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Competition and Efficiency: Overseas students and technical efficiency in Australian and New Zealand universities

Chris (Hristos) Doucouliagos
School of Accounting, Economics and Finance
Deakin University

Malcolm Abbott
KPMG

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Chris (Hristos) Doucouliagos

School of Accounting, Economics and Finance
Deakin University

Malcolm Abbott

KPMG

Abstract

Economic theory suggests that competitive pressures will impact on organisational efficiency. In recent years, universities in Australia and New Zealand have faced increased competition for students. The aim of this paper is to explore the efficiency of Australian and New Zealand public universities and to investigate the impact of competition for students from overseas on efficiency. Output distance functions are estimated using panel data for the period 1995-2002 for Australia and 1997-2003 for New Zealand. The results show that competition for overseas students has led to increased efficiency in Australian universities. However, competition for overseas students appears to have had no effect on efficiency in New Zealand.

[1] Corresponding author: Doucouliagos, Deakin University, 221 Burwood Highway, Burwood, Victoria, 3125, Australia. Email: douc@deakin.edu.au

[2] All views, comments, errors and omissions are the responsibility of the authors and not their employing organisations.

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1. Introduction

In recent years, one of the fastest growing areas of international trade has been in the provision of education services across national borders. In the early 2000s, around two million higher education students were studying outside of their country of origin and it has been estimated that this number could potentially rise to five million over the next twenty years (OECD 2002).

In the Australian case, the growth of higher education overseas student numbers was quite substantial during the late 1990s and early 2000s. From a figure of 40,494 students in 1994 (or 6.9 per cent of all students enrolled in Australian higher education), overseas student numbers (either onshore, distance or offshore) have risen to 210,397 by 2003 (or 22.6 percent of students: *Selected higher education student statistics*). The vast majority of these overseas students are enrolled in the government-owned universities.[3] As well as attracting students to home campuses in Australia, these universities have also promoted overseas enrolments through the use of offshore provision and distance education. Through the development of twinning programmes and direct investment abroad, Australian universities now have a presence in countries such as Malaysia, Hong Kong, China, Singapore, Fiji, South Africa, New Zealand and the Gulf States. Although New Zealand universities do not have as high a proportion of their students from overseas, they do enrol a far higher proportion of students from overseas than was the case in the early 1990s. In 1994 there were 5,567 overseas students enrolled in New Zealand tertiary institutions. By 2003 this figure had risen to 34,915 (10.4 percent in 2002 compared to only 2.8 percent in 1994; Table 1).[4]

TABLE 1 ABOUT HERE

[3] In 2003, Australian universities (including Bond and Notre Dame) enrolled 209,803 overseas students or 99.7 percent of overseas higher education students studying in Australia (*Selected higher education student statistics*).

[4] The New Zealand tertiary education figures include those for the polytechnics. The bulk of overseas students however are enrolled in the eight universities (Auckland, Canterbury, Victoria, Otago, Massey, Waikato, Lincoln and AUT). In 2003 there were 25,090 overseas enrolments in New Zealand universities (15.6 percent of total enrolments: *Annual reports*).

In both cases expansion of overseas enrolments in Australian and New Zealand universities has tended to be driven by the growth in demand by students from the rapidly emerging economies in Northeast and Southeast Asia. In attempting to attract students from these locations, Australian and New Zealand universities have had to compete strenuously with universities from within their own countries, as well as with countries such as the United States, Canada, Malaysia, Japan, the United Kingdom and Ireland. These universities, therefore, are now the subject of greater levels of competition because of their attempts to venture into international markets.

Australian and New Zealand universities have been attracted to seeking overseas enrolments for two main reasons. First, overseas students are more profitable than domestic students. Universities are able to charge full-fees for overseas students, while most domestic placements attract a lower fee.[5] Second, financial pressures on universities have increased as Federal governments in both countries have sought to increase the number of students enrolled at the tertiary sector without corresponding increases in real funding. The purpose of this paper is to examine if this exposure to international markets has impacted on the level of efficiency and productivity of Australian and New Zealand universities. Stochastic Frontier Analysis (SFA) is used to determine the levels of efficiency of the universities in both countries, and to explore the links between efficiency and exposure of the universities to international competition (as indicated by the proportion of students in universities from abroad). In the first section of this paper, a general background is given to the nature of the universities in Australia and New Zealand and the effects of competition on efficiency. In the following section the analytical framework is explained. This is then followed by a presentation and examination of the results.

2. Background

Over the past twenty years, the Australian and New Zealand economies have been through a process of considerable micro-economic reform. One of the key elements of this process has been the opening up of markets to increasing levels of competition. The purpose of this reform has not been to promote competition for its own sake, but instead for competition to be used as a means by which higher levels of efficiency might be achieved, and social

[5] In recent years, Australian universities have been able to offer full-fee positions for domestic students, but these are still a smaller proportion of the domestic market.

welfare increased. Economists generally accept that market competition is an important driver of efficiency. Companies - and indeed organisations in general - that are strongly exposed to the pressures of competition are generally compelled to improve their methods of production and increase their levels of output compared to inputs (technical efficiency) and allocate resources to the production of goods and services that consumers desire (allocative efficiency). If they do not do so, then they often lose market share to their more efficient rivals. If companies in general were forced to achieve higher levels of efficiency then it would be expected that the productive capacity of the economy would be raised and a higher standard of living for a country's inhabitants achieved.

Traditionally, Australian and New Zealand universities have operated in markets that were imperfect in that the institutions did not have to fully compete with each other or with institutions abroad. During the 1970s and 1980s students in both countries had their fees paid entirely by government subsidy. In the 1990s domestic students paid a proportion of their fees in both countries, although these did not cover the full cost of their tuition. This means that the demand by domestic students for higher education in both countries was greater than it would have been had students paid for the full cost of their education. Most universities in Australia and New Zealand, therefore, saw domestic enrolments grow at steady rates over the course of the 1970s, 80s and 90s without them having to compete too strenuously with each other. Competition between institutions certainly did occur, in the sense that universities did try to attract the better students, but few institutions in either country faced insufficient student demand for places as overall student demand in each country ran ahead of the supply of places.[6]

Australian and New Zealand universities today still operate in a climate of heavy government regulation. Nevertheless, the Australian university system in particular has over the years been sequentially partially deregulated.[7] Government funding in both countries has a large degree of influence on what universities can teach and fee levels in both countries for domestic students are the subject of controls. Universities in both countries are the subject of government imposed quality assurance regimes and to some degree the institutional

[6] Certainly there were a few institutions that did struggle to attract students but in most cases student places were filled simply by lowering entry standards rather than by competing in terms of fees charged.

[7] For a history of the deregulation process and the evolution of funding arrangements for Australian universities see Marginson (2006).

arrangements of job tenure and enterprise salary agreements restrict the degree of autonomy of university managers.

With a lack of competitive pressure in the higher education market evident in both countries, it would be expected that a number of universities would operate at below best practice levels of efficiency and productivity. This would appear to have been borne out by the few studies that have been conducted on this issue (Coelli 1996; Abbott and Doucouliagos 2003; Carrington, Coelli and Rao 2005).[8] The situation in both countries has not been a static one; however, and in fact universities in both countries are now forced to attract an increasing proportion of their students from overseas, which do have to pay the full cost of their tuition. As this proportion rises, it would be expected that there would be additional pressure put on the universities to improve their level of efficiency so that they could remain price competitive in international markets. It needs to be noted that increasing the number of overseas students does not lessen competitive pressures, it increases them. An important feature of overseas students is that universities are able to charge them higher fees. This makes overseas students more attractive than domestic students and, hence, Australian and New Zealand universities have been aggressively targeting overseas students and competing against each other in this more lucrative market.

The raising of the efficiency at which universities operate is an important issue. The better resources are used to educate students and to conduct research in the universities, the more of both that can be produced with a given level of resources, or alternatively the greater the resources that can be released for other purposes. If the growing level of competition that the universities face is not bringing about higher levels of efficiency, then it is important to identify why this might not be occurring and rectify whatever impediments to efficiency enhancement there may be. Efficiency is an important component of productivity. *Ceteris paribus*, an increase in efficiency results in an increase in productivity. Hence, the association between competition for overseas students and the efficiency of universities is of major policy interest.

[8] These studies do however find that overall Australian universities operate at relative high levels of technical efficiency.

2.1 The importance of competition

Hay and Liu (1997) discuss several channels through which competition can affect efficiency. First, competition creates incentives to compare performance and it creates possibilities for performance appraisal. Information on relative performance is an important step in changing practices. Second, relative performance can be used as an indicator of managerial effort and this may spur managers to implement change. Third, efficiency improvements result in lower relative costs and, hence, higher market share and higher price cost margins.

While these forces may not apply with equal force to non-profit organizations such as universities, it is nevertheless the case that even in higher education there are strong incentives for administrators to monitor their costs. There is also a strong incentive for administrators to raise revenues. Universities derive revenue from many sources: governments, private donations, tuition fees and research and consultancy activities. The relative profitability of these different activities depends on the varying marginal costs and benefits. A profit maximising organisation would obviously strive to maximize the difference between revenues derived from all activities and the costs associated with those activities. In a multi-product setting, the profit maximiser would strive to produce where the marginal rate of transformation between the alternative products is equal to the ratio of their prices. It would be a bold to assume that the publicly funded universities under investigation are profit maximisers. Even though they have been partly deregulated and the importance of commercial considerations has grown significantly, their objective function is unlikely to be to maximize profits. Moreover, they may even lack some of the critical data on costs and prices for some of the outputs are not clear.[9] Nevertheless, it is reasonable to assume that administrators would prefer more revenue to less. For example, university managers prefer better facilities and they would like to keep academics happy, e.g. through higher salaries, more generous conference funding, and state-of-the-art research facilities. Moreover, budget constraints exert at least some discipline on costs.

Some authors argue that competition does not apply to the university sector, at least not in the same way as it would in the private sector. For example, Winston (1999) and Franck and

[9] There is some interdependence between these factors. For example, if they are not concerned about maximizing profits, they will exert less effort to collect all the data on costs.

Schönfelder (2000) note the 'credence good' nature of much of university output, while Marginson (2006) focuses on the 'positional good' nature of university qualifications.[10] It is true that the quality of many of the university outputs is unknown. This is particularly so for teaching, though not so for consultancy and all types of research. It is also true, that reputation is important for many, if not most students. These factors, however, shape the nature of competition but do not eliminate it. Nor do they necessarily prevent competition from affecting efficiency.

Competition between universities occurs across a wide range of markets. At one level, universities compete for positional goods (Marginson 2006). This involves competition among students for places at the elite and higher ranked universities. Marginson (2006, p. 8) notes that at the other end of the higher education market there "… is high volume basic higher education, under-funded by states and often produced in quasi-commercial or commercial markets, marked by place-filling, expansionism and low unit positional value." These institutions 'struggle to fill their places and secure revenues' (p. 7).

In addition to competing to attract students (government subsidized places, domestic full-fee paying students, and the lucrative full-fee international student market), universities compete for external research funding and consultancy projects. They compete for relative status and ranking and they compete for research impact.[11] [12] They compete in academic labour markets to attract staff. Additionally, the Australian government (like those of the U.K. and New Zealand) is introducing a research assessment exercise. Known as the Research Quality Framework, this will rank universities according to research quality and research impact. This has already had the effect of increasing competition between universities in the research domain. Further, there is growing competition from the private sector, both from private

[10] There is also the view that universities are custodian of "truth". Consequently, some authors fear that commercialization will convert universities from scholars to entrepreneurs, which may have a negative effect on universities' ability to meet the public interests (Currie and Vidovich 2000).

[11] For example, Australian universities encourage staff to engage with media and policy communities.

[12] It is not uncommon for universities to use Open Days as a form of competition, with many open days held either on the same day or close to each other. There is an amusing story of one university parking a bus with their own advertisement outside another university's open day.

universities and other education and training providers and private consulting and research firms.[13]

Since enrolments for non-full-fee paying students are constrained by the government, universities have an incentive to expand enrolments of full-fee paying students. Three broad sets of incentives reinforce the pressure to do so. First, expansion in enrollments is warranted commercially if it enables the realization of economies of scale and scope. Second, managerialism results in the quest for larger departments and better facilities. Third, it could arise indirectly from academic pressure. Expansion of student enrollments enables expansion of academic internal labour markets and creates more senior academic positions. This benefits academic staff, some of whom may even protest the commercialisation of faculties, even if they directly and indirectly benefit from it.[14]

Universities do not have to become more efficient in order to attract students. However, the process of competing for students may force universities to become more efficient. That is, the issue is an empirical matter. Unfortunately, there is a dearth of evidence linking competition to efficiency, and the extant literature is not solid (see Whitty and Power 2000). This paper is one attempt to inform on this issue.

2.2 The importance of international students

Our particular focus in this paper is competition for overseas students. The effects of competition for overseas students are derived from the effects of competition outlined above. We show in this paper that it has been competition for overseas students that has resulted in increased efficiency, *on average*, across Australian universities. This has not for been the case in New Zealand. The reason for focusing on international students can be found in Table 2, which traces the evolution of full-fee students in Australia over 1999 to 2005 period. It can be seen from this table that not only are overseas full-fee paying students the largest component of the fee paying population, but their share has increased over the period. In

[13] The Australian government has also offered universities additional funding if they introduce the somewhat controversial Australian Workplace Agreements.

[14] Administrative efficiency is not a top priority for students. However, where administrative practices impinge upon students, students may put pressure on universities to improve efficiency.

1999, domestic full-fee paying students were 25% of the total number of full-fee paying students. By 2005, this had declined to 15%. At the same time, however, the proportion of all students who were full-fee paying had increased from just under 20% to just over one third. That is, full-fee paying students have become more important in Australia and the main factor behind this has been competition for overseas students.

TABLE 2 ABOUT HERE

As deregulation of the Australian university sector continues, competition for both students and research income has increased. However, for the period studied in this paper, competition in the teaching domain was predominantly for overseas students. Hence, we focus on this group.[15]

Overseas enrollments are an addition to domestic enrollments – they do not displace domestic students. The fees charged to international students are meant to cover the total cost of tuition, including a capital component. International students are not cross-subsidised by the taxpayer (except for those cases involving foreign aid). Students are attracted to Australia for many reasons. Part of the attraction has to do with costs relative to other countries (see, for example, Back, Davis and Olsen 1997), part of it has to do with the experience of studying in Australia and part of it relates to visa issues.

Fees vary from course to course and from university to university. The costs of delivering university courses are complex, involving different modes of delivery, and information is limited. Even if it is assumed that the marginal cost of an overseas student is at least equal to if not higher than a domestic one, the higher fees charged to overseas students should offset these costs. Australian universities have been keen to enroll these students and, hence, it has to be assumed that there is a net benefit to them from doing so.

The distribution of overseas student enrollments is not equal across all disciplines and faculties. For example, in 2002, 20.2% of domestic students were enrolled in the management and commerce field, compared to 35.2% of all overseas students residing in Australia and

[15] As data accumulates, it will be interesting to see how the further liberalisation of the fee structure has affected universities.

58.7% of all overseas students residing overseas. In contrast, 11.2% of domestic students were enrolled in education compared to only 2% of overseas students residing in Australia (see Department of Education, Science and Training 2004).

Amongst the Australian universities it is possible to divide them into three groups based on their origins. The first group are the older universities that existed before the creation of the Unified National System in 1988. The rest of the universities were created substantially from converted Colleges of Advanced Education after 1988 and are often referred to as "Dawkins universities" after John Dawkins, the government minister associated with their conversion. Of the older universities a sub-group of eight universities are often associated as being those with the greatest prestige in Australia and are often known as the "Group of Eight". The most substantial difference between these groups is that the Dawkins universities tend to have lower research output compared to the older universities and in particular the Group of Eight. Another point of difference between the Dawkins universities and the other universities is the proportion of students that they have from overseas. Figure 1 compares the proportion of overseas students for the Dawkins universities, the non-Dawkins universities, and the Group of Eight. It is clear from Figure 1 that the Dawkins universities have the highest overseas students ratio and highest rate of growth in this ratio.[16] The most likely explanation for this is that the Dawkins universities are at a relative disadvantage in attracting income because of their often lower relative standing, and their lower research output, and subsequent lower government funding and research contract income. Enrolling full-fee paying overseas students has been one way for them to attract additional income. The issue then is what impact this has on their operational efficiency.

FIGURE 1 ABOUT HERE

[16] The Dawkins universities are: the Australian Catholic University, Central Queensland University, Charles Sturt University, Curtin University of Technology, Edith Cowan University, Queensland University of Technology, RMIT University, Southern Cross University, Swinburne University of Technology, University of Ballarat, University of Canberra, University of Southern Queensland, University of Technology, Sydney, University of Western Sydney, and Victoria University of Technology. The Group of 8 universities are: the Australian National University, Monash University, University of Adelaide, University of Melbourne, University of New South Wales, University of Queensland, University of Sydney, and University of Western Australia.

3. Analytical Approach

Both Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) can be used to estimate the degree of technical efficiency in the university system. In the past, both methods have been used to evaluate the efficiency of institutions in a range of industries including higher education (for summaries see Abbott and Doucouliagos 2003; and Worthington 2001). DEA and SFA are two means by which efficiency levels of like institutions can be ranked. They both effectively compare outputs to inputs and order the institutions in terms of their relationship to a best practice standard. In the case of the non-parametric technique, DEA, the best practice standard is the most efficient institution(s) in the group. In the case of the parametric estimation technique, SFA, a best practice (maximum output attainable) frontier is estimated and the sample institutions compared to this level. That is, with DEA there will always be some institutions that are deemed to be on the frontier, while with SFA none of the institutions need be on the frontier. For a full explanation of these methodologies see Coelli, Rao and Battese (1998). In this paper, we present the results of applying SFA to the three different samples in order to determine if any consistency in the results can be achieved. In our context, a major benefit of SFA is that it enables statistical significance testing of key associations. Moreover, it enables also the adoption of the Translog functional form, so that complex interactions can be modelled.

3.1 Econometric Specification

Our preferred estimation methodology is to estimate a stochastic output distance frontier. This parametric technique offers useful information on the underlying education production process, as well as information on the extent of inefficiency and the determinants of inefficiency. The Translog version of the output distance function is given by:

$$\ln D_{Oit} = \alpha_0 + \sum_{m=1}^{M} \alpha_m \ln y_{mit} + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{M} \alpha_{mn} \ln y_{mit} \ln y_{nit} + \sum_{k=1}^{K} \beta_k \ln x_{kit} + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \beta_{kl} \ln x_{kit} \ln x_{lit} + \sum_{k=1}^{K}\sum_{m=1}^{M} \gamma_{km} \ln x_{kit} \ln y_{mit} \quad (1)$$

where ln denotes the natural logarithm, i denotes the ith university, D_0 is the output distance function, there are m outputs (y) and k inputs (x). Equation 1 enables interaction between the various inputs and outputs. The benefit of using a Translog specification is that the inclusion of cross-terms offers valuable information on input and output substitution possibilities. Hence, this specification is preferable to more restrictive specifications, such as the Cobb-Douglas version. It is necessary to impose a number of constraints on the output distance function in order to ensure homogeneity of degree one in *outputs*, as well as symmetry (see O'Donell and Coelli (2005). This can be achieved by choosing arbitrarily one of the outputs as the normalizing variable, and in this paper research performance is used to serve this role.[17] Equation 2 shows the normalized output-orientated distance function.

$$\ln\left(D_{oit} / y_{1it}\right) = \alpha_{0i} + \sum_{m=2}^{M} \alpha_m \ln y^*_{mit} + \frac{1}{2}\sum_{m=2}^{M} \sum_{n=1}^{M} \alpha_{mn} \ln y^*_{mit} \ln y^*_{nit} + \sum_{k=1}^{K} \beta_k \ln x_{kit}$$
$$+ \frac{1}{2}\sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kl} \ln x_{kit} \ln x_{lit} + \sum_{k=1}^{K} \sum_{m=2}^{M} \gamma_{km} \ln x_{kit} \ln y^*_{mit} \qquad (2)$$

where $y^*_m = y_m/y_1$ and thus $y^*_1 = 1$. $\ln D_0$ is obviously not observable. However, when normalised, the dependent variable in equation 1 becomes $\ln(D_{0i}/y_{1it})$, as in equation 2. This can be rewritten as $\ln(D_0)-\ln(y_m)$. Hence, we can make the dependent variable $-\ln(y_m)$, and transfer $\ln(D_0)$ to the residuals.

Coelli and Perelman (2000) use $-\ln(y_m)$, while we follow Paul *et. al.* (2000) and use $\ln(y_m)$ as the dependent variable. Using stochastic frontier estimation techniques applied to output distance function means that we allow both inefficiency as well as random errors to occur in the production process.[18] This is achieved by adding an error/residual term to equation (2) and then decomposing the error/residual term into a random component as well as a component attributable to technical inefficiency. For an excellent discussion on these issues, as well as the estimation of the output distance function by maximum likelihood techniques see Coelli *et al.* (1998).

For Australian universities, we use a three outputs and two inputs model, where the three

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[17] The restrictions required for homogeneity of degree one in outputs are: $\sum_{m=1}^{M} \alpha_m = 1$; $\sum_{n=1}^{M} \alpha_{mn} = 0$; and $\sum_{m=1}^{M} \gamma_{km} = 0$. For symmetry we require: $\alpha_{nm} = \alpha_{mn}$ and $\beta_{kl} = \beta_{lk}$.

[18] In our specification, the random error also captures the influence of any inputs other than academic and non-academic labour.

outputs are research output, the number of post-graduate students and under-graduate students (the two teaching outputs), and the two inputs are academic and non-academic employees. Note that the student numbers are not actual numbers of students but the equivalent full-time status (or EFTSU). Academic and non-academic employees are also measured on a full-time equivalent basis. Estimating the research output of a university is a contentious issue. In the Australian case a weighted index of various research outputs is calculated. The research types are: books, book chapters, journal articles and other. The weighting used was books (0.4), book chapters (0.2), journal articles (0.3) and other (0.1).[19] The Australian Government's, Department of Education, Science and Technology collect data on the different research categories. For details on the use of this series and the weights used to construct an aggregate research output series see Abbott and Doucouliagos (2004).

We chose not to include students as an input. One approach is to include the number of enrolments as an input and the number of graduates as an output. For example, this is the approach adopted by Worthington and Lee (2007). We follow Abbott and Doucouliagos (2003) and treat the number of students enrolled as an output. We wish to capture the teaching aspect of academia. This, we believe, is best captured by including the number of students enrolled as an output not an input, and instead of using the number who graduate as an output. Enrolments is a better proxy for teaching activity (teaching, consultation, marking) than the number of students that graduate. Abbott and Doucouliagos (2003) note two additional problems with the use of graduations as an output measure. First, a high rate of graduation could just as easily reflect low standards (tendency to pass students, especially full-fee paying ones) rather than teaching effort. Second, graduations are highly correlated with enrolments. This means that econometric estimates that use a similar and highly correlated measure as both an input and an output could lead to biased estimates. An additional consideration is that both Worthington and Lee (2007) and Abbott and Doucouliagos (2003) use DEA, while we are using a Translog specification of a stochastic output distance function. This means that we face greater restrictions on degrees of freedom.

[19] Using different weights does not change the results reported in the paper to any significant extent.

3.2 Data issues

In conducting this study, a variety of sources of data are used. In the Australian section we use two separate samples. The first involves using data from the 36 Australian government-owned universities that operated over the years 1995 to 2002.[20] The second sample used is for seven government-owned universities in New Zealand for the period 1997 to 2003.[21] The data for the Australian study has been taken from the statistical publications of the Higher Education Division of the Australian Government's Department of Education, Science and Technology. The New Zealand data has been taken from the Annual Reports of the seven universities. The time periods have been selected due to the availability of relevant information in all two cases.[22]

The econometric results need to be interpreted in the context of several data issues.

First, universities deliver several outputs, including research, teaching, community services and consultancies. We lack data on community services and consultancies and, hence, are forced to abstract from these outputs. This abstraction should not come at too big a cost, as research and teaching are indeed the primary activities of Australian universities.

Second, we lack data on capital inputs and, hence, are unable to consider the contribution of this factor to the education production process. Labour and research income are the main

[20] To maintain homogeneity of the sample, private universities such as Bond University in Queensland and Notre Dame in Western Australia have been excluded from the analysis, as is the University of the Sunshine Coast, which did not operate throughout the whole of the period.

[21] Data for the Auckland University of Technology has not been included as it had polytechnic status before 2000.

[22] We collected also data for a third sample, for 34 business or commerce faculties associated with the Australian government universities, for the period 1997 to 2000. Commerce faculties attract the largest proportion of overseas students to Australian universities. In 2003, 45 percent of all overseas enrolments at Australian higher education institutions were in business faculties (*Selected higher education statistics*). We used data from Cecez-Kecmanovic *et al.* (2002). Unfortunately, the level of detail is not as good as at the university level. Data at the business faculty level is available for the total number of equivalent full-time students, the full-time equivalent academics employed and non-academic staff employed. The analysis for Business faculties is somewhat problematic in that universities differ in the share of administrative and other duties that occurs at the faculty, rather than the university level. However, the analysis does confirm the results for Australian universities as a whole: the coefficient on the overseas students variable is statistically significant and has the expected positive effect on effeciency. These results are available from the authors.

inputs and, hence, this restriction should also not be too problematic for our analysis. Indeed, over the period studied, direct salaries were 60 percent of total operating expenses.

Third, we are forced to ignore issues of quality differences on both the inputs and outputs. This is an issue that has plagued all prior researchers of Australian universities (see Abbott and Doucouliagos 2003 on this issue) and indeed most studies of university efficiency world-wide. However, we do attempt to capture teaching quality with a measure of generic skills.

Fourth, there is obviously a lag between the publication of research output and the generation of that research. In establishing input-output associations, it is necessary to match the inputs to the outputs. Our approach is to follow Abbott and Doucouliagos (2004) and assume that there is, on average, a one year lag between the generation of research and the reporting of research in journals, conferences etc. [23]

Equation 2 is used to identify the best practice frontier. We also use a separate equation to identify the determinants of technical inefficiency. This is given by:

$$DTE_{it} = \alpha_0 + \alpha_1 OS_{it} + \alpha_2 OS_{it}^2 + \alpha_3 RA_{it} + \alpha_4 D_{it} + \alpha_5 SA_{it} + \alpha_6 SC_{it} + \alpha_7 O_{it} + \alpha_8 T + \varepsilon_{it} \quad (3)$$

where DTE is the measure of technical inefficiency (not efficiency) of the ith university, OS denotes the proportion of overseas students, OS^2 is included to capture non-linearities in the association between overseas students and technical efficiency, RA is the ratio of general to academic staff, D is a dummy variable for the Dawkins universities, SA is the proportion of senior administrative staff, SC is the proportion of senior academic staff, O is the number of undergraduate program offerings, and T is a time trend.

Unfortunately, the literature does not provide guidance on what are the key drivers of university efficiency. Thus, while a production function is preferred when identifying the degree of inefficiency (the efficiency scores), there is relatively little guidance on the functional form or the set of potential explanatory variables in inefficiency. Thus, our

[23] Actually, there is little difference if this adjustment is not made. This suggests that the weighted publications per full-time equivalent academic has not varied over the years studied. Using a two-year lag does not change our conclusions.

approach for the identification of the *determinants* of inefficiency is a data driven one. We do, however, believe that it is important to move beyond estimating efficiency scores to identifying also the sources of inefficiency.

The primary variables of interest in this study are the variables OS and OS^2, as these represent the degree to which the universities are exposed to overseas competition. The squared term is included to capture non-linearities (if they exist) in the association between overseas students and technical efficiency. At low levels of enrolments of overseas students, there may actually be a reduction of technical efficiency if the university is not sufficiently prepared to service these students adequately. For example, overseas students have, on average, poorer English communication skills, and this can place a greater workload on academics, diverting time and effort from other activities. Additional resources might also need to be devoted to overseas marketing and support services for overseas students. However, at higher levels of overseas student enrolments, universities can be expected to become more efficient. They should be significantly greater in size and therefore reap economies of scale. Additionally, they may be compelled to improve their level of technical efficiency in the face of competition from their many rivals in international markets. Importantly, there are also internal pressures arising from academic staff, who may respond to changes in the mix of students by demanding changes in policies, procedures and practices. The association may, of course, be linear or non-existent. It is entirely an empirical matter.

Concerning the status of a university, it is unclear whether the Dawkins universities are less or more efficient than the older universities. On the one hand, they may tend to be less efficient as their output levels tend to be low because of their relative weak research output. On the other hand, it is possible that this lack of research output is more than counter balanced by a much greater level of teaching output per academic.[24]

RA is the ratio of non-academic staff to academic staff and is a rough measure of administrative efficiency. A second administrative efficiency variable is the proportion of senior administrative staff, which is included to control for differences in administrative

[24] Note that we do not explore allocative efficiency (for which we lack adequate data) and, hence, are unable to test whether the higher teaching as a substitute for lower research is associated with allocative efficiency loses.

skills.[25] Academic functions often rely on non-academic staff support. It is expected that more senior administrative staff would have a positive impact on technical efficiency. Such staff can relieve academics from unproductive administrative duties and can free up academics to focus on their comparative advantage. Additionally, senior administrative staff tend to be the more efficient and productive administrative staff. They can implement changes to process and procedures that enhance efficiency.

The proportion of senior academic staff is included to control for differences in academic skills.[26] We are unclear about the impact of this variable. On the one hand, it would be expected that it would have a positive impact on efficiency, if promotion to professorial level reflects higher levels of productivity and competency (particularly in creating research output). However, if promotion occurs for reasons not related to productivity, or if the research and teaching productivity of professors is tied down with committee and other administrative work, we would expect a negative impact on technical efficiency.

Another potential explanatory variable is the number of offerings. This is the number of broad fields of study in which undergraduates are enrolled. As the number of offerings increases, administrative burdens rise and it is possible that this leads to inefficiency. On the other hand, if there are economies of scope, then we should find that the number of offerings should be associated with higher levels of technical efficiency.

3.3 Estimation Issues

It is possible to estimate, first, the output distance function (equation 2), calculate the inefficiency effects from this and then estimate the inefficiency effects equation (equation 3). Battese and Coelli (1995) have noted this two-stage estimation approach is inconsistent, as it assumes that there is independence in the inefficiency effects in the two estimation stages. A better estimation framework is to estimate the output distance function and the determinants of inefficiency in a single step, producing more efficient estimates. We follow Battese and Coelli (1995), but do also compared the results with the two-stage estimation procedure. The two equations are estimated jointly using Maximum Likelihood techniques. Applications of

[25] Senior administrative staff are those with a classification of level six to nine.

[26] This variable is defined as academics with a classification above the senior lecturer level (including Associate Professors, Readers and Professors).

this technique include Battese and Coelli (1995), Battese and Broca (1997), Paul *et al.* (2000), Coelli and Perelman (2000) and Paul and Nehring (2005).[27]

The choice of one normalising output which in turn becomes the dependent variable in the econometric specification can be considered somewhat *ad hoc*. Which output we choose to use is arbitrary and as such any of the outputs could be considered as endogenous. As explained by Kumbhakar and Lovell (2000, p. 95) this implies that maybe some regressors are not exogenous and as such introduce simultaneous equation bias. However, various authors, in particular Coelli (2000) have argued that the endogeneity issue is less important than we might imagine. Coelli proves that under typically accepted behavioural assumptions (e.g., expected profit maximising or revenue maximising) that Ordinary Least Squares yields consistent output distance function estimates for a Translog functional form. Thus, like other authors, such as Paul *et al.* (2000) and Cuesta and Zofio (2005) we assume that Coelli's results apply to our econometric approach and that we need not be concerned with the endogeneity issue.[28]

4. Results

4.1 Australian Universities

The estimated parameters of the stochastic education output distance frontier applied to Australian universities are presented in Table 3a, for the period 1995-1999, and in Table 3b for the period 1995-2002. The two different periods are used to investigate the robustness of the results. The results reported in Table 3b are preferred to those in Table 3a because they use a longer time period.[29] Column 2 presents the results without the time trend (as a proxy for technological change) included in the university frontier, without non-linear overseas student effects and without the senior academic and non-academic inputs in the inefficiency effects equation. In Column 3, the senior academic and non-academic inputs are included as explanatory variables to the technical inefficiency effects. Column 4 includes non-linear

[27] We used *Frontier 4.1* for the estimation. For full details on the joint estimation of these two equations, and the measurement of individual efficiency scores can be found in Battese and Coelli (1993) and Battese and Coelli (1995).

[28] Indeed, for our datasets, changing the normalising variable does not alter our results.

[29] The 1995-99 time period was chosen arbitrarily in order to explore the robustness of the results. Results using other time periods are available from the authors.

overseas student effects. The results reported in Column 5 allow for non-neutral technological change in the education production process. That is, allowing for technological change to result in factor using bias. The results of re-estimating equation 5 without the non-linear overseas students term are presented in Column 6.

In Table 3a, Columns 2 and 3, overseas students has a negative coefficient, which is statistically significant in Column 3. The non-linear effects are statistically significant in Column 4, but they are not as significant when technological change is introduced (Column 5).[30] Given the statistical insignificance of the overseas students interactive term, our preferred results are presented in Column 6, where the linear overseas students variable has a negative sign and is highly statistically significant, indicating that higher proportions of overseas students is associated with *lower* levels of technical inefficiency. Recall that the dependent variable is technical inefficiency; hence, a negative coefficient on overseas variable indicates that higher percentages of overseas students are associated with lower levels of technical inefficiency. When the longer time period is used (1995-2002), the results are weaker (Table 3b). The overseas students variable continues to have a negative coefficient, but this is in most cases not statistically significant at conventional levels. However, in the preferred specification (column 6), it has the expected negative sign and is statistically significant. The coefficient is -0.03 in Table 3b compared to -0.04 in Table 3a. We conclude that the effects of overseas students is to increase technical efficiency in Australian universities and that this effect is linear.[31]

Turning to the other variables, the dummy for the Dawkins universities has a robust negative and statistically significant coefficient. This indicates that the newer universities have implemented measures that are reducing technical inefficiency. The coefficient on RA is variable, but it does have a negative coefficient and is statistically significant in the preferred specification. The number of offerings has a positive effect on efficiency (has a negative coefficient), suggesting that economies of scope arise from offering several fields of study.

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[30] The explanation for this is probably that in columns 2 to 4, technological change is excluded from the frontier. This is likely to result in a misspecification of the frontier. Enabling the frontier to shift out over time is a more realistic specification. Hence, we prefer the results presented in columns 5 and 6.

[31] Multicollinearity may, of course, be a factor here, but in the absence of strong theoretical considerations and prior empirical evidence, we prefer to go with the linear specification.

As expected, the proportion of staff who are senior administrators (SA) is associated with higher levels of efficiency. However, the proportion of academics who are at the professorial level are associated with higher levels of inefficiency. A similar finding has been reported by Carrington, Coelli and Rao (2005). This later result is somewhat unsettling, as it implies that Australian universities are not getting as much research and teaching output as they might be. This result is consistent with research conducted elsewhere. For example, in their review of Australian academic economists, Pomfret and Wang (2003) conclude that: "Despite concerns about deleterious consequences of a publish-or-perish ethos, the Australian norm is that most academic economists do neither". In their analysis of publication patterns of Australian economics professors, Bhattacharya and Smyth (2003) found that, as expected, time spent on teaching and administration had an adverse effect on research productivity.[32]

It is possible that the professorial effect reflects inefficient matching of jobs to academics. It can reflect also good staff stuck in professorial administrative positions. It is consistent also with a self-sorting process, where some less productive staff seek promotion to escape academic work and who subsequently implement policies that interfere with the work of others. That is, there are joint marginal products and these are reduced by committee, intrusive policies and tasks, etc.[33] Clearly more research is needed to identify whether this effect arises because of heavy administrative load (a substitution of effort effect) or because of low productivity (poor promotion effect). However, given the effect of SA, there is scope within universities to increase senior administrators and decreases the administration load of senior academics.[34]

TABLE 3a ABOUT HERE

TABLE 3b ABOUT HERE

[32] They found also that there was no real difference in the performance of professors from the top five universities and those not in the top five.

[33] The notion that it is lack of performance incentives for senior faculty that drives this result, seems implausible. Senior faculty should, by definition, be the more productive and more efficient staff. Where performance incentives are inappropriate, we would expect the coefficient on senior faculty to be zero and not negative.

[34] There is no reason why the total administrative load would change as a result of this.

4.2. The New Zealand experience

As mentioned earlier, the New Zealand universities are less exposed to overseas competition in the sense that they have a lower proportion of their students from overseas compared to the Australia ones. In 2003 for instance 15.6 percent of students enrolled in New Zealand universities were from overseas. This compares to 22.6 percent in the case of all Australian higher education institutions in 2003.

The dataset for New Zealand is limited to seven universities for the period 1995-2003. With only seven cross-sections, it becomes very difficult to use either DEA or SFA. Given the small cross-section, the SFA approach is preferred. However, the results should be interpreted with caution. For New Zealand we use a two output and two input model, with the number of equivalent full-time students and Research Items as the two outputs, and academic and non-academic labour as the two inputs.[35] The results are presented in Table 4a for the period 1997-2003 and in Table 4b for the full period 1995-2003.[36] Column 2 presents the results from the full Translog specification; Column 3 presents the results of eliminating the time interactive terms from the Translog specification, while Column 4 presents the results associated with the Cobb-Douglas specification. For comparison purposes only, Column 5 in Table 4b presents the results when the inefficiency effects equation is not included in the estimation procedure; this is simply the education production function. The coefficient on the overseas variable is not robust, being negative and statistically insignificant in the case of the Translog for the 1997-2003 period, and positive and statistically insignificant in the case of the Translog for the 1995-2003 period. Interestingly, the coefficient is positive and statistically significant in the case of the Cobb-Douglas for the 1997-2003 period. In this later case, the results indicate that the New Zealand universities with higher levels of overseas students are *less* technically efficient. Given the statistically significant factor input and student variables, the Cobb-Douglas is *not* the preferred specification. Removing the non-linear terms (and hence using only OS in the inefficiency effects equation) does not make any difference to the results. Whether OS is used, or OS and OS squared, the coefficient on OS is not statistically significant. Hence, our conclusion is that for the 1995-2003 period, competition for overseas students has not had any impact on

[35] In the New Zealand, case research output is indicated by the number of research outputs as reported in the annual reports of the universities and by the *Tertiary Education Commission* (2002).

[36] As in the case of Australian universities, the different time periods are chosen to explore the sensitivity of the results. Other time periods were used as well. The results are robust.

technical efficiency in New Zealand. This is surprising, given the expectations of the effects of competition and the Australian results. The reasons for this difference between New Zealand and Australian universities warrant further investigation. One important difference between the two countries is that international students are more important in Australia than they are in New Zealand. The general attitude of New Zealand universities towards attracting students is quite different to Australian universities because of the differences in visa requirements on students and the affect that has on incoming students. In New Zealand, the largest proportion of students is at the pre-uni level. They can be found mostly in English schools, foundations schools and the high schools. New Zealand universities recruit most of their overseas students from this pool rather than directly from overseas. This pool is much larger in New Zealand than Australia because it is far easier to enter New Zealand to study when a student's level of English is low. This makes the nature of New Zealand's overseas student group quite different and means that New Zealand universities have not been as active overseas in competing for students, setting up campuses overseas, etc.

TABLE 4a ABOUT HERE

TABLE 4b ABOUT HERE

4.4 Technical efficiency levels

The associated levels of technical inefficiency are presented in Table 5.[37] Note that the table reports university efficiency levels relative to their individual country. That is, the scores are relative scores. We have not pooled the Australian and New Zealand data together. Hence, it is not possible to conclude, for example, that Australian universities are more efficient than New Zealand ones. For the university sector as a whole, technical efficiency levels are relatively high (this finding is similar to that of Abbott and Doucouliagos, 2003). Relative technical efficiency levels are highest among the Australian universities, with a geometric mean of 0.917, compared to 0.880 for New Zealand. For both Australian and New Zealand universities, technical efficiency levels were highest in the late 1990s, and have deteriorated somewhat since then, with the deterioration more noticeable in New Zealand. The reasons for

[37] For Australian universities, we use the results from column 6 Table 3b and for New Zealand, we use the results from column 2, Table 5b.

this deterioration warrant further investigation. Part of the answer may be found in the partial deregulation of the university sector, as well as from technological change in the sector. For example, if the sector is experiencing technological change, the best practice frontier is shifting out over time, but universities *on average* might not have been able to keep up with the changes. This is supported by the positive sign on the time trend variable in the inefficiency effects equation. Holding all other factors constant (including international enrolments) inefficiency has increased over time. A more detailed econometric analysis, coupled with case studies, could help shed light on this issue.

TABLE 5 ABOUT HERE

4.5. Sensitivity Analysis

The results presented in the previous tables were derived from the certain specifications. It is pertinent to explore the impact of different specifications on the estimates. This sensitivity analysis is presented in Table 6, which compares the key determinants of technical inefficiency.[38] The first row reproduces the estimates from Table 3b – where the production function is estimated jointly with the inefficiency effects equation. The second row reports results from following a two-step procedure. That is, estimating first the output distance function and then estimating the inefficiency effects equation. The third row reports results from adjusting the post-graduate and under-graduate enrolment numbers by the CEQ Generic Skills index. The Course Experience Questionnaire (CEQ) is generic survey of students that complete a qualification at Australian universities to elicit their perceptions of various aspects of the course just completed. We used the percentage of student respondents who where in broad agreement about the generic skills. This is a rough measure of teaching quality. Hence, our "quality adjusted" measure of teaching output is: enrolments multiplied by the average generic skills index.

The fourth row reports results from using a three input model, academic labour, general staff, plus other expenses (deflated by the Australian Government's Final Consumption Expenditure price deflator). The idea behind the use of this measure is to capture some of the non-academic inputs that may be sub-contracted outside of the university (e.g. cleaning and

[38] Note that all the sensitivity analysis reported in Table 6 use the specification reported in column 6, Table 3b. Non-linear terms are not statically significant when these are added to these specifications.

security). The fifth row uses a model where all the inputs are expressed in real dollar terms. That is, instead of using the full-time equivalent number of academic and non-academic staff, we use the salaries paid to academic and general staff as the labour input measures. The sixth row reports results of including the proportion of students from low socioeconomic background as a regressor in the inefficiency effects equation. Students from disadvantaged backgrounds may not have received adequate schooling to prepare them for university studies. Thus additional resources may be required to ensure they are successful in their studies.[39]

The seventh row reports the results of adding the real value of available financial resources as an explanatory variable of inefficiency (equation 3). This tests whether available cash resources affect efficiency, once the other factors are controlled for. The inclusion of this variable does not affect any of the results. The cash resources variable itself has the expected negative sign (improves efficiency), however this variable is not statistically significant (-0.056, t-statistic = -0.65).

In the final row, we report the results of including both the overseas variable, as well as an interactive term. We interact the overseas variable with a Group of Eight dummy variable. The variable for overseas students continues to have a negative and statistically significant coefficient. Interestingly, the interactive term has a positive coefficient (0.026, t-statistic = 3.76). This suggests that the effects of competition for overseas students are stronger among the non-Group of 8 universities (0.03 compared to 0.01). This is consistent with the notion that demand for university positions within the Group of Eight is driven more by the 'positional' nature of a qualification. With the rest of the Australian university system offering a more standardised education, competition for students has greater impact on efficiency.

Because of limitations on data availability (especially for socio-economic status), not all regressions reported in Table 6 use the same number of observations as the full dataset used in Table 3b. However, the results do indicate that the impact of overseas students on technical efficiency in Australian universities is robust. In all cases, the proportion of overseas students has a positive impact on technical efficiency (it has a negative sign that is always statistically

[39] It turns out that this variable has a negative coefficient but is only of weak statistical significance.

significant).The other determinants of inefficiency are also robust – while the magnitudes of the coefficients do change, there are no sign reversals and all are statistically significant. The only noticeable difference is the results of applying a two-step procedure. This leads to average efficiency scores that are much lower than the other specifications and lower than what has been found by other authors.

TABLE 6 ABOUT HERE

4.6 Alternative Explanations

Our interpretation of the results is that there is a positive association between competition for overseas students and efficiency in Australian universities, but not in New Zealand. Are the results consistent with other explanations? Two alternative explanations are: (1) *Travel experience*: it may have become more fashionable to study abroad.[40] (2) *Permanent Residence*: a related explanation may be that students from overseas are choosing to come to Australia with the hope of gaining permanent residence after graduation.[41] The assumption behind these explanations is that universities are not really competing against each other. However, there is ample data indicating that Australian universities do compete against those from other countries (Australia is not the only place for international study). Moreover, it is a fact that universities earn higher fees from overseas students. Hence, even for those students who have decided to study in Australia, universities find it attractive to compete against each other. Universities certainly see themselves as rivals and they do try to attract students, through price (fees charged and other service charges) and non-price competition (branding, teaching and learning experience, university life experience, graduate employment outcomes, etc). This is competitive behaviour.

5. Summary

Universities worldwide are increasingly facing the pressure of competition. The effect of this competition on their operational performance is an important research question. It is also an important policy question. Using two different datasets for Australia and New Zealand, and estimating various stochastic production frontiers and output distance functions, a number of

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[40] More likely is the inability of home country education, particularly in parts of Asia, to keep up with the pace for demand for higher education. As investment in higher education at the home country increases (both in terms of number of places and the quality of education), there is less need to seek education overseas.

[41] The so-called 'Master of Permanent Residence'!

important conclusions can be made from this study. First and most importantly of all it was found that there is an important link between competition in the market for overseas students that a university in Australia is exposed to and the level of technical efficiency at which they operate.

A related issue is that the Dawkins universities tend to have a high level of technical efficiency as well as a relatively high level of overseas enrolments. Clearly these universities do have a tendency to seek higher overseas students in order to supplement their domestic income and this is helping to some degree to create pressure on them to improve their efficiency level. In the case of the older universities, perhaps with a smaller proportion of students from overseas and higher level of government grants in lieu of their research output,[42] there is less competitive pressure on them to improve their levels of efficiency.

In the New Zealand case, enrolments of overseas students appears to have had no affect on technical efficiency. This result may be driven by the nature of the system in that country: universities tend to recruit international students that are already in New Zealand, compared to Australian universities that have to compete for them from outside of Australia.

Finally, interesting results were derived in terms of the types of staff employed by the universities. The employment of additional senior administrators appears to have a positive impact on efficiency levels, whist in the case of the employment of senior academics the reverse is true. The reasons for these links are not entirely clear and so therefore further research into these links should be undertaken.

An important extension to our work will be to explore the impact of competition for overseas students on U.K, U.S. and Canadian universities, many of whom compete for the same cohorts of students as the Australian and New Zealand universities.

[42] They enjoy also significant income from private sources, other than overseas income paying students.

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Table 1: Higher education/tertiary education student numbers in Australia and New Zealand 1994 to 2003

	Australia			New Zealand		
year	Total student numbers	Overseas student numbers	Overseas percentage	Total student numbers	Overseas student numbers	Overseas percentage
1994	585,435	40,494	6.9	201,968	5,567	2.8
1995	604,176	46,187	7.6	212,068	6,742	3.2
1996	634,094	53,188	8.4	214,260	6,034	2.8
1997	658,849	62,996	9.6	242,826	7,587	3.1
1998	671,853	72,183	10.7	255,094	8,430	3.3
1999	686,267	83,111	12.1	253,773	9,034	3.6
2000	695,755	95,607	13.7	264,353	11,638	4.4
2001	726,418	112,342	15.5	282,808	17,659	6.2
2002	896,621	185,058	20.6	319,886	26,878	8.4
2003	929,951	210,397	22.6	337,004	34,915	10.4

Source: Australia, Department of Education, Science and Technology. New Zealand, Tertiary Education Commission.

Table 2: Domestic and Overseas full-fee paying students, All Australian universities 1999 to 2005

	1999	2000	2001	2002	2003	2004	2005
Domestic undergraduate	1.80%	2.25%	2.92%	4.21%	4.48%	5.36%	5.08%
Domestic postgraduate	24.07%	21.20%	20.50%	15.00%	12.17%	10.02%	10.62%
All overseas	74.14%	76.55%	76.58%	80.79%	83.35%	84.62%	84.30%
Fee paying as % of all students	18.98%	21.55%	24.11%	26.92%	29.91%	31.85%	33.74%

Source: DEST Selected Higher Education Student Publication, various

Table 3a: Maximum-likelihood parameter estimates of the Translog stochastic output distance function, Australian universities, 1995-1999

	(2)	(3)	(4)	(5)	(6)
Variable	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**
Constant	7.64 (5.76)*	4.72 (3.53)*	3.76 (3.42)*	1.31 (1.20)*	1.90 (1.72)*
Post-Graduate	-0.22 (-0.50)	-0.46 (-0.90)	-0.19 (-0.28)	-1.41 (-2.82)*	-1.18 (-2.34)*
Under-Graduate	-0.12 (-2.70)*	-0.92 (-1.60)*	-1.17 (-1.57)*	0.07 (0.13)	-0.25 (-0.46)
Post-Graduate squared	-0.05 (-0.56)	-0.09 (-0.72)	-0.08 (-0.55)	-0.03 (-0.24)	-0.02 (-0.17)
Under-Graduate squared	-0.12 (-1.38)*	-0.11 (-0.98)	-0.10 (-0.77)	-0.06 (-0.61)	-0.03 (-0.24)
Post-Graduate · Under-Graduate	0.12 (0.72)	0.17 (0.72)	0.14 (0.56)	0.05 (0.24)	0.01 (0.03)
Academics	1.73 (2.28)*	1.78 (2.01)*	1.98 (2.50)*	1.79 (2.40)*	2.18 (2.75)*
Non-academics	-1.98 (-2.58)*	-1.10 (-1.34)*	-1.06 (-1.39)*	-0.64 (-0.86)	-1.06 (-1.43)*
Academics squared	0.29 (3.51)*	0.23 (2.65)*	0.25 (2.71)*	0.13 (1.73)*	0.12 (1.43)*
Non-academics squared	0.33 (4.68)*	0.26 (3.63)*	0.27 (3.85)*	0.17 (2.56)*	0.20 (2.82)*
Academics·Non-academics	-0.58 (-4.42)*	-0.52 (-3.83)*	-0.57 (-4.02)*	-0.34 (-2.88)*	-0.36 (-2.68)*
Post-Graduate·Academics	0.31 (1.67)*	0.50 (2.29)*	0.51 (2.20)*	0.40 (2.09)*	0.47 (2.39)*
Post-Graduate·Non-academics	-0.31 (-1.78)	-0.48 (-2.23)*	-0.52 (-2.45)*	-0.23 (-1.25)*	-0.32 (-1.71)*
Under-Graduate·Academics	-0.45 (-2.71)*	-0.52 (-2.60)*	-0.55 (-2.61)*	-0.38 (-2.33)*	-0.47 (-2.61)*
Under-Graduate·Non-academics	0.61 (3.83)*	0.61 (3.23)*	0.67 (3.33)*	0.34 (2.02)*	0.44 (2.53)*
Time	-	-	-	0.17 (1.49)*	0.17 (1.43)*
Time squared	-	-	-	-0.01 (-1.28)*	-0.01 (-1.11)*
Academics·Time	-	-	-	-0.03 (-0.78)	-0.02 (-0.69)
Non-Academics·Time	-	-	-	0.03 (0.69)	0.02 (0.64)
Post-Graduate ·Time	-	-	-	0.04 (1.85)*	0.05 (1.83)*
Under-Graduate ·Time	-	-	-	-0.04 (-1.72)*	-0.04 (-1.70)*
Inefficiency Effects:					
δ	0.25 (1.82)*	1.70 (3.42)*	0.98 (2.31)*	0.91 (2.33)*	1.17 (3.12)*
Overseas students (OS)	-0.02 (-1.56)	-0.04 (-2.26)*	0.05 (2.04)*	-0.01 (-0.02)	-0.04 (-3.45)*
Overseas students squared (OS^2)	-	-	-0.003 (-3.88)*	-0.01 (-1.54)*	-
Dawkins (D)	-1.58 (-2.42)*	-1.16 (-2.85)*	-0.57 (-3.53)*	-1.07 (-4.27)*	-1.07 (-4.06)*
Ratio (RA)	0.11 (1.53)*	-0.08 (-0.86)	-0.01 (-0.04)	-0.13 (-1.52)*	-0.12 (-1.59)*
Time	-0.20 (-2.91)*	-0.14 (-2.47)*	-0.08 (-2.31)*	0.08 (2.61)*	0.08 (2.35)*
% Senior Admin (SA)	-	-0.09 (-2.85)*	-0.06 (-2.94)*	-0.11 (-4.85)*	-0.10 (-3.96)*
% Senior Academics (SC)	-	0.10 (2.89)*	0.05 (3.90)*	0.11 (4.85)*	0.10 (4.85)*
Offerings (O)	-	-0.17 (-2.86)*	-0.10 (-2.93)*	-0.16 (-4.71)*	-0.16 (-4.31)*
σ^2	0.22 (2.68)	0.15 (2.73)	0.08 (4.48)	0.11 (4.40)	0.10 (4.69)
γ	0.95 (47.48)	0.97 (65.30)	0.96 (51.32)	0.98 (94.24)	0.97 (4.69)
LR test one-sided	120.94	124.69	127.91	158.36	156.17
Sample size	180	180	180	180	180

* denotes a t-statistic greater than 1. The post-graduate and under-graduate enrolment variables are normalized by research output.

Table 3b: Maximum-likelihood parameter estimates of the Translog stochastic output distance function, Australian universities, 1995-2002

	(2)	(3)	(4)	(5)	(6)
Variable	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**
Constant	-9.58 (-5.98)*	-12.00 (-6.78)*	8.79 (7.03)*	2.69 (0.64)	1.69 (0.87)
Post-Graduate	0.26 (0.36)	0.20 (0.31)	-0.07 (-0.08)	-0.23 (-0.24)	-0.94 (-1.76)*
Under-Graduate	1.16 (1.72)*	1.29 (2.03)*	2.47 (3.25)	-1.20 (-1.09)*	-0.66 (-1.07)*
Post-Graduate squared	-0.003 (-3.72)*	0.02 (0.19)	0.81 (2.88)	-0.03 (-0.22)	-0.12 (-1.24)*
Under-Graduate squared	-0.16 (-1.74)*	-0.14 (-1.48)*	0.65 (3.14)	-0.02 (-0.11)	-0.08 (-0.86)
Post-Graduate · Under-Graduate	0.006 (0.03)	-0.04 (-0.24)	-1.78 (-3.95)	0.02 (0.07)	0.18 (0.97)
Academics	1.79 (2.47)*	1.89 (2.59)*	-11.90 (-10.25)*	1.62 (1.89)*	1.66 (2.28)*
Non-academics	1.06 (1.51)*	1.34 (1.94)*	8.38 (6.63)*	-0.43 (-0.54)	-0.27 (-0.36)
Academics squared	0.24 (3.39)*	0.25 (3.64)*	0.56 (2.73)*	0.35 (0.79)	0.17 (2.42)*
Non-academics squared	0.18 (3.24)*	0.17 (3.11)*	-0.47 (-2.90)*	0.28 (0.66)	0.15 (2.40)*
Academics·Non-academics	-0.53 (-5.09)*	-0.55 (-5.49)*	0.30 (0.90)	-0.68 (-0.85)	-0.39 (-3.52)*
Post-Graduate· Academics	0.13 (0.80)	0.21 (1.46)*	1.16 (2.06)*	0.40 (1.90)*	0.29 (1.78)*
Post-Graduate·Non-academics	-0.16 (-1.09)*	-0.22 (-1.54)*	-0.65 (-1.19)*	-0.38 (-1.59)*	-0.19 (-1.23)*
Under-Graduate· Academics	-0.28 (-1.94)*	-0.35 (-2.68)*	-0.24 (-0.51)	-0.48 (-2.54)*	-0.32 (-2.08)*
Under-Graduate·Non-academics	0.22 (1.58)*	0.25 (1.99)*	-0.29 (-0.65)	0.54 (2.45)*	0.34 (2.24)*
Time	-	-	-	0.07 (0.75)	0.09 (1.22)*
Time squared	-	-	-	-0.003 (-1.07)*	-0.04 (-1.83)*
Academics·Time	-	-	-	-0.06 (-3.25)*	-0.05 (-2.71)*
Non-Academics·Time	-	-	-	0.07 (2.94)*	0.05 (2.80)*
Post-Graduate ·Time	-	-	-	0.005 (0.32)	0.03 (1.79)*
Under-Graduate ·Time	-	-	-	-0.003 (-0.20)	-0.02 (-1.52)*
Inefficiency Effects:					
δ	0.19 (2.08)*	0.14 (0.56)	-0.24 (-0.61)	0.57 (1.10)*	0.83 (2.21)*
Overseas students (OS)	-0.001 (-0.03)	-0.01 (-1.24)	-0.006 (-0.36)	0.008 (0.21)	-0.03 (-5.80)*
Overseas students squared (OS^2)	-	-	0.003 (0.63)	-0.009 (-0.56)	-
Dawkins (D)	-0.44 (-4.30)*	-0.21 (-2.66)*	0.36 (2.91)*	-0.46 (-2.20)*	-1.05 (-5.32)*
Ratio (RA)	0.29 (5.32)*	0.04 (1.04)*	-0.02 (-0.17)	0.03 (0.70)	-0.26 (-3.68)*
Time	-0.38 (-6.31)*	-0.23 (-5.97)*	-0.08 (-3.43)*	0.06 (3.10)*	0.07 (3.39)*
% Senior Admin (SA)	-	0.003 (0.25)	0.03 (1.41)*	-0.05 (-2.35)*	-0.07 (-4.20)*
% Senior Academics (SC)	-	0.06 (6.68)*	0.01 (0.92)	0.04 (2.69)*	0.09 (4.88)*
Offerings (O)	-	-0.11 (-4.36)*	0.01 (0.03)	-0.08 (-2.89)*	-0.14 (-4.14)*
σ^2	0.15 (6.25)	0.08 (5.01)	0.22 (9.46)	0.06 (6.20)	0.11 (3.91)
γ	0.95 (72.68)	0.90 (31.41)	0.01 (0.25)	0.90 (27.48)	0.94 (46.68)
LR test one-sided	143.95	183.56	22.70	173.35	182.52
Sample size	288	288	288	288	288

* denotes a t-statistic greater than 1. The post-graduate and under-graduate enrolment variables are normalized by research output.

Table 4a: Maximum-likelihood parameter estimates of the stochastic output distance function, New Zealand universities, 1997-2003

Variable	**Translog Coefficient (t-statistic)** (2)	**Restricted Translog Coefficient (t-statistic)** (3)	**Cobb-Douglas Coefficient (t-statistic)** (4)
Constant	-1.16 (-1.19)*	1.16 (1.17)*	3.27 (14.02)*
Students	5.74 (5.83)*	4.90 (5.02)*	-0.72 (-34.32)*
Students squared	-0.10 (-2.99)*	-0.08 (-3.17)*	-
Academics	5.68 (7.34)*	5.71 (7.35)*	1.23 (12.17)*
Non-academics	-4.79 (-6.49)*	-5.43 (-7.44)*	-0.35 (-2.83)*
Academics squared	0.93 (2.14)*	0.65 (1.41)*	-
Non-academics squared	2.20 (5.11)*	1.90 (4.58)*	-
Academics·Non-academics	-3.06 (-3.75)*	-2.43 (-2.89)*	-
Students · Academics	1.95 (2.78)*	1.76 (2.55)*	-
Students · Non-academics	-2.80 (-4.06)*	-2.50 (-3.67)*	-
Time	-0.17 (-0.23)	0.02 (1.30)*	0.02 (7.96)*
Time squared	0.01 (0.54)	-	-
Students·Time	0.03 (0.09)	-	-
Academics·Time	0.08 (0.29)	-	-
Non-Academics·Time	-0.06 (-0.15)	-	-
Inefficiency Effects:			
δ	0.34 (0.98)	0.58 (1.02)*	2.55 (4.90)*
Overseas students (OS)	-0.01 (-0.10)	0.60 (0.88)	3.67 (3.83)*
Overseas students squared (OS^2)	-0.02 (-0.02)	0.51 (0.56)	1.93 (1.94)*
Ratio (RA)	-0.33 (-1.28)*	-0.53 (-1.34)*	-2.72 (-5.56)*
Time	0.04 (1.30)*	0.03 (0.84)	0.03 (1.08)*
σ^2	0.01 (2.82)	0.02 (3.14)	0.07 (6.07)
γ	0.94 (3.36)	0.99 (19.25)	0.99 (85.79)
LR test one-sided	6.57	14.24	46.48
Sample size	49	49	49

* denotes a t-statistic greater than 1. The post-graduate and under-graduate enrolment variables are normalized by research output.

Table 4b: Maximum-likelihood parameter estimates of the stochastic output distance function, New Zealand universities, 1995-2003

Variable	Translog Coefficient (t-statistic)	Restricted Translog Coefficient (t-statistic)	Cobb-Douglas Coefficient (t-statistic)	Translog Coefficient (t-statistic)
Constant	3.82 (5.01)*	7.26 (7.43)*	1.98 (1.65)*	1.13 (1.05)*
Students	6.92 (10.32)*	6.40 (6.50)*	-0.63 (-3.43)*	5.10 (5.75)*
Students squared	-0.12 (-5.44)*	-0.09 (-1.49)*	-	-0.18 (-6.41)*
Academics	8.67 (13.10)*	7.68 (10.19)*	0.64 (1.27)*	4.09 (0.91)
Non-academics	-9.67 (-16.94)*	-9.64 (-13.47)*	0.38 (0.62)	-7.16 (-1.17)
Academics squared	1.97 (5.62)*	1.62 (3.69)*	-	1.94 (1.89)*
Non-academics squared	3.95 (13.78)*	3.42 (8.06)*	-	3.09 (1.91)*
Academics·Non-academics	-5.69 (-8.76)*	-4.74 (-5.81)*	-	-4.66 (-1.84)*
Students · Academics	2.42 (8.24)*	2.13 (3.01)*	-	1.29 (3.14)*
Students · Non-academics	-3.41 (-21.36)*	-3.06 (-4.39)*	-	-1.98 (-4.19)*
Time	0.03 (1.97)	0.02 (0.33)	0.02 (1.47)*	0.03 (1.59)*
Time squared	0.003 (1.00)	-	-	0.006 (1.53)*
Students·Time	-0.02 (-1.22)	-	-	-0.06 (-3.22)*
Academics·Time	0.11 (21.40)	-	-	0.07 (0.95)
Non-Academics·Time	-0.11 (-7.56)	-	-	-0.06 (-0.81)
Inefficiency Effects:				
δ	0.35 (1.29)	0.03 (0.03)	0.71 (0.35)	-
Overseas students (OS)	0.12 (0.22)	0.01 (0.09)	1.98 (0.67)	-
Overseas students squared (OS^2)	0.09 (0.09)	0.006 (0.06)	-0.22 (-0.14)	-
Ratio (RA)	-0.27 (-3.19)*	-0.02 (-0.01)	-0.65 (-0.32)	-
Time	0.01 (0.26)	-0.01 (-0.01)	-0.005 (-0.12)	-
σ^2	0.03 (1.92)	0.04 (0.50)	0.05 (2.92)	0.21 (0.39)
γ	0.99 (27.85)	0.97 (0.98)	0.99 (306.11)	0.97 (11.45)
LR test one-sided	14.84	10.00	48.29	19.51
Sample size	63	63	63	63

* denotes a t-statistic greater than 1.

Table 5: Median technical efficiency levels, Australian and New Zealand universities

Year	Australian Universities	New Zealand Universities
1995	0.93	0.88
1996	0.93	0.87
1997	0.92	0.90
1998	0.93	0.92
1999	0.93	0.95
2000	0.91	0.88
2001	0.88	0.82
2002	0.91	0.84
2003	-	0.87

Table 6: Determinants of Efficiency, Australian Universities, Sensitivity Analysis, 1995-2002

	Percentage Overseas	Senior Admin	Senior Academics	Offerings	Average TE
Basic Results	-0.03 (-5.80)*	-0.07 (-4.20)*	0.09 (4.88)*	-0.14 (-4.14)*	0.92
Two-Step Approach	-0.01 (-5.09)*	-0.03 (-9.65)*	0.01 (4.76)*	-0.06 (8.67)*	0.55
Teaching "Quality" adjusted	-0.02 (-3.82)*	-0.04 (-2.72)*	0.08 (7.09)*	-0.18 (-6.08)*	0.92
3 inputs model	-0.02 (-1.94)*	-0.04 (-2.76)*	0.09 (8.05)*	-0.16 (-3.86)*	0.88
3 inputs model, all measured in dollars	-0.04 (-4.32)*	-0.04 (-2.43)*	0.07 (5.04)*	-0.14 (-4.53)*	0.88
Socio-economic status included	-0.04 (-3.77)*	-0.18 (-4.52)*	0.11 (5.76)*	-0.15 (-3.08)*	0.86
Other resources included	-0.03 (-3.30)*	-0.06 (-3.16)*	0.08 (4.02)*	-0.12 (-3.42)*	0.87
With Go8*OS interaction	-0.03 (-3.91)*	-0.06 (-3.79)*	0.05 (5.33)*	-0.10 (-3.99)*	0.87

* statistically significant at the 5% level. Two-step results derived from Tobit regression.

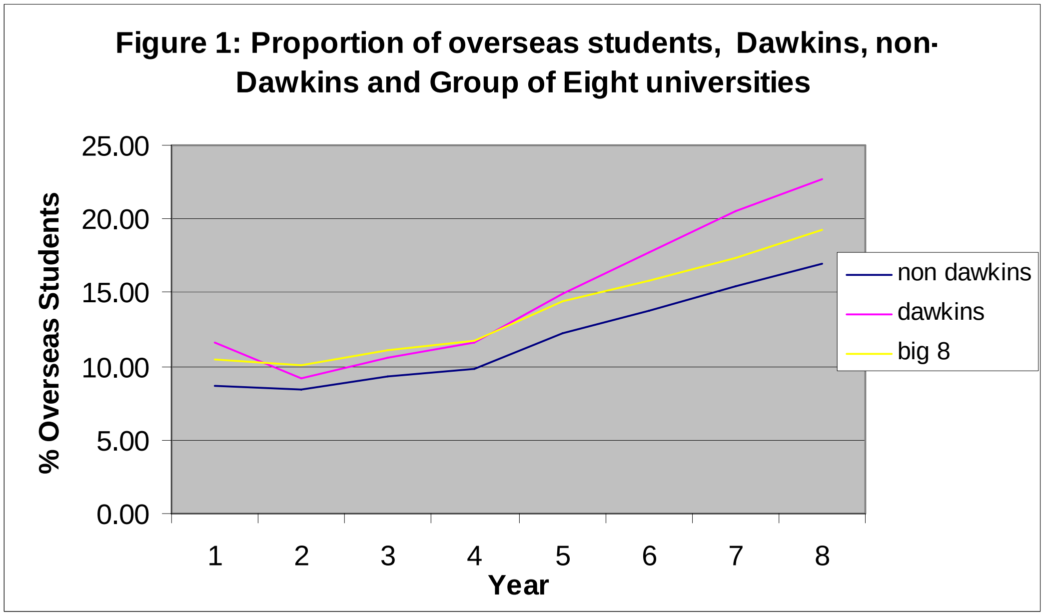
Figure 1: Proportion of overseas students, Dawkins, non-Dawkins and Group of Eight universities
% Overseas Students
25.00
20.00
15.00
10.00
5.00
0.00
1
2
3
4
5
6
7
8
Year
non dawkins
dawkins
big 8