	1.00
z_{g9}	Institutions located over one state	0.03	-	0.00	0.00

Notes: [a] (i) In thousands of AUD (2003 = 100); (ii)Science includes the following fields of education: natural and physical sciences Information Technology, engineering and related technologies, architecture and building agriculture environmental and related studies and health; (iii)Non-science includes education, management and commerce, society and culture, creative arts, food hospitality and personal services (see ABS (2001) for details)

Table 4

Cost Function Estimates

	Field of Education		Level of Education			Field of Education		Level of Education	
	Coefficient	*t*-value	Coefficient	*t*-value		Coefficient	*t*-value	Coefficient	*t*-value
β_0	411.0147*	2.7252	696.7494*	4.2927	β_{w1}	0.2831*	3.5815	0.2874*	5.1144
β_1	2.9976*	3.7988	1.6992*	4.1931	β_{w2}	0.2703*	3.3364	0.2368*	3.5558
β_2	1.3520*	4.8983	2.3275*	3.8911	β_{w3}	0.4466*	15.3293	0.4758*	15.0091
β_3	0.3719	0.6536	2.4503*	6.0998	β_q	0.0060*	3.3739	0.0039	1.5477
β_4	1.1981*	3.4621	0.4040	0.9780	β_{a1}	0.0433	0.8917	0.1067*	3.6343
β_5	3.8387*	4.6462	4.6511*	6.4362	β_{a2}	0.0292	0.5343	0.0596	0.9351
β_{11}	-0.0013	-1.4302	0.0000	0.1418	β_{a3}	0.0307	0.9549	0.0530*	2.1884
β_{22}	-0.0003	-1.2703	-0.0008	-0.7724	β_{a4}	-0.0663	-1.6785	-0.0456	-1.0438
β_{33}	-0.0003	-0.3074	0.0002	0.9343	β_{r1}	-0.0579	-1.3844	-0.1104*	-3.3992
β_{44}	-0.0006*	-3.3123	0.0002	0.8082	β_{r2}	-0.0049	-0.1176	-0.0215	-0.4764
β_{55}	-0.0005	-1.3856	-0.0009*	-2.5403	β_{r3}	-0.0055	-0.1138	-0.0232	-0.4986
β_{12}	0.0000	-0.0350	-0.0005	-1.0298	β_{r4}	-0.0634	-1.3817	-0.1059*	-2.6130
β_{13}	0.0017	1.6645	-0.0003	-1.3205	β_{r5}	-0.1322*	-2.7630	-0.1530*	-4.0268
β_{14}	0.0000	0.1816	0.0007	1.6998	β_{r6}	-0.1943*	-4.3945	-0.2464*	-5.5495
β_{15}	0.0004	0.7957	0.0001	0.3176	β_{r7}	0.0131	0.2511	0.0031	0.0450
β_{23}	-0.0001	-0.4165	0.0003	0.4708	β_{r8}	-0.2334*	-4.0023	-0.2739*	-3.9268
β_{24}	0.0000	0.0989	-0.0001	-0.1593	*RSE*	0.0679		0.0675	
β_{25}	0.0003	1.0387	0.0007	1.6890	*AIC*	-904.3865		-908.5504	
β_{34}	0.0003	0.8375	-0.0012*	-2.5764	*SW*	0.9937		0.9855*	
β_{35}	-0.0020*	-2.0071	0.0002	0.6594	*Runs*	1.7921		-0.2559	
β_{45}	0.0004	1.2967	-0.0004	-0.5419					

Notes: (i) This table provides pooled NLS estimates for the nonlinear panel regression of ln(cost) on ln(independent variables); (ii) all coefficients ($\boldsymbol{\beta} = [\beta_i, \beta_{ii}, \beta_{ij}, \beta_{wl}, \beta_{zm}]\ where\ \beta_{zm} = [\beta_{ai}, \beta_{ri}, \beta_q]$) are consistent with the notations in equation (4): $\beta_{i,i=\{0,1,2,3,4,5\}}$ are the slope coefficients of the linear terms, $\beta_{ii,i=\{1,2,3,4,5\}}$ are the slope coefficients of the quadratic terms, $\beta_{ij,i=\{1,2,3,4,5\},j=\{1,2,3,4,5\}\ but\ i\neq j}$ are the slope coefficients of the cross-product terms, $\beta_{wl,l=\{1,2,3\}}$ are the slope coefficients of the prices, $\beta_{ai,i=\{1,2,3,4\}}$ are the slope coefficients of the dummy variables for alliance group, $\beta_{ri,i=\{1,\dots,8\}}$ are the slope coefficients of the dummy variables for region, and β_q is the slope coefficient of the dropout rate; (iii) all *t* tests for coefficients are corrected by using clustering standard errors at the institution level; and (iv) * denote significance at the 0.05 level. (v) $\beta_{0i}F_{ih}$ are not included in the function since all the institutions in the sample provide positive values of all outputs (Longlong, Fengliang, & Weifang 2009)

Table 5

Point Estimates of Average Incremental Costs of Teaching Outputs by Broad Field of Education

p	$AIC(y_{1p})$	$AIC(y_{2p})$	$AIC(y_{3p})$	$AIC(y_{4p})$	$AIC(y_{5p})$	$AIC(y_{1p}) - AIC(y_{3p})$	$AIC(y_{2p}) - AIC(y_{4p})$
25	88.77	37.20	13.70	36.83	112.54	75.07*	0.37
						[8.62 141.52]	[-24.5 25.23]
50	92.53	36.06	16.85	39.68	116.23	75.68*	-3.63
						[7.13 144.23]	[-25.8 18.55]
75	96.30	34.91	20.00	42.54	119.92	76.30*	-7.62
						[2.87 149.73]	[-29.29 14.05]
100	100.07	33.77	23.15	45.39	123.61	76.91	-11.61
						[-3.68 157.50]	[-35.09 11.86]
125	103.83	32.63	26.30	48.24	127.30	77.53	-15.61
						[-11.95 167.01]	[-42.76 11.54]
150	107.60	31.49	29.46	51.09	130.99	78.14	-19.60
						[-21.5 177.78]	[-51.65 12.44]
175	111.36	30.35	32.61	53.95	134.68	78.76	-23.60
						[-31.97 189.48]	[-61.3 14.1]
200	115.13	29.21	35.76	56.80	138.37	79.37	-27.59
						[-43.1 201.85]	[-71.4 16.22]

Notes: (i) All estimates in A$ thousands (2003 = 100); (ii) output mean is the arithmetic mean over the 10 years (i.e. 370 observations) while input prices are set to their respective means in all of the calculations; (iii) 95% confidence intervals for each difference estimate are given below in square brackets [ ]; and (iv) * denote estimates statistically significant difference from zero at the 0.05 level for a two–tailed *t*-test.

Table 6

Point Estimates of Marginal Costs of Teaching Outputs by Broad Field of Education

p	$MC(y_{1p})$	$MC(y_{2p})$	$MC(y_{3p})$	$MC(y_{4p})$	$MC(y_{5p})$	$MC(y_{1p}) - MC(y_{3p})$	$MC(y_{2p}) - MC(y_{4p})$
25	80.99	33.97	12.93	33.44	110.28	68.05*	0.53
						[9.31 126.79]	[-22.94 24.00]
50	76.97	29.61	15.32	32.91	111.70	61.65*	-3.30
						[10.89 112.42]	[-22.22 15.61]
75	72.96	25.24	17.71	32.38	113.12	55.25*	-7.14
						[11.41 99.09]	[-23.55 9.28]
100	68.95	20.88	20.09	31.85	114.54	48.85*	-10.97
						[10.31 87.39]	[-27.88 5.94]
125	64.93	16.52	22.48	31.32	115.97	42.45*	-14.80
						[6.85 78.05]	[-34.98 5.38]
150	60.92	12.15	24.87	30.79	117.39	36.05*	-18.63
						[0.45 71.65]	[-43.8 6.53]
175	56.90	7.79	27.26	30.26	118.81	29.65	-22.47
						[-8.9 68.20]	[-53.52 8.58]
200	52.89	3.42	29.64	29.72	120.23	23.25	-26.30
						[-20.6 67.10]	[-63.71 11.11]

Notes: (i) All estimates in A$ thousands (2003 = 100); (ii) output mean is the arithmetic mean over the 10 years (i.e. 370 observations) while other shared variables are set to their respective means in all of the calculations; (iii) 95% confidence intervals for each difference estimate are given below in square brackets [ ]; and (iv) * denotes estimates statistically significant difference from zero at the 0.05 level for a two–tailed *t*-test.

Table 7

Point Estimates of Scale Economies at Percentages of Current Mean Output

p	$PSCE(y_{1p})$	$PSCE(y_{2p})$	$PSCE(y_{3p})$	$PSCE(y_{4p})$	$PSCE(y_{5p})$	SRAY$(\boldsymbol{y_p})$
25	1.10	1.09	1.06	1.10*	1.02	1.13*
	[0.97 1.22]	[0.97 1.22]	[0.78 1.34]	[1.02 1.18]	[0.99 1.05]	[1.05 1.20]
50	1.20	1.22	1.10	1.21*	1.04	1.10*
	[0.94 1.47]	[0.90 1.51]	[0.58 1.62]	[1.06 1.35]	[0.99 1.09]	[1.06 1.14]
75	1.32	1.38	1.13	1.31*	1.06	1.10*
	[0.91 1.73]	[0.76 1.88]	[0.42 1.84]	[1.13 1.50]	[0.98 1.14]	[1.07 1.14]
100	1.45	1.62	1.15	1.43*	1.08	1.12*
	[0.88 2.03]	[0.49 2.42]	[0.27 2.03]	[1.20 1.65]	[0.98 1.18]	[1.07 1.17]
125	1.60	1.98	1.17	1.54*	1.10	1.14*
	[0.83 2.37]	[-0.12 3.32]	[0.15 2.19]	[1.29 1.79]	[0.97 1.22]	[1.07 1.22]
150	1.77	2.59	1.18	1.66*	1.12	1.17*
	[0.77 2.76]	[-1.68 5.21]	[0.05 2.32]	[1.37 1.95]	[0.97 1.26]	[1.08 1.27]
175	1.96	3.90	1.20	1.78*	1.13	1.20*
	[0.66 3.25]	[-7.17 11.09]	[-0.05 2.44]	[1.43 2.13]	[0.96 1.30]	[1.08 1.33]
200	2.18	8.53	1.21	1.91*	1.15	1.24*
	[0.48 3.87]	[-50.74 55.09]	[-0.13 2.54]	[1.45 2.37]	[0.96 1.34]	[1.08 1.40]

Notes: (i) Output mean is the arithmetic mean over the 10 years (i.e. 370 observations) while other shared variables are set to their respective means in all of the calculations; (ii) 95% confidence intervals for each difference estimate are given below in square brackets [ ]; and (iii) * denotes estimates statistically significant difference from one at the 0.05 level for a two–tailed *t*-test.

Table 8

Point Estimates of Economies of Scope at Percentages of Current Mean Output

p	$\mathrm{PSOE}(y_{1\mathrm{p}})$	$\mathrm{PSOE}(y_{2\mathrm{p}})$	$\mathrm{PSOE}(y_{3\mathrm{p}})$	$\mathrm{PSOE}(y_{4\mathrm{p}})$	$\mathrm{PSOE}(y_{5\mathrm{p}})$	$\mathrm{GSE}(\boldsymbol{y}_{\mathbf{p}})$
25	0.06	0.08*	0.09*	0.08*	0.08*	0.34*
	[-0.03 0.14]	[0.01 0.16]	[0.03 0.15]	[0.01 0.14]	[0.00 0.16]	[0.09 0.58]
50	-0.03	0.02	0.04*	0.01	0.02	0.11
	[-0.19 0.13]	[-0.08 0.13]	[0.00 0.08]	[-0.05 0.07]	[-0.06 0.10]	[-0.05 0.27]
75	-0.10	-0.01	0.02	-0.03	-0.01	-0.01
	[-0.35 0.16]	[-0.17 0.16]	[-0.03 0.06]	[-0.1 0.04]	[-0.11 0.08]	[-0.20 0.18]
100	-0.15	-0.03	0.00	-0.06	-0.04	-0.10
	[-0.51 0.20]	[-0.26 0.20]	[-0.05 0.06]	[-0.16 0.04]	[-0.17 0.09]	[-0.35 0.15]
125	-0.21	-0.05	-0.01	-0.09	-0.07	-0.18
	[-0.67 0.25]	[-0.35 0.25]	[-0.08 0.06]	[-0.21 0.03]	[-0.22 0.09]	[-0.50 0.14]
150	-0.27	-0.07	-0.02	-0.12	-0.09	-0.26
	[-0.83 0.30]	[-0.44 0.29]	[-0.11 0.07]	[-0.27 0.03]	[-0.28 0.10]	[-0.65 0.14]
175	-0.32	-0.09	-0.03	-0.15	-0.11	-0.33
	[-1.00 0.35]	[-0.53 0.35]	[-0.13 0.07]	[-0.33 0.03]	[-0.34 0.12]	[-0.80 0.14]
200	-0.38	-0.11	-0.04	-0.18	-0.14	-0.40
	[-1.17 0.4]	[-0.63 0.40]	[-0.16 0.08]	[-0.39 0.03]	[-0.40 0.13]	[-0.96 0.15]

Notes: (i) Output mean is the arithmetic mean over the 10 years (i.e. 370 observations) while other shared variables are set to their respective means in all of the calculations; (ii) 95% confidence intervals for each difference estimate are given below in square brackets [ ]; (iii) * denotes estimates statistically significant difference from zero at the 0.05 level for a two–tailed *t*-test.