Productivity Change in Australasian Universities 1997-2005: A Malmquist Analysis

by

Dimitris Margaritis and Warren Smart

Introduction

New Zealand universities are the largest providers of tertiary education in New Zealand – in 2009 around 135,000 full-time equivalent students were enrolled in the eight universities. As such, they play a crucial role in first generating knowledge and then ensuring that this knowledge is transferred to students. To achieve this, large financial resources are consumed by the universities. In 2009, they attracted around $3 billion in revenue. Given its size, it is important that this resource is used efficiently.

This paper uses DEA to analyse the productive efficiency of New Zealand universities and compares their performance to Australian universities by estimating Malmquist indices for the period 1997 to 2005. DEA is a useful approach in this regard, as it takes into account the multiple input/output nature of tertiary education delivery. However, the use of DEA in a New Zealand university context is problematic, given there are only eight institutions. If DEA is to be used, it requires a wider coverage than just the New Zealand universities.[1] So, in this study, the data for 36 Australian public universities are added to data for the eight New Zealand universities to conduct the DEA analysis.[2]

The structure of this paper is as follows. First, we present background on New Zealand and Australian universities. This includes a discussion of trends in government funding and also changes to the structure of the university sectors over the period of analysis. Then, the inputs and outputs used in the DEA analysis are described. Empirical estimates of total factor productivity are then presented and analysed. This is followed by a second-stage regression analysis of the factors associated with the total factor productivity estimates. Finally, some conclusions are presented.

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[1] Abbott and Doucouliagos (2000) used DEA to analyse the technical efficiency of a combined set of New Zealand polytechnics and Victorian Technical and Further Education institutions. Coelli *et al*. (2004) suggested combining the datasets of Australian universities with other countries, such as New Zealand.

[2] Not all Australian universities are included in this analysis. Suitable data is not available for the following universities: University of Sunshine Coast, and the two private universities, Bond University and Notre Dame University.

Background

Most New Zealand universities have a history that can be traced back to the 19th century. The first university, the University of Otago, was established in 1869. However, a federal University of New Zealand, with affiliated member colleges, was set up by statute in 1870 and became the umbrella organisation that conferred all degrees in New Zealand. Among the early member colleges were the forerunners of the Universities of Otago, Canterbury, Auckland, Lincoln University and Victoria University of Wellington (VUW).

In 1962, the University of New Zealand was disestablished, and the ability to grant degrees given to the individual universities. In 1964, Massey University and the University of Waikato were established.[3]

In 1990, Lincoln University became a university in its own right. On the disestablishment of the University of New Zealand it had become a constituent college of the University of Canterbury although it enjoyed relative autonomy. Lincoln is the smallest of the New Zealand universities and is specialised in the agricultural and land sciences.

The last institution granted university status in New Zealand was the Auckland University of Technology (AUT). Prior to being granted university status in 2000, AUT operated as a polytechnic. Therefore, the research capability of AUT is below that of the other universities and it is still maturing as a university.

For the purposes on this study, we split the Australian public universities into three tiers. Firstly, there are the Group of Eight (G8) universities. These are large metropolitan universities that are research intensive and include several universities that were established in the 19th century. Then comes a group of older universities that were mostly established during the 1960s and 1970s (AUS_OLD). These universities are less research intensive than the G8 universities.

The last tier of Australian universities was created by the Dawkin's reforms of the late 1980s and early 1990s (AUS_NEW). Some of these universities were created through a series of merges of colleges of advanced education. These universities tend to have a lower level of

[3] Although Massey Agricultural College, which was the predecessor of Massey University, was established as an affiliated college of the University of New Zealand in 1927.

research intensity, with more of a focus on bachelors level teaching. The members of the respective university groupings are listed in Table 1.

Table 1, Groupings of Australian universities

G8	AUS_OLD	AUS_NEW
New South Wales (NSW)	Macquarie	Charles Sturt
Sydney	New England	Southern Cross
Monash	Newcastle	University of Technology, Sydney (UTS)
Melbourne	Wollongong	Western Sydney
Queensland	Deakin	RMIT University (RMIT)
Western Australia	La Trobe	Swinburne
Adelaide	Griffith	Ballarat
Australian National University (ANU)	James Cook	Victoria University of Technology (VUT)
	Edith Cowan	Central Queensland University (CQU)
	Murdoch	Queensland University of Technology (QUT)
	Flinders	Southern Queensland
	Tasmania	Curtin
		South Australia
		Northern Territory University (NTU)
		Canberra
		Catholic

Inevitably, one of the greatest influences in institutional performance is the level of funding they receive. A study by the NZVCC (2006) compared the income per equivalent full-time student in New Zealand and Australian universities in 2004. They found that after adjusting for purchasing power parity, the funding in New Zealand universities was 53 percent of that received by G8 universities and 74 percent that received by all Australian universities. Therefore, Australian universities would appear to have a significant funding advantage over their New Zealand counterparts.

The incentives provided by the respective funding systems are also potential influences on the productive efficiency of the institutions. For most of the period of analysis in this study, New Zealand universities were funded by the government on the number of domestic student enrolments. It was only in 2004, with the introduction of the Performance-Based Research Fund (PBRF), that an element of performance-based funding was introduced to the New Zealand tertiary funding system. The PBRF measures the performance of universities across three dimensions, the quality of research produced by eligible staff, the number of research degree completions and the amount of external research income earned. Universities that achieve higher performance in these three measures receive a greater proportion of funding via the PBRF.

In Australia, the majority of government funding for universities is attached to the number of student enrolments. However, since the early 1990s, research funding has been allocated to universities based on their performance in a number of metrics. The performance measures used for funding purposes included: external research income, the number of students completing research degrees and the volume of research output (as measured by books, book chapters, and journal articles). Therefore, the funding system in place in Australia provided greater incentives for degree completion and research publication than in the New Zealand system.

Both New Zealand and Australian universities experienced decreases in government funding per student over the period of this study.[4] This is likely to have provided some incentive for institutions on both sides of the Tasman to maximise their efficiency.

Data Envelopment Analysis

In this paper, we use Data Envelopment Analysis (DEA) to measure the productivity of Australasian universities. DEA is a non-parametric linear programming methodology that constructs a linear piecewise technology frontier that allows relative measures of technical efficiency (distances from the frontier) and scale efficiency to be estimated. DEA is a particularly useful methodology for the study of higher education institutions, which are multi-output, where output prices are not easily available and neither optimisation (e.g., profit maximisation), nor specific frontier functional form assumptions are required (Banker *et al*. 1984).

The theoretical foundation of efficiency measurement can be traced back to the seminal article on the efficiency of firms by Farrell (1957). He proposed to split the measures of efficiency for a firm into technical and price (allocative) efficiency, which when combined together, form a measure of overall efficiency. Farrell (1957, p.259) defined technical efficiency as "the maximisation of output from a given set of inputs". Alternatively, technical efficiency can be seen as the minimisation of input usage, given a set of outputs.

[4] See Marginson (2009) for more detail on the drop in funding for Australian universities. In New Zealand, the government reduced funding per student from 1997 to 1999. Since then, there have been some increases to tuition subsidies, but it is unlikely that the real funding per student has recovered to previous levels.

Deriving Malmquist estimates

The use of linear programming methods to construct empirically the frontier of production technology (under constant returns to scale) and provide measures of technical efficiency for decision making units (DMUs) dates back to the work of Charnes *et al*. (1978). It was the result of work by the authors to evaluate educational programmes designed to aid disadvantaged students in US Public schools. This was in response to several failed attempts by the US Office of Education to produce sensible results, by employing conventional statistical-econometric methods (see Cooper *et al*. 2000).[5]

Technical efficiency can be further disaggregated into two distinct components, (local) pure efficiency and scale efficiency. Banker *et al*. (1984) used this approach to extend the Charnes *et al*. (1978) model so that estimates of the scale efficiency of a DMU could be derived. This was in recognition that the operating scale of the DMU can have an impact on efficiency as well as the mix of the inputs. In other words, although a DMU may be purely technically efficient, it may not be operating at the optimal scale of operations.

The relationship between pure technical efficiency and scale efficiency can be described thus:

$$\text{Technical efficiency} = \text{pure technical efficiency} \times \text{scale efficiency} \tag{1}$$

Färe *et al*. (1992) merged the ideas on measurement of efficiency from Farrell (1957) with measurement of productivity from Caves *et al*. (1982) to develop Malmquist indices of productivity change. This extended the approach of Caves *et al*. (1982) to enable productivity to be decomposed into indices describing changes in technical efficiency and technology.

The Malmquist index representing total factor productivity growth developed by Färe *et al*. (1992) can be generated via the process below:

$$M_0^{t+1}(y_t, x_t, y_{t+1}, x_{t+1}) = \left[\frac{D_0^t(x_{t+1}, y_{t+1})}{D_0^t(x_t, y_t)} \times \frac{D_0^{t+1}(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_t, y_t)} \right]^{1/2} \tag{2}$$

[5] One of the key advances of DEA was the allowance for each of the DMUs to define their own set of weights so that their relative performance can be seen in the best light (Boussofiane *et al*. 1991).

where the subscript *0* indicates an output orientation, *M* is the productivity of the most recent production point (x_{t+1}, y_{t+1}) (using period $t + 1$ technology) relative to the earlier production point (x_t, y_t) (using period *t* technology), *D* are output distance functions.

Values greater than 1 indicate positive total factor productivity growth between two periods, while values less than 1 indicate that total factor productivity has fallen.

Another way that the Malmquist index can be presented is:

$$M_0^{t+1}(y_t, x_t, y_{t+1}, x_{t+1}) = \frac{D_0^{t+1}(x_{t+1}, y_{t+1})}{D_0^t(x_t, y_t)} \left[\frac{D_0^t(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_{t+1}, y_{t+1})} \times \frac{D_0^t(x_t, y_t)}{D_0^{t+1}(x_t, y_t)} \right]^{1/2} \quad (3)$$

where the right hand side represents the product of technical efficiency growth and technological progress. An increase in technology results in the production frontier shifting outwards, while improving technical efficiency growth is a result of the DMU moving closer to the frontier. In the university context, changes in technology might be due to changed methods of delivery, including the setting up of off-shore campuses. Another example of technology change would be the move to the electronic access to journals, rather than holding hard copies on campus.

To generate the Malmquist indices requires to solving of four linear programs for each pair of data using DEA. Assume there are *N* DMUs and each DMU consumes varying amounts of *K* different inputs to produce *M* outputs. The *i*th DMU is represented by the vectors $x_i y_i$ and the ($K \times N$) input matrix and the ($M \times N$) output matrix *Y* represent the data of all DMUs in the sample.

The first two linear programmes below are where the technology and the observation to be evaluated are from the same period, and the solution value is less than or equal to unity. The second two linear programmes occur where the reference technology is constructed from data in one period, whereas the observation to be evaluated is from another period. Assuming constant returns to scale the following linear programs are used:

$$\left[D_0^{t+1}(x_{t+1}, y_{t+1})\right]^{-1} = \max_{\theta,\lambda}\phi$$
$$s.t. -\phi y_{i,t+1} + Y_{t+1}\lambda \geq 0$$
$$x_{i,t+1} - X_{t+1}\lambda \geq 0 \tag{4}$$
$$\lambda \geq 0$$

$$\left[D_0^{t}(x_t, y)\right]^{-1} = \max_{\theta,\lambda}\phi$$
$$s.t. -\phi y_{i,t} + Y_t\lambda \geq 0$$
$$x_{i,t} - X_t \geq 0 \tag{5}$$
$$\lambda \geq 0$$

$$\left[D_0^{t+1}(x, y)\right]^{-1} = \max_{\theta,\lambda}\phi$$
$$s.t. -\phi y_{i,t} + Y_t\lambda \geq 0$$
$$x_{i,t} - X_t\lambda \geq 0 \tag{6}$$
$$\lambda \geq 0$$

$$\left[D_0^{t}(x_{t+1}, y_{t+1})\right]^{-1} = \max_{\theta,\lambda}\phi$$
$$s.t. -\phi y_{i,t+1} + Y_t\lambda \geq 0$$
$$x_{i,t+1} - X_t\lambda \geq 0 \tag{7}$$
$$\lambda \geq 0$$

By introducing a convexity constraint $N1'\lambda=1$ to programs (7) to (10) the technical efficiency change can be decomposed into pure technical efficiency change and scale efficiency change. This can be written as the following:

$$\frac{D_0^{t+1}(y_{t+1}, x_{t+1})_{CRS}}{D_0^{t}(y_t, x_t)_{CRS}} = \frac{D_0^{t+1}(x_{t+1}, y_{t+1})_{VRS}}{D_0^{t}(x_t, y_t)_{VRS}} \times \left[\frac{D_0^{t}(x_t, y_t)_{VRS}}{D_0^{t}(x_t, y_t)_{CRS}} \times \frac{D_0^{t+1}(x_{t+1}, y_{t+1})_{CRS}}{D_0^{t+1}(x_{t+1}, y_{t+1})_{VRS}}\right] \tag{8}$$

where the left hand side represents technical efficiency change and the right hand side represents pure technical efficiency change and scale efficiency change, respectively.

Data

The selection of appropriate input and output variables for the analysis of the efficiency of Australian and New Zealand universities is problematic, especially in the research output area. As there are no common standards for reporting, the choice of input and output variables to be included in this analysis are constrained.[6]

To capture the labour inputs in the universities, the equivalent full-time number of academic staff (ACADEMIC) and general staff (GENERAL) are included in the DEA analysis.[7]

To measure non-labour inputs, a variable capturing total non-labour expenditure (in $NZ millions) is included in the DEA model (OTHEREXP). To make this variable comparable between New Zealand and Australia, the expenditure has been deflated by an appropriate price index in both countries,[8] before being converted to New Zealand dollars using GDP purchasing power parity estimates from the OECD. This is the approach recommended and followed by the OECD when comparing educational expenditure between countries (Schreyer and Koechlin 2002).

As is common in DEA studies of tertiary education which use qualification completions as an output variable, the number of equivalent full-time student enrolments (STUDENTS) is included in the model as an input variable.

Although Worthington and Lee (2005) used research income as an input variable in their Malmquist analysis of Australian universities, this is not possible in this study, given the different ways that the universities report research income in New Zealand and Australia.[9]

The output variables used in the DEA model include the number of undergraduate qualification completions (UNDERGRAD) and the number of postgraduate completions

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[6] A variety of model specifications were tested using the approach followed by Johnes (2006) which utilised Spearman's rank order coefficient and the Pastor *et al* test (2002) before as arriving at the final model.
[7] The Australian staffing data includes actual casual staffing to ensure comparability with the New Zealand university data.
[8] The deflator used in the case of New Zealand universities was the post-school education producer price index from Statistics New Zealand (PPIQ.SPNN01410). The deflator used for the Australian universities was the GDP implicit GDP price deflator for National-non-defence from the Australian Bureau of Statistics.
[9] This also precludes the use of research contract income as a possible output variable.

(POSTGRAD). This is a similar model specification to that used by Flegg *et al*. (2004) in their DEA study of United Kingdom universities.

Although the teaching output of universities is reasonably straightforward to align between countries, finding a research output is more difficult. The research output information reported for Australian universities is comprehensive, but the reporting of research output by the New Zealand universities is less so. Australian universities report detailed information on research output and external research income. However, there is no standard reporting system of research outputs by New Zealand universities. Although some institutions report total research outputs in their research reports or annual reports, they use different methods for categorising research outputs and some universities report research output in a manner that is inconsistent over time. Given the need for a stable time series measuring research output over time for the Malmquist analysis, alternative sources of research output need to be found.

This study uses the number of journal articles and reviews indexed in the Web of Science as a proxy for research output by the universities. The Web of Science captures the publication details of over 9,000 journals.[10] However, this measure of research output has its limitations. Disciplines such as the social sciences and humanities, which disseminate a significant proportion of research findings in the form of books and book chapters, do not have the same degree of coverage in the Web of Science compared with the natural and medical sciences.

To adjust for this bias, a weighting of 2 was applied to indexed publications from the social sciences and humanities areas. This is the approach used in the Shanghai Jiao Tong University rankings to adjust for the subject bias of the Web of Science.[11] Also, because of the lag between submission of a journal article and its publication, the articles and reviews are lagged one year. In other words, articles and reviews published in 2006 are linked to inputs used in 2005.[12]

The definitions of the input and outputs variables are presented in Table 2.

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[10] Note that the Web of Science adds and removes journals to the Web of Science over time. Around two percent of the journals are changed in any one year.
[11] Use of weighted outputs is not without precedent in DEA analysis. Coelli *et al*. (2004) used a weighted value for equivalent full-time students.
[12] A feature of the Web of Science is its selectivity – it aims to only include high-quality journals. Although this means that the coverage of the research outputs of New Zealand and Australian universities will be less comprehensive, it does mean that the articles and reviews published should be of high quality.

Table 2, Definitions of input and output variables used in the DEA of Australasian universities

Variables	Definition
Inputs:	
ACADEMIC	Total full-time equivalent academic staff.
GENERAL	Total full-time equivalent general staff.
OTHEREXP	Total real non-labour operating expenditure (NZ$million) in 1997 dollars.
STUDENTS	Total equivalent full-time students.
Outputs:	
UNDERGRAD	Total qualification completions at the undergraduate level.
POSTGRAD	Total qualification completions at the postgraduate level.
RESEARCH	Total number of indexed articles and reviews in Web of Science, lagged one year and with outputs in the social sciences and humanities having a weighting of 2.

Source, Ministry of Education, Department of Education, Science and Technology, Web of Science and annual reports of New Zealand universities.

Results

The means of the input and output variables in each year of the analysis are presented in Table 3. The fastest growth in inputs was OTHEXP, which increased by 51 percent between 1997 and 2005, while the slowest growth of 16 percent was by ACADEMIC. The fastest growth in outputs was in completions at the postgraduate level (75 percent), while the smallest growth was in undergraduate completions (32 percent).

Table 3, Mean values of inputs and outputs in Malmquist analysis of Australasian universities 1997-2005

Variables	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**% Δ 97-05**
Inputs:										
ACADEMIC	964	960	970	977	994	1,027	1,052	1,094	1,118	16%
GENERAL	1,180	1,179	1,189	1,195	1,213	1,265	1,313	1,358	1,389	18%
OTHEREXP	83	88	92	97	102	117	118	124	125	51%
STUDENTS	13,891	14,164	14,660	14,945	15,750	16,714	17,368	17,665	17,823	28%
Outputs:										
UNDERGRAD	2,927	3,067	3,147	3,174	3,375	3,574	3,732	3,894	3,876	32%
POSTGRAD	1,238	1,288	1,329	1,439	1,562	1,739	1,926	2,026	2,162	75%
RESEARCH	558	581	605	618	635	691	741	790	890	60%

Note, ACADEMIC and GENERAL in FTEs, OTHEREXP in $NZmillions, STUDENTS in EFTS.

A summary table of the Malmquist indices is presented in Table 4, while the full Malmquist indices are presented in Tables 7 to 11.[13] Note that a value of 1.02 for an index indicates that

[13] We used DEAP 2.1, developed by Tim Coelli (Coelli 1996), to generate the Malmquist estimates.

productivity had increased by 2 percent. A value of 0.98 would indicate that productivity had decreased by 2 percent.

Overall, New Zealand universities exhibited mean total factor productivity growth of 0.1 percent per year compared with 2.8 percent for Australian universities. This compares with mean total factor productivity growth of 3.1 percent per year for G8 universities, 1.4 percent per year for AUS_OLD universities and 3.6 percent per year for AUS_NEW universities.

The breakdown of the components of the Malmquist index in Table 4 shows that the main driver of productivity growth in Australian universities was an improvement in technology. The mean growth in technology at Australian universities was 1.9 percent, compared with a fall of 0.1 percent for New Zealand universities.[14]

Table 4, Mean Malmquist indices of Australasian universities 1997-1998 to 2004-2005, completions specification

University	Total factor productivityΔ	TechnologyΔ	Technical efficiencyΔ	Pure technical efficiencyΔ	Scale efficiencyΔ
AUT	0.961	0.961	1.000	1.000	1.000
Lincoln	1.015	0.989	1.026	1.000	1.026
Massey	1.014	1.019	0.994	0.993	1.002
Auckland	1.018	1.014	1.004	1.007	0.997
Canterbury	1.004	1.006	0.998	1.000	0.998
Otago	0.996	1.006	0.990	0.991	1.000
Waikato	0.990	0.997	0.993	0.994	0.999
VUW	1.011	1.000	1.011	1.011	1.000
NZ	*1.001*	*0.999*	*1.002*	*0.999*	*1.003*
G8	1.031	1.029	1.003	1.000	1.003
AUS_OLD	1.014	1.013	1.001	1.000	1.001
AUS_NEW	1.036	1.019	1.017	1.007	1.010
Australia	*1.028*	*1.019*	*1.009*	*1.003*	*1.006*

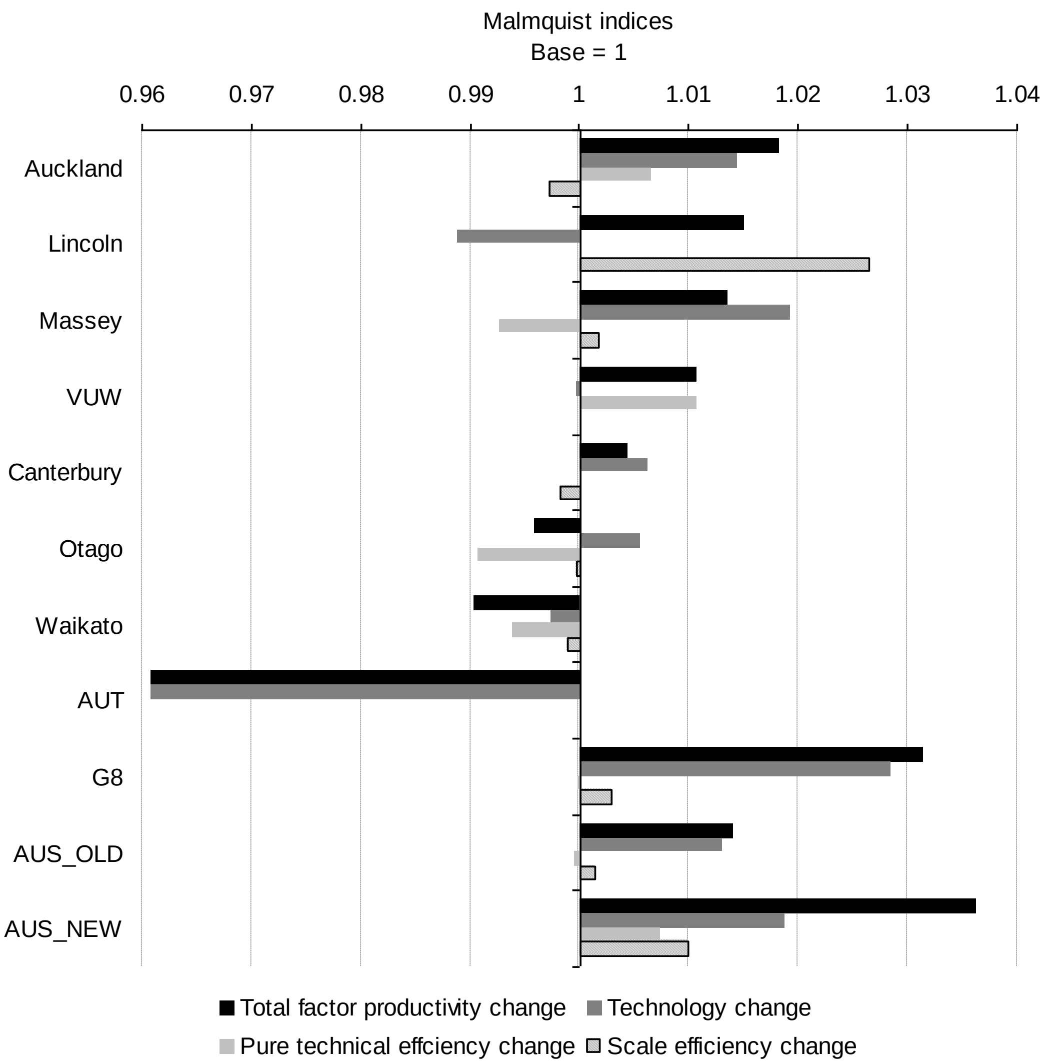
Note, all means are geometric means.

The performance of each of the New Zealand universities is summarised in Figure 1, which ranks the universities in order of average total factor productivity growth. The New Zealand university with the highest total factor productivity growth was the University of Auckland (1.8 percent per year), followed by Lincoln University (1.5 percent per year) and Massey

[14] The performance of one New Zealand university, the Auckland University of Technology (AUT) tends to skew the average New Zealand university performance.

University (1.4 percent per year). On the other hand, AUT exhibited a decrease in total factor productivity of 3.9 percent per year.

Figure 1, Mean Malmquist indices for Australasian universities 1997-1998 to 2004-2005

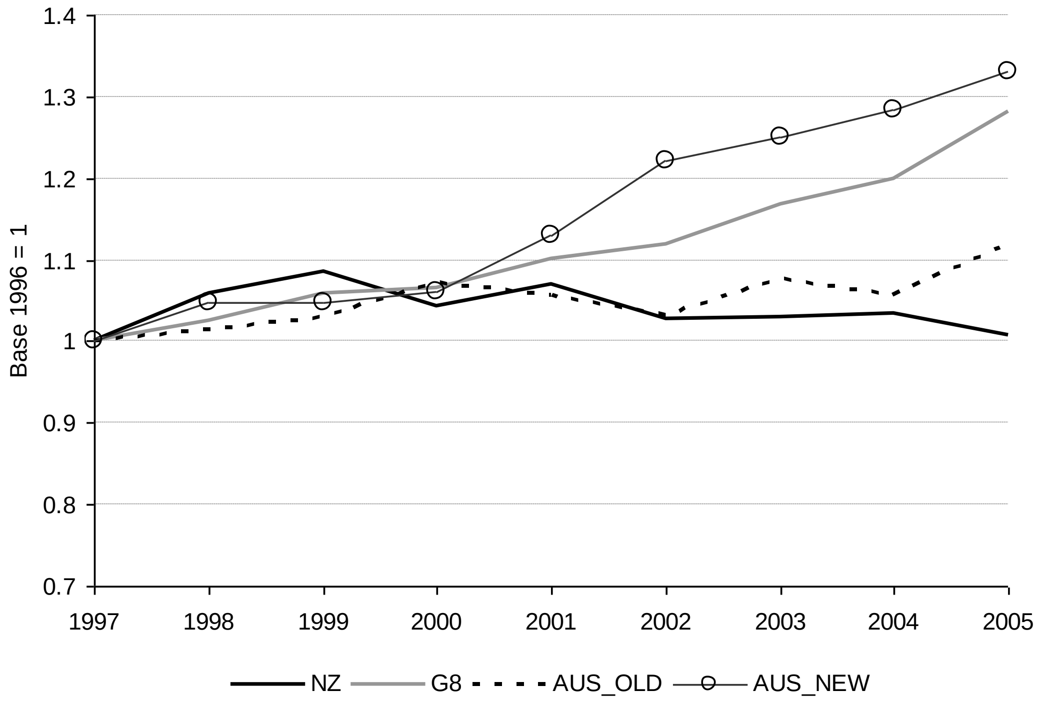


Improvement in technology was the key driver of total factor productivity growth at the University of Auckland. This was also the case at Massey University and the University of Canterbury. Of the older New Zealand universities, VUW exhibited the most significant pure technical efficiency growth. In fact, all of its total factor productivity growth was driven by improvement in pure technical efficiency, rather than by improvement in technology. At Lincoln University, a strong improvement in scale efficiency offset a decline in technology.

The decrease in total factor productivity at AUT is likely a result of this institution being granted university status in 2000. Since then, the university has been re-orientating itself away from sub-degree provision and increasing its research capability. As a result, a decrease in technology has driven the fall in total factor productivity.

Analysing the cumulative effect of total factor productivity growth on the universities can shed more light on the factors that may influence total factor productivity change. The cumulative total factor productivity growth for selected university groupings are presented in Figure 2.

Figure 2, Cumulative total factor productivity growth by Australasian university grouping 1997-2005



Cumulative total factor productivity growth was strongest at the AUS_NEW universities over the period. In particular, strong growth was exhibited over the period between 2000 and 2002. The cumulative total factor productivity growth at the G8 universities was consistent over time, with a slight lift in the rate of total factor productivity growth in 2005.

Both the New Zealand universities and AUS_OLD universities exhibited broadly similar patterns of total factor productivity growth. On average, there was little cumulative total factor productivity growth in New Zealand universities. The growth between 1997 and 1999 was offset by a fall in total factor productivity between 1999 and 2005. Only a slight rise in total factor productivity in 2005 prevented a similar result for the AUS_OLD universities.

Total factor productivity change can be disaggregated into cumulative technical efficiency change and cumulative technology change. The cumulative technology change indices for the university groupings are presented in Figure 3. The G8 universities exhibited the most consistent and strongest growth in technology over the time period, with a contraction in the frontier experienced by all but the G8 universities in 2002.

The growth in technology for G8 and AUS_NEW is likely to be partly related to the impact of increased enrolments of international students. Many Australian universities have set up campuses overseas to deliver the programmes. New Zealand universities have not engaged in this behaviour to the same extent and so have not benefited as much from this option to improve technology.

Figure 3, Cumulative technology growth by Australasian university grouping 1997-2005

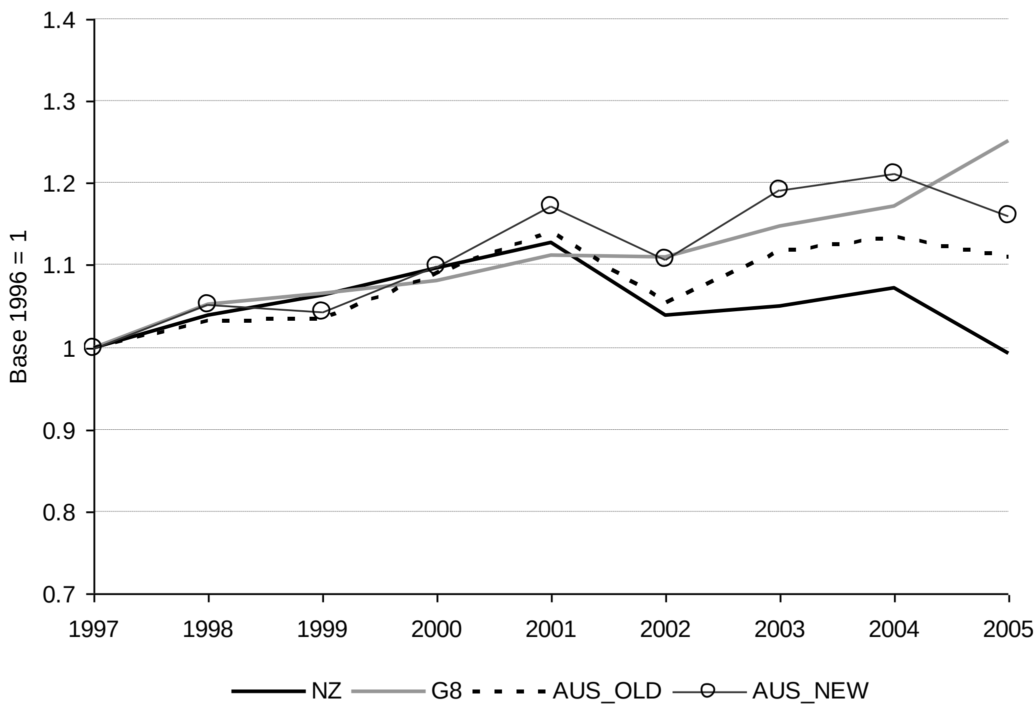
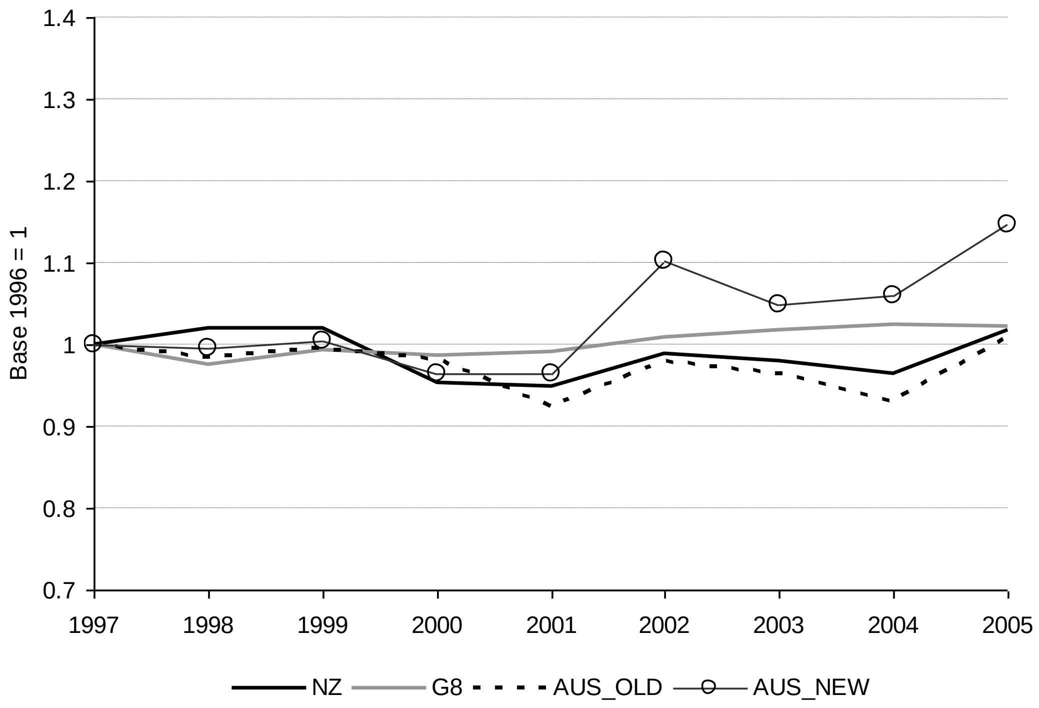


Figure 4 presents the cumulative technical efficiency growth for the groupings of Australasian universities. On average, technical efficiency growth in New Zealand, G8 and AUS_OLD universities has been sluggish. Only in the case of the AUS_NEW universities was there a significant rise in cumulative technical efficiency and that was restricted to two years, 2002 and 2005. Given that technical efficiency growth is often a result of the maturing of a university,[15] this result is not surprising.

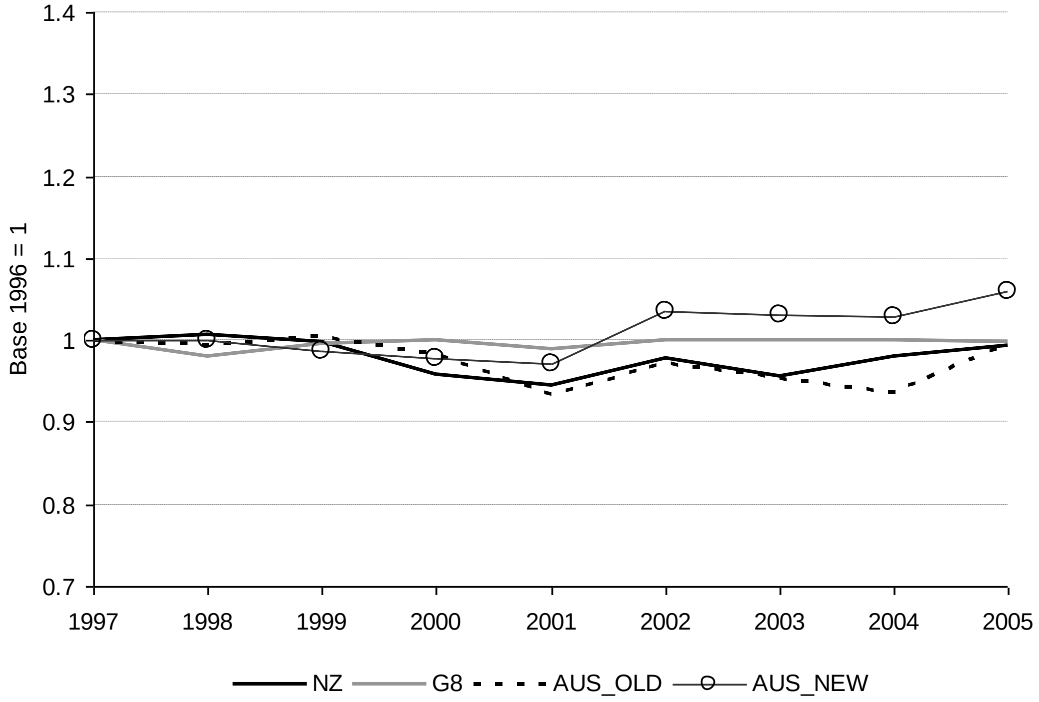
Figure 4, Cumulative technical efficiency growth by Australasian university grouping 1997-2005



Technical efficiency growth can be disaggregated into pure technical efficiency and scale efficiency growth. Figure 5 shows the cumulative pure technical efficiency growth for the four groupings of Australasian universities. Between 1997 and 2001, all four of the university groupings exhibited deterioration in cumulative pure technical efficiency. Since then, only AUS_NEW universities achieved significant pure technical efficiency growth.

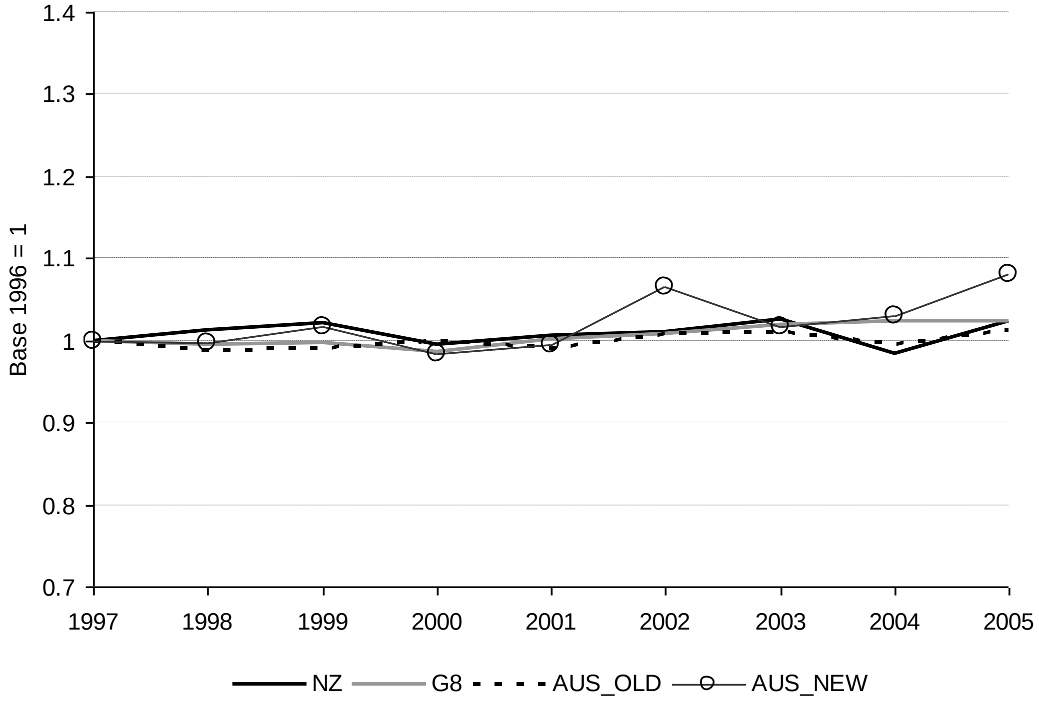
[15] A new university would be unlikely to begin in a position of high technical efficiency. There is likely to be some 'learning' required by the management of the institution before a new university begins to improve their mix of inputs and outputs.

Figure 5, Cumulative pure technical efficiency growth by Australasian university grouping 1997-2005



The cumulative scale efficiency change for the four Australasian groupings of universities is presented in Figure 6. It shows that there was little change in cumulative scale efficiency in any of the university groupings. Once again, the AUS_NEW universities achieved the highest cumulative scale efficiency growth, though it was of a modest level.

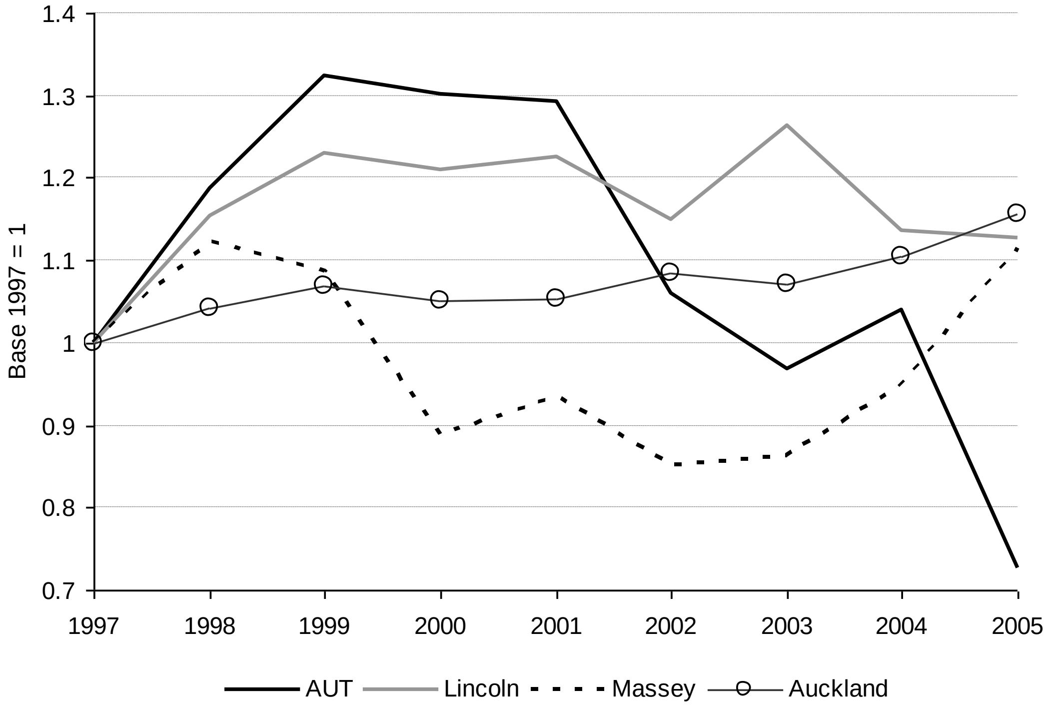
Figure 6, Cumulative scale efficiency growth by Australasian university grouping 1997-2005

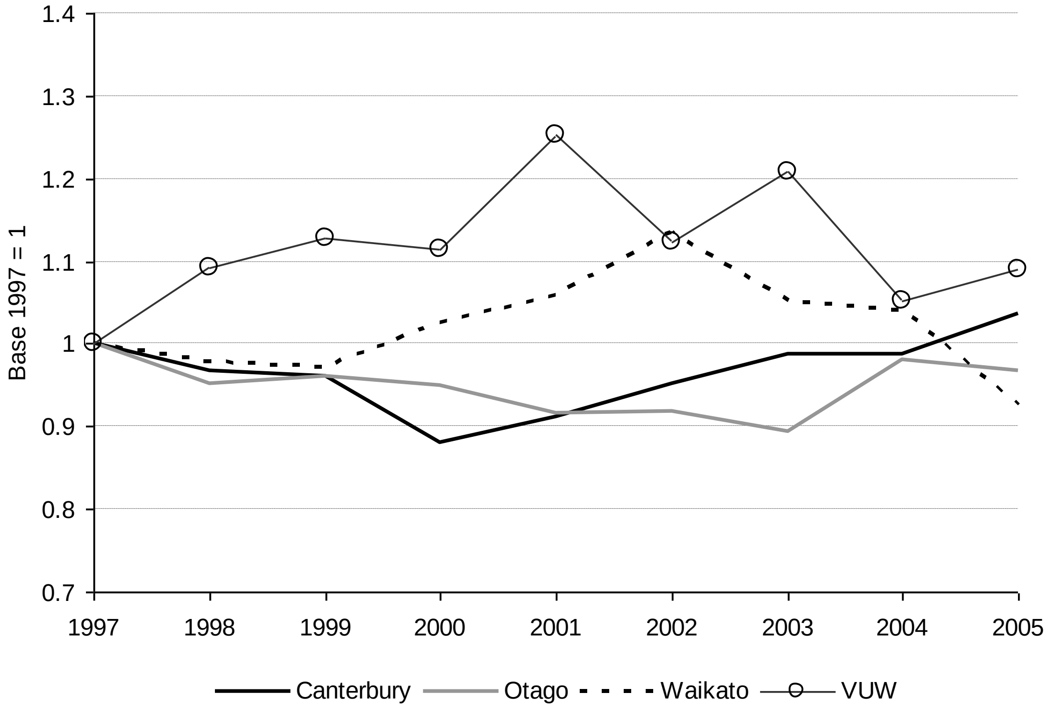


The mean total factor productivity growth presented in Figure 2 masks trends in the performance of the individual New Zealand universities. In particular, the strong growth at AUT while it was still a polytechnic and then fall in total factor productivity following it becoming a university impact on the overall New Zealand average. Figure 7 presents the cumulative total factor productivity indices for each of the New Zealand universities over the period 1997 to 2005.

Between 1997 and 1999, AUT exhibited the strongest total factor productivity growth of the New Zealand universities. However, this was a period during which AUT was a polytechnic, and benefited from significant levels of provision at the sub-degree level. After becoming a university, total factor productivity growth was static for two years, before declining significantly over the next three years. This fall in total factor productivity is likely to be a result of AUT reducing its provision at the sub-degree level while increasing degree and postgraduate provision and investing in upgrading research capability, all of which incur significant set up costs.

Figure 7, Cumulative total factor productivity growth by individual New Zealand universities 1997-2005





Between 1997 and 1999, Lincoln University also exhibited relatively strong total factor productivity growth. Since then, Lincoln has exhibited a general decrease in total factor productivity over time. The performance of Lincoln tends to be reliant upon trends in international student enrolments. As almost half of enrolments at Lincoln are international students, so any downturn in their enrolments, such as that since 2004, impacts on the performance of this university. In addition, the research output of Lincoln has fallen since 2004.

The performance of Massey University can be split into two periods. Following the merger with Wellington Polytechnic in 1999, Massey exhibited a fall in total factor productivity. This appeared to inhibit growth at Massey until 2002. Since 2002, Massey has exhibited the most significant growth in total factor productivity of all the New Zealand universities. This has mostly been driven by an increase in research outputs.

The experience of Massey in absorbing a polytechnic contrasts with the experience of AUT changing from a polytechnic to a university. Whereas, Massey as an existing university would have the infrastructure in place to successfully manage the absorption of Wellington Polytechnic, AUT has had to build up its research capability from a low base. This has led to the extended period of adjustment at AUT.

The University of Auckland exhibited the greatest cumulative total factor productivity growth of all the New Zealand universities over the period. Its growth since 2003 has been particularly strong. This has been led by significant growth in research output and also growth in undergraduate and postgraduate qualification completions.

The University of Canterbury displayed falling total factor productivity between 1997 and 2000. However, since 2000 the University of Canterbury has experienced steady total factor productivity improvement, mainly as a result of higher research output.

Between 1997 and 2003, the University of Otago exhibited falling total factor productivity. As in a number of other New Zealand universities, increased research output has resulted in an improvement in total factor productivity at Otago over the last few years.

In terms of the University of Waikato, although there was steady growth in total factor productivity between 1997 and 2002, since then total factor productivity has fallen significantly.[16]

VUW displayed uneven growth in total factor productivity over the period between 2000 and 2005, mostly as a result of variation in indexed research within the Web of Science. However, the overall trend is downwards in total factor productivity since 2001.

To identify the factors that may be influencing total factor productivity growth, panel regression was applied to data for the Australasian universities between 1997 and 2005. The regression analysis was run using the data for all universities and then run separately for New Zealand and Australian universities. This is to see if the impact of the explanatory variables varies between countries.

The explanatory variables included in the panel regression analysis included a variable (INTERNATIONAL) that measured the change in proportion of international students enrolled at a university.[17] Abbott and Doucouliagos (2007) found that competition for international students was a factor in improving the productivity of universities in Australia. Importantly, they found that this was not a factor in New Zealand universities.

Also included in the model was a variable (LOSS) that takes a value of 1 if the university ran an operating deficit in the previous year, else it takes a value of 0. This captures if poor financial performance is responded to by moves to improve productive efficiency.

A variable to capture the impact of time (TIME) was also included in the model. This takes a value of 1 in 1997/8, 2 in 1998/9 and so on.

A variable to capture the different groupings of universities was also included in the model (UNI_GROUPING). The separates out the three tiers of Australian universities and also identifies AUT in the period prior to becoming a university and also the period since.

[16] A likely reason is that the number of students has declined at this university and the university has not reduced staffing levels in response For example, in 2000, the number of equivalent full-time students (EFTS) per full-time equivalent (FTE) academic staff at the University of Waikato was 16.2, compared with 15.1 in 2005.
[17] Mean = 0.019, standard deviation = 0.025, minimum = -0.115, maximum = 0.161.

The explanatory variables included in the regression analysis are defined in Table 5.

Table 5, Definitions of explanatory variables in panel regression of total factor productivity of Australasian universities 1997-2005

Variable	Definition
INTERNATIONAL	This is the change in the proportion of total equivalent full-time students that are international.
LOSS	This variable takes a value of 1 if the university ran an operating deficit in the previous year, else it takes a value of 0.
UNI_GROUPING	This variable is made up of 6 categories. G8, AUS_OLD, AUS_NEW, AUT_OLD, AUT_NEW and NZ.
TIME	This variable takes a value of 1 in 1997/8, 2 in 1998/9 and so on.

Source, Ministry of Education and Department of Education, Science and Technology.

The results of the panel regression analysis are presented in Table 6.

Table 6, Results of panel regression: Total factor productivity of Australasian universities 1997-2005

(Dependent variable = total factor productivity)

Variable	**All**		**New Zealand**		**Australian**	
	Coefficient	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
LOSS	-0.014	0.014	0.062*	0.028	-0.024	0.015
INTERNATIONAL	0.535*	0.262	-0.210	0.328	0.684*	0.323
TIME	0.002	0.002	-0.001	0.004	0.003	0.002
UNI_GROUPING						
AUS_NEW	0.031*	0.014	n/a		-0.014	0.011
AUS_OLD	0.010	0.013	n/a		0.007	0.011
G8	0.024*	0.012	n/a		Reference category	
AUT_OLD	0.152*	0.074	0.143	0.079	n/a	
AUT_NEW	-0.104*	0.043	-0.088	0.046	n/a	
NZ	Reference category		Reference category		n/a	
CONSTANT	0.994**	0.014	1.009**	0.021	1.010**	0.014
R^2	0.08		0.26		0.06	
N	352		64		288	

Note, *, ** significant at the 5 percent level and 1 percent level, respectively.

The results show some interesting divergence in factors associated with total factor productivity growth in New Zealand and Australia. In the enrolments specification, LOSS was significant in the analysis including all universities. However, when the regression was applied to New Zealand and Australian universities separately, only in the case of New Zealand universities was there a statistically significant association. For New Zealand universities, a loss in the preceding year was associated with an increase of 7.6 percentage points in total factor productivity.

The difference in the apparent response to an operating loss may be due to a difference in monitoring of financial performance between the two countries. In New Zealand, the financial performance of the universities is monitored by the government and if it is assessed that the viability of the institution is at risk the Minister for Tertiary Education may appoint a Crown Observer to provide operational advice. If it is assessed that the institution is at imminent risk of failure, then the Minister has the power to dissolve the Council of that institution and appoint a Commissioner to run the institution.[18] These powers have never been used in the case of New Zealand universities, but have been in the polytechnic and wānanga sectors.

The legislation governing the operation of higher education providers in Australia outlines the requirement that providers need to be financially viable, and must be likely to remain viable.[19] Failure to do so can result in the federal government revoking the higher education provider status of an institution.

It may be that there is a more stringent monitoring of financial performance in New Zealand, which results in a greater response to a financial loss, compared to the situation in Australia. The fact that the New Zealand government has intervened in the polytechnic and wānanga sectors may act as motivation to the universities to improve their financial performance.

An increase in the proportion of international students was associated with higher total factor productivity growth in Australian universities, but not in New Zealand institutions. This is consistent with the findings of Abbott and Doucouliagos (2007).

The results in Table 6 show that the rate of total factor productivity growth was higher in G8 and AUS_NEW universities, compared with New Zealand universities. Total factor productivity growth in the G8 universities was 2.4 percentage points higher and growth in

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[18] See http://www.tec.govt.nz/templates/standard.aspx?id=1194 for more information.

[19] See http://www.comlaw.gov.au/ComLaw/Legislation/ActCompilation1.nsf/framelodgmentattachments/8BC8DC3CEB9AC2ACCA256F7100579866. for more information.

AUS_NEW universities 3.1 percentage points higher than the New Zealand universities (excluding AUT).

The contrasting performance of AUT, compared with the other New Zealand universities, is clear in both model specifications. Prior to becoming a university, AUT's total factor productivity growth was above that of the other New Zealand universities. However, since achieving university status, total factor productivity has been below that of the other New Zealand universities.

Conclusion

New Zealand universities predominantly list the objective of disseminating knowledge through conferring qualifications on their students and the publication of research as a key part of their mission or vision statements. The analysis in this paper has examined the ability of the universities to achieve these objectives efficiently.

The analysis of the productivity growth of New Zealand universities has identified some key trends in their performance. On average, the productivity growth of New Zealand universities between 1997 and 2005 was lower than that of the G8 and newer universities in Australia. The disparity of growth to the G8 universities in particular is a cause of concern, given that New Zealand universities commonly benchmark their performance against this group of institutions.

It is clear that structural changes in the sector have had a negative impact – notably the merger of Massey University with Wellington Polytechnic and the granting of university status to AUT. However, the different incentives that exist under New Zealand and Australian funding systems of higher education would also play a role here – Australian universities were at least partly funded on their performance for the whole period under analysis, while the New Zealand universities were only partly-funded under a performance-based system for the last two years of this study.

It was also apparent that New Zealand universities were more likely to improve their productivity in the year following a financial loss than their Australian counterparts. This may be a result of more proactive monitoring and intervention by the New Zealand government of tertiary education institutions.

That a number of New Zealand universities exhibited significant improvement in total factor productivity in the last few years, mostly as a result of increased research output, would suggest that the introduction of the PBRF has stimulated productivity improvements in the New Zealand university sector. Whether the increased use of performance-based funding would result in further productivity improvements may be an area that policy makers wish to pursue.

Appendix

Table 7, Total factor productivity change estimates for Australasian universities 1997-1998 to 2004-2005

University	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	mean
AUT	1.188	1.115	0.983	0.994	0.820	0.914	1.072	0.699	*0.961*
Lincoln	1.154	1.066	0.983	1.012	0.939	1.098	0.899	0.993	*1.015*
Massey	1.123	0.968	0.817	1.054	0.911	1.012	1.098	1.176	*1.014*
Auckland	1.042	1.026	0.982	1.001	1.030	0.989	1.030	1.047	*1.018*
Canterbury	0.967	0.994	0.916	1.037	1.042	1.038	1.001	1.048	*1.004*
Otago	0.951	1.011	0.989	0.963	1.003	0.973	1.099	0.986	*0.996*
Waikato	0.979	0.993	1.056	1.033	1.071	0.927	0.989	0.890	*0.990*
VUW	1.093	1.033	0.988	1.124	0.896	1.077	0.870	1.035	*1.011*
Charles Sturt	1.163	0.951	1.089	1.192	0.985	1.122	1.082	0.844	*1.047*
Macquarie	0.992	0.993	1.247	1.131	0.809	1.138	0.931	1.024	*1.025*
Southern Cross	0.996	0.971	0.781	1.274	1.234	0.996	0.974	0.949	*1.011*
New England	1.030	0.896	0.937	0.933	1.010	1.075	1.018	1.144	*1.003*
NSW	1.099	1.029	1.026	1.122	1.023	1.018	1.020	1.056	*1.049*
Newcastle	1.006	1.112	0.953	1.066	1.036	1.050	0.910	1.034	*1.019*
Sydney	1.063	1.063	0.970	1.004	0.987	1.079	1.063	1.097	*1.040*
UTS	1.002	1.061	1.090	0.931	1.009	1.145	0.884	1.189	*1.034*
Western Sydney	1.114	0.992	1.096	1.035	1.164	1.053	0.888	1.002	*1.040*
Wollongong	0.991	1.091	0.991	0.983	1.015	1.066	1.099	1.119	*1.043*
Deakin	0.983	0.946	1.341	0.992	0.882	1.007	0.977	1.084	*1.019*
La Trobe	1.027	0.933	0.954	0.951	1.018	1.025	1.004	1.039	*0.993*
Monash	0.963	0.987	1.092	1.129	0.992	1.036	1.031	1.027	*1.031*
RMIT	0.973	1.055	1.039	1.007	1.069	0.927	1.026	1.048	*1.017*
Swinburne	1.080	1.030	1.074	1.117	0.990	1.018	0.947	1.051	*1.037*
Ballarat	1.039	1.087	1.027	1.039	1.265	0.605	1.415	1.289	*1.067*
Melbourne	0.997	1.076	1.049	1.004	1.024	1.061	1.001	1.081	*1.036*
VUT	0.992	0.924	0.983	0.973	1.045	1.076	1.142	0.889	*1.000*
CQU	1.123	1.026	1.244	1.476	1.201	0.946	0.870	1.277	*1.131*
Griffith	1.061	0.989	1.035	0.925	1.035	1.098	1.046	1.009	*1.023*
James Cook	1.092	0.995	1.062	0.994	0.934	1.052	1.049	1.140	*1.038*
QUT	1.063	0.968	0.975	1.006	1.020	0.992	1.058	1.040	*1.015*
Queensland	1.048	0.968	0.944	1.051	1.035	1.068	1.070	1.087	*1.033*
Sth Queensland	1.068	1.024	1.009	0.955	1.302	1.197	0.935	1.086	*1.066*
Curtin	0.998	0.979	1.099	1.018	1.027	1.036	0.982	0.973	*1.013*
Edith Cowan	1.067	0.970	0.994	1.031	1.132	1.076	1.023	1.055	*1.042*
Murdoch	0.968	1.030	1.011	0.956	1.037	0.958	1.032	0.928	*0.989*
West Australia	1.064	1.004	0.968	1.032	1.000	1.055	1.012	1.055	*1.023*
Flinders	0.916	1.173	1.045	0.968	0.976	1.001	0.853	1.188	*1.009*
Adelaide	0.895	1.142	1.024	0.928	1.122	1.016	0.994	1.050	*1.018*
South Australia	1.014	0.886	1.076	1.077	0.983	1.125	1.075	1.017	*1.029*
Tasmania	1.114	1.028	0.952	0.966	1.031	1.007	0.920	0.958	*0.995*
NTU	0.994	1.030	0.916	0.977	1.092	1.310	0.974	1.075	*1.040*
ANU	1.093	0.996	0.991	1.019	0.956	1.019	1.024	1.087	*1.022*
Canberra	1.185	1.096	0.976	1.053	0.996	0.993	1.125	1.010	*1.052*
Catholic	0.975	0.967	0.838	1.090	0.943	0.974	1.194	0.927	*0.983*
Mean	*1.037*	*1.013*	*1.009*	*1.033*	*1.020*	*1.028*	*1.012*	*1.036*	*1.023*

Notes:

1. All means are geometric means.
2. The indices represent change from one year to the next and the first year in each column represents the base year.
3. Note that a value of 1.02 for an index indicates that productivity had increased by 2 percent. A value of 0.98 would indicate that productivity had decreased by 2 percent.

Table 8, Technical efficiency change estimates for Australasian universities 1997-1998 to 2004-2005

University	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	mean
AUT	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Lincoln	1.118	1.056	0.935	0.977	1.021	1.108	0.858	1.177	*1.026*
Massey	1.026	0.954	0.739	1.017	0.997	0.979	1.082	1.232	*0.994*
Auckland	0.982	1.030	0.924	0.987	1.057	0.943	1.019	1.102	*1.004*
Canterbury	1.000	1.000	0.916	0.991	1.102	1.000	1.000	0.986	*0.998*
Otago	1.000	1.000	1.000	0.947	1.033	0.922	1.076	0.954	*0.990*
Waikato	0.949	0.974	1.028	1.015	1.137	0.982	0.938	0.936	*0.993*
VUW	1.091	1.000	0.958	1.044	1.000	1.000	0.916	1.091	*1.011*
Charles Sturt	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Macquarie	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Southern Cross	0.954	0.970	0.758	1.231	1.328	0.952	0.904	1.100	*1.010*
New England	1.000	1.000	0.890	0.875	1.094	0.985	0.979	1.153	*0.993*
NSW	1.039	1.056	0.952	1.052	1.000	1.000	1.000	1.000	*1.012*
Newcastle	0.984	1.077	0.952	1.033	1.099	0.999	0.883	1.054	*1.008*
Sydney	0.998	1.035	0.975	0.988	0.999	1.063	1.000	1.000	*1.007*
UTS	1.009	1.030	1.000	0.945	1.058	1.000	1.000	1.000	*1.005*
Western Sydney	1.050	0.967	1.040	0.985	1.255	1.000	0.868	1.152	*1.034*
Wollongong	0.978	1.077	0.926	0.923	1.107	0.955	1.135	1.000	*1.010*
Deakin	0.922	0.942	1.150	0.964	0.946	0.945	0.924	1.169	*0.991*
La Trobe	1.000	0.976	0.914	0.911	1.122	0.964	0.978	1.060	*0.989*
Monash	0.922	0.949	1.011	1.106	1.019	0.999	1.007	1.003	*1.001*
RMIT	0.899	1.031	0.942	0.921	1.228	0.887	1.001	1.191	*1.006*
Swinburne	1.029	1.034	0.935	1.068	1.101	0.950	0.959	1.081	*1.018*
Ballarat	0.987	1.093	0.967	0.973	1.303	0.568	1.411	1.248	*1.035*
Melbourne	0.967	1.034	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
VUT	0.950	0.893	0.978	0.851	1.185	1.016	1.137	0.928	*0.987*
CQU	1.031	1.084	1.084	1.229	1.000	1.000	0.879	1.138	*1.051*
Griffith	1.011	0.971	0.989	0.876	1.134	1.054	0.969	1.106	*1.011*
James Cook	1.027	0.968	1.079	0.957	0.970	0.993	1.056	1.117	*1.019*
QUT	1.012	1.008	0.904	0.942	1.123	0.939	0.966	1.197	*1.007*
Queensland	1.035	0.958	0.968	1.000	1.025	1.017	1.040	1.017	*1.007*
Sth Queensland	0.961	1.062	0.960	0.949	1.326	1.000	1.000	1.000	*1.027*
Curtin	0.919	0.968	1.042	1.002	1.104	1.022	0.902	1.136	*1.009*
Edith Cowan	1.034	0.976	0.938	1.007	1.216	1.012	0.933	1.223	*1.037*
Murdoch	0.979	1.003	0.998	0.917	1.117	0.942	0.979	1.061	*0.998*
West Australia	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Flinders	0.890	1.123	1.000	1.000	1.000	1.000	0.856	1.168	*1.000*
Adelaide	0.856	1.122	1.041	0.907	1.102	1.000	1.000	0.970	*0.996*
South Australia	1.022	0.864	1.020	1.040	1.080	1.058	1.021	1.099	*1.023*
Tasmania	1.040	1.001	0.988	0.921	1.079	0.989	0.905	1.032	*0.993*
NTU	0.987	1.053	0.877	0.926	1.167	1.213	0.989	0.992	*1.020*
ANU	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Canberra	1.120	1.126	0.937	1.019	1.037	0.884	1.145	0.991	*1.029*
Catholic	1.000	1.000	1.000	1.000	1.000	0.850	1.177	1.000	*1.000*
Mean	*0.994*	*1.009*	*0.968*	*0.986*	*1.079*	*0.977*	*0.993*	*1.062*	*1.008*

Notes:
1. All means are geometric means.
2. The indices represent change from one year to the next and the first year in each column represents the base year.
3. Note that a value of 1.02 for an index indicates that productivity had increased by 2 percent. A value of 0.98 would indicate that productivity had decreased by 2 percent.

Table 9, Technological change estimates for Australasian universities 1997-1998 to 2004-2005

University	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	mean
AUT	1.188	1.115	0.983	0.994	0.820	0.914	1.072	0.699	*0.961*
Lincoln	1.032	1.010	1.051	1.037	0.920	0.991	1.047	0.844	*0.989*
Massey	1.095	1.014	1.106	1.036	0.914	1.033	1.015	0.955	*1.019*
Auckland	1.062	0.997	1.063	1.015	0.975	1.049	1.011	0.950	*1.014*
Canterbury	0.967	0.994	1.000	1.046	0.946	1.038	1.001	1.064	*1.006*
Otago	0.951	1.011	0.989	1.016	0.971	1.055	1.021	1.034	*1.006*
Waikato	1.032	1.020	1.027	1.017	0.941	0.944	1.055	0.951	*0.997*
VUW	1.001	1.033	1.032	1.076	0.896	1.077	0.950	0.948	*1.000*
Charles Sturt	1.163	0.951	1.089	1.192	0.985	1.122	1.082	0.844	*1.047*
Macquarie	0.992	0.993	1.247	1.131	0.809	1.138	0.931	1.024	*1.025*
Southern Cross	1.045	1.001	1.030	1.035	0.929	1.047	1.078	0.863	*1.001*
New England	1.030	0.896	1.053	1.066	0.923	1.092	1.040	0.992	*1.009*
NSW	1.058	0.975	1.078	1.067	1.023	1.018	1.020	1.056	*1.036*
Newcastle	1.023	1.033	1.000	1.031	0.943	1.051	1.030	0.982	*1.011*
Sydney	1.065	1.027	0.995	1.017	0.988	1.015	1.063	1.097	*1.033*
UTS	0.993	1.030	1.090	0.985	0.953	1.145	0.884	1.189	*1.029*
Western Sydney	1.061	1.026	1.054	1.051	0.928	1.053	1.022	0.871	*1.006*
Wollongong	1.013	1.013	1.070	1.065	0.917	1.116	0.968	1.119	*1.033*
Deakin	1.066	1.004	1.166	1.029	0.932	1.066	1.057	0.927	*1.028*
La Trobe	1.027	0.955	1.043	1.043	0.907	1.063	1.027	0.980	*1.004*
Monash	1.044	1.041	1.080	1.020	0.974	1.037	1.024	1.024	*1.030*
RMIT	1.081	1.023	1.103	1.093	0.870	1.046	1.024	0.880	*1.011*
Swinburne	1.050	0.997	1.149	1.046	0.900	1.071	0.987	0.972	*1.019*
Ballarat	1.053	0.995	1.062	1.068	0.971	1.066	1.003	1.033	*1.031*
Melbourne	1.031	1.040	1.049	1.004	1.024	1.061	1.001	1.081	*1.036*
VUT	1.045	1.034	1.005	1.142	0.882	1.059	1.005	0.958	*1.014*
CQU	1.090	0.947	1.147	1.202	1.201	0.946	0.990	1.122	*1.076*
Griffith	1.049	1.018	1.046	1.056	0.913	1.042	1.079	0.912	*1.013*
James Cook	1.064	1.028	0.984	1.039	0.963	1.060	0.993	1.021	*1.018*
QUT	1.050	0.960	1.079	1.068	0.909	1.056	1.095	0.869	*1.007*
Queensland	1.013	1.011	0.975	1.052	1.009	1.050	1.029	1.069	*1.026*
Sth Queensland	1.111	0.965	1.051	1.006	0.982	1.197	0.935	1.086	*1.039*
Curtin	1.086	1.012	1.054	1.016	0.931	1.013	1.088	0.857	*1.004*
Edith Cowan	1.031	0.993	1.060	1.024	0.931	1.063	1.097	0.863	*1.005*
Murdoch	0.989	1.027	1.012	1.042	0.928	1.017	1.054	0.875	*0.991*
West Australia	1.064	1.004	0.968	1.032	1.000	1.055	1.012	1.055	*1.023*
Flinders	1.029	1.044	1.045	0.968	0.976	1.001	0.996	1.017	*1.009*
Adelaide	1.046	1.018	0.984	1.023	1.018	1.016	0.994	1.082	*1.022*
South Australia	0.992	1.025	1.055	1.035	0.910	1.064	1.052	0.925	*1.006*
Tasmania	1.071	1.027	0.964	1.048	0.955	1.018	1.016	0.928	*1.002*
NTU	1.007	0.978	1.044	1.055	0.935	1.080	0.984	1.084	*1.020*
ANU	1.093	0.996	0.991	1.019	0.956	1.019	1.024	1.087	*1.022*
Canberra	1.058	0.973	1.042	1.034	0.960	1.124	0.983	1.019	*1.023*
Catholic	0.975	0.967	0.838	1.090	0.943	1.146	1.015	0.927	*0.983*
Mean	*1.044*	*1.004*	*1.042*	*1.047*	*0.945*	*1.052*	*1.018*	*0.975*	*1.015*

Notes:

1. All means are geometric means.
2. The indices represent change from one year to the next and the first year in each column represents the base year.
3. Note that a value of 1.02 for an index indicates that productivity had increased by 2 percent. A value of 0.98 would indicate that productivity had decreased by 2 percent.

Table 10, Pure technical efficiency change estimates for Australasian universities 1997-1998 to 2004-2005

University	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	mean
AUT	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Lincoln	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Massey	1.000	0.966	0.782	0.978	1.002	0.967	1.063	1.239	*0.993*
Auckland	1.006	1.007	0.924	0.949	1.092	0.931	1.094	1.065	*1.007*
Canterbury	1.000	1.000	0.960	0.985	1.058	1.000	1.000	1.000	*1.000*
Otago	1.000	1.000	1.000	0.957	1.026	0.925	1.070	0.954	*0.991*
Waikato	0.962	0.963	1.041	1.012	1.122	0.998	0.974	0.896	*0.994*
VUW	1.090	1.000	0.997	1.003	1.000	1.000	1.000	1.000	*1.011*
Charles Sturt	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Macquarie	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Southern Cross	0.914	0.938	0.754	1.244	1.302	1.000	0.987	1.013	*1.006*
New England	1.000	1.000	0.925	0.905	1.062	1.001	1.048	1.060	*0.999*
NSW	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Newcastle	0.988	1.070	0.948	1.053	1.097	0.985	0.874	1.052	*1.006*
Sydney	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
UTS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Western Sydney	1.081	1.032	1.000	0.964	1.037	1.000	0.967	1.034	*1.014*
Wollongong	0.954	1.080	0.954	0.916	1.091	0.981	1.092	1.000	*1.006*
Deakin	0.998	0.932	1.075	1.000	0.922	0.935	0.924	1.181	*0.992*
La Trobe	1.000	1.000	0.895	0.926	1.115	0.959	0.971	1.060	*0.989*
Monash	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
RMIT	0.964	1.004	1.024	0.891	1.030	0.903	1.020	1.076	*0.987*
Swinburne	1.009	1.045	0.948	1.080	1.092	0.891	0.979	1.067	*1.012*
Ballarat	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Melbourne	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
VUT	1.000	0.873	0.953	0.857	1.175	1.042	1.146	0.905	*0.988*
CQU	1.003	1.106	1.094	1.123	1.000	1.000	0.930	1.075	*1.040*
Griffith	1.018	0.985	0.971	0.880	1.060	1.033	0.986	1.103	*1.003*
James Cook	1.046	0.964	1.051	0.956	0.954	0.963	1.107	1.105	*1.016*
QUT	1.000	1.000	1.000	0.951	1.014	0.973	1.025	1.039	*1.000*
Queensland	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Sth Queensland	0.958	1.031	1.036	0.880	1.315	1.000	1.000	1.000	*1.021*
Curtin	0.962	0.952	1.123	0.914	1.056	1.063	0.951	1.049	*1.006*
Edith Cowan	1.005	0.950	0.940	1.004	1.218	1.018	0.931	1.222	*1.031*
Murdoch	0.966	0.994	0.996	0.902	1.098	0.955	1.023	1.002	*0.991*
West Australia	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Flinders	0.936	1.068	1.000	1.000	1.000	1.000	0.895	1.117	*1.000*
Adelaide	0.856	1.128	1.035	0.914	1.094	1.000	1.000	0.992	*0.999*
South Australia	0.960	0.870	1.051	1.009	0.984	1.055	1.053	1.062	*1.004*
Tasmania	1.041	1.015	0.977	0.929	1.069	0.977	0.918	1.032	*0.993*
NTU	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
ANU	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Canberra	1.172	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.020*
Catholic	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Mean	*0.996*	*0.998*	*0.985*	*0.979*	*1.045*	*0.989*	*0.999*	*1.030*	*1.003*

Notes:

1. All means are geometric means.
2. The indices represent change from one year to the next and the first year in each column represents the base year.
3. Note that a value of 1.02 for an index indicates that productivity had increased by 2 percent. A value of 0.98 would indicate that productivity had decreased by 2 percent.

Table 11, Scale efficiency change estimates for Australasian universities 1997-1998 to 2004-2005

University	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	mean
AUT	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Lincoln	1.118	1.056	0.935	0.977	1.021	1.108	0.858	1.177	*1.026*
Massey	1.026	0.987	0.944	1.040	0.995	1.012	1.018	0.995	*1.002*
Auckland	0.976	1.023	1.000	1.039	0.968	1.012	0.931	1.034	*0.997*
Canterbury	1.000	1.000	0.954	1.006	1.042	1.000	1.000	0.986	*0.998*
Otago	1.000	1.000	1.000	0.990	1.007	0.997	1.005	1.000	*1.000*
Waikato	0.987	1.011	0.987	1.003	1.014	0.983	0.964	1.045	*0.999*
VUW	1.001	1.000	0.961	1.040	1.000	1.000	0.916	1.091	*1.000*
Charles Sturt	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Macquarie	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Southern Cross	1.044	1.034	1.006	0.989	1.019	0.952	0.915	1.086	*1.004*
New England	1.000	1.000	0.962	0.968	1.031	0.983	0.934	1.088	*0.995*
NSW	1.039	1.056	0.952	1.052	1.000	1.000	1.000	1.000	*1.012*
Newcastle	0.996	1.007	1.005	0.981	1.001	1.014	1.010	1.001	*1.002*
Sydney	0.998	1.035	0.975	0.988	0.998	1.063	1.000	1.000	*1.007*
UTS	1.009	1.030	1.000	0.945	1.058	1.000	1.000	1.000	*1.005*
Western Sydney	0.971	0.937	1.040	1.022	1.210	1.000	0.898	1.114	*1.020*
Wollongong	1.025	0.997	0.970	1.008	1.015	0.973	1.040	1.000	*1.003*
Deakin	0.924	1.011	1.071	0.964	1.026	1.010	1.000	0.989	*0.999*
La Trobe	1.000	0.976	1.022	0.984	1.006	1.005	1.007	0.999	*1.000*
Monash	0.922	0.949	1.011	1.106	1.019	0.999	1.007	1.003	*1.001*
RMIT	0.933	1.028	0.920	1.034	1.192	0.982	0.982	1.107	*1.019*
Swinburne	1.020	0.989	0.987	0.989	1.008	1.067	0.980	1.013	*1.006*
Ballarat	0.987	1.093	0.967	0.973	1.303	0.568	1.411	1.248	*1.035*
Melbourne	0.967	1.034	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
VUT	0.950	1.024	1.026	0.994	1.009	0.975	0.992	1.026	*0.999*
CQU	1.027	0.980	0.991	1.094	1.000	1.000	0.945	1.058	*1.011*
Griffith	0.994	0.986	1.019	0.995	1.069	1.020	0.983	1.003	*1.008*
James Cook	0.982	1.004	1.026	1.001	1.017	1.031	0.954	1.010	*1.003*
QUT	1.012	1.008	0.904	0.990	1.108	0.964	0.942	1.152	*1.007*
Queensland	1.035	0.958	0.968	1.000	1.025	1.017	1.040	1.017	*1.007*
Sth Queensland	1.003	1.030	0.927	1.079	1.008	1.000	1.000	1.000	*1.005*
Curtin	0.955	1.017	0.928	1.095	1.045	0.961	0.949	1.083	*1.002*
Edith Cowan	1.029	1.028	0.997	1.003	0.998	0.994	1.002	1.001	*1.006*
Murdoch	1.014	1.008	1.002	1.017	1.017	0.986	0.957	1.059	*1.007*
West Australia	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Flinders	0.951	1.052	1.000	1.000	1.000	1.000	0.956	1.046	*1.000*
Adelaide	1.000	0.995	1.005	0.993	1.007	1.000	1.000	0.978	*0.997*
South Australia	1.065	0.993	0.970	1.031	1.098	1.002	0.969	1.034	*1.019*
Tasmania	0.999	0.986	1.012	0.992	1.009	1.013	0.986	1.001	*0.999*
NTU	0.987	1.053	0.877	0.926	1.167	1.213	0.989	0.992	*1.020*
ANU	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Canberra	0.955	1.126	0.937	1.019	1.037	0.884	1.145	0.991	*1.008*
Catholic	1.000	1.000	1.000	1.000	1.000	0.850	1.177	1.000	*1.000*
Mean	*0.997*	*1.011*	*0.982*	*1.007*	*1.033*	*0.988*	*0.994*	*1.031*	*1.005*

Notes:

1. All means are geometric means.
2. The indices represent change from one year to the next and the first year in each column represents the base year.
3. Note that a value of 1.02 for an index indicates that productivity had increased by 2 percent. A value of 0.98 would indicate that productivity had decreased by 2 percent.

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