The Measurement of the Performance of New Zealand Tertiary Education Institutions and the Demand for their Services

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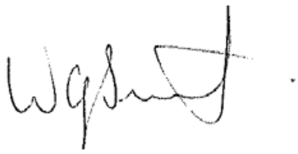
Attestation of authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.



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Abstract

This thesis explored the measurement of performance of New Zealand tertiary education institutions (TEIs) and the demand for their services. This involved analysing the research performance of New Zealand universities, analysing the productive efficiency of New Zealand TEIs and examining the choice of provider by bachelors degree starters.

Bibliometric data was used to measure the research productivity of New Zealand universities. This showed that following a fall during the early 2000s, the research productivity of New Zealand universities increased following the introduction of the Performance-Based Research Fund (PBRF). A multi-dimensional analysis of university research performance between 2000 and 2005 showed that no individual university was top in all four of the performance measures assessed. The overall performance of three universities, Massey University, Lincoln University and Auckland University of Technology, were noticeably below that of the other five universities.

Data Envelopment Analysis (DEA) was then applied to input and output data of New Zealand TEIs to analyse their productive efficiency. In 2006, polytechnics that had: low levels of bachelors degree provision, were not regionally based, had a high proportion of subcontracting and were larger institutions, achieved higher levels of pure technical efficiency. The analysis showed that several polytechnics could improve their technical efficiency by reducing their scale of operations. In polytechnics, higher technical efficiency was associated with better financial performance. A number of technically efficient polytechnics struggled financially, indicating that the overall efficiency of the polytechnic sector was not high, or the funding model they operate under is not appropriate. The analysis also showed that decreasing bachelors degree provision, poor financial performance in the previous year, an increase in provision of community education, was associated with higher growth in total factor productivity between 1996 and 2006.

The application of DEA to Australasian university data between 1997 and 2005 showed that New Zealand universities performed relatively well in terms of relative pure technical efficiency, compared with their Australian counterparts. However, the total factor productivity of New Zealand universities increased at a lower rate, on average, than that of the Australian Group of Eight and newer Australian universities. The application of DEA to a dataset of the participating TEIs in the PBRF showed that polytechnics had lower technical efficiency, on average, than other TEIs.

The choices of bachelors degree starters in 2006 were analysed for evidence of a lack of parity of esteem between university and polytechnic degrees. The results showed that a lack of parity of esteem between polytechnic and university degrees may be influencing student choices. Students from higher decile schools, with higher secondary school qualifications, Asians, students who travel for study, were all more likely to enrol in a university to start a bachelors degree. There was less clear cut evidence of a lack of parity of esteem between selected groupings of New Zealand universities. However, there did appear to be a lack of parity of esteem between the four older metropolitan universities and the two newest universities, with signs the former were held in higher esteem.

1 Introduction

A defining feature of higher education in the early 21st century is the attention being placed on measuring the performance of tertiary education institutions (TEIs). Worldwide, governments are increasingly applying performance measures to their higher education sectors.[1] In addition, international ranking systems of institutional performance are proliferating.[2]

The increased application of performance measurement to tertiary education is a result of increased interest in performance measurement of not-for-profit institutions in the public sector. The large sums devoted to expenditure in the public sector led to increasing public concern about the management of not-for-profit institutions (Ramanathan 1985). Initially, developments in this area produced small batches of indicators which had curiosity value rather than functionality (Mayston 1985).

However, a view soon developed that rather than a focus on narrow financial ratios, there should be wider measurement of performance. This was best illustrated by the so-called Balanced Scorecard approach developed by Kaplan and Norton (1992). This proposed that institutions (both for profit and not-for-profit) should look to have a suite of indicators that measured performance from a variety of perspectives, not just financial.

In New Zealand, the reforms of the public sector during the 1980s resulted in increased interest in performance measurement of the local not-for-profit sector. Boston *et al*. (1996, p.13) argue that the "…new model of public management [was] built largely around the notion of performance. Improving the efficiency and effectiveness of public institutions was a central plank of the reforms."

[1] For example, the Australian government is introducing a comprehensive system of research performance measurement via the Excellence in Research Australia initiative. Also, the United Kingdom government is contemplating introducing a system of metrics to measure and fund research performance.

[2] Several ranking systems now measure the performance of universities in particular. Two of the better known rankings systems include the Shanghai Jai Tong rankings and the Times Higher Education Supplement rankings.

Historically, greater interest in performance measurement in the tertiary education area was a result of increased scrutiny of performance during times of static or falling student numbers (Cave *et al*. 1991). However, the recent upswing in interest has occurred in an environment of stable or growing student numbers.

For many governments, the recent drive to use performance indicators is about accountability of public expenditure (especially during the current economic downturn) and a desire to provide students with more information with which to make their choices. Tertiary institutions are also showing increased interest in performance measurement. For them, it is about benchmarking performance against other providers and enhancing their reputation in order to attract students.

Pollitt (1989) suggests that, depending on the circumstances within a country, there is a 'lifecycle' of interest in the application of performance indicators to the education sector. He also asserts that although there may initially be strong interest in performance indicators, eventually, due to complications in the application or definition of the performance indicators, the momentum stops.

A lifecycle of interest is evident in the application of performance measurement to the New Zealand tertiary sector. In the late 1980's there was a push for the introduction of performance indicators into the tertiary education sector, which stemmed from the changes to the Education Act allowing more autonomous management of the TEI's. In 1989, 64 performance indicators were presented in for possible implementation in a report by a government-appointed sector reference group (Performance Indicators Task Force 1989). A lack of capability in the information systems and the initial satisfactory performance of the tertiary insuitutions saw interest in the indicators fade.

However, there is no sign of any cooling-off in the recent renewed interest in performance measurement of tertiary institutions in New Zealand. If anything, the government is upping the ante by signalling increased use of performance indicators across a variety of dimensions (Tolley 2009). Clearly, the paradigm in which performance measurement is viewed and used in the New Zealand tertiary education system is changing.[3]

In another important shift in emphasis, the New Zealand government is signalling that improving the efficiency of the tertiary education system is a key priority (Ministry of Education 2009). Undoubtedly, the economic slowdown and the stress this is placing on the government's finances is a major factor. This places importance on not just measuring performance, but also measuring efficiency to ensure that scarce resources are being used wisely.

Although the financial performance of New Zealand TEIs has been closely monitored for more than a decade, the application of other measures of performance in a sector-wide context has been more piecemeal and generally linked to the introduction of funding systems.[4] For example, the Performance-Based Research Fund (PBRF) was introduced in 2004 and allocates funding to participating tertiary education organisations based on their research performance. The availability of detailed data on the quality of research produced by participating tertiary education organisations has seen attention focused on this one specific dimension of their performance.

It is within the context of the growing use and interest in performance measurement and in improving efficiency in tertiary education that this thesis measures the performance of New Zealand TEIs and the demand for their services. A multi-dimensional approach to measuring the performance of TEIs is used in this study. Firstly, the research performance of the New Zealand universities is analysed across a number of dimensions. These include dimensions such as quality, academic impact and productivity. By doing so, the intention is to present a more balanced view of the relative performance of the universities.

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[3] It will be interesting to see how the introduction of this set of indicators is accepted, given that the one common factor in all countries implementing performance indicators is the controversy that resulted (Cave *et al*. 1991).

[4] In New Zealand, individual tertiary providers have published detailed performance information in their annual reports, but the measures are not standardised and so comparison of performance between institutions is not possible.

Data Envelopment Analysis (DEA) is then used to measure the technical efficiency and productivity change in New Zealand TEIs. The use of DEA allows for the multiple input/output nature of TEIs to be taken into account when measuring performance. In an advance in previous studies, this analysis also introduces an international dimension by comparing the efficiency of New Zealand and Australian universities. The factors that explain differences in efficiency are also examined.

An analysis of the demand for tertiary education provides a balance to the supply-side focus of performance measurement and tackles arguably the biggest issue resulting from the 'Learning for Living' reforms of the late 1980s early 1990s ─ the perception of a lack of parity of esteem between degrees conferred by universities and those conferred by polytechnics. Anecdotal evidence suggests that students who choose to study for a bachelors degree at a polytechnic are disadvantaged in the labour market. Whether or not this is true, this perception could influence the decisions of students. The high stakes involved are illustrated by the attempt by two polytechnics to become universities, along with legislation being proposed to create a new classification for less research intensive universities, the university of technology.

The issue of parity of esteem is examined by applying logistic regression to administrative data to identify the student characteristics associated with the choice of a polytechnic or university for degree study. By analysing the behaviour of students from different socioeconomic backgrounds and with different levels of school qualifications, this can identify if the perception of a lack of parity of esteem is in fact real.

The structure of this thesis is as follows. First, the research performance of New Zealand universities is analysed in chapter 2. This includes an examination of research productivity over time, as well as a multi-dimensional analysis of university performance. In chapter 3, the productive efficiency of New Zealand TEIs is examined using DEA. This analysis also includes an analysis of productivity trends over time. In chapter 4, the choice of a university or polytechnic to begin a bachelors degree is examined to analyse the impact of parity of esteem. Finally, in chapter 5, conclusions are presented along with proposed areas of further research.

2 Measuring the research performance of New Zealand universities

2.1 Introduction

The research performance of New Zealand universities is subject to more scrutiny than other areas of their operations, such as teaching or service. This is, in part, because the requirement to produce world class research is a defining characteristic of universities that sets them apart from other tertiary education institutions (TEIs).[5] The focus on research also arises because of the greater availability of performance measures, compared with other areas such as teaching.[6] In particular, discussion of the results of the Performance-Based Research Fund (PBRF) Quality Evaluations has dominated the discourse around university performance since the first results were released in 2004.[7] This has arguably placed undue focus on research quality at the expense of other measures of research performance, such as research productivity.

As a result, some New Zealand universities have ceased reporting totals of research output and instead concentrate on measures of research quality. Yet research productivity is a key area of performance, especially in understanding how the introduction of the PBRF has influenced research activity in the universities. Importantly, the focus on just one element of research performance can also present an unbalanced view of an institution's performance.

This chapter presents a balanced analysis of the research performance of New Zealand universities by using data from the 2006 PBRF Quality Evaluation and the Web of Science to measure their research performance across multiple dimensions. These include the quality of research, the academic impact of research and the productivity of researchers.

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[5] Education Act 1989, Section 162(4).

[6] Marginson (2007) argues this is why international rankings systems of university performance, such as the Shanghai Jai Tong and The Times Higher Education Supplement, are predominantly made up of measures of research performance.

[7] The publication of detailed results at the individual provider level is undoubtedly a factor in this interest. Although performance measures, such as completion rates of qualifications, are reported by the Ministry of Education at the subsector level, currently the data is not published at the provider level.

This chapter also examines university research productivity of New Zealand universities between 1997 and 2007 from a variety of data sources to analyse the impact of the introduction of the PBRF. In addition, the viability of using bibliometric databases to measure research productivity over time is analysed.

The structure of this chapter is as follows. First, a review of the literature on the use of bibliometrics to measure research performance is presented in section 2.2. This also includes the results of studies that applied bibliometrics to measure New Zealand university performance. Then, the data used to measure research performance is presented in section 2.3. This is followed by the results of the analysis of research productivity over time in section 2.4.1. Finally, the results of an analysis of university research performance across multiple dimensions are presented in section 2.4.2.

2.2 Review of the literature

This section presents a review of the literature that examines New Zealand university research performance. First, the use of bibliometrics to measure research performance is examined in section 2.2.1. Then, an examination of the findings of studies that have analysed the performance of New Zealand universities using bibliometric data sources are presented in section 2.2.2.

2.2.1 Use of bibliometrics

The key underlying assumption in the use of bibliometrics to measure research performance is that the rate of citation is a proxy for the quality of research – a higher rate of citation indicates that the research is of higher quality. Several studies have found a reasonably strong correlation between peer-assessed quality and citation counts. Smith and Eyesenk (2002) and Norris and Oppenheim (2003) compared results from the Research Assessment Exercise (RAE) in the United Kingdom with the rate of citation in the areas of psychology and archaeology, respectively. They found rates of correlation between rates of citation and peer-assessed levels of quality of up to 0.91 and 0.85 using Spearman's rank order coefficient.

A study by Smart (2007) examined the association between the quality of research, as measured by the results of the PBRF Quality Evaluations, and the rate of citation of New Zealand university research using a dataset from Thomson Reuters.[8] He found that the strength of the numerical association varied among subject disciplines. Subject areas like the biological sciences had higher levels of correlation than subjects like commerce.[9] This was not an unexpected result, given the different publishing conventions of the various subject areas.

Despite the increasing use of bibliometrics to measure research performance, there are a number of important caveats that need to be considered when using bibliometric data. Coryn (2007, pp.118-119) provides a useful summary of the

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[8] Who produce the Web of Science.

[9] The Spearman's rank order coefficient for the biological sciences was around 0.91, compared with 0.52 for commerce.

potential pitfalls of bibliometrics, with a specific focus on the Web of Science. Some of the key points are summarised below.

Perhaps the greatest limitation is that the coverage of the Web of Science varies based on the field of research. In disciplines, such as science and medicine, where journal publication is the acknowledged way of disseminating research, there is reasonable coverage. However, in disciplines, such as the humanities and social sciences, coverage of the research output of academics is limited. In these disciplines, dissemination of research through books and book chapters is commonplace. Also, in the area of creative arts, exhibitions are a key way that research is disseminated. Therefore, the Web of Science, with its reliance on journal publication, will not be capturing all the research output produced by academics across the various subject disciplines.

Another limitation is that the journals in the Web of Science are dominated by English language journals that are based mainly in the United States. Therefore, the coverage of journals published in New Zealand is low. Finally, there is the issue of errors in the bibliometric databases. This applies in particular to assigning work to individual authors and to institutions.

Given these issues, caution should be used in the interpretation of results based on the Web of Science. Nevertheless, bibliometric databases, such as the Web of Science, are increasingly being used in the measurement of research performance.

2.2.2 New Zealand bibliometric studies

The Ministry of Research, Science and Technology (MoRST) has published two National Bibliometric Reports (MoRST 2003, 2006a). These studies used unit-record data from Thomson Reuters to analyse publication and citation trends in New Zealand. The results of the latest National Bibliometric Report showed that the indexed articles and reviews by authors from New Zealand universities had risen significantly in the period between 1997 and 2003. Unfortunately, the reports do not separate out the rates of citation by university authors.

A report by MoRST (2006b) analysed research output between 1997 and 2003 at each of the universities using data from Thomson Reuters. This study showed a decline in the research productivity of New Zealand universities of 4.2% between 2000 and 2003.

The Ministry of Education has produced a number of reports using bibliometric data from Thomson Reuters that analyse the academic impact of research.[10] Smart and Weusten (2007a) examined the academic impact of New Zealand university research between 1981 and 2005. This study found that research in the 'Health' and 'Medicine and public health' subject panels achieved the highest relative academic impact compared to the world average over the period 1981-2005.

A further study by Smart and Weusten (2007b) compared the bibliometric performance of New Zealand and Australian universities. This study found that overall the relative impact of New Zealand universities was below that of the Australian Group of Eight (G8) universities but above that of the non-G8 universities.

Smart (2009a) examined the impact of the PBRF on the bibliometric performance of universities. The study found that the share of world indexed publications by New Zealand university authors has increased since the PBRF was introduced. In addition, the share of world citations has also increased since the PBRF was introduced.

A drawback of the studies by Smart and Weusten (2007a, 2007b) and Smart (2007, 2009a) relates to how the data is aggregated upwards in broader subject panels. The Thomson Reuters dataset used in these studies assigns a journal to up to three narrow subject categories. As a result, when aggregating upwards to broader subject panels there will be an element of double counting. In addition, the categorisation of articles and citations into years is based on the time they were entered into the Thomson Reuters database and not the year of publication.

[10] Relative academic impact is measured by (citations per article in New Zealand)/(citations per article in world).

Smart (2009b) examined the impact of the PBRF on research productivity, as measured by articles and reviews from the Web of Science. The author used a production function approach to suggest that research output was around 30 percent higher following the introduction of the PBRF, controlling for other factors.

Dale and Goldfinch (2005) used data extracted from the Web of Science to measure the research output and impact of the research of political science units in Australasian universities over the period 1995 to 2001. The authors found that the political science department at the Australian National University produced the highest number of research articles per staff member overall, while the best-performing unit from New Zealand was at the University of Waikato.

Macri and Sinha (2006) measured the quality and quantity of research by economists at New Zealand and Australian universities during the period 1988 to 2002 using data extracted from the ECONLIT database. The study found that over the period 1996 to 2002, economics staff at the University of Melbourne were the largest producers of journal articles per staff member overall. The most productive of New Zealand's economics departments was at the University of Otago.

Although not using bibliometric data, a study by the Ministry of Education (2008) used data collected as part of the PBRF to compare the research profile of the New Zealand universities across multiple dimensions. The four measures used include the average PBRF quality score, the average external research income earned by universities per FTE staff, the weighted number of research degree completions per FTE staff and the number of bachelors or higher students enrolled in the universities per FTE staff.

The study then categorised the eight universities based on the pattern in their performance. These categories with the associated universities in brackets were: older university with medical school (Universities of Auckland and Otago), older universities without medical schools (Massey University, The University of Canterbury, University of Waikato and Victoria University of Wellington), specialised university (Lincoln University) and new university (Auckland University of Technology).

The review of the literature shows that there is increasing use of bibliometrics to measure the research performance of university staff. However, a significant proportion of these studies focussed on individual disciplines, which means a wider picture of the strengths and weaknesses of universities across multiple disciplines cannot be identified.

Those studies that did examine a broader number of subject disciplines, such as those by Smart and Weusten (2007a, 2007b) and Smart (2009a), do not examine the issue of research productivity due to limitations in the datasets used. Finally, there has been little research into the productivity of university research over time.

This analysis in this chapter fills these gaps in the literature by taking a broad-based look at the research performance of New Zealand universities across the majority of subject disciplines. This allows for a balanced picture of performance to be gained without placing undue focus on the results of the PBRF Quality Evaluations.

2.3 Data and method

In this section, the datasets used to analyse the research performance of New Zealand universities are discussed. First, the data used to measure the research productivity of New Zealand universities is presented in section 2.3.1. This is followed by the discussion of the datasets used to measure the research performance of the universities across multiple dimensions in section 2.3.2.

2.3.1 Research productivity

There are two key sources of data used to analyse the research productivity of the New Zealand universities over time. These are the counts of research outputs reported by universities in their annual reports and the counts of research publications indexed in the Web of Science.

A key problem in measuring the research output of universities in New Zealand is a lack of consistency in the way the universities report their research output. Although universities have routinely reported counts of research output in their annual reports for several years, they use different categories and thresholds to report research output, and several have changed the way they report over time.[11] Some universities have even ceased reporting the total number of research outputs in their annual reports. This makes a year-on-year comparison of research output at all eight universities problematic for any extended period of time. In addition, because of the issue of double counting of research outputs when authors are from different universities, it is hard to determine overall productivity trends in the university sector. This is why finding alternative sources of research output data, such as those recorded in bibliometric databases, is crucial to gaining a better understanding of the research productivity of New Zealand universities.

Another problem in analysing changes in the research productivity of New Zealand universities over time is the impact of mergers of tertiary institutions with the universities. During this period of analysis, there were five mergers of note. These

[11] Although Australia collects detailed information on the quantity of published research at each university in order to inform research funding, there is no comparable dataset available for the New Zealand universities.

were: the merger of Massey University with Wellington Polytechnic in 1999. This was followed by the merger of the Auckland College of Education with the University of Auckland in 2004, the Wellington College of Education with Victoria University of Wellington in 2005, Christchurch College of Education with the University of Canterbury in 2007 and the Dunedin College of Education with the University of Otago, also in 2007. In this chapter, the data for the universities is generated assuming they were merged with those TEIs for the entire period. This creates a more consistent time-series dataset.

The bibliometric database used to generate counts of research output is the Web of Science, produced by Thomson Reuters. The two types of research output counted for the analysis of university research output are the articles and reviews by authors from New Zealand universities.[12]

In generating counts of output using the Web of Science, care was taken to ensure that the output counts for each university was as accurate as possible. Sometimes, university authors will list an affiliation of a school within a university, rather than the university itself. This particularly applies to staff at the various schools of medicine attached to the University of Otago.[13]

2.3.2 Multi-dimensional research performance

Two data sources are used to measure the research performance of the universities across multiple dimensions. These are the results of the 2006 Performance-Based Research Fund (PBRF) Quality Evaluation and the counts of articles and their associated citations from the Web of Science.

The PBRF Quality Evaluation uses a peer review approach to measure the quality of research produced by staff at participating tertiary education organisations (TEOs). Each staff member is assessed over three dimensions: the quality of their research output (which contributes 70 percent towards the quality category assigned to participating staff, the esteem with which they are held by their peers (15 percent)

[12] As argued by Dale and Goldfinch (2005), these are the publications indexed within the Web of Science that can be treated as true research outputs.
[13] More issues surrounding the use of the Web of Science are discussed in the next section.

and their contribution to the research environment (15 percent). A staff member assessed as producing research that is esteemed internationally receives an ‘A’ quality category. A researcher who is nationally recognised receives a ‘B’ quality category and research recognised at the institutional level would earn a ‘C’ quality category for staff. Staff not reaching the threshold of a ‘C’ quality category receive an ‘R’ quality category.

For the 2006 quality evaluation, an additional two quality categories were introduced. These were the C(NE) and the R(NE). These categories were for staff identified as new and emerging. These staff faced a lower threshold in the assessment of the quality of their research than experienced researchers.

For publication purposes, those staff who received an A were assigned a score of 10 (out of 10), staff with a B received 6, staff with a C 2 and staff with an R 0 points. Then, a weighted score was published by the Tertiary Education Commission in 42 subject areas for each of the TEOs.

For the purposes of this study, the performance measures (including the PBRF quality scores) are aggregated into nine groupings based on PBRF panel areas.[14] This is similar to the approach used by Evidence Ltd (2007) in analysing the research performance of the United Kingdom. Aggregating into larger subject panels helps to overcome the issue of the smaller size of academic departments in New Zealand universities. A focus on academic departments can lead to a small number of articles and reviews which, in turn, can lead to volatility in the data. Note that Psychology is reported separately from the rest of the subjects within the Social sciences panel, given the dominance of publications in this area within the Web of Science.[15]

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[14] The mapping of the PBRF narrow subject areas to panel areas is presented in Table 2.10. The Creative arts and Māori knowledge and development panels are not included in this analysis. Journal publication is not the main way that staff in this area would publish their research and it is impossible to identify the publications by staff in the Māori knowledge and development area. In addition, because of the difficulty in identifying articles that would apply to the Biological sciences panel, Public health and the Medical panel, these panels are combined.

[15] Although reporting at the panel level helps to moderate the issue of small numbers of papers in the Web of Science for New Zealand universities, it can have the problem of masking good performance within individual subject areas.

For the 2006 PBRF Quality Evaluation, staff could submit research outputs that were published between 2000 and 2005. Therefore, the bibliometric data used in this study is sourced from articles that were published in this same publication window.[16] The Web of Science was accessed in February 2008 to generate the citation counts associated with the articles published between 2000 and 2005.

The Web of Science categorises journal articles into around 230 subject areas. These have been mapped to the PBRF subject panels. This mapping is presented in Table 2.11.

The four measures of performance used in this analysis are defined below:

1. Quality:	PBRF average quality score per full-time equivalent (FTE) PBRF-eligible staff member in the 2006 Quality Evaluation[17]
2. Impact (FTE):	Number of citations per FTE PBRF-eligible staff member in the 2006 Quality Evaluation
3. Impact (article):	Number of citations per article
4. Productivity:	Number of articles per FTE PBRF-eligible staff member in the 2006 Quality Evaluation

To compare the performance of universities across the various subject panels, the data needs to be normalised, as different panel areas have different rates of citation. Smart (2009a) normalised New Zealand university performance to the world average. However, the online tool used in this study to access the Web of Science database can only generate citations for a limited number of articles. So, the performance of each university is normalised to the New Zealand university average. A value of one indicates that a university performed at the university average, a value of less than one indicates they performed below the New Zealand university average

[16] Note that only articles were used in this analysis, given that different rates of citation generally apply to articles and reviews.

[17] This refers to the average quality score published by the Tertiary Education Commission, not the individual component scores (research output, peer esteem and contribution to the research environment).

and a value above one indicates they performed above the New Zealand university average.

It is important to note that the PBRF Quality Evaluation results presented here are relative to the average subject performance and so differ from the PBRF scores published by the Tertiary Education Commission. It is also important to note that the articles from the Web of Science are not linked to actual authors. Rather, they are linked to university names. Therefore, in some subject areas, the FTE used as the denominator in the bibliometric performance measures may only be an estimate of the actual academic resource being used to produce the research.

2.4 Results

This section presents the results of the analysis of the research performance of New Zealand universities. First, the research productivity of New Zealand universities is examined in section 2.4.1. Then, the research performance of New Zealand universities across multiple dimensions is analysed in section 2.4.2.

2.4.1 Research productivity of New Zealand universities

In this section the results of the analysis of research productivity are presented in section 2.4.1.1. Then, some conclusions are presented in section 2.4.1.2.

2.4.1.1 Results

The total research output counts reported by the universities between 1997 and 2007 are presented in Table 2.1. Of those universities that have reported in a consistent manner over time, Auckland University of Technology (AUT) has exhibited the largest increase in research output (247 percent), followed by the University of Canterbury (106 percent), University of Otago (72 percent) and Victoria University of Wellington (Victoria) (61 percent). The size of the increase in research outputs at AUT is not surprising, as they are building their research capability from a low base.

Table 2.1, Reported research outputs of New Zealand universities 1997-2007

University	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
AUT	530	419	572	717	942	1,109	1,203	1,238	1,596	1,678	1,841
Lincoln (old)	897	804	828	914	732	728	636	741			
Lincoln (new)								773	826	661	573
Massey	2,311	2,447	2,683	2,557	2,306	1,896	2,003	2,371			
Auckland	5,074	5,693	5,214	5,421	5,858	5,342	5,841	6,221			
Canterbury	1,198	1,292	1,308	1,501	1,580	1,839	1,870	2,156	2,299	2,455	2,464
Otago	2,371	2,714	2,713	2,468	2,348	2,306	2,372	2,886	3,804	4,341	4,078
Waikato	1,312	1,075	1,051	2,322	2,376	1,774	1,274	1,398	1,566	1,099	1,016
Victoria	1,638	1,828	1,809	1,745	1,874	1,782	1,899	2,361	2,434	2,843	2,640

Source, Annual reports of the universities and Ministry of Education

As can be seen in Table 2.1, there is inconsistency in the way that the universities have reported their total research outputs. The University of Auckland and Massey University ceased reporting total research outputs in 2004, while Lincoln University has changed the way they report total research output over the period. Although the University of Waikato has not overtly changed the way they count outputs, the near doubling of output in 2000 and then dramatic fall between 2001 and 2003, suggest the way that research outputs are counted has changed. The fact that total reported research output fell by 23 percent between 1997 and 2007 is also an indicator of different reporting standards, given it is unlikely research output would have declined to that extent, if at all.

To gain an understanding of how research productivity has changed for these universities over time, the number of research outputs per full-time equivalent (FTE) academic are presented in Table 2.2 (this data is also graphed in Figure 2.1).

As the universities have different standards of reporting, the number of research outputs per FTE should not be compared between universities. Instead the focus is on how the productivity has changed at each individual university over time.

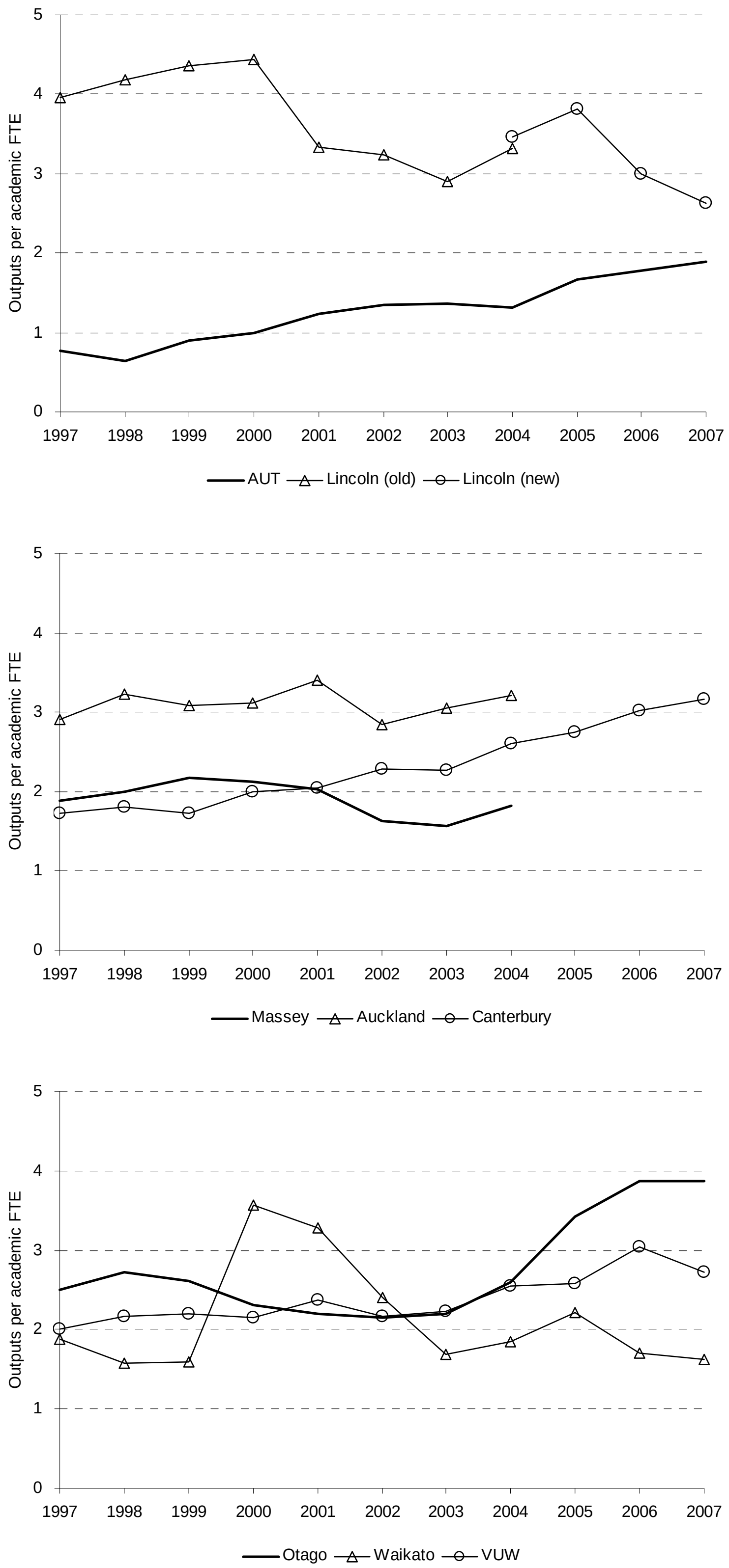
Table 2.2, Reported research outputs of New Zealand universities per FTE academic staff 1997-2007

University	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
AUT	0.8	0.6	0.9	1.0	1.2	1.3	1.4	1.3	1.7	1.8	1.9
Lincoln (old)	4.0	4.2	4.4	4.4	3.3	3.2	2.9	3.3			
Lincoln (new)								3.5	3.8	3.0	2.6
Massey	1.9	2.0	2.2	2.1	2.0	1.6	1.6	1.8			
Auckland	2.9	3.2	3.1	3.1	3.4	2.8	3.0	3.2			
Canterbury	1.7	1.8	1.7	2.0	2.1	2.3	2.3	2.6	2.7	3.0	3.2
Otago	2.5	2.7	2.6	2.3	2.2	2.1	2.2	2.6	3.4	3.9	3.9
Waikato	1.9	1.6	1.6	3.6	3.3	2.4	1.7	1.9	2.2	1.7	1.6
Victoria	2.0	2.2	2.2	2.1	2.4	2.2	2.2	2.6	2.6	3.0	2.7

Of the universities that reported research output in a consistent manner over the period, the largest increase in output per FTE academic was at AUT (146 percent) followed by the University of Canterbury (84 percent), University of Otago (55 percent) and Victoria (36 percent).

At the remaining universities, due to changes in reporting or cessation of reporting of research output, it is difficult to determine what has happened to research productivity since 2004. This is unfortunate, given that the PBRF was introduced in 2004, making it important to assess what the impact of this policy has been on research productivity.

Figure 2.1, Reported research outputs of individual New Zealand universities per FTE academic staff 1997-2007



To gain a better understanding of how research productivity has been affected by the PBRF, bibliometric data is examined to analyse trends in research output. The counts of articles and reviews indexed in the Web of Science between 1997 and 2006 are presented in Table 2.3. Also included in Table 2.3 is a count of total articles and reviews by New Zealand university authors which avoids double counting of co-authored research.[18]

Table 2.3, Counts of articles and reviews by New Zealand universities in the Web of Science 1997-2006

University	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
AUT	9	6	14	19	26	33	52	70	107	108
Lincoln	88	122	132	131	127	101	113	140	132	124
Massey	360	382	437	489	410	449	434	526	664	634
Auckland	863	907	954	942	986	999	1,029	1,072	1,183	1,334
Canterbury	345	362	389	408	412	446	441	511	528	559
Otago	743	821	852	874	861	854	926	893	1,058	1,027
Waikato	200	208	233	187	188	192	235	217	248	246
Victoria	184	198	233	236	211	267	248	382	340	421
Total	*2,693*	*2,891*	*3,090*	*3,149*	*3,101*	*3,175*	*3,296*	*3,625*	*4,056*	*4,301*

Source, Web of Science

The largest growth in total outputs was at AUT (1,100 percent) though this was off a very low base, followed by Victoria (129 percent) and Massey University (76 percent). The lowest increase in total outputs was exhibited by the University of Waikato (23 percent). Overall, the counts of research output by New Zealand university authors increased by 60 percent between 1997 and 2006 (see Figure 2.3). However, much of the increase in output took place between 2003 and 2006, following four years of flat output.

One way of assessing the performance of the universities is to examine the share of total indexed research outputs achieved by each of the universities. Given the selective nature of journals included in the Web of Science, an increase in share would imply an increase in the proportion of quality research outputs produced by New Zealand universities. Table 2.4 presents the share of articles and reviews produced by the individual New Zealand universities. The share of total Web of

[18] As a result, the sum of outputs of the individual universities is greater than the overall total.

Science publications produced by each of the universities is also illustrated in Figure 2.2.

Table 2.4, Share of articles and reviews in the Web of Science by New Zealand universities 1997-2006

University	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
AUT	0.3%	0.2%	0.5%	0.6%	0.8%	1.0%	1.6%	1.9%	2.6%	2.5%
Lincoln	3.3%	4.2%	4.3%	4.2%	4.1%	3.2%	3.4%	3.9%	3.3%	2.9%
Massey	13.4%	13.2%	14.1%	15.5%	13.2%	14.1%	13.2%	14.5%	16.4%	14.7%
Auckland	32.0%	31.4%	30.9%	29.9%	31.8%	31.5%	31.2%	29.6%	29.2%	31.0%
Canterbury	12.8%	12.5%	12.6%	13.0%	13.3%	14.0%	13.4%	14.1%	13.0%	13.0%
Otago	27.6%	28.4%	27.6%	27.8%	27.8%	26.9%	28.1%	24.6%	26.1%	23.9%
Waikato	7.4%	7.2%	7.5%	5.9%	6.1%	6.0%	7.1%	6.0%	6.1%	5.7%
Victoria	6.8%	6.8%	7.5%	7.5%	6.8%	8.4%	7.5%	10.5%	8.4%	9.8%

Note, due to joint authorship the shares add up to more than 100 percent

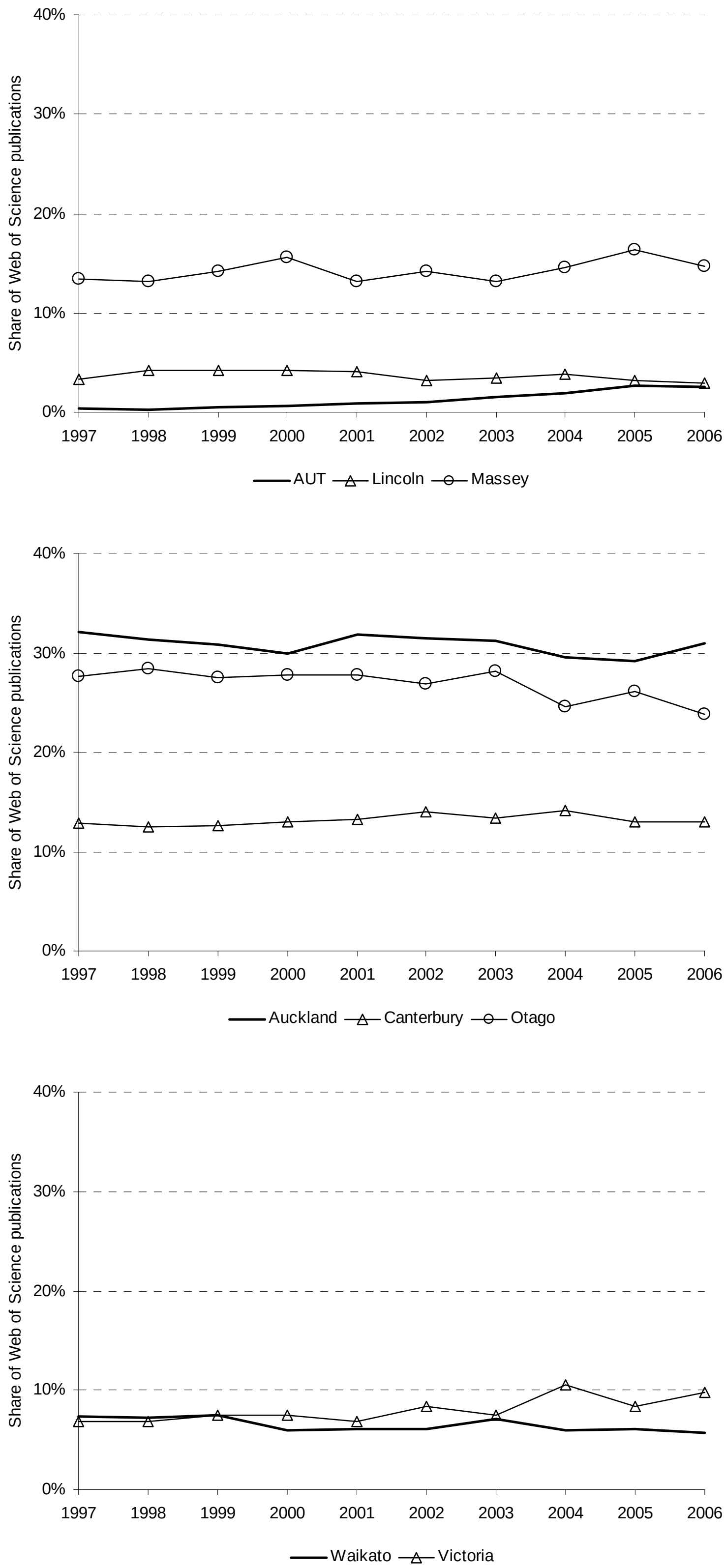
The Universities of Auckland and Otago have the largest shares of indexed articles and reviews. This is not surprising, given their size. The presence of medical schools at these institutions is also a factor in their large share of research publications. The University of Auckland has the largest share of outputs, with its share fluctuating between 29 percent and 32 percent. In 2006, Auckland's share of total indexed outputs was 31 percent. The University of Otago has exhibited a general downward trend in their share of indexed outputs since 2003. Otago's share of outputs decreased from 28 percent in 2003 to 24 percent in 2006.

AUT displays a steady increase in their share of total articles and reviews over time, albeit off a low base. AUT's share of total outputs increased from 0.3 percent in 1997 to 2.5 percent in 2006.

Of the two universities with an agricultural focus, Lincoln University's share of total indexed outputs has declined over time. Lincoln's share peaked at 4.3 percent in 1999, before declining to 2.9 percent in 2006. The share of indexed outputs produced by authors at Massey University has fluctuated over time, with their share peaking at 16 percent in 2000 and 2005.

The share of indexed research outputs by the University of Canterbury increased gradually from 13 percent in 1997 to 14 percent in 2002. However, since then, the share has decreased slightly to reach 13 percent in 2006.

Figure 2.2, Share of articles and reviews in the Web of Science by New Zealand universities 1997-2006



The University of Waikato's share of indexed outputs has ranged between 5.7 percent (in 2006) and 7.5 percent (in 1999). Since 2003, the University of Waikato has exhibited a slightly declining share of output.

Victoria's share of indexed output has exhibited some instability since 2003. However, the share of indexed outputs increased from 7.5 percent in 2003 to 9.8 percent in 2006.

Although examining the share of Web of Science publications is a useful exercise, the number of indexed outputs per FTE academic staff gives a better indication of research productivity. Table 2.5 shows the number of articles and reviews per FTE academic staff at the universities.

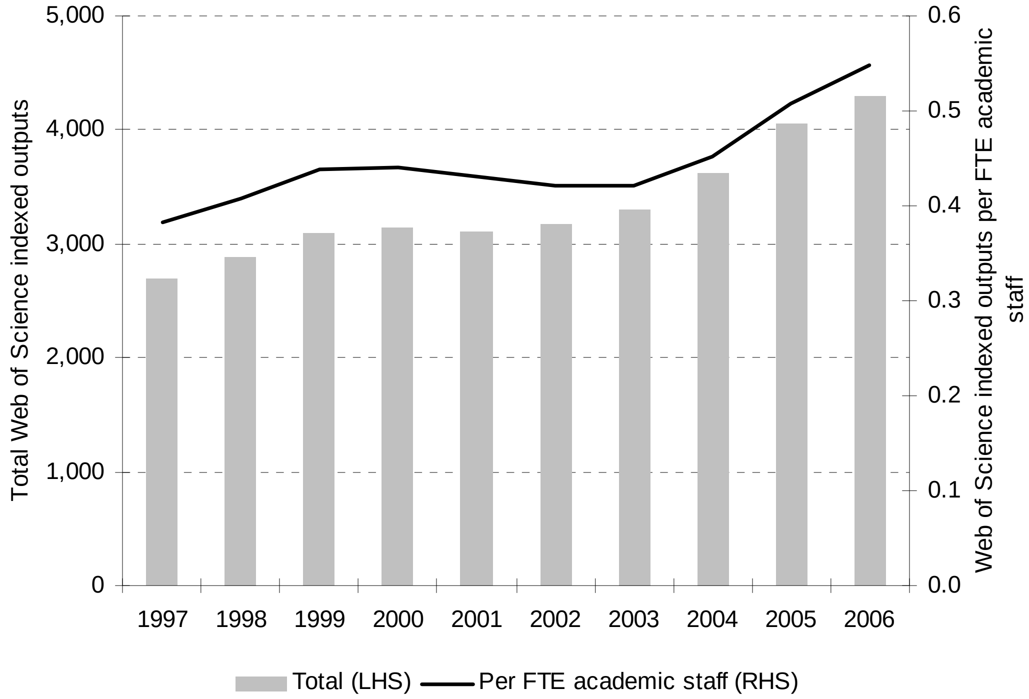
Table 2.5, Articles and reviews per FTE academic staff by New Zealand universities in the Web of Science 1997-2006

University	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
AUT	0.01	0.01	0.02	0.03	0.03	0.04	0.06	0.07	0.11	0.11
Lincoln	0.39	0.64	0.69	0.64	0.58	0.45	0.52	0.63	0.61	0.56
Massey	0.29	0.31	0.35	0.41	0.36	0.39	0.34	0.40	0.53	0.52
Auckland	0.50	0.51	0.56	0.54	0.57	0.53	0.54	0.55	0.60	0.68
Canterbury	0.50	0.50	0.51	0.54	0.53	0.55	0.53	0.62	0.63	0.69
Otago	0.78	0.82	0.82	0.82	0.80	0.79	0.86	0.80	0.95	0.91
Waikato	0.29	0.31	0.35	0.29	0.26	0.26	0.31	0.29	0.35	0.38
Victoria	0.22	0.23	0.28	0.29	0.27	0.32	0.29	0.41	0.36	0.45
Total	*0.38*	*0.41*	*0.44*	*0.44*	*0.43*	*0.42*	*0.42*	*0.45*	*0.51*	*0.55*

The number of articles and reviews per FTE academic staff for New Zealand universities in total is illustrated in Figure 2.3. It shows that research productivity increased by 30 percent between 2003 and 2006. This followed a drop of four percent between 1999 and 2003. The increased focus on research resulting from the introduction of the PBRF is likely to be a major factor in the significant increase in productivity since 2003.[19]

[19] See Smart (2009b) for more detail on the increased attention placed on research by the introduction of the PBRF.

Figure 2.3, Counts of articles and reviews from the Web of Science by authors from New Zealand universities 1997-2006



It is useful to analyse research productivity at Australian universities to help identify if the patterns exhibited in New Zealand are mirrored overseas. Trends in the research productivity at three Australian universities are presented in Figure 2.4. The University of Melbourne is a Group of Eight university. La Trobe University is an older Non-Group of Eight university. Central Queensland University is one of the so-called Dawkin's universities and only became a university in the early 1990s. Figure 2.4 shows the number of articles and reviews indexed in the Web of Science per FTE academic staff at these three Australian universities.[20]

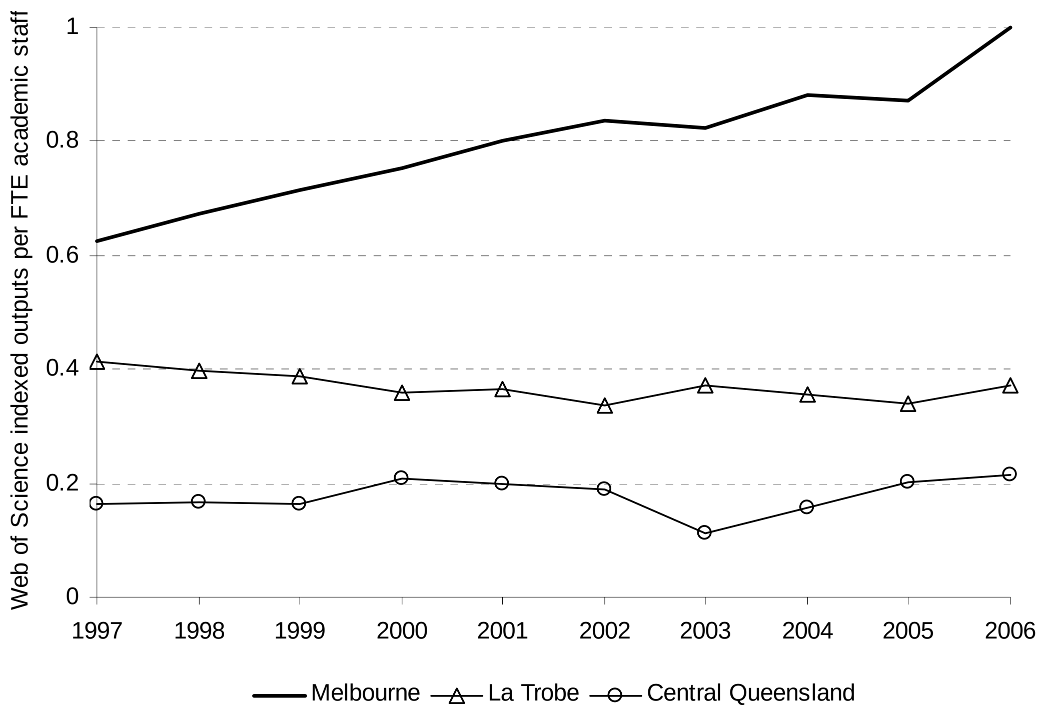
The number of research outputs per FTE academic at the University of Melbourne, one of Australia's largest and most research-intensive universities, displays a steady increase between 1997 and 2002. Thereafter, research productivity continued to trend upwards but displayed more variation from year to year. At La Trobe University, research productivity declined between 1997 and 2002. From 2002, research productivity has remained relatively static. At Central Queensland University,

[20] Note that because of a limit to the number of articles and reviews that can be analysed using the Web of Science a total for all Australian universities cannot be calculated.

research productivity dropped in 2003 and then trended upwards over the following three years.

Only in the case of Central Queensland University is there a surge in research output from 2003 similar to that exhibited by many of the New Zealand universities. This suggests that the introduction of the PBRF is a factor in the increased research productivity at New Zealand universities.

Figure 2.4, Indexed articles and reviews per FTE academic staff for selected Australian universities in the Web of Science 1997-2006



As mentioned earlier, one of the problems with using annual report data of the universities to measure research productivity was a cessation of reporting or a lack of consistent reporting over time. This made it difficult to get a clear picture of how research productivity was tracking at all New Zealand universities. To get a sense of how research productivity has changed at the individual New Zealand universities, the number of research outputs per FTE academic staff using annual report data is compared with data from the Web of Science.

The research productivity of the Auckland University of Technology (AUT) is presented in Figure 2.5. Because AUT has reported research outputs in a relatively consistent manner over time, a reasonable idea of the trend in research productivity is available via annual report data. This shows that productivity has been increasing over time as AUT builds is research capability. Between 1997 and 2007, research productivity increased by 146 percent.

The trends in productivity illustrated by the Web of Science data mirrors several of those exhibited by the annual report data. The Web of Science productivity data shows similar year to year changes, such as the decrease in 1998, the surge in productivity between 2004 and 2005 and the slow down in the rate of growth between 2005 and 2006. Overall, the number of articles and reviews per FTE academic staff in the Web of Science increased by 782 percent between 1997 and 2006.

Figure 2.5, Research outputs per FTE academic staff at Auckland University of Technology 1997-2007

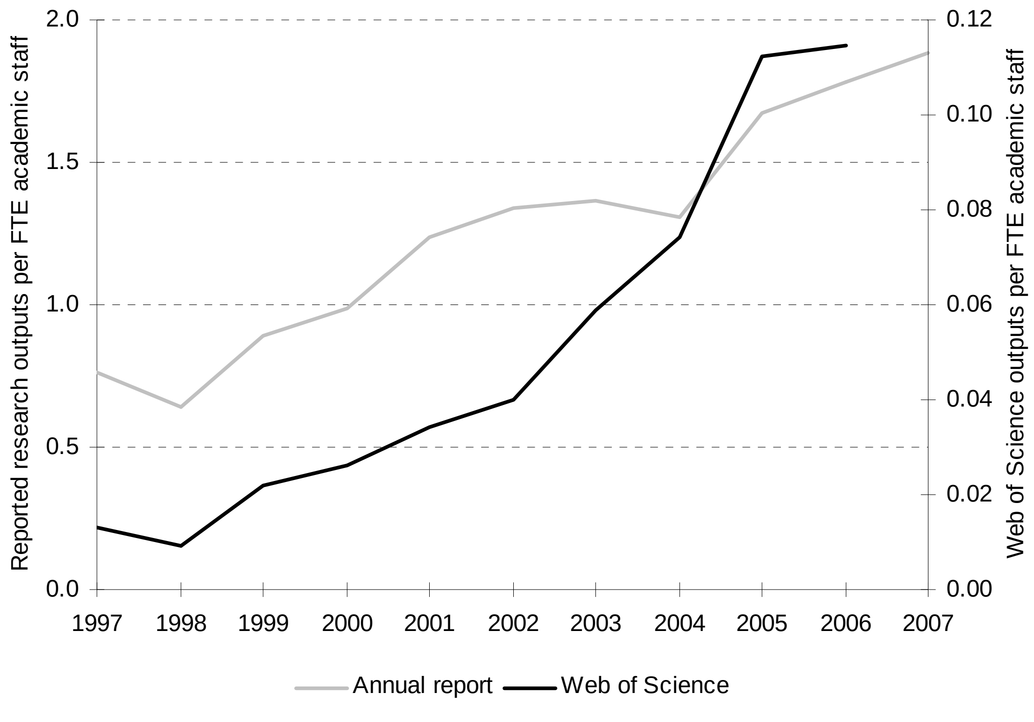
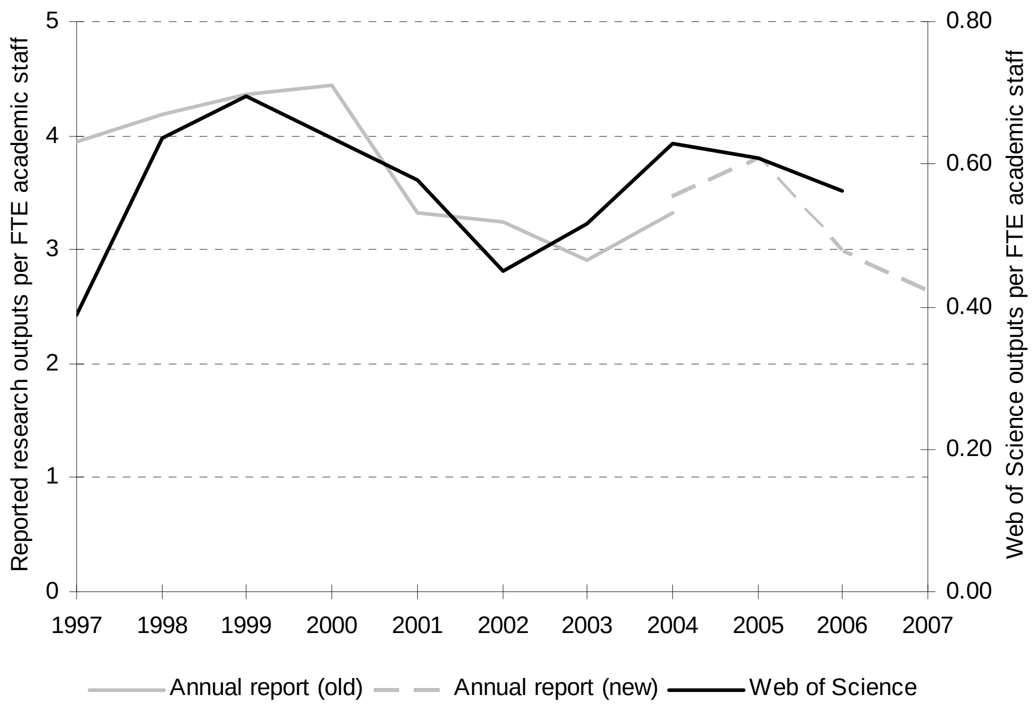


Figure 2.6 presents the reported research outputs and Web of Science publications for Lincoln University on a per FTE academic staff basis. There is an apparent discontinuity in Lincoln's reported outputs between 2003 and 2004. However, it does suggest that research productivity peaked at Lincoln around 2000 before declining to reach a trough in 2003. After 2003, there was a surge in productivity. However, research productivity then declined by 31 percent between 2005 and 2007.

The Web of Science data for Lincoln University exhibits the same general patterns as the annual report data, but the downturns and surges in productivity occur a year earlier. For example, research productivity appears to take a downward turn in 2005 using Web of Science counts but the downturn doesn't occur till 2006 in the annual report data. Nevertheless, the Web of Science data captures the overall trends in research productivity at Lincoln University reasonably well.

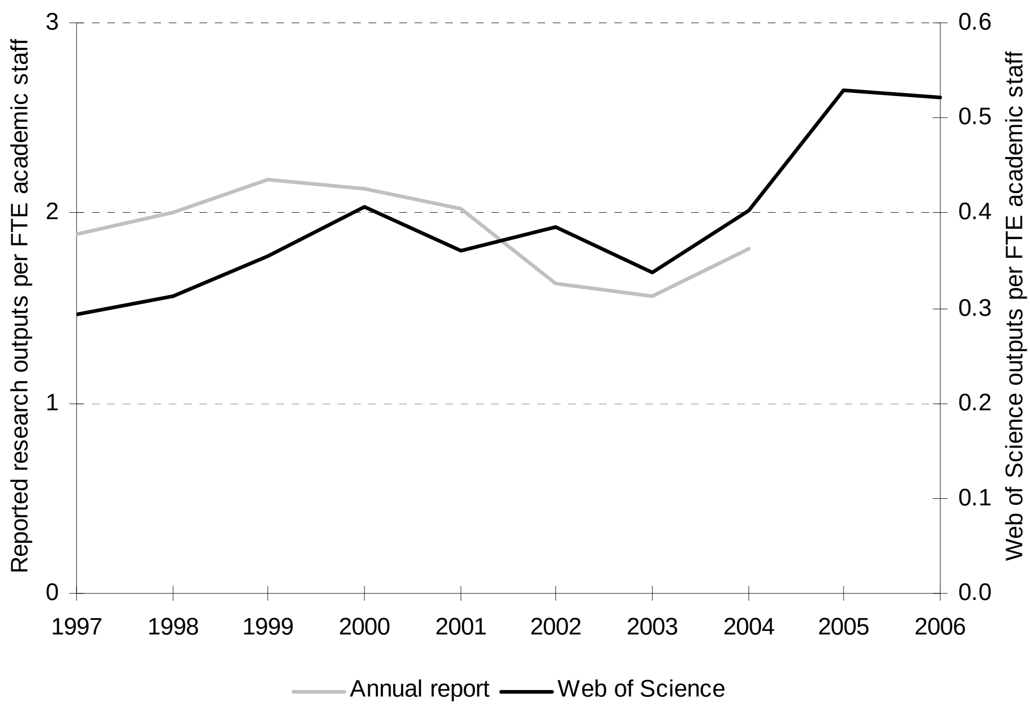
Figure 2.6, Research outputs per FTE academic staff at Lincoln University 1997-2007



The research productivity for Massey University is presented in Figure 2.7. The annual report data shows an increase in productivity to 1999, followed by a fall in reported research outputs per FTE academic staff, with research productivity reaching its lowest point in 2003. Although Massey's research productivity improved in 2004, this is the final year that Massey University reported research outputs. So it is unclear if this was the start of an extended period of improved productivity.

The Web of Science data exhibits broadly similar patterns to the annual report research data at Massey University. Overall, the number of Web of Science publications per FTE academic declined between 2000 and 2003, mirroring the fall exhibited by the annual report data. However, since 2003, the Web of Science data suggests there has been a strong increase in research productivity, with the number of research outputs per FTE academic staff increasing by 54 percent between 2003 and 2006.

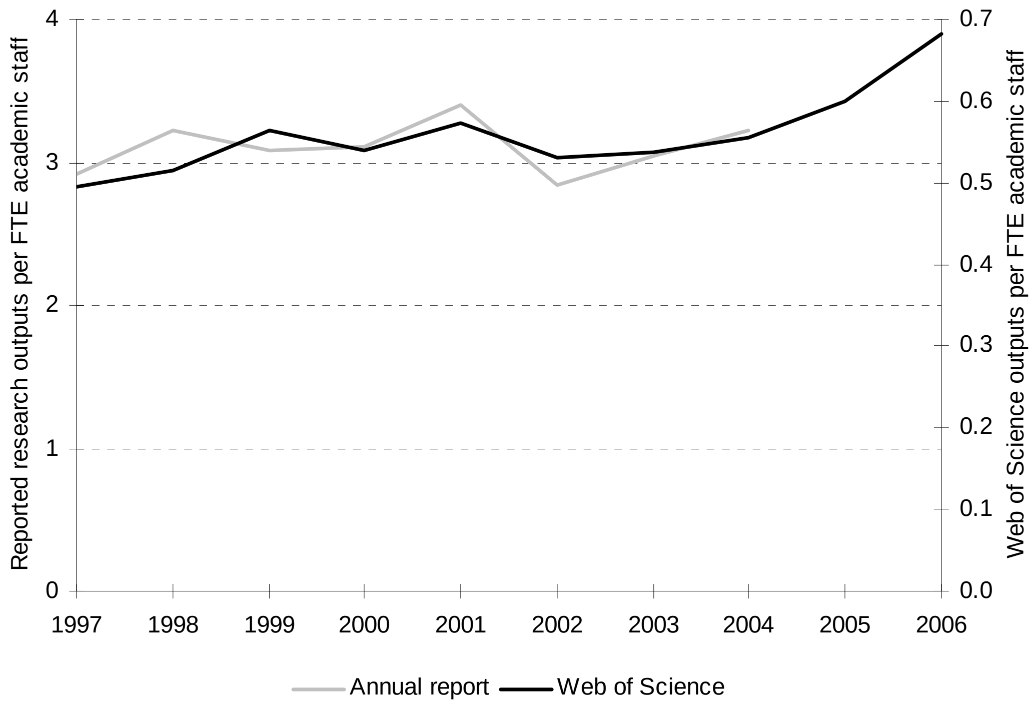
Figure 2.7, Research outputs per FTE academic staff at Massey University 1997-2006



Like Massey University, the University of Auckland ceased reporting counts of research output in 2004. Up to that date, the annual report data suggests that research output per FTE academic staff fluctuated between 2.8 and 3.4 between 1997 and 2004.

The Web of Science data shows a similar pattern of small fluctuations around 0.52 outputs per FTE academic staff between 1997 and 2004. Since 2004, the Web of Science data suggests there has been a significant upward shift in the research productivity of the University of Auckland. Between 2004 and 2006, the outputs per FTE academic staff increased by 23 percent, indicating substantial improvement in research productivity at the University of Auckland.

Figure 2.8, Research outputs per FTE academic staff at the University of Auckland 1997-2006



The research productivity of the University of Canterbury is presented in Figure 2.9. Annual report data indicates that research output per FTE academic staff has been rising steadily over time. Between 1997 and 2007, research productivity increased by 84 percent.

The Web of Science data mirrors this trend of a rise in productivity. Between 1997 and 2006, the number of articles and reviews per FTE academic staff increased by 39 percent (compared with an increase of 62 percent per FTE academic staff using annual report data). The Web of Science data suggests that the rate of increase in productivity has increased since 2003.

Figure 2.9, Research outputs per FTE academic staff at the University of Canterbury 1997-2007

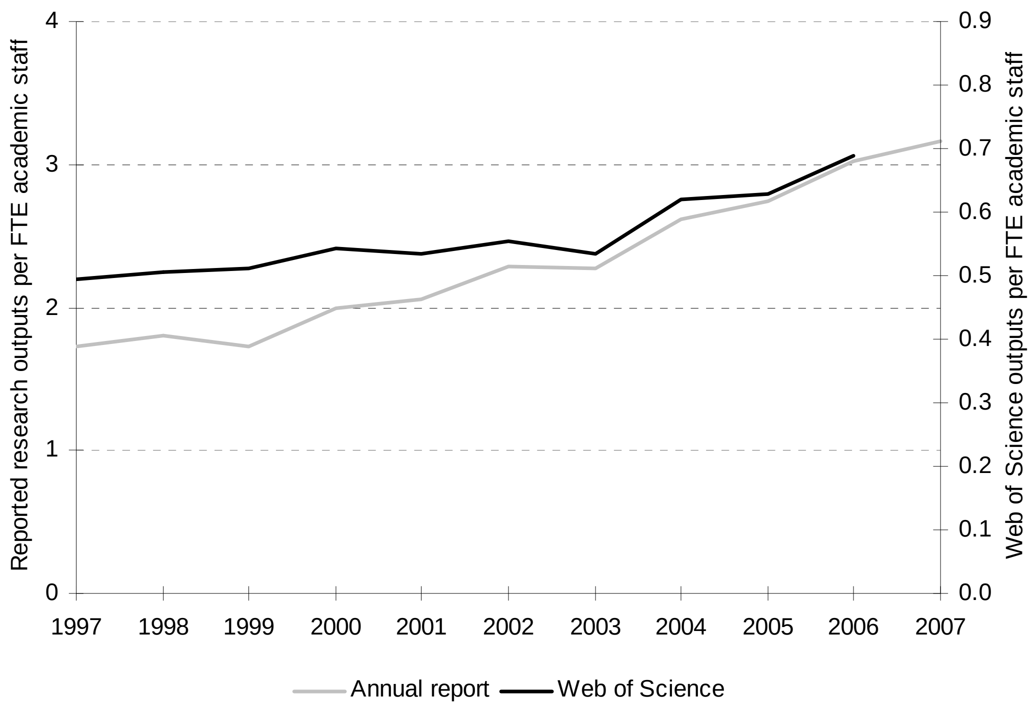
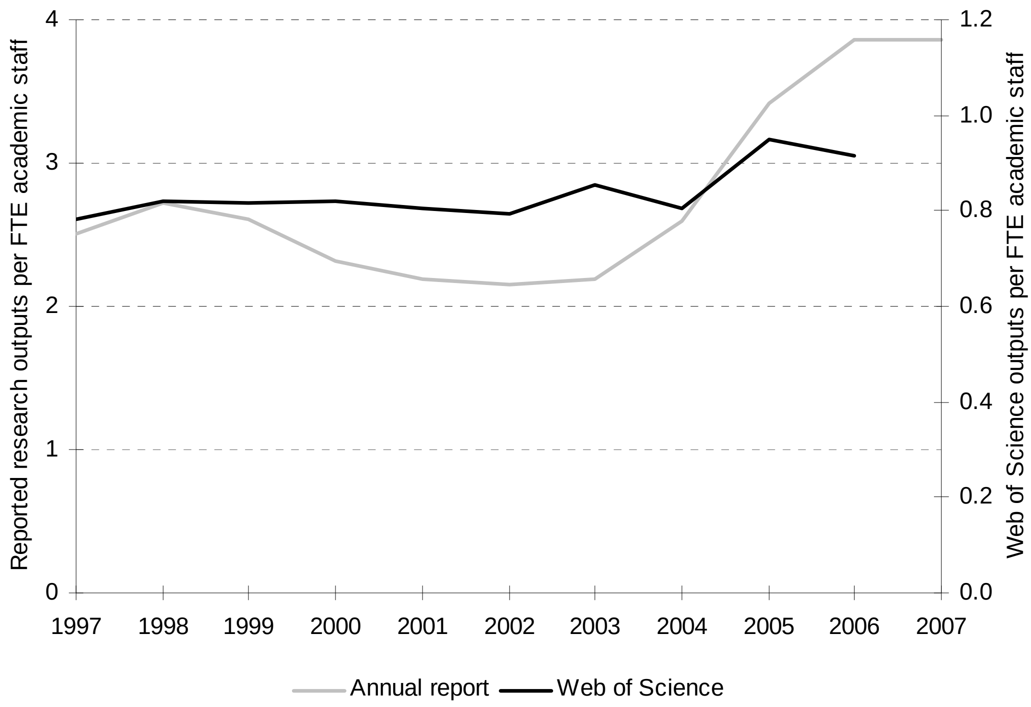


Figure 2.10 illustrates the research productivity for the University of Otago. The annual report data indicates a significant drop in research productivity between 1998 and 2003. The number of reported research outputs per FTE academic decreased by 19 percent between 1998 and 2003. However, between 2003 and 2007 there has been a significant increase in research productivity of 76 percent.[21]

A comparison of the Web of Science data with the annual report data suggests a weaker relationship between the two data sources than for some of the other universities. For example, the decline in productivity was lower for the Web of Science data between 1998 and 2002. Since then, the Web of Science data has exhibited considerable fluctuation, but nevertheless broadly shows the upward trend exhibited by the annual report data.

Figure 2.10, Research outputs per FTE academic staff at the University of Otago 1997-2007

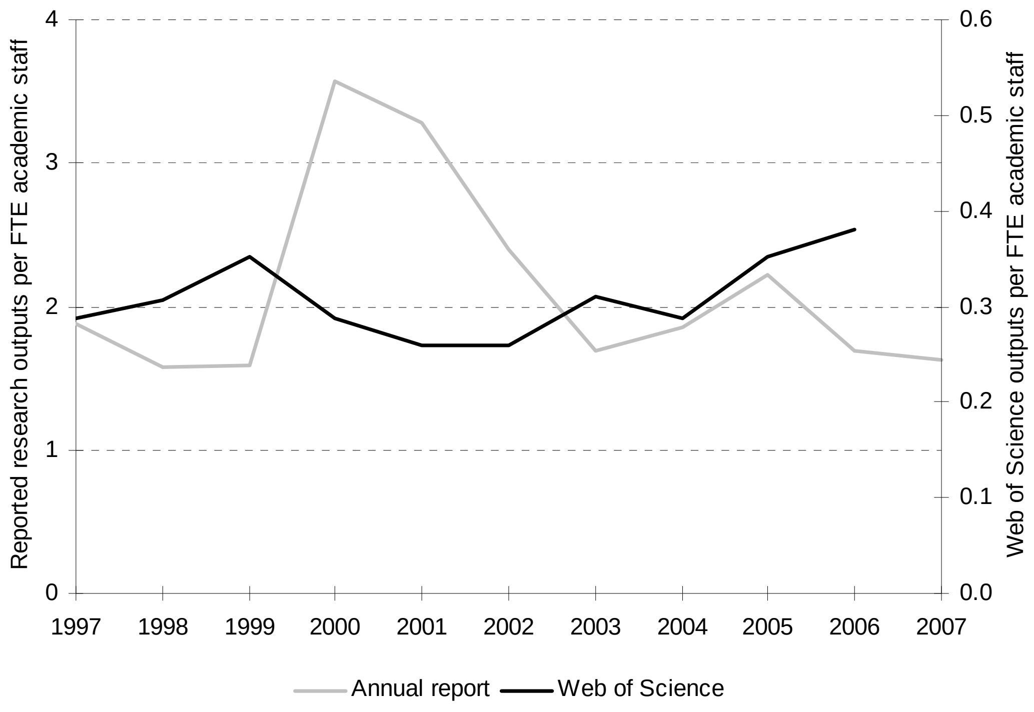


[21] Although research output per FTE academic staff tapers off slightly in 2007, the figures for that year were reported as preliminary and may be slightly higher once the counts are finalised.

As can be seen in Figure 2.11, the annual report research productivity data for the University of Waikato exhibits substantial variation. There is a massive rise in reported research outputs per FTE academic in 2000 followed by a drop of similar proportions over the next two years. This scale of variation suggests that the method of counting research outputs changed over this time. Therefore, little insight can be gained from annual report data on trends in research productivity at the University of Waikato.

The Web of Science data suggests that research productivity was falling at the University of Waikato from 1999 to 2003. Since then, there are signs that research output has increased. Between 2002 and 2006, per FTE academic staff research output increased by 46 percent.

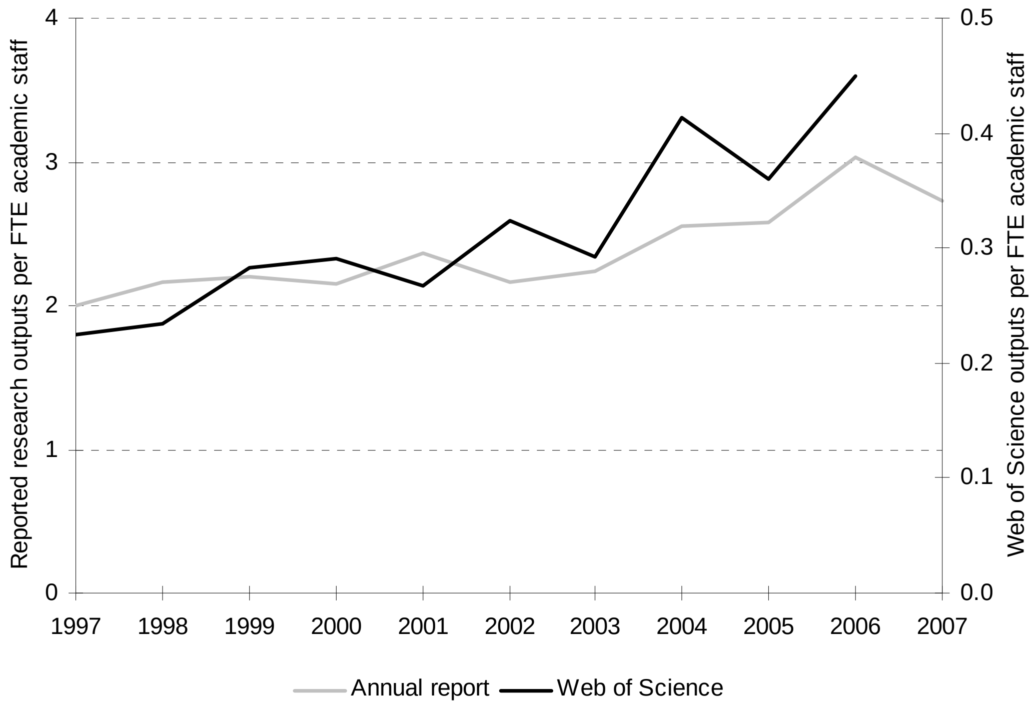
Figure 2.11, Research outputs per FTE academic staff at the University of Waikato 1997-2007



Victoria University of Wellington (VUW) is another university that exhibits an increase in research productivity following the introduction of the PBRF. Between 2003 and 2006, annual report data suggests that research productivity has increased by 36 percent.

The Web of Science data also suggests that research productivity at VUW has increased since 2003, although it is subject to significant variation. Between 2003 and 2006, output per FTE increased by 54 percent.

Figure 2.12, Research outputs per FTE academic staff at Victoria University of Wellington 1997-2007



2.4.1.2 Conclusion

Given the significant changes to government policy in funding research since 2004, it is important that a sense of the impact of these changes on the research productivity of New Zealand universities can be ascertained. The use of bibliometric data has shown that the research productivity of New Zealand universities has increased significantly following the introduction of the PBRF.

This in itself is not a surprising result, given the sharper focus that has been placed on the research activities of New Zealand universities by the PBRF. Nevertheless, without the use of bibliometric data, the identification of this trend across the university sector would have been difficult.

The comparison of reported research outputs with bibliometric counts of research output suggests that the Web of Science provides a reasonable proxy for overall research productivity of New Zealand universities. This provides an important justification for the use of bibliometric data to represent the research output of the universities in the Data Envelopment Analysis in Chapter 3.

2.4.2 Multi-dimensional analysis of New Zealand university research performance

This section presents the results of the multi-dimensional analysis of the research performance of New Zealand universities between 2000 and 2005 using the performance measures outlined in section 2.3.2. These measures are repeated below:

1. Quality: PBRF average quality score per full-time equivalent (FTE) PBRF-eligible staff member in the 2006 Quality Evaluation
2. Impact (FTE): Number of citations per FTE PBRF-eligible staff member in the 2006 Quality Evaluation
3. Impact (article): Number of citations per article
4. Productivity: Number of articles per FTE PBRF-eligible staff member in the 2006 Quality Evaluation

In sections 2.4.2.1 to 2.4.2.8, the performance of each university in these dimensions is examined separately.[22] Then, the performance of each university within each subject panel is examined in section 2.4.2.9. In section 2.4.2.10, an overall weighted ranking of the performance of the eight universities in each of the four measures of performance is presented. This is followed by an examination of the association

[22] Note that impact per article and impact per FTE are displayed on the same graph in this section for comparison purposes.

between each of the four measures in section 2.4.2.11. Finally, some conclusions are presented in section 2.4.2.12.

A reminder that a value of one in the relative performance measures indicates that the performance of a university was equal to the overall university average. A value above one indicates that the performance of a university was above the overall university average and a value of less than one indicates the performance was below the overall university average. Also, the FTE measure used to measure productivity and citations per staff member in this section uses the number of FTE PBRF-eligible staff from the 2006 Quality Evaluation.

2.4.2.1 Auckland University of Technology

The performance of Auckland University of Technology (AUT) in the four performance measures is presented in Figure 2.13 to Figure 2.15. The relative performance of AUT is generally well below the university average across all three performance dimensions and reflects its relatively new university status. In terms of relative quality, the strongest relative performance by AUT was in Commerce (0.90) and the weakest in Psychology (0.17).

AUT has above average academic impact in the Humanities when using the citations per article measure (1.37), although this is off a very low number of articles (seven) and so should be viewed with caution. This is reinforced by the relative impact of AUT's research in the Humanities being very low when using the per FTE measure of impact (0.27).

The relative productivity of AUT is also below the university average in all subject disciplines. The best relative performance is in Engineering (0.64) and the worst in Commerce (0.13).

Figure 2.13: Research quality ─ Auckland University of Technology

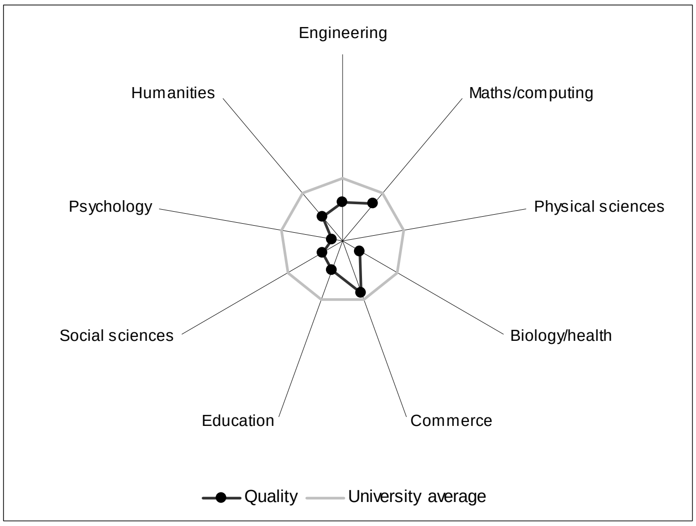


Figure 2.14, Research impact ─ Auckland University of Technology

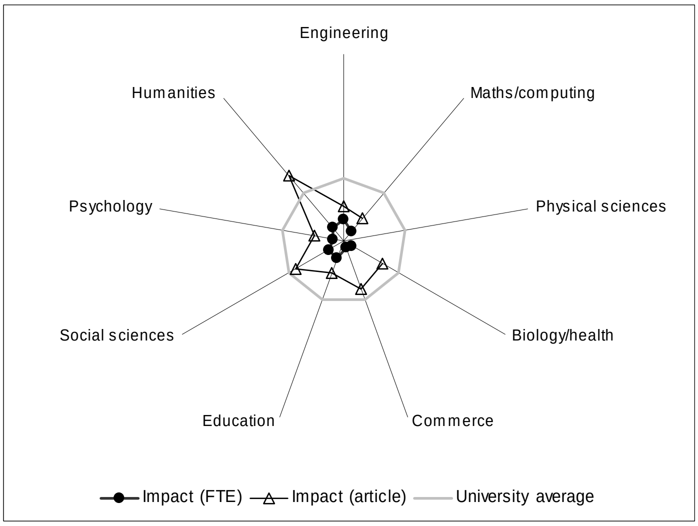
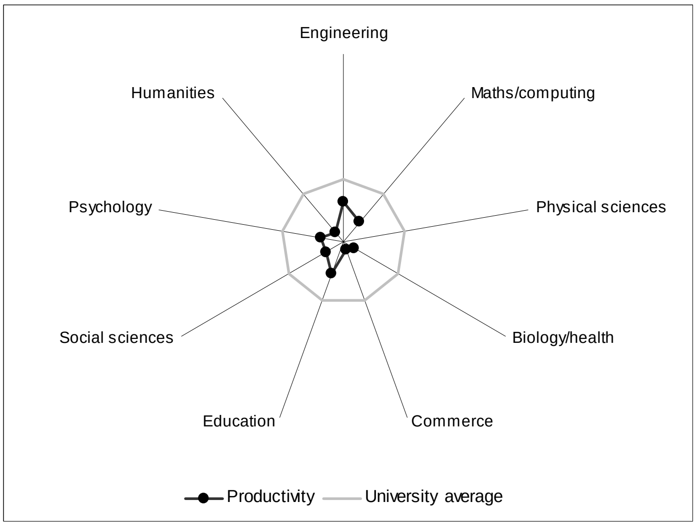


Figure 2.15, Research productivity ─ Auckland University of Technology



2.4.2.2 Lincoln University

The performance of Lincoln University in the four measures of research performance is illustrated in Figure 2.16 to Figure 2.18. Lincoln University is the smallest of the New Zealand universities, with its research specialised in subjects in primary industries such as agriculture.

Lincoln University was one of the lowest performing universities in the 2006 PBRF Quality Evaluation. This low performance is reflected in Lincoln having no panel areas with relative research quality above the university average. The best performing area was Engineering (0.78), while the lowest relative quality was in Commerce (0.62).

Lincoln fares slightly better in the relative impact measure. Using the citation per article measure, the impact of Lincoln research is above average in the Social sciences (1.45), and Commerce (1.06). Using the citation per FTE measure, Lincoln has above average relative performance in the Social sciences (1.36).

Lincoln struggled to reach the university average in terms of productivity. The relative productivity for Lincoln was strongest in the Physical sciences (0.98) and weakest in Engineering (0.25).

Figure 2.16, Research quality ─ Lincoln University

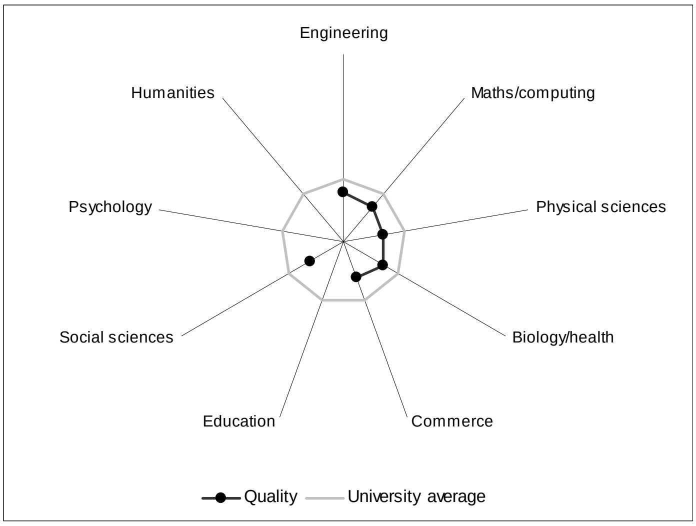


Figure 2.17, Research impact ─ Lincoln University

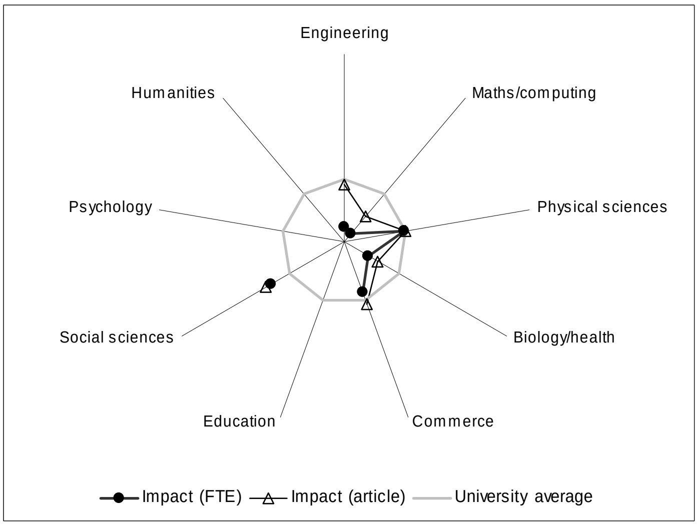
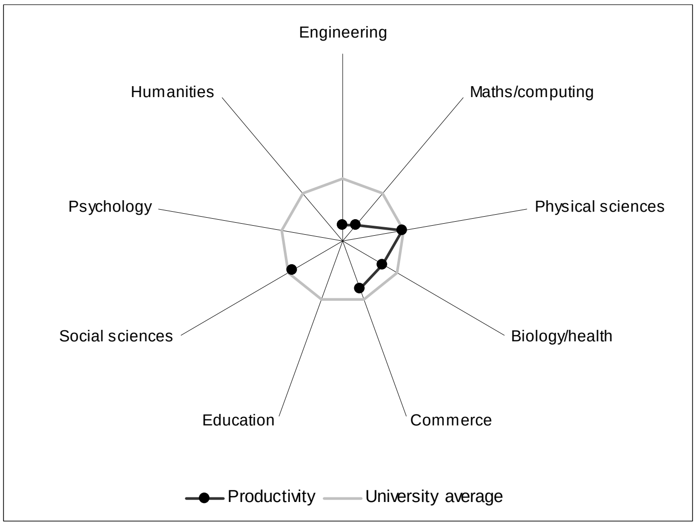


Figure 2.18, Research productivity ─ Lincoln University



2.4.2.3 Massey University

The performance of Massey University in the four measures of research performance is illustrated in Figure 2.19 to Figure 2.21. Massey University was created in 1964 from Massey Agricultural College and part of Victoria University of Wellington. It has degree provision across most of the subject panels, but has an historical specialisation in the biological and agricultural sciences.

As can be seen in Figure 2.19, the relative quality of research at Massey University is lower than the university average in eight of the nine subject panels. However, the relative quality of research in education is well above the university average (1.57).

The impact of Massey University research is similar using both the per article and per FTE measures. Using the per article measure, the best performing subject panel was Commerce (0.91) and the worst performing Psychology (0.38). Using the per FTE measure, Education is once again the best relative performer (1.37).

In seven of the nine subject panels, Massey's productivity is below the university average. The best performing subject area at Massey was Education (1.64), as it was in terms of relative quality and relative impact (per FTE). Psychology is the worst performing subject area (0.54).

Figure 2.19, Research quality ─ Massey University

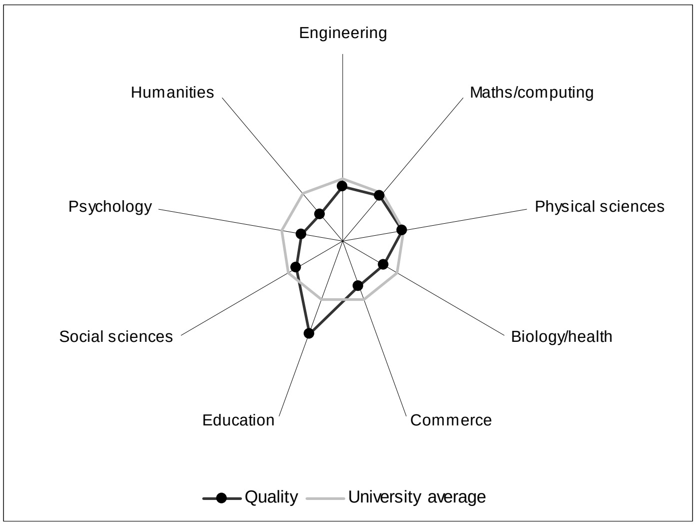


Figure 2.20, Research impact ─ Massey University

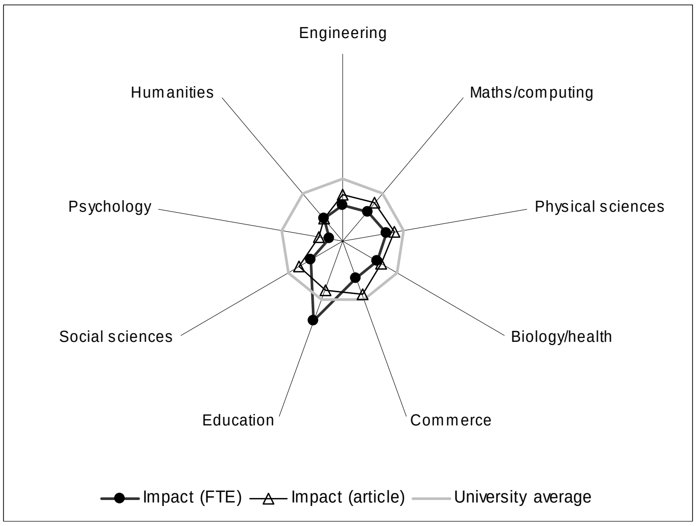
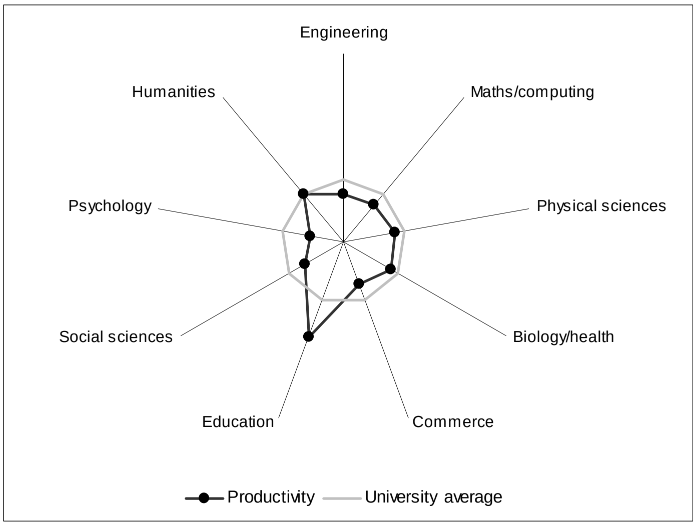


Figure 2.21, Research productivity ─ Massey University



2.4.2.4 University of Auckland

The performance of the University of Auckland in the four measures of research performance is illustrated in Figure 2.22 to Figure 2.24. The University of Auckland is New Zealand's largest university and was the top university in the 2003 PBRF Quality Evaluation and the second-placed in the 2006 PBRF Quality Evaluation. Auckland was also the top placed New Zealand university in the Times Higher Education Supplement and Shanghai Jai Tong rankings. Auckland has degree provision across all subject panels and has a medical school.

The strong performance of Auckland in the 2006 PBRF Quality Evaluation is reflected in above average relative quality in eight of the nine subject areas. The areas of strongest relative quality were the Social sciences (1.35) and Biology/health (1.25).

On a per article basis, the relative impact of research at Auckland was above the university average in eight of the nine subject areas. The best performing subject panel was Education (1.22). The worst performing panel was the Humanities (0.96), but this was just below the university average. Using the per FTE relative impact measure, Auckland performs especially well in Commerce (2.28) and the Social sciences (1.87).

As can be observed in Figure 2.24, eight of the nine subject panels had relative productivity above the university average. Relative productivity in the Social sciences (1.76) and Commerce (2.00) panels was well above the university average

Figure 2.22, Research quality ─ University of Auckland

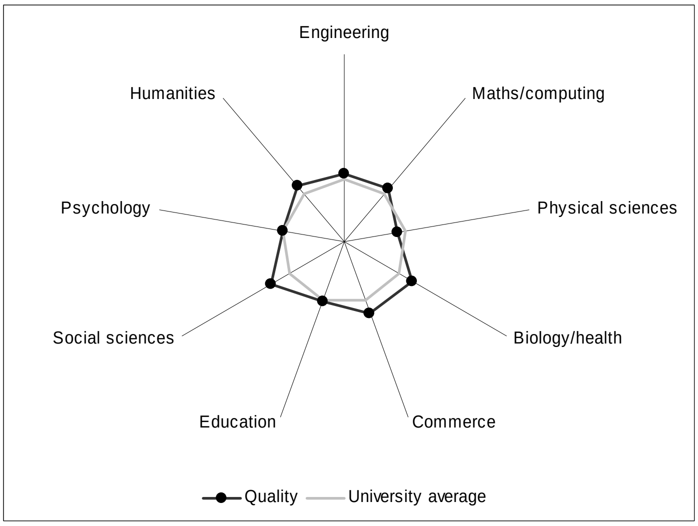


Figure 2.23, Research impact ─ University of Auckland

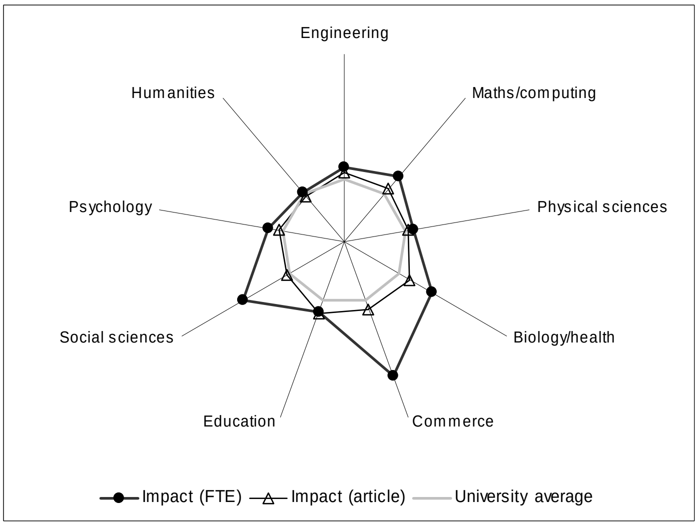
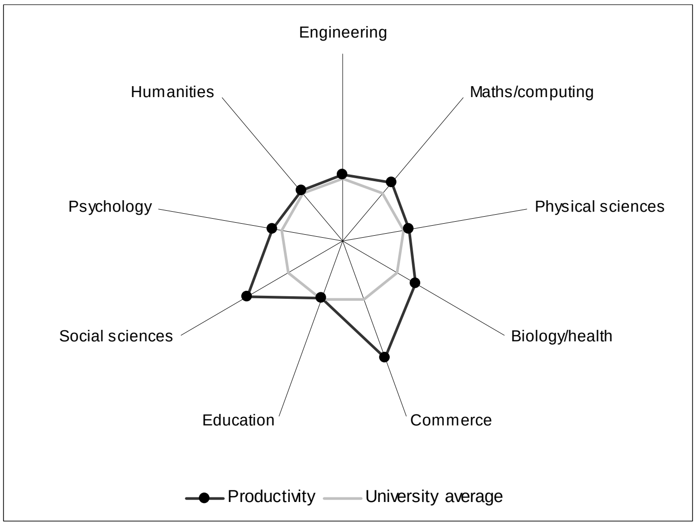


Figure 2.24, Research productivity ─ University of Auckland



2.4.2.5 University of Canterbury

The performance of the University of Canterbury in the four performance measures is presented in Figure 2.25 to Figure 2.27. The University of Canterbury is one of New Zealand oldest universities. It has degree provision across all nine subject panels and has one of New Zealand’s longest-established engineering schools.

The relative quality of research at Canterbury was around the university average in seven of the nine subject areas. Relative quality was lowest in Education (0.52) and highest in Engineering (1.19).

The relative impact of research at the University of Canterbury was highest in Commerce (1.23) using the per article measure. Maths/computing (1.10) and Psychology (1.12) were also relatively well performing panels. Education is the worst performing subject panel by some margin (0.41). On a per FTE basis, the relative impact of research in Commerce (1.80), Maths/computing (1.89), and Engineering (1.39) was high. The weakest area of relative impact was once again Education (0.33).

The relative productivity at Canterbury was high in a number of subject areas, especially Engineering (1.48), Maths/computing (1.71), Biology/health (1.82) and Commerce (1.46). Education (0.79) was the only subject area where productivity was below the university average.

Figure 2.25, Research quality ─ University of Canterbury

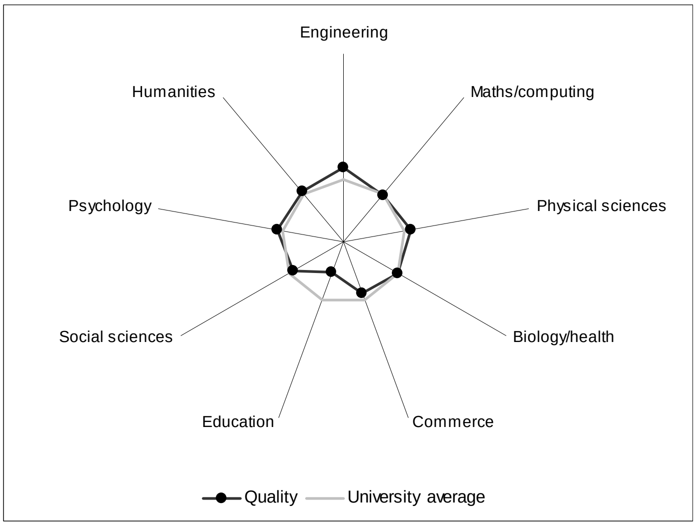


Figure 2.26, Research impact ─ University of Canterbury

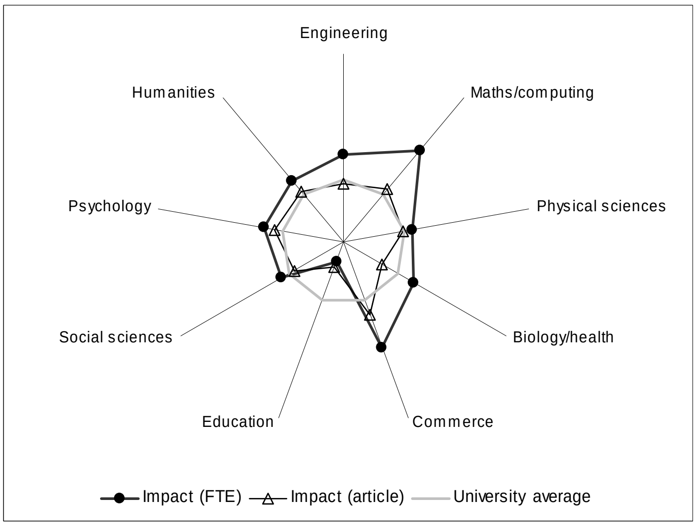
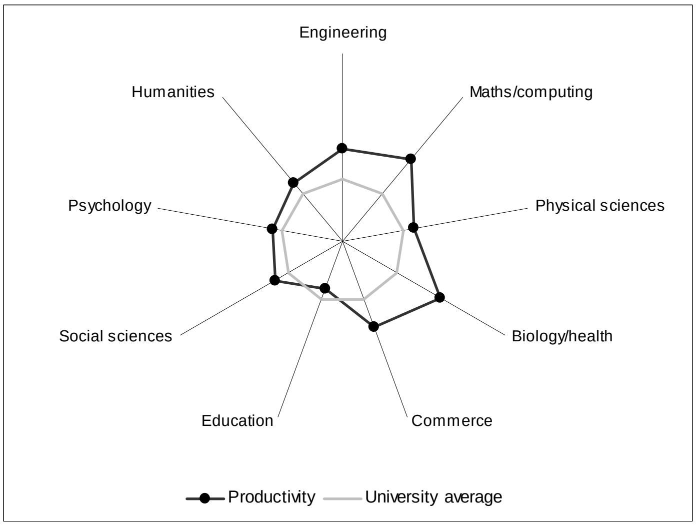


Figure 2.27, Research productivity ─ University of Canterbury



2.4.2.6 University of Otago

The performance of the University of Otago in the four performance measures is presented in Figure 2.28 to Figure 2.30. The University of Otago is New Zealand's oldest university. It has degree provision across all the subject panels and has a medical school. The University of Otago was the top performing university in the 2006 PBRF Quality Evaluation

The relative research quality at Otago is highest in the area of Psychology (1.35). The weakest areas of relative performance were in Education (0.92), Engineering (0.90) and Maths/computing (0.91).

Using the per article measure of relative impact, the Humanities (1.49), Social sciences (1.36) and Psychology (1.34) were all well above the university average. The weakest relative impact was in Commerce (0.80). A similar pattern of performance is evident using the per FTE measure. The best performing panel was Engineering (2.02), followed by the Humanities (1.98) and Psychology (1.82). The two lowest performing panels were Commerce (0.66) and Maths/computing (0.81).

Several subject areas at the University of Otago exhibit productivity well above the university average. The best performing was Engineering (1.61), followed by Education (1.40). As was the case with the relative impact measures, the worst performing panel areas were Commerce (0.82) and Maths/computing (0.83).

Figure 2.28, Research quality ─ University of Otago

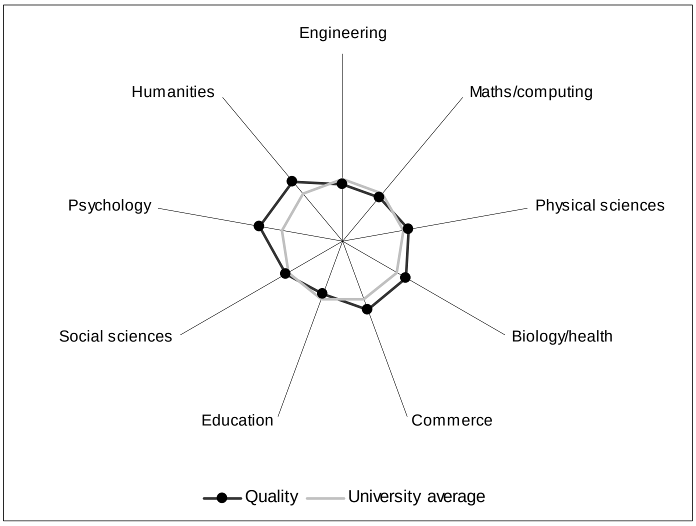


Figure 2.29, Research impact ─ University of Otago

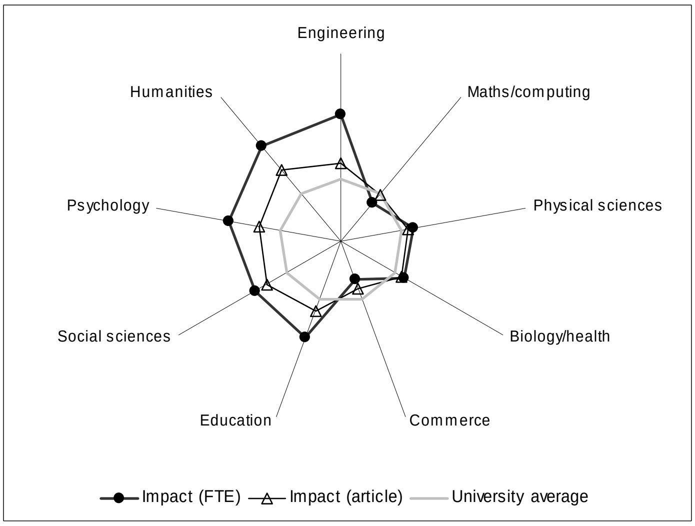
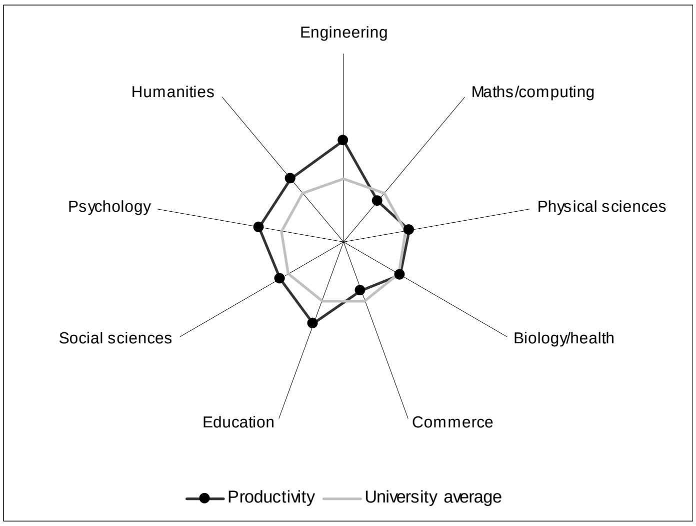


Figure 2.30, Research productivity ─ University of Otago



2.4.2.7 University of Waikato

The performance of the University of Waikato in the four performance measures is presented in Figure 2.31 to Figure 2.33. The University of Waikato was established in 1964. It has degree provision across all subject panels. Arguably, commerce is one of Waikato's strongest areas.

In seven out of the nine subject panels, Waikato achieved relative quality that was above or equal to the university average. The relative quality of research is strongest in Education (1.68) and Commerce (1.28). The lowest relative quality of research was in the Humanities (0.76).

Using the per article measure of relative impact, only one subject panel was at the university average. This was Engineering (1.00). The lowest performing subject panel was Psychology (0.56). Using the per FTE measure, the relative impact of research at Waikato was particularly high in Biology/health (1.77), followed by Engineering (1.40) and Physical sciences (1.20). The lowest relative impact was in the area of Psychology (0.50).

The relative productivity at the University of Waikato was above the university average in six of the nine subject panels. Relative productivity was highest in Biology/health (2.66), followed by Engineering (1.41). The lowest relative productivity was in the Social sciences (0.80).

Figure 2.31, Research quality ─ University of Waikato

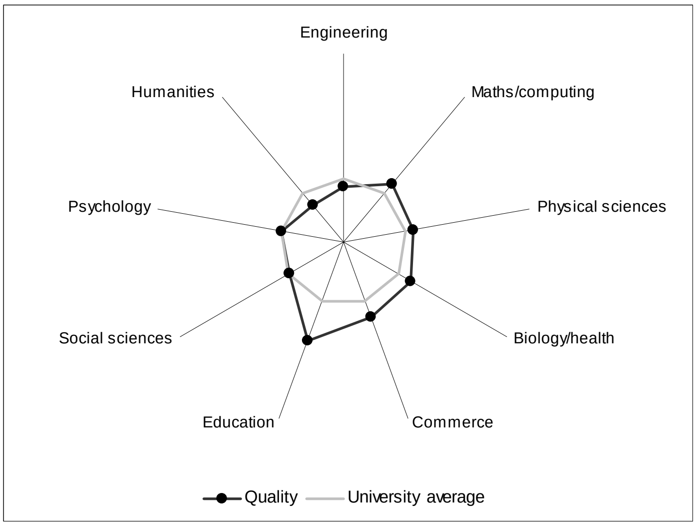


Figure 2.32, Research impact ─ University of Waikato

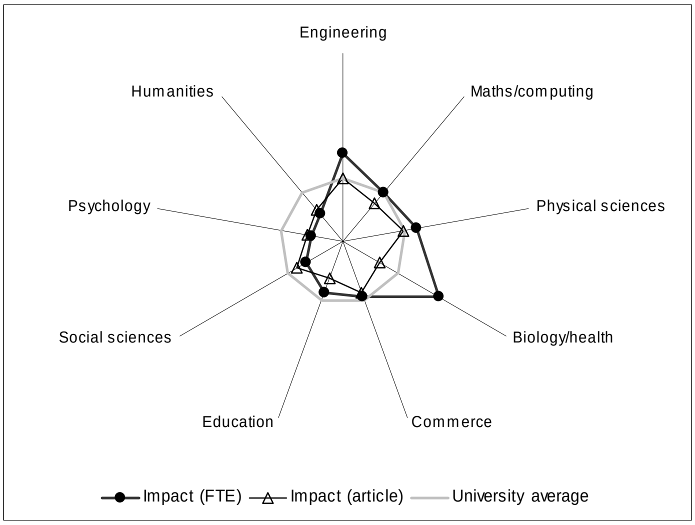
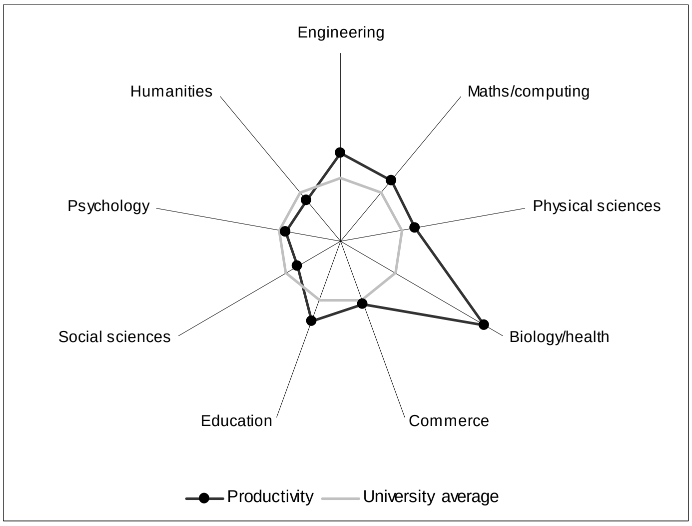


Figure 2.33, Research productivity ─ University of Waikato



2.4.2.8 Victoria University of Wellington

The performance of Victoria University of Wellington (Victoria) in the four performance measures is presented in Figure 2.34 to Figure 2.36. Victoria is one of five universities established in the 19^{th} century. The specialisation of Victoria in the Social sciences was reflected in its high level of relative quality (1.20) and also in Psychology (1.35). The weakest area of performance in this measure was Education (0.63).

In terms of impact per article, the panel areas of Physical sciences (1.02), Maths/computing (1.09) were good relative performers. Although Education (1.93) has a high level of relative impact in this measure, this is from a small number of articles (14). On a per FTE basis, the areas of Psychology (1.43) and Maths/computing (1.10) were above the university average. The lowest relative performance is in the area of Engineering (0.38).

Relative productivity was highest at Victoria in the areas of Psychology (1.57) and the Social sciences (1.10) and lowest in Education (0.44).

Figure 2.34, Research quality ─ Victoria University of Wellington

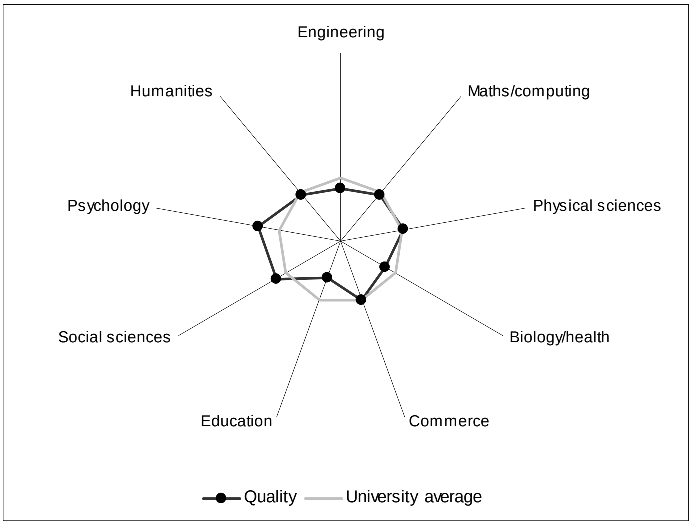


Figure 2.35, Research impact ─ Victoria University of Wellington

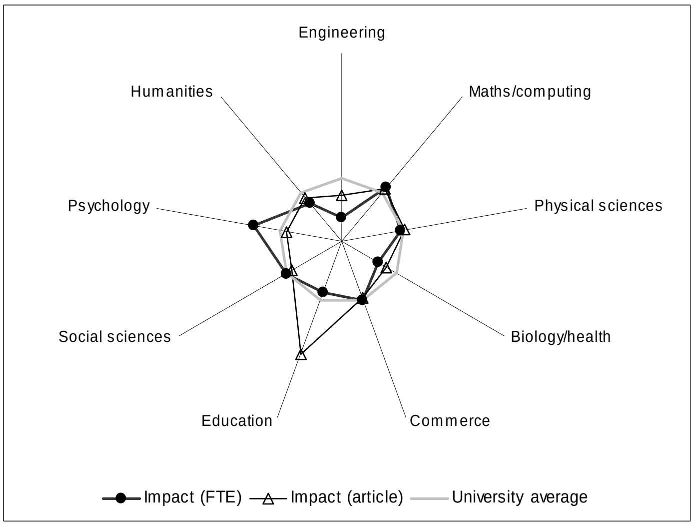
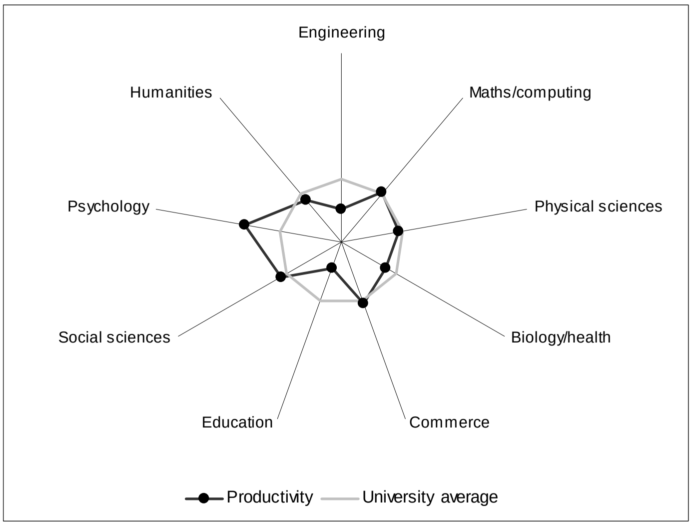


Figure 2.36, Research productivity ─ Victoria University of Wellington



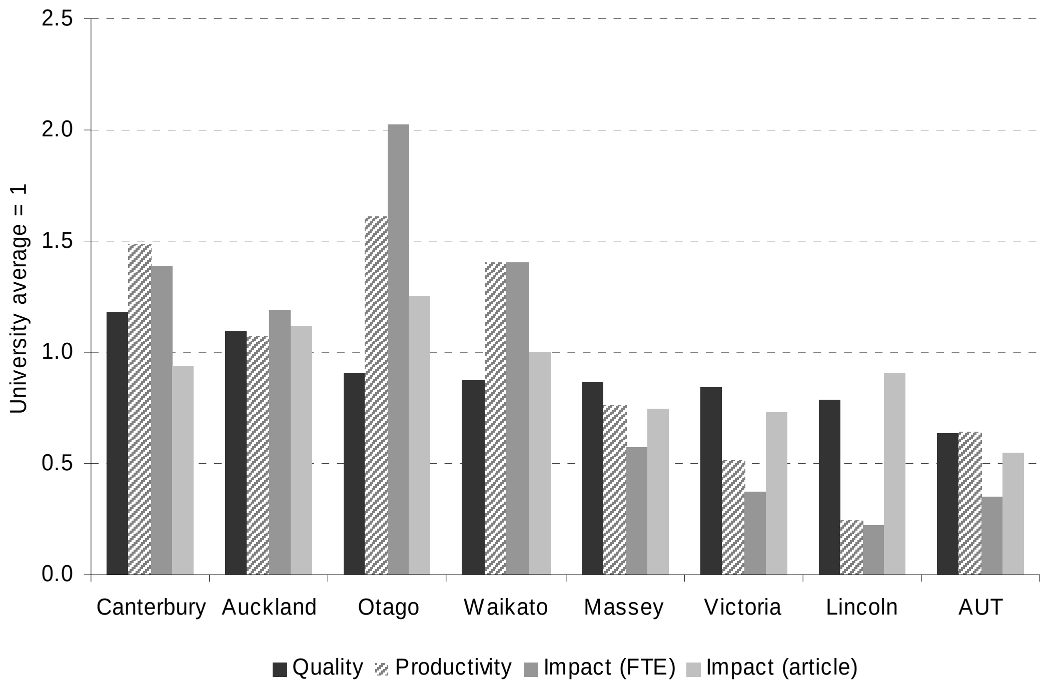
2.4.2.9 University research performance by subject panel

This section presents the results of the multi-dimensional analysis of university research performance by subject panel, rather than by individual university. This allows for a better comparison of inter-university performance across the four measures of relative performance. In each case, the universities are ranked from highest to lowest in terms of their relative research quality.

Figure 2.37 presents the results for the Engineering subject panel. Of the two universities with the longest-established engineering schools, Canterbury outperformed Auckland in both productivity and impact using the per FTE measure. However, Auckland exhibited higher relative impact using the per article measure. Although Otago and Waikato outperform Canterbury and Auckland in some of the non-PBRF measures, the size of these faculties are much smaller.

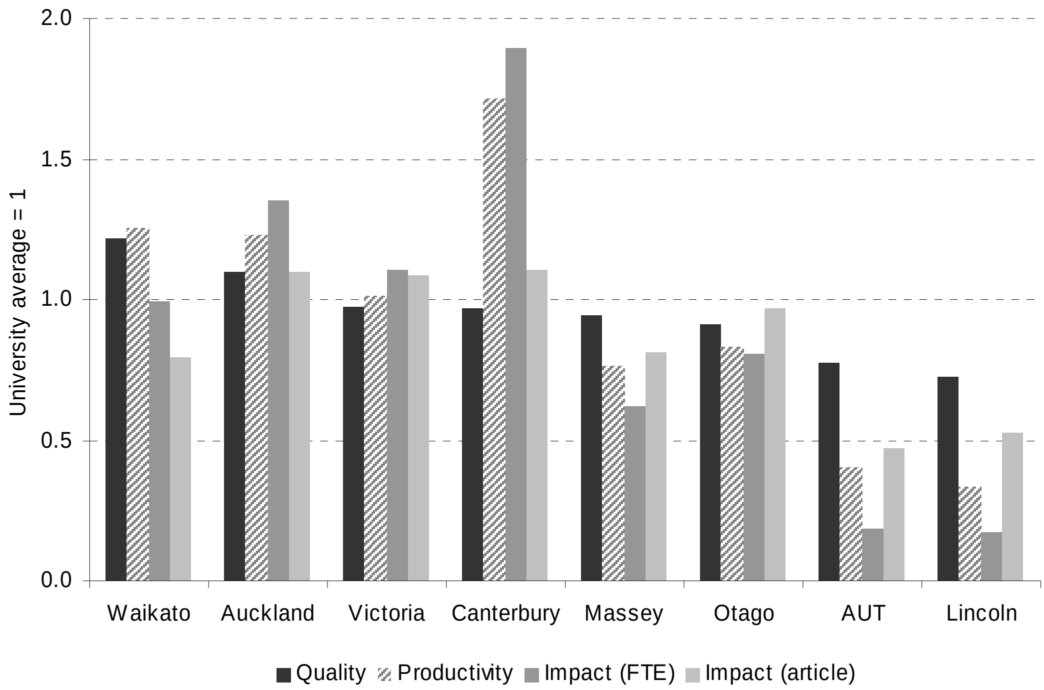
Massey University is the other university with a sizeable number of FTE staff in the engineering panel, with the bibliometric data essentially supporting its ranking in the PBRF average quality score.

Figure 2.37, University research performance in Engineering



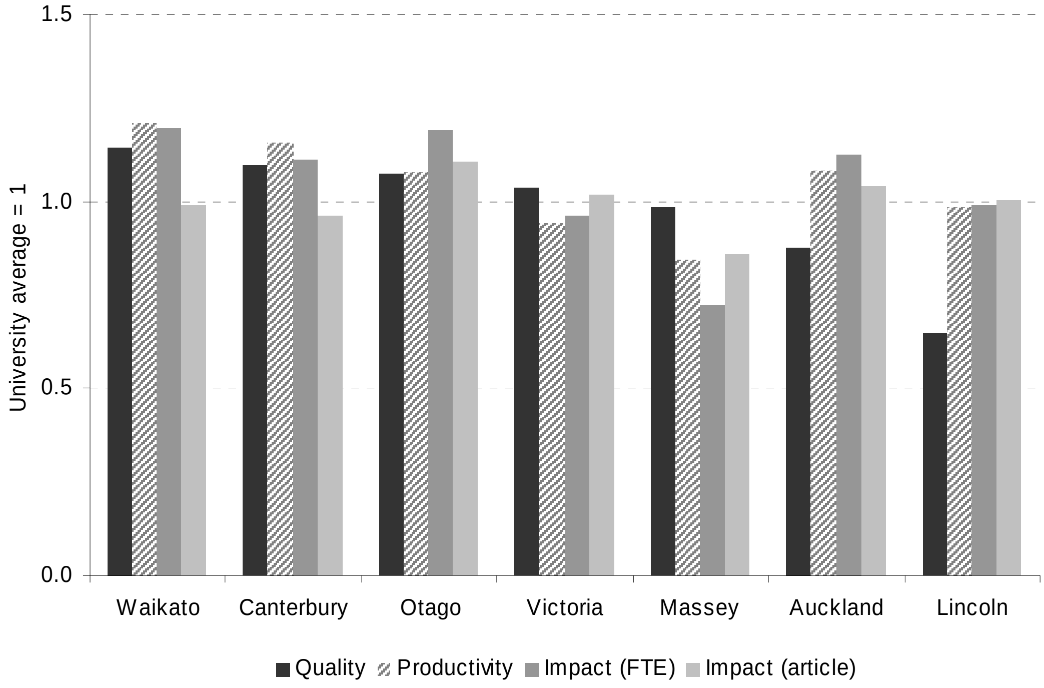
The research performance of the universities in the Maths/computing panel is presented in Figure 2.38. It shows that although the relative quality of research at Canterbury was lower than both Waikato and Auckland, it performed highly in productivity and citations per FTE. However, the performance of Canterbury in terms of citations per article was of a similar level to Victoria and Auckland.

Figure 2.38, Research performance in Maths/computing



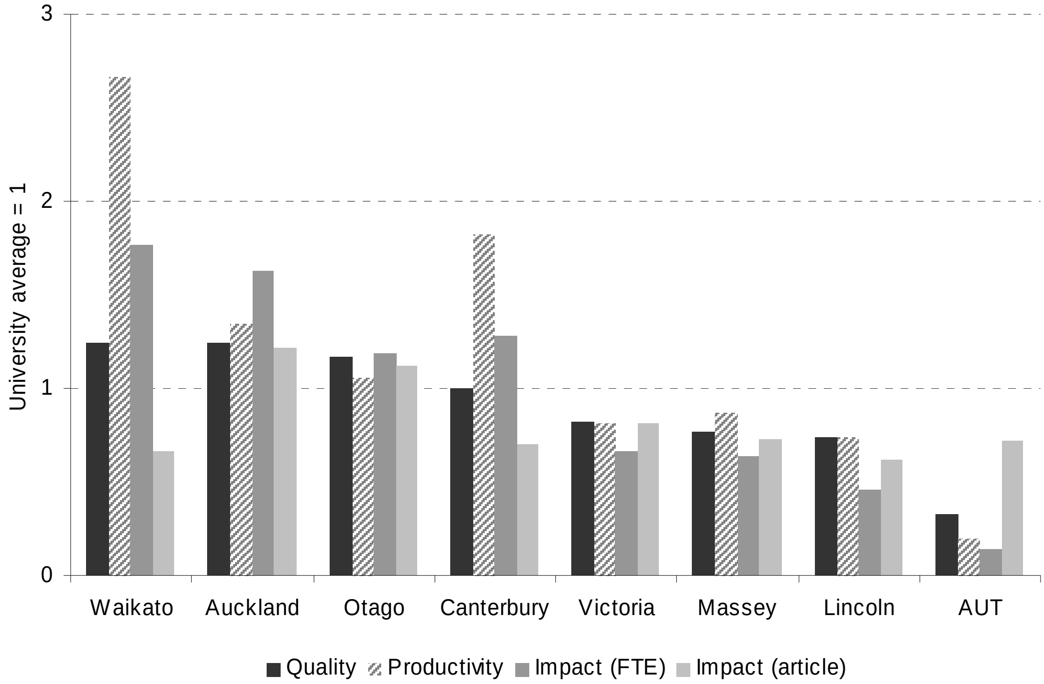
The research performance of the universities in the Physical sciences panel is presented in Figure 2.39. Although the University of Auckland only rated sixth out of the seven universities in this panel for relative research quality, they performed above average in terms of impact and productivity. The relative performance of Lincoln University in the three bibliometric measures also suggest their performance was slightly better than indicated by their relative PBRF quality score performance.

Figure 2.39, Research performance in Physical sciences



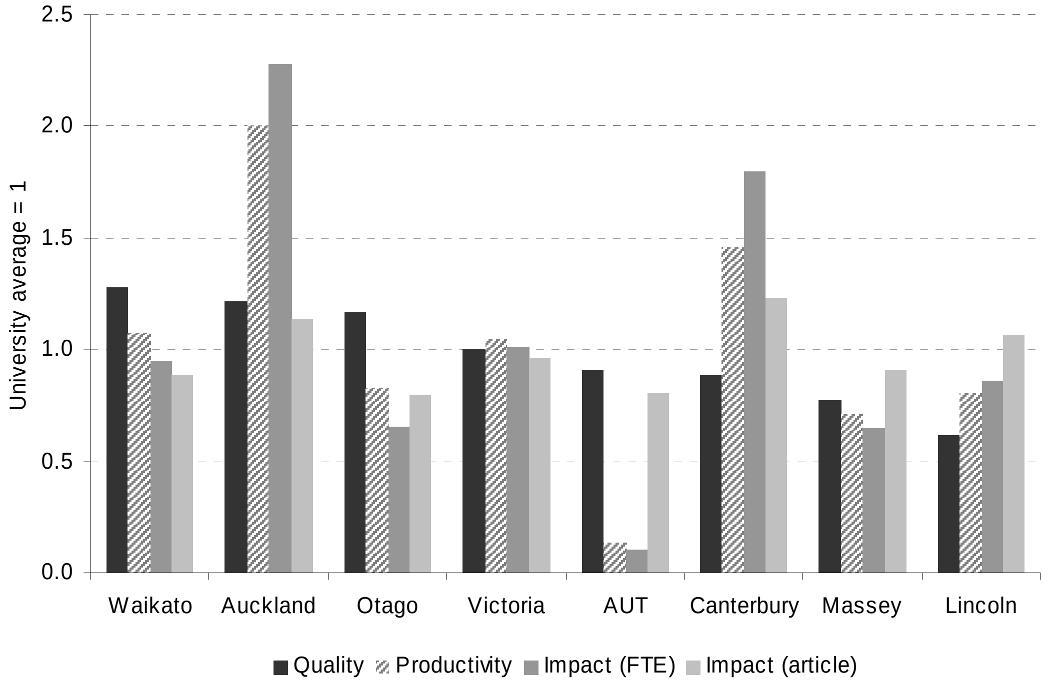
The research performance of the universities in the Biology/health subject area is presented in Figure 2.40. The ranking of the universities in the bibliometric measures generally aligns with the relative research quality. It could be argued that the University of Canterbury exhibited slightly better performance in terms of citations per FTE than was indicated by their relative performance in the PBRF Quality Evaluation.

Figure 2.40, Research performance Biology/health



The research performance of the universities in the Commerce area is presented in Figure 2.41. Perhaps not surprisingly, given the coverage of the Web of Science, this is one of the subject panels where the PBRF and bibliometric measures show the greatest variance. The key observation to make about Figure 2.41 is that the performance of the Universities of Auckland and Canterbury are much stronger in the bibliometric measures than were indicated by the measure of relative quality from the PBRF Quality Evaluation.

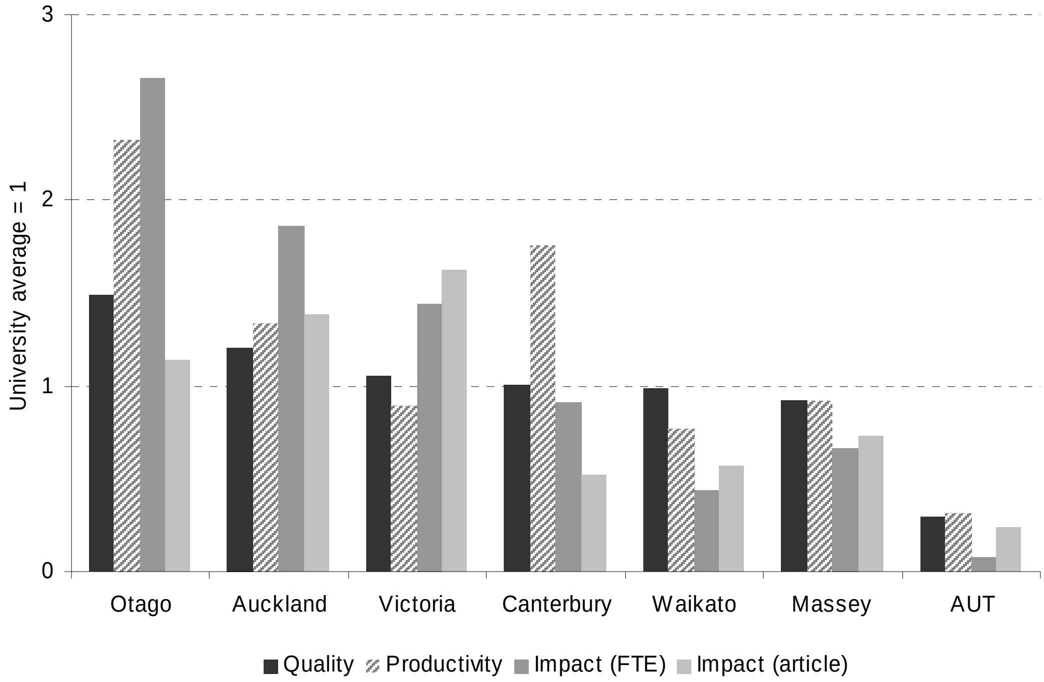
Figure 2.41, Research performance in Commerce



The research performance of the universities in the Education subject panel is presented in Figure 2.42. Once again, the bibliometric measures are at somewhat of variance with the PBRF Quality Evaluation results. Given the small number of articles the bibliometric performance is based on, this is not a surprising result.

The University of Otago achieved the highest PBRF average quality score, and also performs well in terms of productivity and citations per FTE. However the citations per article performance by Otago was more moderate.

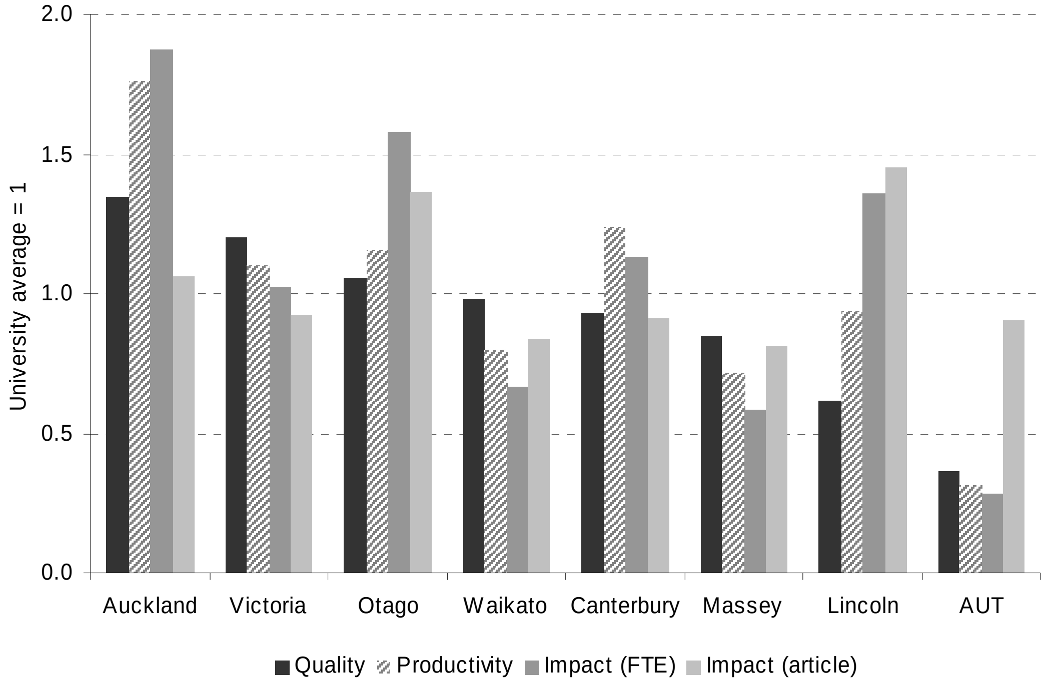
Figure 2.42, Research performance in Education



The research performance of the universities in the Social sciences area is presented in Figure 2.43. The University of Auckland achieved the best relative performance in the PBRF. It also performed well in terms of citations per FTE and productivity.

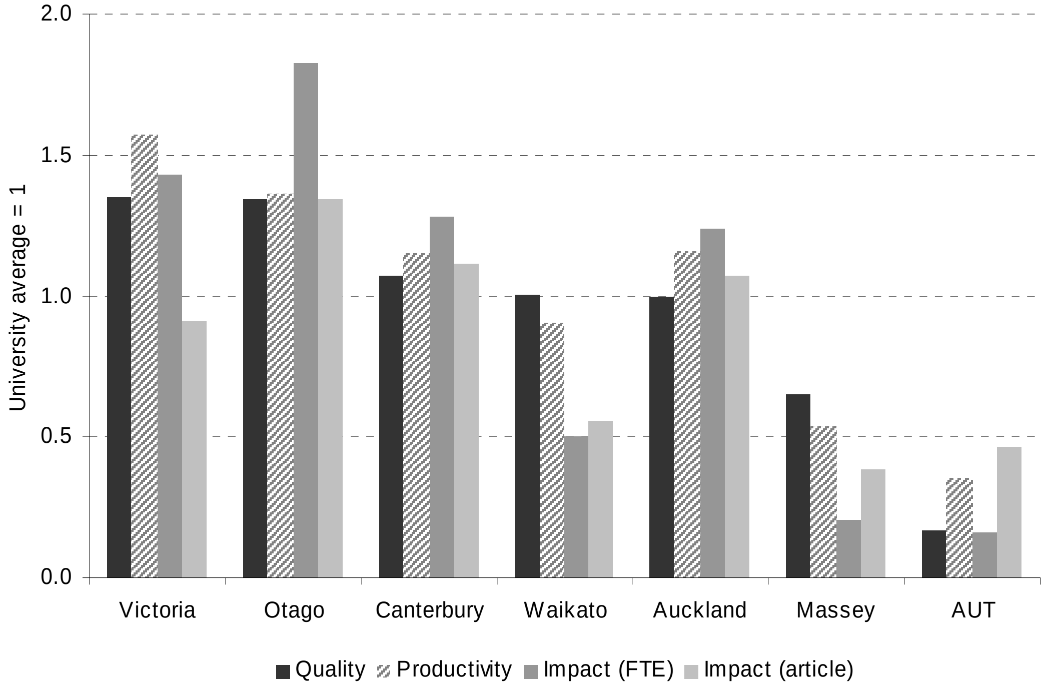
The bibliometric data would also suggest that the University of Otago performed better than indicated by the PBRF Quality Evaluation results. Although the performance of Lincoln University in the bibliometric measures is stronger than the PBRF quality score would indicate, this was achieved off a small number of articles (17) and should be treated with caution.

Figure 2.43, Research performance in the Social sciences



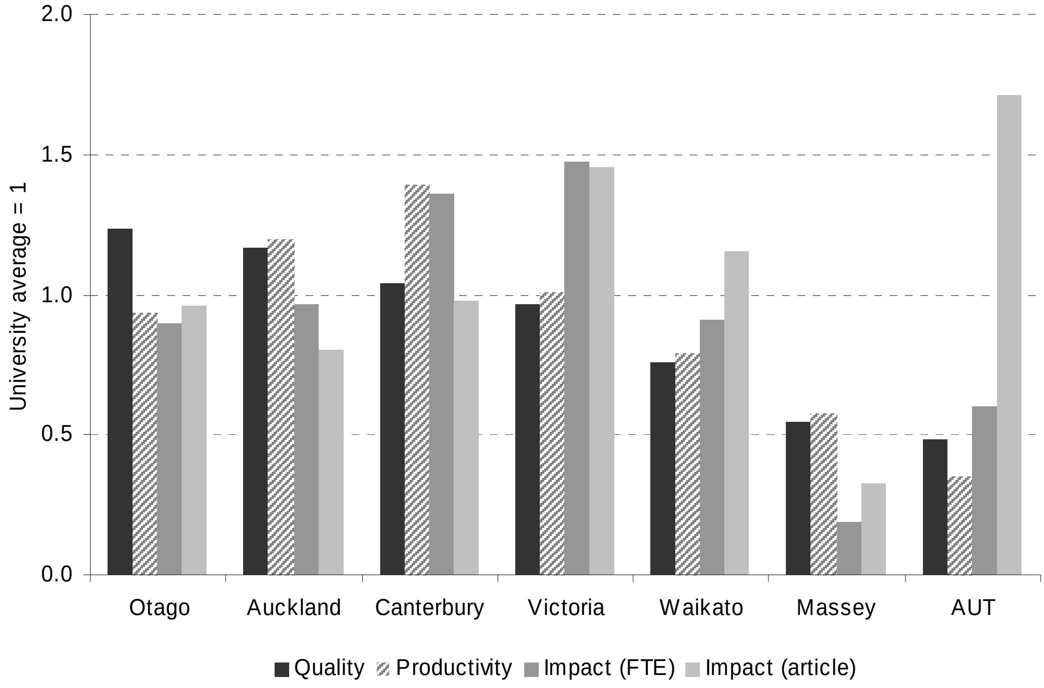
The research performance of the universities in the area of Psychology is presented in Figure 2.44. Victoria University of Wellington and the University of Otago were the best performed institutions in this subject area in the PBRF Quality Evaluation and perform relatively well in terms of the bibliometric measures of performance. The bibliometric results for the University of Auckland would suggest they performed slightly better than was indicated by the PBRF Quality Evaluation.

Figure 2.44, Research performance in Psychology



The research performance of the universities in the Humanities is presented in Figure 2.45. As one would expect, given the nature of research output in this subject panel, there is not a strong association between PBRF performance and bibliometric performance. The University of Canterbury and Victoria University of Wellington perform well in the bibliometric measures which are not reflected in their PBRF quality score performance. Although AUT has an especially strong performance in terms of citations per article, this was off a small number of articles (seven).

Figure 2.45, Research performance in the Humanities



2.4.2.10 Overall weighted research performance

By weighting each of the four research performance measures by the proportion of FTE staff in each of the subject areas, an overall weighted average of each of the relative performance measures can be calculated. This provides an overall measure of performance for relative quality, impact and productivity. These results are presented in Table 2.6. The number in brackets refers to the ranking of each university in that measure.

Table 2.6, Weighted average research performance of New Zealand universities

University	Quality	Productivity	Impact (FTE)	Impact (article)
Waikato	1.22 (1)	1.18 (3)	0.90 (4)	0.77 (6)
Auckland	1.13 (2)	1.25 (2)	1.41 (1)	1.12 (2)
Otago	1.12 (3)	1.12 (4)	1.31 (2)	1.15 (1)
Canterbury	0.94 (4)	1.28 (1)	1.18 (3)	0.89 (4)
Victoria	0.92 (5)	0.86 (6)	0.86 (5)	1.05 (3)
Massey	0.87 (6)	0.88 (5)	0.67 (6)	0.76 (7)
Lincoln	0.69 (7)	0.74 (7)	0.65 (7)	0.85 (5)
AUT	0.53 (8)	0.29 (8)	0.20 (8)	0.75 (8)

Note, University average in each measure = 1.

When comparing the weighted performance of the universities, Auckland and Otago perform above the university average across all four measures, while Waikato and Canterbury perform above the university average in two areas. Of the remaining universities, only Victoria manages to perform above the university average in one of the measures.

Interestingly, the results in Table 2.6 show that no individual university is top in more than one of the relative performance measures. The Universities of Waikato, Auckland, Otago and Canterbury all fill the top spot in one of the measures. Overall, the performance of these four universities would appear to be somewhat better than the other four universities. In particular, AUT, Lincoln and Massey have much lower performance than the other universities across all of these dimensions.

2.4.2.11 The association between measures of research performance

This section examines the association between the various measures of performance. Two measures are used to assess the relationship between the measures – Pearson's correlation coefficient and Spearman's rank order coefficient. The Pearson's correlation coefficients for the various measures are presented in Table 2.7 and the Spearman's rank order coefficients in Table 2.8. In addition, the association between the various measures is illustrated in Figures 2.46 to 2.51.

A stronger association between quality and impact (FTE) is apparent, compared with that between quality and impact (article). A larger number of subject panels had statistically significant association between quality and impact (FTE). The strongest are Biology/health, Psychology, the Humanities and Education. The strong association of the latter two panels is a little surprising, given the significant amount of research output in those areas outside of journal publication.

A much weaker association between quality and impact (article) was apparent. At the individual panel level, just one panel had a statistically significant association in terms of ranking of performance (Engineering).

Table 2.7, Pearson correlation coefficients by subject panel

Subject panel	Quality vs Impact (FTE)	Quality vs Impact (article)	Quality vs Productivity	Productivity vs Impact (article)	Productivity vs Impact (FTE)	Impact (article) vs Impact (FTE)
Biology/health	0.95*	0.52	0.78*	-0.05	0.88*	0.42
Commerce	0.31	-0.21	0.43	0.75*	0.98*	0.84*
Education	0.87*	0.67	0.83*	0.33	0.82*	0.75
Engineering	0.58	0.58	0.60	0.67	0.96*	0.83*
Humanities	0.87*	0.36	0.76*	-0.10	0.79*	0.52
Maths/computing	0.63	0.59	0.74*	0.81*	0.98*	0.89*
Physical sciences	0.30	-0.02	0.41	0.44	0.92*	0.76*
Social sciences	0.65	-0.05	0.84*	0.27	0.90*	0.65
Psychology	0.86*	0.75	0.95*	0.81*	0.92*	0.96*
Overall	*0.70**	*0.43**	*0.70**	*0.33**	*0.87**	*0.70**

Note, * indicates significant at the 5 percent level.

Table 2.8, Spearman's rank order coefficients by subject panel

Subject panel	Quality vs Impact (FTE)	Quality vs Impact (article)	Quality vs Productivity	Productivity vs Impact (article)	Productivity vs Impact (FTE)	Impact (article) vs Impact (FTE)
Biology/health	0.98*	0.29	0.90*	0.05	0.95*	0.19
Commerce	0.36	-0.29	0.55	0.60	0.95*	0.76*
Education	0.96*	0.71	0.75	0.32	0.82*	0.75
Engineering	0.79*	0.76*	0.81*	0.74*	0.95*	0.79*
Humanities	0.96*	0.43	0.86*	0.36	0.89*	0.46
Maths/computing	0.76*	0.52	0.83*	0.74*	0.93*	0.90*
Physical sciences	0.54	-0.18	0.61	0.07	0.86*	0.43
Social sciences	0.62	0.26	0.74*	0.57	0.88*	0.81*
Psychology	0.93*	0.68	0.89*	0.71	0.93*	0.86*
Overall	*0.71**	*0.43**	*0.73**	*0.49**	*0.91**	*0.76**

Note, * indicates significant at the 5 percent level.

Figure 2.46 compares the quality and impact (FTE) of research across the various subject panels. It would appear that although there is the expected positive association between quality and impact (FTE), there are diminishing returns to quality from higher levels of impact (FTE). An explanation for this is that while the number of citations is not capped as such, PBRF quality scores are capped.

The relationship between productivity and quality is equally as strong as that between quality and impact (FTE). Several of the subject panels displayed a statistically significant association between productivity and quality. The strongest association was in the Psychology panel area.

There is a much stronger association between productivity and impact (FTE) than between productivity and impact (article). Figure 2.50 compares the relative impact (FTE) and relative productivity. It appears that once productivity reaches a threshold level around 0.8 there is an increase in the rate at which higher productivity is associated with higher impact (FTE). There is also a suggestion in Figure 2.50 that the rate of increase then begins to diminish once relative productivity reaches a value of around 1.5. The association between productivity and impact (article) is still positive, but of a weaker level (see Figure 2.49).

Figure 2.46, Quality vs impact (FTE)

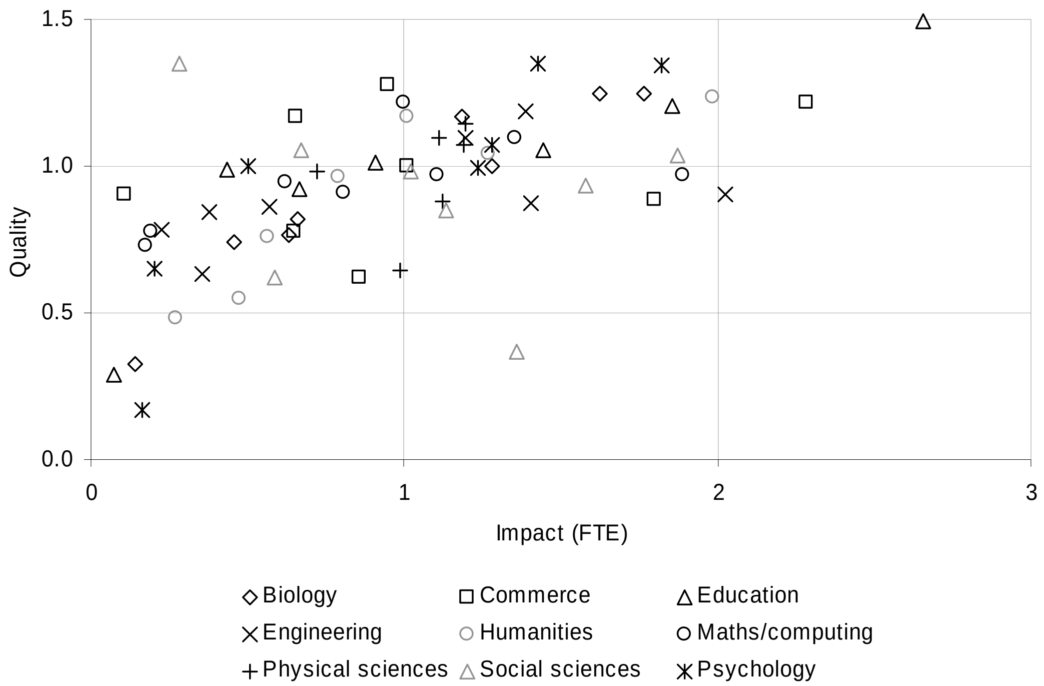


Figure 2.47, Quality vs impact (article)

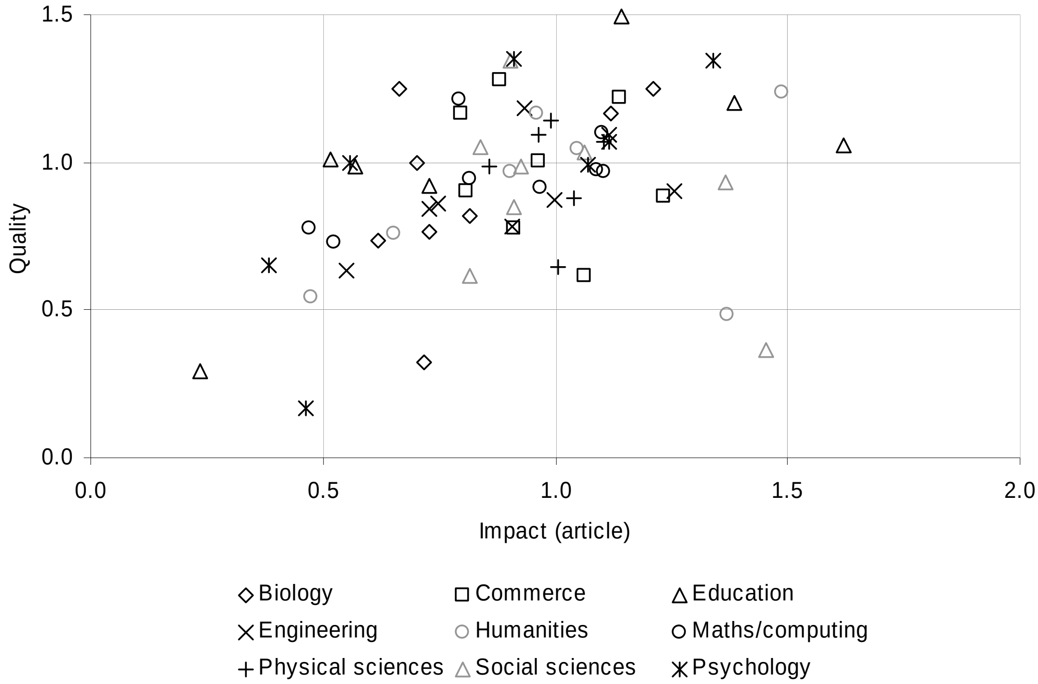


Figure 2.48, Quality vs productivity

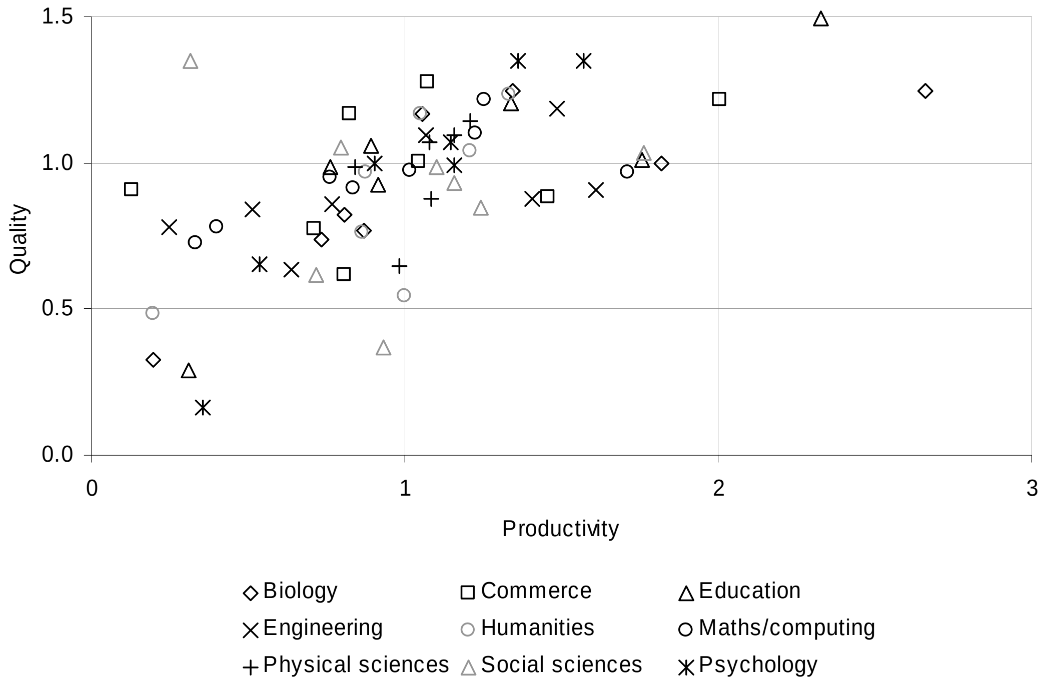


Figure 2.49, Impact (article) vs productivity

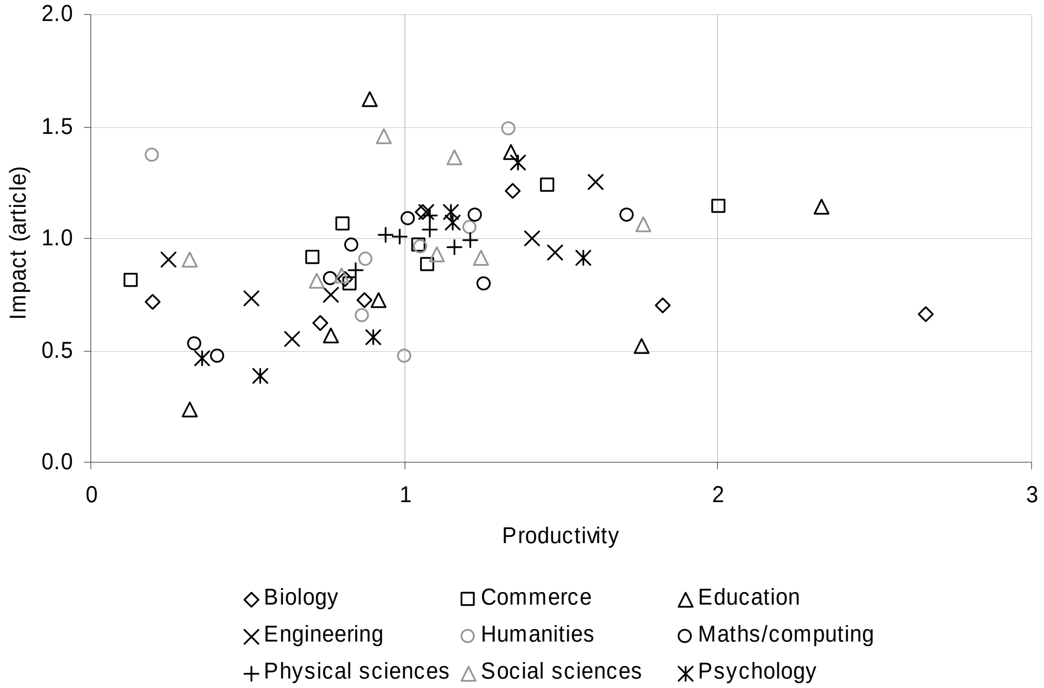


Figure 2.50, Impact (FTE) vs productivity

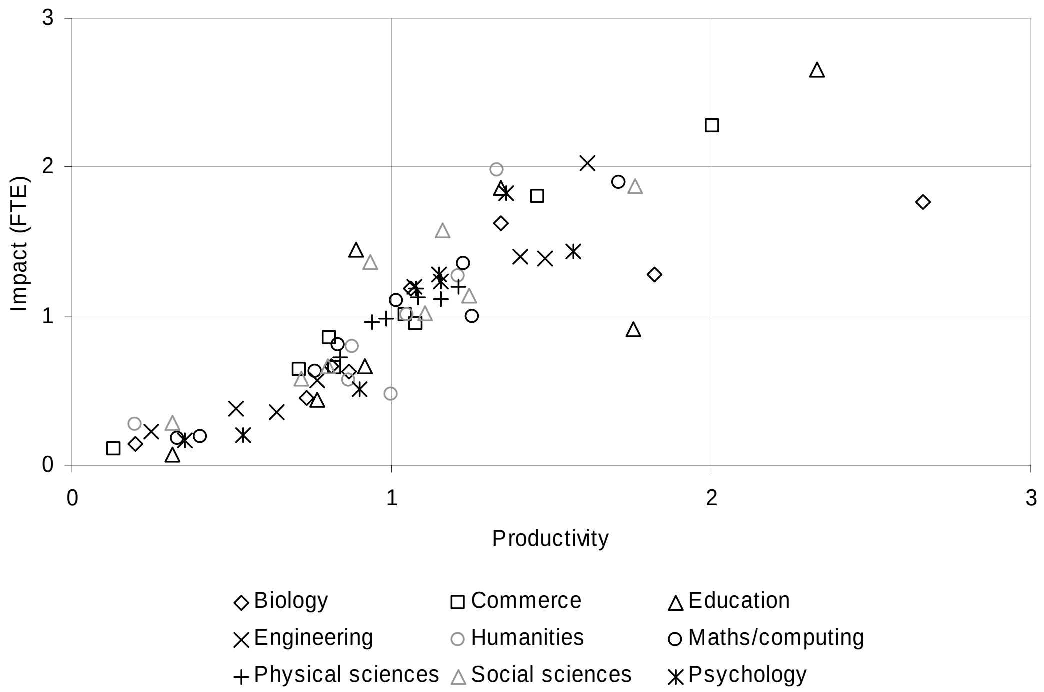
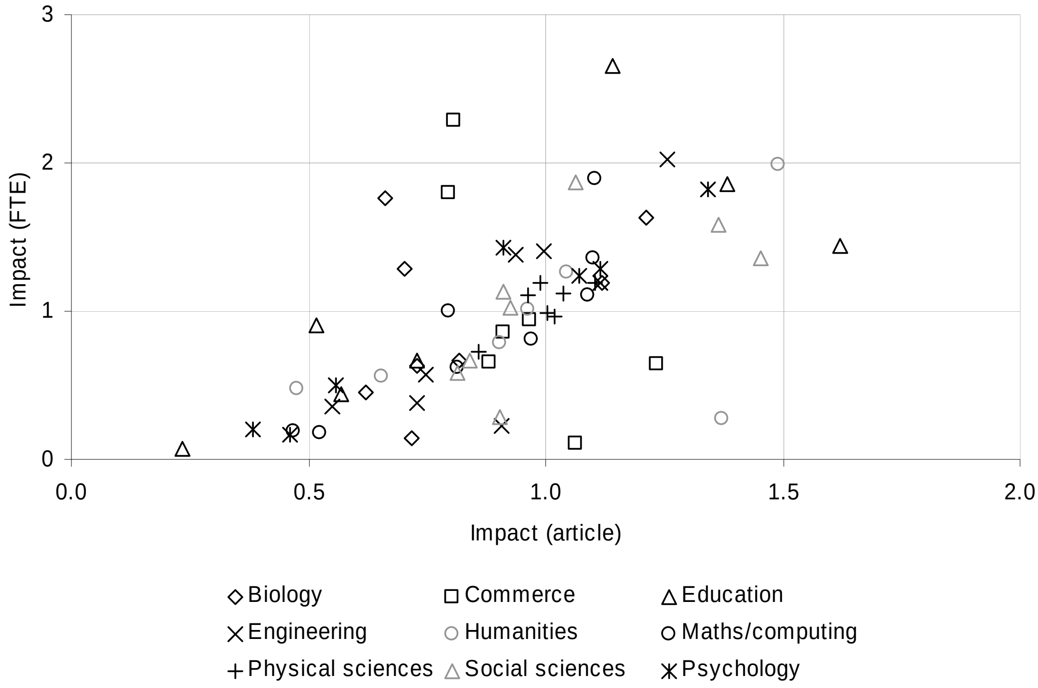


Figure 2.51, Impact (FTE) vs impact (article)



2.4.2.12 Conclusion

The results of the PBRF Quality Evaluations have dominated the discourse around university research performance since 2004. The analysis in this section has indicated that this concentration on one measure of performance, peer-assessed quality, presents a one-dimensional view of research performance. No one university dominated all four performance measures in this analysis. Therefore, taking a balanced view of university performance, it would appear that the top four universities are closer in overall research performance than is indicated by a sole focus on the PBRF Quality Evaluations.

In terms of the association between the various measures, there was better alignment of bibliometric measures with the PBRF quality measure in disciplines where bibliometrics have better coverage. But there were also some surprising results. There was good alignment of quality and impact (FTE) in the Humanities and Education.

It was also apparent that the impact (FTE) measure was more closely associated with quality than with impact (article). The implication of this finding is that if bibliometrics are to be used to perhaps replace peer-assessment in the PBRF Quality Evaluation, calculating citations on a per FTE basis will provide a better proxy than using the more common measure of citations per article

The publication of as many research performance measures as is prudent allows for a more balanced appraisal of the performance of each of the universities. However, it is also important when taking a multi-dimensional approach to the measurement of university performance that more than just the area of research is examined. In Chapter 3, a multi-input/output analysis is applied to teaching and research data for New Zealand universities to obtain relative measures of performance.

2.4.2.13 Appendix

Table 2.9, Relative research performance of New Zealand universities 2000-2005

Note: New Zealand university average = 1

University	Discipline	Quality	Productivity	Impact (FTE)	Impact (article)
Auckland University of Technology	Engineering	0.63	0.64	0.35	0.55
	Maths/computing	0.78	0.40	0.19	0.47
	Physical sciences	n/a	n/a	n/a	n/a
	Biology/health	0.32	0.20	0.14	0.72
	Commerce	0.90	0.13	0.11	0.81
	Education	0.49	0.56	0.30	0.55
	Social sciences	0.37	0.31	0.28	0.90
	Psychology	0.17	0.35	0.16	0.46
	Humanities	0.48	0.20	0.27	1.37
Lincoln University	Engineering	0.78	0.25	0.23	0.91
	Maths/computing	0.73	0.33	0.17	0.53
	Physical sciences	0.65	0.98	0.99	1.00
	Biology/health	0.74	0.73	0.46	0.62
	Commerce	0.62	0.81	0.86	1.06
	Education	n/a	n/a	n/a	n/a
	Social sciences	0.62	0.93	1.36	1.45
	Psychology	n/a	n/a	n/a	n/a
	Humanities	n/a	n/a	n/a	n/a
Massey University	Engineering	0.86	0.77	0.57	0.75
	Maths/computing	0.95	0.76	0.62	0.82
	Physical sciences	0.98	0.84	0.72	0.86
	Biology/health	0.77	0.87	0.63	0.73
	Commerce	0.78	0.71	0.65	0.91
	Education	1.57	1.64	1.37	0.84
	Social sciences	0.85	0.72	0.59	0.81
	Psychology	0.65	0.54	0.21	0.38
	Humanities	0.55	1.00	0.48	0.48
University of Auckland	Engineering	1.09	1.07	1.19	1.12
	Maths/computing	1.10	1.23	1.35	1.10
	Physical sciences	0.88	1.08	1.12	1.04
	Biology/health	1.25	1.34	1.63	1.21
	Commerce	1.22	2.00	2.28	1.14
	Education	1.02	0.98	1.19	1.22
	Social sciences	1.35	1.76	1.87	1.06
	Psychology	0.99	1.16	1.24	1.07
	Humanities	1.17	1.05	1.01	0.96
University of Canterbury	Engineering	1.19	1.48	1.39	0.94
	Maths/computing	0.97	1.71	1.89	1.10
	Physical sciences	1.10	1.16	1.11	0.96
	Biology/health	1.00	1.82	1.28	0.70
	Commerce	0.88	1.46	1.80	1.23
	Education	0.52	0.79	0.33	0.41
	Social sciences	0.93	1.24	1.13	0.91
	Psychology	1.07	1.15	1.28	1.12
	Humanities	1.04	1.21	1.27	1.05

Table 2.9, Relative research performance of New Zealand universities 2000-2005 continued…

University	Discipline	Quality	Productivity	Impact	
				(FTE)	(article)
University of Otago	Engineering	0.90	1.61	2.02	1.26
	Maths/IT	0.91	0.83	0.81	0.97
	Physical sciences	1.07	1.08	1.19	1.10
	Biology/health	1.17	1.06	1.19	1.12
	Commerce	1.17	0.82	0.66	0.80
	Education	0.92	1.40	1.64	1.18
	Social sciences	1.05	1.16	1.58	1.36
	Psychology	1.35	1.36	1.82	1.34
	Humanities/law	1.24	1.33	1.98	1.49
University of Waikato	Engineering	0.87	1.41	1.40	1.00
	Maths/IT	1.22	1.26	1.00	0.79
	Physical sciences	1.14	1.21	1.20	0.99
	Biology/health	1.25	2.66	1.77	0.66
	Commerce	1.28	1.07	0.95	0.88
	Education	1.68	1.36	0.86	0.63
	Social sciences	0.98	0.80	0.67	0.84
	Psychology	1.00	0.90	0.50	0.56
	Humanities/law	0.76	0.86	0.57	0.65
Victoria University of Wellington	Engineering	0.84	0.51	0.38	0.73
	Maths/IT	0.97	1.01	1.10	1.09
	Physical sciences	1.03	0.94	0.96	1.02
	Biology/health	0.82	0.81	0.66	0.82
	Commerce	1.00	1.05	1.01	0.97
	Education	0.63	0.44	0.85	1.93
	Social sciences	1.20	1.10	1.02	0.93
	Psychology	1.35	1.57	1.43	0.91
	Humanities/law	0.97	0.88	0.79	0.90

Sources, Tertiary Education Commission and Web of Science

Table 2.10, Mapping of PBRF Quality Evaluation narrow subject areas to PBRF Panels

PBRF panel	PBRF narrow subject areas
Biology/health	Agriculture and other applied biological sciences
	Ecology, evolution and behaviour
	Molecular, cellular and whole organism biology
	Biomedical
	Clinical medicine
	Public health
	Dentistry
	Nursing
	Other health studies (including rehabilitation therapies)
	Pharmacy
	Sport and exercise science
	Veterinary studies and large animal science
Commerce	Accounting and finance
	Economics
	Management, human resources, industrial relations, international business and other business
	Marketing and tourism
Education	Education
Engineering	Architecture, design, planning, surveying
	Engineering and technology
Humanities	English language and literature
	Foreign languages and linguistics
	History, history of art, classics and curatorial studies
	Law
	Philosophy
	Religious studies and theology
Maths/computing	Computer science, information technology, information sciences
	Pure and applied mathematics
	Statistics
Physical sciences	Chemistry
	Earth sciences
	Physics
Social sciences	Anthropology and archaeology
	Communications, journalism and media studies
	Human geography
	Political science, international relations and public policy
	Sociology, social policy, social work, criminology and gender studies
Psychology	Psychology

Source, Tertiary Education Commission (2007: 14)

Table 2.11, Mapping of Web of Science subject areas to PBRF subject panels

Subject panel	Web of Science subject category
Maths/computing	COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE
	COMPUTER SCIENCE, CYBERNETICS
	COMPUTER SCIENCE, HARDWARE & ARCHITECTURE
	COMPUTER SCIENCE, INFORMATION SYSTEMS
	COMPUTER SCIENCE, INTERDISCIPLINARY APPLICATIONS
	COMPUTER SCIENCE, SOFTWARE ENGINEERING
	COMPUTER SCIENCE, THEORY & METHODS
	INFORMATION SCIENCE & LIBRARY SCIENCE
	MATHEMATICS
	MATHEMATICS, APPLIED
	MATHEMATICS, INTERDISCIPLINARY APPLICATIONS
	STATISTICS & PROBABILITY
	MATHEMATICAL AND COMPUTATIONAL BIOLOGY
Humanities	APPLIED LINGUISTICS
	CLASSICS
	ETHICS
	FOLKLORE
	HISTORY
	HISTORY & PHILOSOPHY OF SCIENCE
	HISTORY OF SOCIAL SCIENCES
	HUMANITIES, MULTIDISCIPLINARY
	LANGUAGE & LINGUISTICS THEORY
	LAW
	LITERARY REVIEWS
	LITERARY THEORY & CRITICISM
	LITERATURE
	LITERATURE, AFRICAN, AUSTRALIAN, CANADIAN
	LITERATURE, BRITISH ISLES
	LITERATURE, GERMAN, DUTCH, SCANDINAVIAN
	LITERATURE, ROMANCE
	LITERATURE, SLAVIC
	MEDICINE, LEGAL
	MEDIEVAL & RENAISSANCE STUDIES
	PHILOSOPHY
	RELIGION
Social sciences	ANTHROPOLOGY
	ARCHAEOLOGY
	AREA STUDIES
	ASIAN STUDIES
	COMMUNICATION
	CRIMINOLOGY & PENOLOGY
	DEMOGRAPHY
	ETHNIC STUDIES
	FAMILY STUDIES
	INTERNATIONAL RELATIONS
	POLITICAL SCIENCE
	PUBLIC ADMINISTRATION
	SOCIAL ISSUES
	SOCIAL WORK
	SOCIOLOGY
	TELECOMMUNICATIONS

Table 2.11, continued…

Subject panel	Web of Science subject category
Social sciences continued…	TRANSPORTATION
	TRANSPORTATION SCIENCE & TECHNOLOGY
	URBAN STUDIES
	WOMEN'S STUDIES
Psychology	PSYCHOLOGY
	PSYCHOLOGY, APPLIED
	PSYCHOLOGY, BIOLOGICAL
	PSYCHOLOGY, DEVELOPMENTAL
	PSYCHOLOGY, EDUCATIONAL
	PSYCHOLOGY, EXPERIMENTAL
	PSYCHOLOGY, MATHEMATICAL
	PSYCHOLOGY, MULTIDISCIPLINARY
	PSYCHOLOGY, SOCIAL
Physical sciences	ACOUSTICS
	ASTRONOMY & ASTROPHYSICS
	BIOPHYSICS
	CHEMISTRY, ANALYTICAL
	CHEMISTRY, APPLIED
	CHEMISTRY, INORGANIC & NUCLEAR
	CHEMISTRY, MEDICINAL
	CHEMISTRY, MULTIDISCIPLINARY
	CHEMISTRY, ORGANIC
	CHEMISTRY, PHYSICAL
	CRYSTALLOGRAPHY
	ELECTROCHEMISTRY
	ENERGY & FUELS
	GEOCHEMISTRY & GEOPHYSICS
	GEOGRAPHY
	GEOGRAPHY, PHYSICAL
	GEOLOGY
	GEOSCIENCES, MULTIDISCIPLINARY
	IMAGING SCIENCE & PHOTOGRAPHIC TECHNOLOGY
	LIMNOLOGY
	MATERIALS SCIENCE, BIOMATERIALS
	MATERIALS SCIENCE, CERAMICS
	MATERIALS SCIENCE, CHARACTERIZATION & TESTING
	MATERIALS SCIENCE, COATINGS & FILMS
	MATERIALS SCIENCE, COMPOSITES
	MATERIALS SCIENCE, MULTIDISCIPLINARY
	MATERIALS SCIENCE, PAPER & WOOD
	MATERIALS SCIENCE, TEXTILES
	MECHANICS
	METALLURGY & METALLURGICAL ENGINEERING
	METEOROLOGY & ATMOSPHERIC SCIENCES
	MICROSCOPY
	MINERALOGY
	MINING & MINERAL PROCESSING
	NANOSCIENCE & NANOTECHNOLOGY
	NUCLEAR SCIENCE & TECHNOLOGY
	OCEANOGRAPHY
	OPTICS

Table 2.11, continued…

Subject panel	Web of Science subject category
Physical sciences continued…	PALEONTOLOGY
	PHYSICS, APPLIED
	PHYSICS, ATOMIC, MOLECULAR & CHEMICAL
	PHYSICS, CONDENSED MATTER
	PHYSICS, FLUIDS & PLASMAS
	PHYSICS, MATHEMATICAL
	PHYSICS, MULTIDISCIPLINARY
	PHYSICS, NUCLEAR
	PHYSICS, PARTICLES & FIELDS
	POLYMER SCIENCE
	SPECTROSCOPY
	THERMODYNAMICS
	WATER RESOURCES
Biology/medicine	AGRICULTURE, DAIRY & ANIMAL SCIENCE
	AGRICULTURE, MULTIDISCIPLINARY
	AGRICULTURE, SOIL SCIENCE
	AGRONOMY
	ALLERGY
	ANATOMY & MORPHOLOGY
	ANDROLOGY
	ANESTHESIOLOGY
	BEHAVIORAL SCIENCES
	BIOCHEMISTRY & MOLECULAR BIOLOGY
	BIOLOGY
	BIOTECHNOLOGY & APPLIED MICROBIOLOGY
	CARDIAC & CARDIOVASCULAR SYSTEMS
	CELL BIOLOGY
	CLINICAL NEUROLOGY
	CRITICAL CARE MEDICINE
	DERMATOLOGY
	DEVELOPMENTAL BIOLOGY
	ECOLOGY
	EMERGENCY MEDICINE
	ENDOCRINOLOGY & METABOLISM
	ENTOMOLOGY
	ENVIRONMENTAL SCIENCES
	ENVIRONMENTAL STUDIES
	EVOLUTIONARY BIOLOGY
	FISHERIES
	FOOD SCIENCE & TECHNOLOGY
	FORESTRY
	GASTROENTEROLOGY & HEPATOLOGY
	GENETICS & HEREDITY
	GERIATRICS & GERONTOLOGY
	GERONTOLOGY
	HEALTH CARE SCIENCES & SERVICES
	HEALTH POLICY & SERVICES
	HEMATOLOGY
	HORTICULTURE
	IMMUNOLOGY
	INFECTIOUS DISEASES

Table 2.11, continued…

Subject panel	Web of Science subject category
Biology/medicine continued…	INTEGRATIVE & COMPLEMENTARY MEDICINE
	MARINE & FRESHWATER BIOLOGY
	MEDICAL ETHICS
	MEDICAL INFORMATICS
	MEDICAL LABORATORY TECHNOLOGY
	MEDICINE, GENERAL & INTERNAL
	MEDICINE, RESEARCH & EXPERIMENTAL
	MICROBIOLOGY
	MYCOLOGY
	NEUROSCIENCES
	NUTRITION & DIETETICS
	OBSTETRICS & GYNECOLOGY
	ONCOLOGY
	OPHTHALMOLOGY
	ORNITHOLOGY
	ORTHOPEDICS
	OTORHINOLARYNGOLOGY
	PARASITOLOGY
	PATHOLOGY
	PEDIATRICS
	PERIPHERAL VASCULAR DISEASE
	PHARMACOLOGY & PHARMACY
	PHYSIOLOGY
	PHYSIOLOGY
	PLANT SCIENCES
	PSYCHIATRY
	PSYCHOLOGY, CLINICAL
	PUBLIC, ENVIRONMENTAL & OCCUPATIONAL HEALTH
	RADIOLOGY, NUCLEAR MEDICINE & MEDICAL IMAGING
	REPRODUCTIVE BIOLOGY
	RESPIRATORY SYSTEM
	RHEUMATOLOGY
	SOCIAL SCIENCES, BIOMEDICAL
	SUBSTANCE ABUSE
	SURGERY
	TOXICOLOGY
	TRANSPLANTATION
	TROPICAL MEDICINE
	UROLOGY & NEPHROLOGY
	VIROLOGY
	ZOOLOGY
	DENTISTRY, ORAL SURGERY & MEDICINE
	NURSING
	REHABILITATION
	SPORT SCIENCES
	VETERINARY SCIENCES
	NEUROIMAGING
Engineering	AGRICULTURAL ENGINEERING
	ARCHITECTURE
	AUTOMATION & CONTROL SYSTEMS
	CONSTRUCTION & BUILDING TECHNOLOGY

Table 2.11, continued…

Subject panel	Web of Science subject category
	ENGINEERING, AEROSPACE
	ENGINEERING, BIOMEDICAL
	ENGINEERING, CHEMICAL
	ENGINEERING, CIVIL
	ENGINEERING, ELECTRICAL & ELECTRONIC
	ENGINEERING, ENVIRONMENTAL
	ENGINEERING, GEOLOGICAL
	ENGINEERING, INDUSTRIAL
	ENGINEERING, MANUFACTURING
	ENGINEERING, MARINE
	ENGINEERING, MECHANICAL
	ENGINEERING, MULTIDISCIPLINARY
	ENGINEERING, OCEAN
	ENGINEERING, PETROLEUM
	ERGONOMICS
	INSTRUMENTS & INSTRUMENTATION
	PLANNING & DEVELOPMENT
	REMOTE SENSING
	ROBOTICS
Commerce	AGRICULTURAL ECONOMICS & POLICY
	BUSINESS
	BUSINESS, FINANCE
	ECONOMICS
	INDUSTRIAL RELATIONS & LABOR
	MANAGEMENT
	OPERATIONS RESEARCH & MANAGEMENT SCIENCE
Education	EDUCATION & EDUCATIONAL RESEARCH

3 Measuring the productive efficiency of New Zealand tertiary education institutions using Data Envelopment Analysis

3.1 Introduction

The efficient use of resources is central to the study of economics. The measurement of efficiency is therefore of key interest, both to the economic theorist and the economic policy or decision maker (see Farrell 1957; Seiford and Thrall 1990).

The focus of this chapter is on measuring the productive efficiency of New Zealand's tertiary education institutions (TEIs),[23] a topic of increasing public policy interest in New Zealand, given they receive substantial amounts of funding from the government on behalf of the taxpayer.[24] In addition, the introduction of a capped tertiary funding system by the New Zealand government in 2008 places additional pressure on tertiary institutions to operate efficiently. It is in this context that a study of the productive efficiency of TEIs is timely, as decreasing costs can be achieved from reducing inefficiencies.

Generally, the measurement of efficiency of New Zealand TEIs has been restricted to financial measures of performance. Although TEIs received a measure of independence from direct government control with the passing of the Education Act in 1989, government agencies retained a monitoring role, given the substantial Crown assets under the control of TEIs.[25] This monitoring was further enhanced with the creation of a specific unit within the Ministry of Education, the Tertiary Advisory Monitoring Unit (TAMU), in 1998. This unit monitors the financial performance of TEIs and has the power to intervene in the running of the institutions through the appointment of Crown observers or Crown managers.[26] In an extreme case, the government can dismiss the TEI's governing body and appoint a commissioner to

[23] Tertiary education institutions (TEIs) include universities, colleges of education (until the end of 2006), polytechnics and wānanga.
[24] In 2007, New Zealand tertiary education institutions received over $1.8 billion in funding from the government. Note that this sum excludes income earned through research contract income.
[25] Initially by the Ministry of Education and since 2006 the Tertiary Education Commission. In 2007, the total value of TEI assets was around $8 billion.
[26] Which has been done several times in the polytechnic and wānanga subsectors.

oversee the TEI's operation. The detailed financial performance of individual TEIs has been published since 1997.[27]

Too much focus on the financial performance of TEIs can have its problems. Yahanpath and Wang (2003) argue that the wide availability of financial performance indicators can lead to an over-reliance on traditional accounting ratio analysis. This can lead to performance measures that can be one-dimensional in focus, which can be especially problematic in the tertiary education area, given the multiple input/output nature of the sector and the absence of a market based pricing mechanism.

Since 2004, completions rates of qualifications and courses at New Zealand TEIs have been calculated and published by the Ministry of Education at the subsector level.[28] In addition, the quality of research produced by TEIs has been measured and published at the individual institution level in 2004 and 2007.[29] However, rarely are these measures looked at in unison when analysing the efficiency of TEIs.

This chapter uses a non-parametric approach, Data Envelopment Analysis (DEA), which does take into account the multiple input/output nature of tertiary education, to measure the efficiency of New Zealand TEIs between 1996 and 2006. Although this is not the first study to apply DEA to measure the efficiency of New Zealand's TEIs, this study uses data from recent time periods and extends the analysis to new areas, such as comparing the efficiency of New Zealand and Australian universities. In addition, this study goes further than the existing literature in attempting to analyse the reasons for differences in efficiency between TEIs. Finally, in another advance on previous New Zealand studies, tests of statistical inference are applied to the estimates of technical efficiency and Malmquist productivity indices generated using DEA.

This chapter has the following structure. Firstly, the DEA methodology is presented in section 3.2. This discusses the generation of technical and scale efficiency

[27] See www.tec.govt.nz.
[28] See Ministry of Education (2008) and Scott (2004, 2006).
[29] See Tertiary Education Commission (2004, 2007).

estimates, along with the generation of estimates of Malmquist indices. Methods for generating measures of statistical inference for these estimates are also discussed. Then, the second-stage methodology used to analyse the impact of environmental factors on efficiency, is presented.

Following the introduction to DEA, a literature review examining the application of DEA to the tertiary education area is presented in section 3.3. This is followed by the reporting of the results of the application of DEA to three groupings of TEIs. Firstly, an analysis of the efficiency and productivity of New Zealand polytechnics over the period 1996 to 2006 is presented in section 3.4. This is followed by a presentation of the results of an analysis of the efficiency of New Zealand and Australian universities in the period 1997 to 2005 in section 3.5. Finally, an analysis of New Zealand TEI efficiency in 2006 is presented in section 3.6.

3.2 Data Envelopment Analysis

3.2.1 Introduction

In this chapter, Data Envelopment Analysis (DEA) is used to measure the technical efficiency and productivity of New Zealand's tertiary education institutions (TEIs). 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.

3.2.2 Deriving technical efficiency 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*. 1999).[30]

[30] 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).

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.

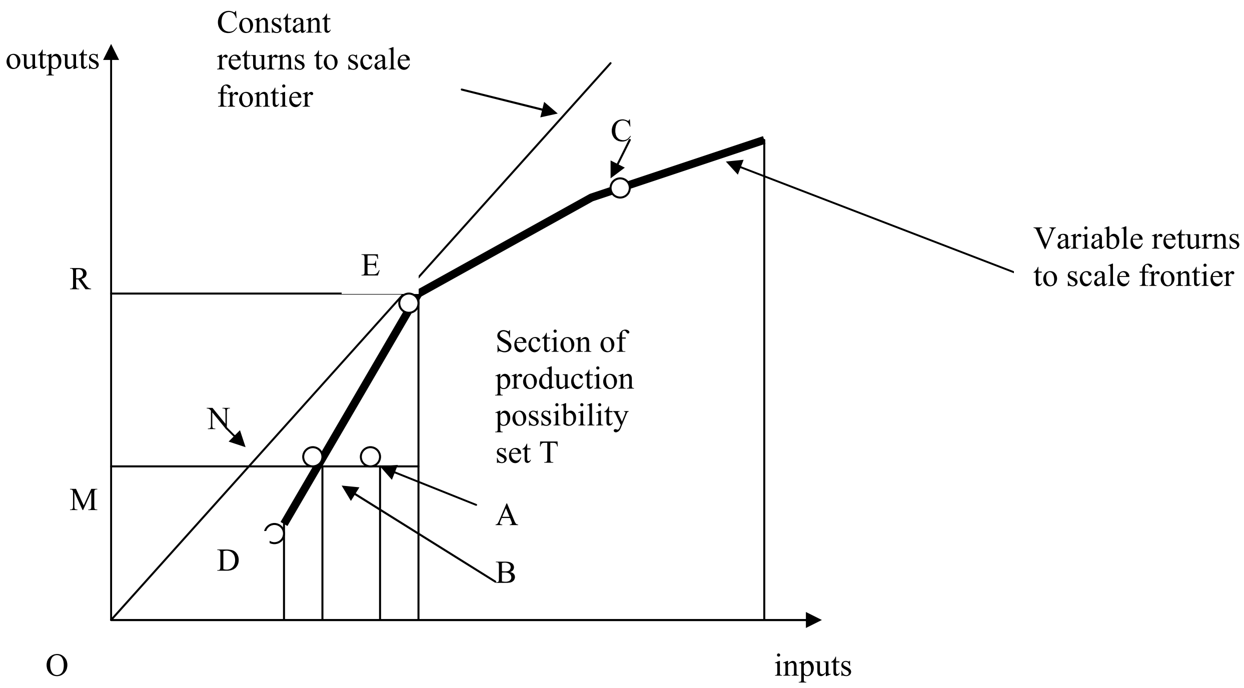
The relationship between pure technical efficiency and scale efficiency can be described thus:

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

Figure 3.1 (from Banker *et al*. 1984, p.1089) illustrates the two concepts. Assume point A represents the DMU under consideration. Overall technical efficiency is measured by the ratio MN / MA. Pure technical efficiency is measured by the ratio MB / MA. The SE of the DMU is measured by the ratio MN / MB.

In this model the envelopment frontier becomes piecewise, representing a variable returns to scale technology. The convex shape to the envelopment surface means that more DMUs will be found to be efficient under this model, than under a constant returns to scale model.

Figure 3.1, Concepts of efficiency



The following linear programming model needs to be solved for each DMU in the dataset to calculate the technical efficiency estimates under the VRS assumption. This is reproduced from Johnes (2006, pp.275-276):

$$\text{Maximize} \qquad \phi_k + \varepsilon \sum_{r=1}^{s} s_r + \varepsilon \sum_{i=1}^{m} s_i \tag{1}$$

$$\text{subject to } \phi_k y_{rk} - \sum_{j=1}^{n} \lambda_j y_{rj} + s_r = 0, \qquad r = 1,\ldots,s, \tag{2}$$

$$x_{ik} - \sum_{r=1}^{n} \lambda_j x_{ij} - s_i = 0, \qquad i = 1,\ldots,m, \tag{3}$$

$$\sum_{j=1}^{n} \lambda_j = 1, \tag{4}$$

$$\lambda_j, s_r, s_i, \geq 0 \quad \forall j = 1,\ldots,n; \quad r = 1, \ldots,s; \quad i = 1,\ldots,m,$$

where there are s outputs and m inputs; y_{rk} is the amount of output r used by DMU k; x_{ik} is the amount of input i used by DMU k; and s_r,s_i are the output and input slacks, respectively. Technical efficiency of DMU *k* is measured by $1/\phi_k$; DMU *k* is efficient if its efficiency score is 1 and all slacks are zero.

The choice of orientation of the DEA model depends on the type of DMUs being analysed. The majority of studies that use DEA to analyse the technical efficiency of higher education institutions use an output orientation (e.g., Coelli *et al*. 2004; Johnes 2006), given that some of the inputs of higher education institutions can be difficult to alter in the short term.[31] Also, increasing academic achievement levels is in line with government policy.

3.2.3 Selection of variables

Some studies that use DEA to measure the efficiency of DMUs arrive at a preferred suite of input and output variables through the estimation of several models and then comparing the technical efficiency estimates that result (see for example, Worthington and Lee 2005). Johnes (2006) suggests using a combination of statistical techniques to introduce statistical robustness into model selection and aid in variable selection in order to identify those measures that can be omitted with no difference in results.[32]

This approach involves applying a Pastor *et al*. (2002) test to different combinations of variables to arrive at a parsimonious model. This test uses a simple binomial test to analyse if the change in technical efficiency estimates that arise from the omission of input and output variables is statistically significant at a pre-specified level, in this study 10 percent. This approach involves estimating a saturated model including all variables. Then, technical efficiency estimates are generated by omitting one variable at a time. A test statistic that is less than 0.15 indicates that the omission of the variable has resulted in a statistically significant change in the technical efficiency estimates. Hence, the variable(s) would be retained in the model. The Pastor *et al*. (2002) test is presented in more detail in section 3.7.1.

[31] For example, tenuring of staff may make it difficult to alter staffing levels.
[32] Because of the limited number of DMUs in any potential analysis of TEIs in New Zealand, arriving at a parsimonious model that minimises the problem of dimensionality is an important step in the use of DEA.

Johnes (2006) also used Spearman's rank coefficient to examine if the omission of a variable(s) has a significant impact on the ranking of the DMUs. If there is a significant change in the ranking of the DMUs from altering the variable selection then the variable would be retained in the model.

For the purposes of this study, if the Spearman's rank coefficient value was greater than 0.95 in both the constant returns to scale and variable returns to scale specifications then it was considered that removing the measure would not have a significant impact on the efficiency rankings.[33]

3.2.4 Statistical inference

The technical efficiency estimates derived using DEA are generally presented as point estimates in the literature. However, Simar and Wilson (2000) have developed a bootstrapping algorithm that can generate confidence intervals for the technical efficiency estimates. This can provide an indication if the difference in technical efficiency between DMUs is statistically significant. The method of producing the confidence intervals is described in section 3.7.2.

3.2.5 Second-stage analysis

Having obtained estimates of technical efficiency using DEA, there is the opportunity to analyse the reasons for disparities in the performance of DMUs. The standard approach is to use a two-stage process to explain differences in efficiency. As outlined in Coelli *et al*. (1998), the initial step is to undertake DEA analysis using only pure input and output variables. Having calculated the efficiency estimates, these are used as the dependent variable in a second-stage regression. Environmental variables are used as the explanatory variables in this process and the signs of the coefficients will indicate the direction of the relationship between them and the dependent variable. The results can also be subjected to econometric tests.[34]

---

[33] This is a more conservative approach than that used by Johnes (2006) which recognises the smaller sample size. In that study, as long as the Spearman's *r* statistic indicated a statistically significant relationship existed between the rankings of the various universities under the different model specifications, the author was prepared to remove the variable.

[34] One drawback is that, if the variables used in the first stage are highly correlated with variables used in the second stage, then the results can be biased (Coelli *et al*. 1998).

One example of this approach in the education area is a paper by Lovell *et al*. (1994) which uses a two-stage approach to explain differences in the efficiency performance of secondary schools in the United States. Examples of the environmental variables used by the authors included: whether a school was Catholic, if the teachers were unionised, and also the proportion of fathers of students that did not have a degree.

A study by Alexander and Jaforullah (2004) used ordinary least squares in a two-stage analysis of the factors influencing the efficiency of New Zealand secondary schools. They found that school type, the socioeconomic status of the community from which schools draw their students, school size and teacher experience were associated with variation in technical efficiency.

A rare example of a two-stage analysis at the tertiary education level is Coelli *et al*. (2004). This study used Tobit regression to analyse the factors that influence the technical efficiency of Australian universities. The study found that location and the proportion of students from rural and remote regions were associated with variation in technical efficiency.

Alternatively Banker and Morey (1986a) suggest that, if the environmental variable can be ordered then it is possible to rank the variables and then perform the DEA analysis with only those DMUs that have similar rankings. A major drawback of this approach is that the number of observations will be reduced to such a level that a large number of the DMUs will be considered efficient.

Another approach is to include the environmental variables as input variables in a one-stage estimation. Coelli *et al*. (1998) suggest two approaches. The environmental variables can be inserted simply as input variables. Alternatively the environmental variables can be inserted as non-discretionary variables (see Banker and Morey 1986b). The main disadvantage of these approaches is that the direction of the influence of the environmental variables on efficiency must be known prior to the estimation. If the relationship is unknown, then the two-stage method is more appropriate.

The majority of studies that include second-stage analysis use Tobit or ordinary least squares regression. However, Simar and Wilson (2007) argue that the technical efficiency estimates derived using DEA are serially correlated in a complicated and unknown way, hence the approaches to inference in these studies are invalid. They suggest an approach that applies a bootstrap or a double bootstrap using truncated regression to allow valid inference and improve statistical efficiency.[35] The confidence intervals can then be used to test if the coefficients of the explanatory variables are statistically significantly. If the confidence interval contains a value of zero, then the effect of the variable is not significant. It is this approach that is used in the analysis of the variation in technical efficiency in New Zealand TEIs. The statistical inference process is described in detail in section 3.7.4.

3.2.6 Malmquist indices

The previous section examined the process of measuring the technical efficiency of DMUs at one point in time. DEA can also be applied to measure how the productivity of DMUs changes over time.

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, which is adapted from Worthington and Lee (2005, pp.5-6):

$$M_0^{t+1}(y_t, x_t, y_{t+1}, x_{t+1}) = \left[\frac{D_0^t(x_{t+1}, y_{t+1})}{D_0^t(x_t, y_t)} \times \frac{D_0^{t+1}(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_t, y_t)} \right]^{\frac{1}{2}} \quad (5)$$

[35] Banker and Natarajan (2008) have suggested that Tobit and ordinary least squares regression can still be applied to technical efficiency estimates, as the data generating process used by Simar and Wilson (2007) is too restrictive. Nevertheless, for the purposes of this study the more restrictive approach of Simar and Wilson is used to ensure robustness of the regression findings.

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:

$$M_0^{t+1}(y_t, x_t, y_{t+1}, x_{t+1}) = \frac{D_0^{t+1}(x_{t+1}, y_{t+1})}{D_0^t(x_t, y_t)} \left[\frac{D_0^t(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_{t+1}, y_{t+1})} \times \frac{D_0^t(x_t, y_t)}{D_0^{t+1}(x_t, y_t)} \right]^{1/2} \quad (6)$$

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.

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:

$$
\begin{aligned}
\left[D_0^{t+1}(x_{t+1}, y_{t+1})\right]^{-1} &= \max_{\theta,\lambda}\phi \\
s.t. -\phi y_{i,t+1} + Y_{t+1}\lambda &\geq 0 \\
x_{i,t+1} - X_{t+1}\lambda &\geq 0 \\
\lambda &\geq 0
\end{aligned}
\tag{7}
$$

$$
\begin{aligned}
\left[D_0^{t}(x_t, y)\right]^{-1} &= \max_{\theta,\lambda}\phi \\
s.t. -\phi y_{i,t} + Y_t\lambda &\geq 0 \\
x_{i,t} - X_t &\geq 0 \\
\lambda &\geq 0
\end{aligned}
\tag{8}
$$

$$
\begin{aligned}
\left[D_0^{t+1}(x, y)\right]^{-1} &= \max_{\theta,\lambda}\phi \\
s.t. -\phi y_{i,t} + Y_t\lambda &\geq 0 \\
x_{i,t} - X_t\lambda &\geq 0 \\
\lambda &\geq 0
\end{aligned}
\tag{9}
$$

$$
\begin{aligned}
\left[D_0^{t}(x_{t+1}, y_{t+1})\right]^{-1} &= \max_{\theta,\lambda}\phi \\
s.t. -\phi y_{i,t+1} + Y_t\lambda &\geq 0 \\
x_{i,t+1} - X_t\lambda &\geq 0 \\
\lambda &\geq 0
\end{aligned}
\tag{10}
$$

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:

$$
\frac{D_0^{t+1}(y_{t+1}, x_{t+1})_{CRS}}{D_0^{t}(y_t, x_t)_{CRS}} = \frac{D_0^{t+1}(x_{t+1}, y_{t+1})_{VRS}}{D_0^{t}(x_t, y_t)_{VRS}} \times \left[\frac{D_0^{t}(x_t, y_t)_{VRS}}{D_0^{t}(x_t, y_t)_{CRS}} \times \frac{D_0^{t+1}(x_{t+1}, y_{t+1})_{CRS}}{D_0^{t+1}(x_{t+1}, y_{t+1})_{VRS}}\right] \tag{11}
$$

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

3.2.7 Statistical inference of Malmquist indices

Simar and Wilson (1999) have developed statistical inference methods that can be applied to estimates of the Malmquist indices. They argue that the construction of confidence intervals is essential in the interpretation of a Malmquist index estimator. The essential nature of statistical inference arises as the linear programming problem yields *estimates* of the distance function, not the distance function itself. To determine if any increase/decrease in productivity is statistically significant and not just an artefact of sampling noise, they developed a bootstrapping approach which replicates the data-generating process generating an appropriately large number of pseudo samples. From these samples 95 percent confidence intervals can be constructed to test the statistical significance of the Malmquist indices. The construction of the confidence intervals is presented in section 3.7.4

3.2.8 DEA software

There are a number of software programmes that generate DEA estimates. This study uses two software programmes. DEAP 2.1, developed by Tim Coelli (Coelli 1996), generates technical efficiency and Malmquist estimates. Importantly, this package also generates the peer institutions and the scale efficiency of DMUs.

The other DEA software package used in this study is FEAR 0.913 by Paul Wilson (Wilson 2005). This package also generates technical efficiency estimates, but in addition, can also generate 95 percent confidence intervals of the technical efficiency estimates.

3.3 Review of the literature

The use of Date Envelopment Analysis (DEA) to estimate the efficiency of decision making units (DMUs) in the tertiary education sector has become widespread since its development in 1978. The review of the literature shows that a relatively similar approach is used to estimate the technical efficiency of DMUs, although there are differences in the various input and output variables used. This process for the estimation of technical efficiency is outlined in the section 3.3.1. Then, the findings of studies that apply DEA to analysing the efficiency of tertiary institutions are presented in section 3.3.2.

3.3.1 Process

The choice of what constitutes a DMU is crucially important in DEA. To be relevant, DEA must compare homogenous entities (Farrell 1957). The selection of DMUs in the tertiary education sector literature has varied depending on the nature of the study, although predominantly they have been at the institution level. A number of studies of the higher education sector have also compared academic departments with one another, rather than universities as a whole (see Beasley 1990, 1995; Johnes and Johnes 1993; Tomkins and Green 1988; and Madden *et al*. 1997).[36]

Abbott and Doucouliagos (2000) in their study of the New Zealand polytechnic sector measured the technical efficiency of similar polytechnic departments, but focussed primarily on the measurement of the efficiency of the institutes as a whole.[37]

Another approach was used by Sarrico and Dyson (2000) to compare the technical efficiency of academic departments within the University of Warwick. Sarrico and Dyson applied DEA to the various academic departments within the University of Warwick to help identify efficient practitioners. To do this the authors compared the efficiency of the departments at Warwick to their counterparts at other universities. Having benchmarked the departments against their counterparts at other universities,

[36] Beasley (1990) argues that using DEA to compare entire universities is invalid, as the different mix of disciplines is more likely to influence the DEA results, rather than any differences in efficiency.
[37] A lack of data meant that only a few polytechnics in the sector could be compared at the departmental level.

the University of Warwick departments were then compared with each other in a performance matrix.

In terms of geographical location, the literature shows that most DEA studies of the tertiary education sector compare the technical efficiency of DMUs within the same country. This means, of course, that all efficiency measurements are relative to the best performers in that country. There is a movement to widen the geographical catchment of the studies so that TEIs are compared across countries. This makes the efficiency comparisons more powerful. Abbot and Doucouliagos (2000) followed this approach by comparing the performance of New Zealand polytechnics with the Technical and Further Education institutions in the state of Victoria, Australia. They argue that the institutions are comparable, as they have a similar focus on vocational education. They also argue that further research could be widened to include TEIs in other countries as well (they mention for example Canada, UK, South Africa).[38]

One of the key decisions when using a DEA approach is the choice of inputs and outputs to include in the model specification. There are a number of options available when choosing the inputs for DEA analysis in the tertiary education sector. It is accepted practice to include a variable that measures the value of the teaching input. In some studies the number of staff (usually the full-time equivalent) is the variable of choice (i.e. Avkiran 2001; Worthington and Lee 2005). Where possible some studies also split the staffing into the teaching and non-teaching components (Avkiran 2001; Madden *et al*. 1997; Johnes and Johnes 1993; Abbott and Doucouliagos 2000, Worthington and Lee 2005). An alternative approach is to use the expenditure on staffing as the input measure, as used by Beasley (1990). Coelli *et al*. (2004) argue that using expenditure on staffing will better capture differences in the quality of staff, the logic being that better quality staff will attract higher wages.

The amount of research funding earned by tertiary institutions is sometimes used as a research input (see Worthington and Lee 2005), while some studies use research income as an output measure. However, as Johnes and Johnes (1993) argue, research grants earned are spent on resources to produce the research, and hence should be

[38] As do Coelli *et al*. (2004).

treated as an input. This view is shared by Beasley (1995), who also used research grants as an input variable.

In studies where the entire institute rather than a department is the DMU, there is a need for an input variable to represent capital.[39] In their study of the New Zealand polytechnic sector Abbott and Doucouliagos (2000) used the value of fixed assets as a proxy for capital. Other studies have used depreciation (Johnes 2005) or non-labour expenditure (Abbott and Doucouliagos 2000; Flegg *et al*. 2004; Worthington and Lee 2005) to capture the contribution of non-labour inputs to the productive process.

In terms of using depreciation as a separate input variable to capture capital, Coelli *et al*. (2004) argue against it as Australian universities vary in the way they value assets and how they calculate depreciation. In their DEA study, they use operating expenditure, including depreciation, as the sole input.

The selection of appropriate output measures in the tertiary sector is a difficult task. Firstly there is the problem of there being no general agreement on the definition and measurement of the output of a tertiary institution (Altbach and Johnstone 1993). Secondly there is the problem of gathering comparable data and integrating quality into the output measurement.

In the tertiary education area, it would be optimal if a measure could be found that looked at the improvement of each individual student over the time at a DMU, and then quantified their increase in knowledge. At this stage, however, no such measure exists, so proxies come into play. Often the number of students enrolled in the TEI is used as a measure of output (i.e. Beasley 1990; Abbott and Doucouliagos 2000, Avkiran 2001), sometimes with an allowance for the different levels of students. Some studies use both the number of undergraduate students, and the number of postgraduate students as output variables. Madden *et al*. (1997) argue that it can be misleading to simply count enrolled students as an output variable and that it is more

[39] A capital input is not typically used in situations where the DMU is a department as opposed to the university in total.

correct to use the numbers of these students who successfully graduate.[40] Other studies that have used undergraduate and postgraduate qualification completions include Madden *et al*. (1997), Worthington and Lee (2005).

As in the case of inputs, there is a difficulty in finding output variables that take into account quality. As indicated by Abbott and Doucouliagos (2000), a TEI that has a high number of outputs (such as equivalent full-time students) but low quality, will receive a high efficiency measure. Despite this, Abbott and Doucouliagos (2000, p. 8) note that "A lack of quality adjusted data for output levels necessitates the abstraction from the issue of quality".

One approach to try and integrate quality into the DEA method is to apply subjective weightings to output measures. For example, Beasley (1995) uses the number of undergraduate and postgraduate students as output measures. The difference between his and other approaches is that he then applies weightings to the outputs. For example, he suggests that postgraduate students should have a weighting 1.25 times that of an undergraduate student, reflecting their higher value. The main drawback of this type of approach is that the weightings applied are subjective.

The measurement of research outputs entails a number of conceptual and technical difficulties. It is important that not only the quantity but the quality of research output is captured (Abbott and Doucouliagos 2003). Beasley (1990) took a simplified approach and applied the research score that United Kingdom universities were allocated by the University Grants Committee in 1985 as a measure of research output. Other studies split the different types of research into various categories. For example Madden *et al*. (1997) splits research publications into five groupings, based on the assessed level of the publication. Articles that were published in more respectable journals were given higher weighting than those that did not. Worthington and Lee (2005) also use the weighted research publications as a measure of research output of Australian universities. Abbott and Doucouliagos

[40] Abbott and Doucouliagos (2000) take issue with this approach, suggesting that a high number of graduating students could just as easily be a sign of *low* educational standards.

(2003) in their studies of the efficiency of Australian universities use the Research Quantum as a measure of the research output.[41]

There have been a number of attempts to measure and compare the research output of New Zealand universities. For example, measures of the research output of economics departments have been obtained by Bairam (1996, 1997) using bibliometric databases. Gibson (2000) has extended this analysis to correct what he sees as flaws in Bairam's weighting process of various research outputs using the same bibliometric databases.

With a large number of polytechnics offering degrees, and hence increasing research output to meet accreditation requirements, research is one output that should be included in any analysis of this sector. The application of DEA to the New Zealand polytechnic sector by Abbot and Doucouliagos (2000) did not include research outputs. The time frame of the study (1995/1996) was at a stage when research outputs were in their infancy at most polytechnics. The availability of data to measure the research outputs is also a major issue, although increasingly the polytechnics are producing detailed annual research reports of their research outputs.

Having specified the model for the DEA, it is important to then apply sensitivity analysis to the results. As Johnes and Johnes (1993) point out, the relative efficiency score achieved by a DMU can be sensitive to the number of inputs and output variables that are specified. Their approach was to trial a number of different orientations of the DEA models, along with a number of different variations of input and output measures.

Another method of applying sensitivity analysis is by altering the number of DMUs used to see if this alters the stability of the analysis. One of the problems of DEA analysis is that if there are few DMUs in the study, a majority of them may well appear as efficient. As a rule of thumb, Avkiran (2001) suggests a minimum ratio of three DMUs to the sum of inputs and outputs is preferred.

---

[41] Avkiran (2001) used the percentage of the Research Quantum earned by the universities as the measure of research output, while Abbott and Doucouliagos (2003) used the actual allocation.

Having produced estimates of technical efficiency for the DMUs, it is important that they are analysed within the right context. Sarrico and Dyson (2000) investigated the use of DEA at Warwick University to help in management practice. They assert that not only must the analysis focus narrowly upon the empirical results of the DEA analysis, but there must be attention paid to the individual missions of the DMUs before a final judgement is made.

This is also important in the New Zealand context, given that the Government places a high weighting on the role of TEIs and how they serve their local community (Maharey 2000). The link between efficiency and the mission statements of TEIs is explored in later sections.

The application of statistical inference to technical efficiency estimates is rare in DEA studies of tertiary education. Johnes (2006) uses Simar and Wilson's (2000) bootstrapping approach to generate 95 percent confidence intervals for technical efficiency estimates of United Kingdom universities.

Few studies use second-stage methods to analyse the factors that influence differences in performance. Coelli *et al*. (2004) uses Tobit regression to analyse differences in efficiency in technical efficiency estimates. The list of independent variables included in the analysis is extensive. For example, the average graduate starting salary and the percentage of part-time students were among the suite of independent variables used in their second-stage analysis of Australian university performance.

3.3.2 Findings

As this study analyses the technical efficiency of tertiary institutions in Australia and New Zealand, the following section examines the findings from studies that have applied DEA to Australasian institutions. Firstly, the findings of the application of DEA to Australian universities are examined.

A consistent result across the Australian studies is that universities operate at a respectable level of technical efficiency and scale efficiency. Avkiran (2001) found a mean pure technical efficiency of 0.96 in his study of Australian universities using

1995 data. This study suggested that the greatest improvement in university performance would come in raising outputs such as fee-paying foreign enrolments and that managers should focus on reducing technical inefficiency before restructuring in terms of scale.[42]

Abbott and Doucouliagos (2003) also used 1995 data for Australian universities to generate efficiency estimates. They reported a mean of 0.93 for pure technical efficiency and 0.94 for scale efficiency. Despite these relatively high figures, the authors suggested there was still room for improvement. Although there may be high technical efficiency, they argue there is the possibility that the production frontier may be relatively static. They also stress the importance of comparing Australian performance with other countries, especially given that Australian universities compete for foreign students and have been establishing campuses in overseas locations.

In their study of the efficiency of Australian universities in 2000, Coelli *et al*. (2004) estimated a mean value of 0.94 for pure technical efficiency and 0.92 for scale efficiency. This study also employed Tobit regression in a second-stage analysis to identify the factors associated with higher technical efficiency. The study found that location and the proportion of students from rural and remote regions were associated with variation in technical efficiency.

Two Australian studies have used DEA to generate estimates of Malmquist indices. Coelli *et al*. (2004) examined productivity change in Australian universities over the period 1996 to 2000. They found that the mean total factor productivity growth per year was 1.8 percent. This was comprised of 2.1 percent mean growth in technology, 0.4 percent in pure technical efficiency and a fall of 0.7 percent in scale efficiency.

Worthington and Lee (2005) also applied DEA to panel data for Australian universities for the period 1998 to 2002. They found total factor productivity growth on average of 3.3 percent per year in Australian universities. This comprised of 3.3 percent growth in technology, a 0.1 percent fall in pure technical efficiency and a 0.1

[42] The focus of Avkiran's study was on establishing a robust approach for the application of DEA, rather than on the actual discussion of the results of the empirical study.

percent increase in scale efficiency. The study found that total factor productivity growth was sourced mainly from technology improvements, with little in the way of efficiency improvement. This improvement in technology was attributed to factors such as electronic library provision of services and online and multi-campus delivery. They also found that productivity improvements were larger in smaller, newer universities.

A number of New Zealand studies have used DEA to measure TEI efficiency and also how their productivity has changed over time. Abbott and Doucouliagos (2000) were the first to apply DEA to New Zealand TEIs. They measured the technical and scale efficiency of polytechnics for the years 1995 and 1996. They found a mean pure technical efficiency of 0.895 and mean scale efficiency of 0.934 in 1996. Abbott and Doucouliagos (2000) suggest that the technical efficiency of New Zealand polytechnics can be improved. This was especially evident when the performance of the New Zealand polytechnics was compared to similar types of tertiary institutions in the state of Victoria, Australia.

The issue of the size of the polytechnics was also subjected to analysis. The findings were that many polytechnics were too small to capture the economies associated with larger size. The authors' suggestion was that instead of merging institutions the number of polytechnics should be frozen and the number of EFTS at the institutions should be allowed to increase. The practicality of this suggestion is open to question. In a number of regional areas the number of students has been static and in some cases declining. This, added to the increased competition from private providers, means the ability to increase student enrolments is limited.

Yahanpath and Wang (2003) undertook an analysis of the use of DEA as a performance indicator in the tertiary education sector. They found that the polytechnic subsector was more efficient than the university subsector. However, the use of a two-dimensional analysis and the lack of a research output measure, means that any comparison of the efficiency of the sectors must be treated with extreme caution.

Abbott and Doucouliagos (2004) performed a Malmquist analysis on New Zealand polytechnics for the period 1995 to 2002 using a translog education production function approach. The authors found that there was cumulative total factor productivity growth of around 30 percent over the period, mostly driven by technology growth of around 5 percent per annum, which was slightly offset by a decline in technical efficiency.

This review of the literature has shown that there have been several studies that have examined the technical efficiency of tertiary institutions in Australasia using DEA. However, these studies are now somewhat dated, given the most recent study examined productivity up to 2002. All but one of the studies focus on institutions within a country, rather than seeking to benchmark against institutions in other countries. In addition, there is a lack of tests of statistical significance of the technical efficiency and Malmquist index estimates.

What is also evident is a lack of second-stage analysis of the technical efficiency and Malmquist estimates. As a consequence, the reported findings tend to be more descriptive in nature, rather than seeking to provide explanations for diversity in performance.

This study aims to fill these gaps in the literature by estimating the technical efficiency of New Zealand TEIs over recent time periods. This study also makes use of the statistical inference methods outlined in sections 3.2.4 and 3.2.7 to test the robustness of the technical efficiency and Malmquist estimates.

In addition, the technical efficiency of a TEI is compared with its financial performance, an approach which is absent from most of the studies in the literature. This is an important step, given that the government intervenes in the governance of TEIs in New Zealand with histories of poor financial performance, and several such TEIs have been disestablished or pressed into mergers with other TEIs.

Finally, significant attention is paid to the factors that influence the technical efficiency and productivity growth of New Zealand TEIs. This involves extensive second-stage analysis, combined with commentary on the key events influencing performance in the TEIs. By doing so, the findings in this study should be of more use to interested parties, such as policy makers, as they attempt to gain greater understanding of the determinants of productive efficiency in a complex sector.

3.4 Measuring the productive efficiency of New Zealand polytechnics

3.4.1 Introduction

In this section, Data Envelopment Analysis (DEA) is applied to data for New Zealand polytechnics between 1996 and 2006. This analysis spans a period of significant upheaval in the polytechnic sector, with several institutions experiencing financial difficulty during this time. As a result of these difficulties, the polytechnic sector has undergone significant structural change. Some polytechnics have changed their status to a university or have been disestablished and absorbed by other tertiary education institutions (TEIs).[43] This has seen the number of polytechnics reduced from a total of 25 in 1999, to the current level of 20.

A key factor influencing the operating environment of the polytechnics was the move to an uncapped tertiary funding system by the government in 1999. As a result, there was an associated surge in enrolments at some polytechnics. The increase in enrolments occurred mainly in community education courses with no formal assessment or in short courses such as First Aid programmes. This led to some controversy over the management practices at some polytechnics.

Previous studies of New Zealand polytechnics using DEA[44] examined the efficiency of polytechnics in periods before the significant expansion in enrolments that occurred, starting in 2003. By encompassing this period, the study aims to quantify how these events impacted on efficiency in the polytechnic sector. In addition, second-stage analysis is used to analyse the factors that are associated with differences in productive efficiency.

The structure of this section is as follows. First, background information on the history and nature of polytechnics in New Zealand is presented. Then, the data used to generate the technical efficiency estimates is presented in section 3.4.3. The results

[43] AUT has become a university, Wellington Polytechnic merged with Massey University, the Central Institute of Technology was absorbed by Hutt Valley Polytechnic (now WELTEC), Waiarapa Polytechnic and Wanganui Community Polytechnic have been absorbed by UCOL.

[44] Such as Abbott and Doucouliagos (2000) and Abbott (2006).

of the DEA analysis are then presented in section 3.4.4. These results include estimates of technical efficiency for polytechnics in 2006 and Malmquist indices for the period 1996 to 2006. The results also include the findings of second-stage analyses to identify the factors associated with variation in the productive efficiency of polytechnics. Finally, in section 3.4.5 some conclusions are made.

3.4.2 Background

There are currently 20 polytechnics in New Zealand, compared with eight universities and three wānanga. Polytechnics are the main providers of tertiary education in the vocational area, with the majority of teaching taking place below degree level. However, in a number of the larger urban polytechnics, such as Unitec New Zealand and Otago Polytechnic, there are significant numbers of students enrolled at the bachelors level or higher.

Most polytechnics can trace their origins back to senior technical divisions attached to secondary schools. In the 1960s, polytechnics (or technical institutes as they were then known) began to offer vocational courses as autonomous institutions. These were mostly in the main urban centres. In the 1970s, more polytechnics were established in regional centres (these were known as community colleges), with the last polytechnic established in the Waiarapa in 1988. As such, they have the broadest regional coverage of the public TEIs.[45]

Polytechnics were operated centrally through the Education Department till the early 1990s, when the passing of the Education Act 1989 granted public TEIs more autonomy in how they operated. Under this new set up, polytechnics were managed by a chief executive, with governance provided by a council.

Some polytechnics are quite specialised in nature. For example, the Open Polytechnic is an extramural provider of vocational education while Telford Rural Polytechnic specialises in providing agricultural and horticultural programmes. Therefore, there are significant differences in the characteristics of the institutions that make up the polytechnic sector.

[45] As will be seen in later sections, the remote regional locations of some polytechnics would appear to be a contributing factor to their levels of efficiency.

The operations of polytechnics have been heavily influenced by the system of funding domestic students. In 1991, the government introduced the equivalent full-time student (EFTS) funding system for all TEIs. The EFTS system distributed funding to TEIs based on the number of EFTS in various funding categories enrolled during the calendar year. Students who were enrolled in more expensive courses attracted higher levels of funding.

Between 1991 and 1998, the government applied a rolling cap to funded enrolments at polytechnics.[46] This meant that while the number of funded enrolments increased modestly each year, the funding per student was cut to keep the total spend on tertiary education within set limits. Nevertheless, it did provide an element of certainty in enrolments that could be expected to make management of the polytechnics more straightforward.

In 1999, the government removed the rolling enrolment cap in a move to a more demand-driven funding system. As a result, TEIs were funded for all domestic students they enrolled. Initially, the effect on total enrolments was modest, but from 2002 enrolments in lower-level courses and community education courses increased significantly, especially in some polytechnics. The attraction of community education enrolments for polytechnics was their lack of formal assessment with its associated lower cost of delivery, which for polytechnics under financial stress would be hard to resist.

In 2004, following the blow-out in such enrolments, the government reintroduced caps on growth in lower-level courses and restricted the funding available for community education courses. This had a massive effect on enrolments in some polytechnics. For example, total enrolments at Tairawhiti Polytechnic fell by around 75 percent in 2004, mostly as a result of the capping of community education courses.[47]

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[46] TEIs could enrol more students than they were funded for, but received no extra government funding. However, these over-enrolments could be taken into account in future years when setting the cap. So there was some incentive to slightly overshoot the funded EFTS.

[47] Although outside the scope of this study, the government moved to reintroduce a capped tertiary funding system in 2008. Once again, polytechnics are funded for a set number of enrolments in each year.

It is the impact of these changes in the funding system and the response of the polytechnics that this study examines. Given the poor financial position of several polytechnics, the analysis of their productive efficiency can help to identify potential areas (if any) where polytechnics may be able to improve their efficiency and hence their financial viability.

3.4.3 Data

Because of the need to establish a stable dataset over time for the Malmquist analysis, the number of potential variables available for the DEA is somewhat restricted. The suite of potential variables to choose from is listed in Table 3.1.

The potential input variables to use in the DEA include the number of academic staff (ACADEMIC) and general staff (GENERAL) in full-time equivalents.[48] Non-labour expenditure (OTHEREXP) is also available to be used as an input measure, as is the value of fixed assets (ASSETS).

Table 3.1, Definitions of input and output variables for the DEA of New Zealand polytechnics 2006

Variables	Definition
Inputs:	
ACADEMIC	Total number of full-time equivalent academic staff.
GENERAL	Total number of full-time equivalent general staff.
OTHEREXP	Total operating expenditure on non-labour items ($000s).
ASSETS	Total fixed assets ($000s).
Outputs:	
STUDENTS	Total number of equivalent full-time students.
RESEARCH	Total number of reported research outputs (includes, books, book chapters, journal papers, conference papers/presentations and exhibitions.)

Source, Ministry of Education, Tertiary Education Commission and annual reports of polytechnics

The output variables available include measures that attempt to capture the teaching and research output of polytechnics. The teaching output variable used in this study is the number of equivalent full-time students enrolled at a polytechnic. Although most DEA studies in the tertiary education area use qualification completions to

[48] Some DEA studies use personnel expenditure to measure labour inputs, as there is an expectation that higher wages are associated with higher quality of staff. Full-time equivalents are used in this study for two reasons. First, there is not a complete time series of personnel expenditure available for all polytechnics over the period of interest in this study. Second, there is no suitable wage cost deflator available that can be used to convert nominal wage expenditure into real expenditure for the Malmquist analysis.

capture the teaching output of tertiary institutions, previous DEA studies of New Zealand polytechnics have used the number of equivalent full-time students (EFTS) as a measure of teaching output. A lack of consistent data on qualification completions is one of the reasons for this approach. Another is that a significant proportion of enrolments in polytechnics are not in formal qualifications. These include enrolments in Training Opportunities Programmes and community education courses. Therefore, the use of qualification completions would not capture the full teaching effort at the polytechnics.

The variable used to capture the research output of polytechnics (RESEARCH) is the number of reported research outputs. Previous DEA studies of New Zealand polytechnics have not included variables to capture research output. Generally, this is because of the lack of comparable data by polytechnics in this area, along with an acknowledgement that research in polytechnics is of a much smaller scale than in the universities (Abbott and Doucouliagos 2000).[49] The reporting of research output by polytechnics has since improved and now reached a stage where it is possible to generate data that can be used in this analysis.

As is the case of a number of DEA studies of tertiary education, the issue of the quality of output has to be set aside.[50] A number of studies in other countries that use qualification completions as a measure of teaching output, use information on the class of honours to inform the quality of the degree. Given the use of enrolments in this study to measure teaching output, there is no comparable way that judgements can be made on the quality of the teaching being undertaken by different polytechnics. However, the issue of the quality of teaching output and its impact on productive efficiency is discussed in more depth in section 3.4.4.3.

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[49] Although data on research outputs is available for an analysis of the technical efficiency of polytechnics in 2006, a lack of comparable data in prior years means that the RESEARCH variable is not available for the Malmquist analysis.
[50] For example, Abbott and Doucouliagos (2000).

3.4.4 Results

This section presents the results of the application of DEA to New Zealand polytechnics. First, technical efficiency estimates for 2006 are presented in section 3.4.4.1. This is followed by a presentation of the results of a Malmquist indices analysis over the period 1996 to 2006 in section 3.4.4.2.

3.4.4.1 Technical efficiency

The summary statistics of the potential input and output variables for the analysis of the technical efficiency of New Zealand polytechnics in 2006 are presented in Table 3.2 below. The wide variety in the polytechnics is apparent in Table 3.2. For example, the largest polytechnic, Unitec, has over 9,800 EFTS, compared with less than 1,600 for the smallest polytechnic, the Western Institute of Technology in Taranaki (WITT).

Table 3.2, Descriptive statistics for the input and output variables in the DEA of New Zealand polytechnics 2006

Variables	Mean	Standard deviation	Min	Max
Inputs:				
ACADEMIC (FTEs)	218	141	55	635
GENERAL (FTEs)	193	128	11	497
OTHEREXP ($000s)	18,555	9,184	7,586	42,119
ASSETS ($000s)	50,797	39,825	2,639	150,094
Outputs:				
STUDENTS (EFTS)	4,154	2,162	1,584	9,809
RESEARCH (total outputs)	125	165	0	741

Given the small number of polytechnics, relative to the number of input and output variables, it is important to arrive at a model which is a parsimonious as possible, without jeopardising the robustness of the technical efficiency estimates. Otherwise, there is a danger a small number of observations to inputs and outputs could result in many polytechnics appearing on the production frontier, hence obtaining a technical efficiency value of 1.

To obtain a parsimonious model and also test the robustness of the technical efficiency estimates, this study uses the approach suggested in Johnes (2006) and outlined in section 3.2.3 to help select the preferred model specification. First, DEA was applied to a saturated model including all input and output variables to obtain technical efficiency estimates. Then, one input or output variable was removed from the model at a time and technical efficiency estimates obtained. Then, the Pastor *et al*. (2002) test and Spearman's correlation test are applied to test for a statistically significant difference in the two sets of technical efficiency estimates. The results of these tests are presented in Table 3.3 and Table 3.4 below. An '×' symbol indicates if the variable was included in the model.[51]

Table 3.3, Testing alternative specifications of the DEA model applied to New Zealand polytechnics, assuming constant returns to scale

Variable	Model				
	1	2	3	4	5
ACADEMIC		×	×	×	×
GENERAL	×		×	×	×
OTHEREXP	×	×		×	×
ASSETS	×	×	×		×
STUDENTS	×	×	×	×	×
RESEARCH	×	×	×	×	
Pastor *et al*. (2002) *p*-value	0.60	0.82	0.00	0.96	0.60
Spearman's *r*	0.89	0.84	0.43	1.00	0.81

Table 3.4, Testing alternative specifications of the DEA model applied to New Zealand polytechnics, assuming variable returns to scale

Variable	Model				
	1	2	3	4	5
ACADEMIC		×	×	×	×
GENERAL	×		×	×	×
OTHEREXP	×	×		×	×
ASSETS	×	×	×		×
STUDENTS	×	×	×	×	×
RESEARCH	×	×	×	×	
Pastor *et al*. (2002) *p*-value	0.60	0.82	0.00	0.96	0.82
Spearman's *r*	0.85	0.89	0.33	1.00	0.92

Only in one case, model 3, did the Pastor *et al*. (2002) *p*-value of 0.00 indicate that removal of the OTHEXP variable resulted in a statistically significant change to the technical efficiency estimates.[52] However, examination of the Spearman's *r* statistic shows that only in the case of the removal of ASSETS from the model was there a negligible impact on the ranking of the polytechnics. As a result of these two tests, the preferred model for the analysis excludes ASSETS but retains the remaining three inputs and two outputs.

[51] Note that STUDENTS is always included in the various model specifications. An attempt to omit this variable resulted in a failure of the software to generate the technical efficiency estimates. This reinforces the importance of including this output variable in the model.

[52] A *p*-value of less than 0.15 indicates there is a statistically significant change in the technical efficiency estimates as a result of removing the input/output variable.

Under this model specification, technical efficiency refers to polytechnics maximising the number of students enrolled in their institution and the volume of their research output, given their mix of inputs.

The results of the application of DEA analysis to polytechnics using the preferred model are presented in Table 3.5. Table 3.5 contains the technical efficiency estimates under a constant returns to scale (CRS) assumption, as well as pure technical efficiency estimates under a variable returns to scale assumption (VRS). Scale efficiency estimates are also provided, along with an indication if they were exhibiting increasing returns to scale (IRS) or decreasing returns to scale (DRS). In addition, 95 percent confidence intervals for the estimates of pure technical efficiency are reported. Figure 3.2 illustrates the pure technical efficiency and scale efficiency estimates for each polytechnic.

Table 3.5, Results of DEA of New Zealand polytechnics 2006

Polytechnic	Technical efficiency		Scale efficiency	Returns to scale	Pure technical efficiency 95 % confidence intervals	
	CRS	VRS			Lower	Upper
Aoraki	0.930	1.000	0.930	IRS	0.929	1.092
BOP	0.942	0.954	0.987	IRS	0.902	0.994
CPIT	0.848	0.950	0.893	DRS	0.924	0.978
EIT	1.000	1.000	1.000	-	0.911	1.094
MIT	0.828	0.955	0.866	DRS	0.925	0.985
NMIT	1.000	1.000	1.000	-	0.953	1.068
Northland	0.866	0.902	0.960	DRS	0.868	0.938
Otago	0.836	0.844	0.991	IRS	0.804	0.885
SIT	0.969	1.000	0.969	DRS	0.931	1.083
Tai Poutini	0.983	1.000	0.983	DRS	0.945	1.074
Tairawhiti	0.705	0.777	0.908	IRS	0.746	0.808
Telford	1.000	1.000	1.000	-	0.913	1.092
TOPNZ	1.000	1.000	1.000	-	0.914	1.097
Unitec	1.000	1.000	1.000	-	0.917	1.094
UCOL	0.723	0.758	0.954	DRS	0.731	0.788
Waiariki	0.937	1.000	0.937	IRS	0.920	1.094
WINTEC	0.891	0.915	0.973	DRS	0.869	0.961
WELTEC	1.000	1.000	1.000	-	0.966	1.047
WITT	0.652	0.761	0.857	IRS	0.731	0.785
Whitireia	0.782	0.872	0.897	DRS	0.835	0.911
Mean	*0.895*	*0.934*	*0.955*		*0.882*	*0.993*

In 2006, the mean pure technical efficiency for New Zealand polytechnics was 0.934. In other words, output could be increased by 6.6 percent with the existing set of inputs.[53] Ten out of 20 polytechnics achieved a pure technical efficiency value of 1, indicating they were on the best practice frontier.[54] Although this implies a relatively high level of pure technical efficiency among the polytechnics, there were a number of polytechnics with significantly lower levels of pure technical efficiency. The lowest pure technical efficiency was exhibited by UCOL (0.758), followed by WITT (0.761) and Tairawhiti (0.777).

From the comparison between CRS and VRS frontiers we can obtain estimates of scale efficiency. The results in Table 3.5 show that the mean scale efficiency for polytechnics in 2006 was 0.955. This indicates that output could be increased by 4.5 percent if polytechnics improved their scale of operations. Those polytechnics which exhibited the largest amounts of scale inefficiency included WITT (0.857, IRS), MIT (0.866, DRS) and CPIT (0.893, DRS).

Seven polytechnics exhibited DRS while six exhibited IRS. Large, urban polytechnics such as WINTEC, MIT and CPIT were among the polytechnics exhibiting DRS. However, even smaller regional polytechnics, such as Tai Poutini and Northland, would benefit from a reduction in scale. This suggests that the rapid expansion experienced by these smaller polytechnics has been at the expense of efficiency. Those polytechnics that would benefit from an increase in scale are with one exception (Otago Polytechnic) located in smaller regional centres.

In terms of the two existing polytechnics that merged with other polytechnics in the past, WELTEC exhibits constant returns to scale, while UCOL exhibits decreasing returns to scale. Given the low technical efficiency exhibited by UCOL, this suggests that the merger with Wanganui Polytechnic and Waiarapa Polytechnic continues to be a burden on its operation.

[53] Given that in the short term, issues of the scale of an organisation are essentially beyond the control of the management of polytechnics, the discussion of the results below concentrates on the technical efficiency estimates assuming VRS.

[54] These were: Aoraki, EIT, NMIT, SIT, Tai Poutini, Telford, TOPNZ, Unitec, Waiariki and WELTEC.

Figure 3.2, Pure technical efficiency and scale efficiency estimates of New Zealand polytechnics 2006

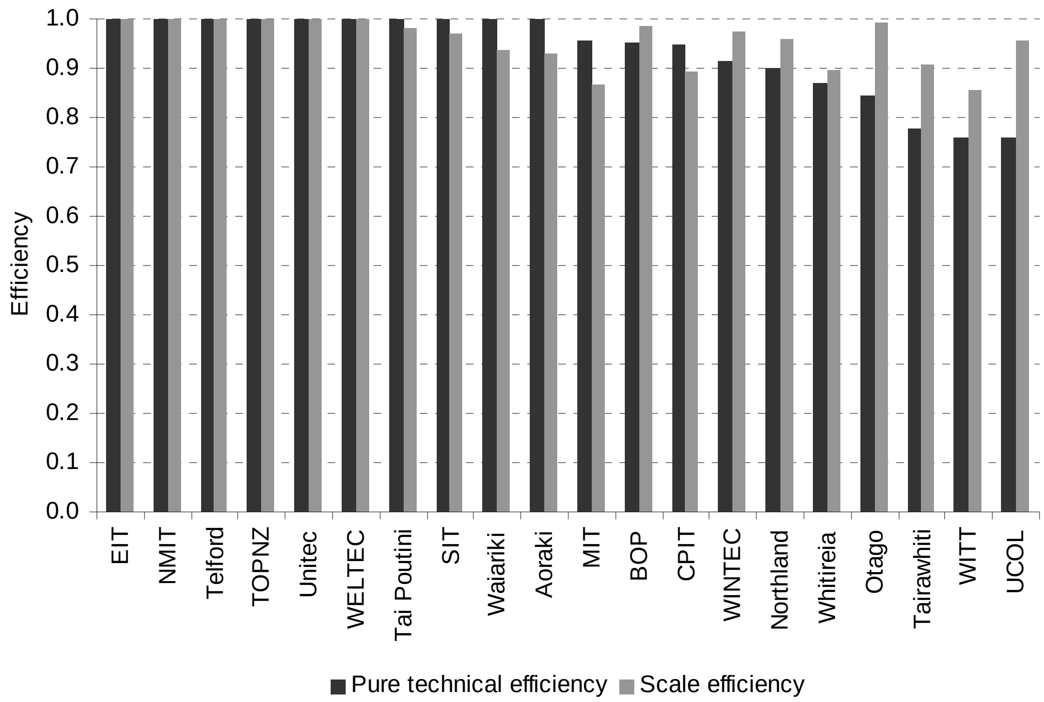
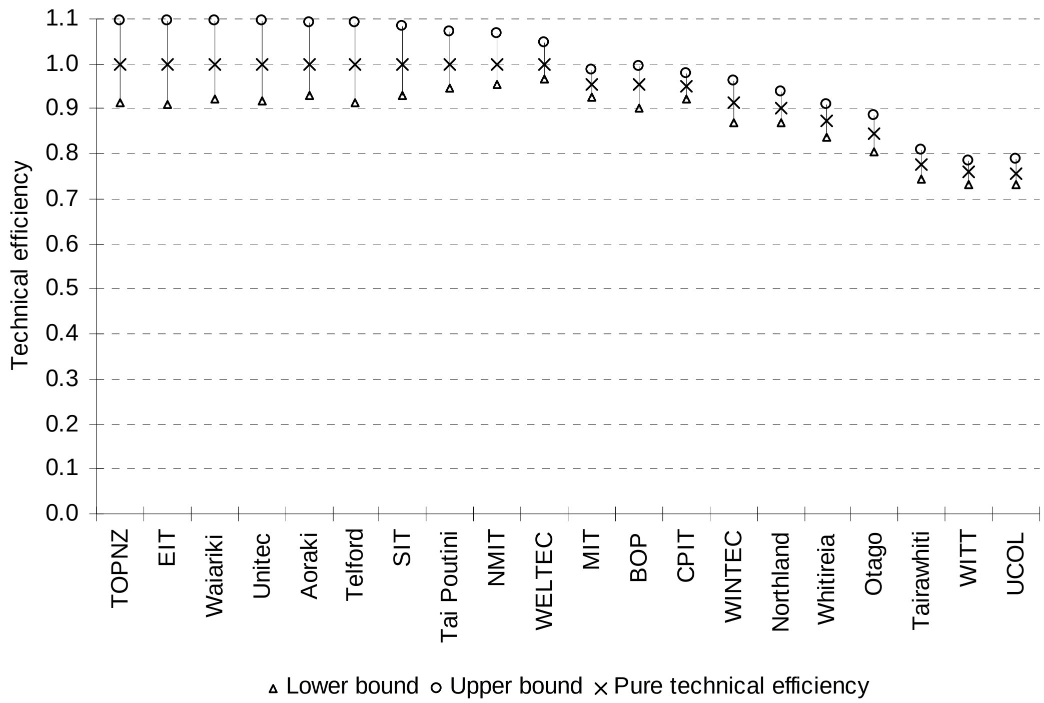


Figure 3.3 shows the pure technical efficiency estimate for each polytechnic and its associated 95 percent confidence intervals to aid in identifying if the difference in efficiency between polytechnics is statistically significant. As can be seen, the pure technical efficiency of the bottom three ranked polytechnics (Tairawhiti, WITT and UCOL) is significantly different from the other polytechnics.

The bottom ranked polytechnic, UCOL, would appear to be suffering the lingering consequences of mergers with two smaller regional polytechnics during the early 2000s. UCOL absorbed Waiarapa Polytechnic in 2001 and Wanganui Regional Polytechnic in 2002. The two latter institutions were disestablished by the government as autonomous institutions following years of poor financial performance due to inefficiency. UCOL seems to have inherited this legacy.

Figure 3.3, Estimates of pure technical efficiency of New Zealand polytechnics and their associated 95 percent confidence intervals 2006



The two other polytechnics, Tairawhiti and WITT, are both regional polytechnics based in isolated geographical areas with relatively small population catchments. They are also polytechnics that face considerable competition from other tertiary providers in their region.[55] Normally, competition is associated with enhanced efficiency. However, the reduced student numbers available to the polytechnics in their local populations as a result of the competition would appear to be a factor in their poor level of technical efficiency. Although the technical efficiency results suggest these polytechnics could produce more output with the same amount of inputs, there may not be a stock of potential students that they can tap into, given they are going to other providers.

Another potential factor inhibiting efficiency for these polytechnics is that it may be harder for these institutions to find staff from the available labour market pool to fill positions. Therefore, they may have to offer full-time positions where the most efficient solution would be to offer it as part-time positions, resulting in over staffing.

[55] Private training establishments (PTEs) in the case of WITT and Te Wānanga o Aotearoa and PTEs for Tairawhiti.

Also, as there will be a lower number of suppliers in the smaller centres, these polytechnics may have to pay higher prices for non-labour inputs.

However, not all regional polytechnics had low technical efficiency. Four were operating on their production frontier.[56] Part of the reason for the relatively large number of polytechnics lying on the DEA constructed efficiency frontier, may be related to the high number of inputs/outputs compared with the number of polytechnics. In addition, some polytechnics may be on the frontier simply because they are 'extreme' cases. These can be identified as polytechnics with a technical efficiency of 1 that are not peers of other polytechnics. Table 3.6 shows there are two polytechnics that exhibit this trait. These are Aoraki and WELTEC.

It is worthwhile examining the peer institutions of those polytechnics with low technical efficiency to see if they can mirror the operation of their more successful peers and hence improve their productive efficiency. As can be seen in Table 3.6, UCOL has four peer institutions. They include: NMIT, SIT, TOPNZ and Unitec. As TOPNZ is an extramural provider, it is unlikely that UCOL would be allowed by the government to engage in more extramural delivery. In terms of SIT, its high technical efficiency is a result of its zero fee policy boosting student numbers. It is unlikely that UCOL could engage in a similar policy, given that other providers may well match that policy and hence there would be no net gain in students.

[56] Such as Aoraki, Tai Poutini, EIT and Telford.

Table 3.6, Peer institutions of New Zealand polytechnics 2006

Polytechnic	Peer institution
Aoraki	n/a
BOP	NMIT, Waiariki
CPIT	NMIT, TOPNZ, Unitec
EIT	n/a
MIT	NMIT, TOPNZ, Unitec
NMIT	n/a
Northland	NMIT, SIT, Telford, Unitec
Otago	EIT, Telford, TOPNZ, Unitec
SIT	n/a
Tai Poutini	n/a
Tairawhiti	NMIT, Telford, Waiariki
Telford	n/a
TOPNZ	n/a
Unitec	n/a
UCOL	NMIT, SIT, TOPNZ, Unitec
Waiariki	n/a
WINTEC	SIT, Tai Poutini, TOPNZ, Unitec
WELTEC	n/a
WITT	EIT, Telford, TOPNZ
Whitireia	SIT, Telford, Unitec

Note, n/a indicates the polytechnic was on the production frontier and therefore had no peer institutions.

Unitec has a large element of bachelors degree provision and the highest research output in the polytechnic sector. Although UCOL might attempt to improve technical efficiency through increasing research output, the financial incentive to do so is limited. UCOL does not participate in the Performance-Based Research Fund and would not be rewarded with any increase in funding from better research output.

NMIT is the other peer institution for UCOL. One of the features of NMITs operations in 2006 was a large element of subcontracted provision, which could be a factor in its good performance.[57] As the government has placed limitations on this practice, it is not likely that UCOL could move into this area.

Given that the main issue for UCOL appears to be the drain created by running campuses in Wanganui and Waiarapa, there is potentially no simple solution for UCOL to improve efficiency, especially if the government is committed to the presence of a polytechnic in those regional areas.

[57] Almost 30 percent of total EFTS at NMIT were delivered via subcontracting. The issue of the impact of subcontracting on technical efficiency is examined later in this section.

WITT has three peer institutions. They are: EIT, Telford and TOPNZ. Given that TOPNZ is an extramural provider, and Telford is a specialist agricultural polytechnic, heavily reliant on subcontracting, the peer institution to focus on is EIT. Like WITT, EIT has a modest number of degree programmes and is regionally based. EIT has a much larger population catchment than WITT, with over 100,000 people living in the Hawkes Bay area. This would likely be one of the key factors in the difference in performance.

Tairawhiti also has three peer institutions: NMIT, Telford and Waiariki. As previously discussed, mirroring the operational models of NMIT and Telford are unlikely to be an option for Tairawhiti. Waiariki is a more likely candidate to look to move towards, given the nature of the programmes it offers and the regional closeness to Tairawhiti. A concerning factor, that will be discussed in more depth later, is that even though Waiariki exhibited a pure technical efficiency value of 1, it still ran an operating deficit in 2006. Therefore, the merits of trying to mirror the operational practices of Waiariki could be questioned.

The discussion of peer institutions above has touched on some of the possible reasons for differences in technical efficiency between polytechnics. To analyse the association between these factors on the technical efficiency of the polytechnics, a second-stage approach involving bootstrapped truncated regression analysis is applied to the polytechnic data. The explanatory variables included in the bootstrapped truncated regression analysis are summarised in Table 3.7.

The proportion of total EFTS subcontracted to other providers is included as an explanatory variable in the model (SUBCONTRACT). Generally, the subcontracting is to private training establishments, who can deliver the programmes at lower cost than polytechnics. It is expected that a higher proportion of subcontracted EFTS should result in greater levels of efficiency.

Table 3.7, Definitions of explanatory variables used in the truncated regression analysis of the technical efficiency of New Zealand polytechnics

Variable	Definition
SUBCONTRACT	This is the proportion of total EFTS that were subcontracted to other providers.
LEVEL	This is the proportion of total EFTS at the bachelors level or higher.
SIZE	This is the number of EFTS in thousands.
REGIONAL	This is a dummy variable that takes a value of 1 if the catchment of the polytechnic has a population of less than 50,000, else it takes a value of 0. The polytechnics where REGIONAL has a value of 1 include: Aoraki, Northland, SIT, Tairawhiti, Telford, Tai Poutini, and WITT.

Source, Ministry of Education and Statistics New Zealand.

A variable (LEVEL) is included in the model to capture the proportion of total EFTS at the polytechnic that are enrolled at the bachelors level or higher. Generally, the costs of provision rises at the higher levels as class sizes decrease and more specialised tuition is required. Therefore, one would expect a higher value for LEVEL would be associated with a fall in technical efficiency.

A variable capturing the size of the polytechnic (SIZE) in EFTS is included in the regression model. There may be economies of scale for larger polytechnics which can take advantage of larger class sizes.

Finally, a dummy variable (REGIONAL) is included in the model which identifies if a polytechnic is located in a region with a population of less than 50,000. As was discussed above, polytechnics in smaller centres may face an overstaffing issue if they cannot fill positions through part-time employment in a limited labour pool. Similarly, the costs of non-labour inputs may be higher in the smaller centres with less potential suppliers to choose from.

The descriptive statistics of the three continuous explanatory variables included in the truncated regression analysis are presented in Table 3.8.

Table 3.8, Descriptive statistics of the explanatory variables used in the truncated regression analysis of the technical efficiency of New Zealand polytechnics

Variable	Mean	Std dev	Min	Max
SUBCONTRACT	0.160	0.247	0.000	0.859
LEVEL	0.172	0.134	0.000	0.455
SIZE (000's EFTS)	4.154	2.162	1.584	9.809

The results of the truncated regression using the methodology outlined by Simar and Wilson (2007) are presented in Table 3.9. The results show that a higher proportion of subcontracted EFTS is associated with a higher level of technical efficiency. Specifically, a 1 percentage point increase in the proportion of EFTS subcontracted increased technical efficiency by 1.82 percentage points.

Table 3.9, Results of truncated regression analysis: Pure technical efficiency of New Zealand polytechnics 2006

(Dependent variable = pure technical efficiency)

Variable	Coefficient	95 % confidence intervals	
		Lower	Upper
SUBCONTRACT	0.182*	0.032	0.326
LEVEL	-0.384*	-0.663	-0.123
REGIONAL	-0.094*	-0.177	-0.013
SIZE	0.020*	0.004	0.035
CONSTANT	0.921*	0.833	1.010
SIGMA	0.601	0.345	0.724
N	20		

Notes:
1. * denotes significant at the 5 percent level.
2. The 95 percent confidence intervals were generated from 2,000 bootstrapped replications.

A higher proportion of EFTS at the bachelors or higher level is associated with lower technical efficiency. An increase in the proportion of EFTS at the bachelors or higher level of 1 percentage point is associated with a decrease in technical efficiency of 3.84 percentage points.

After controlling for other factors, regional polytechnics exhibited technical efficiency that was 9.4 percentage points lower than the non-regional polytechnics. Finally, larger polytechnics were more efficient than smaller ones. An increase in size of 1,000 EFTS was associated with an increase in technical efficiency of 2 percentage points.

In summary, a polytechnic that was large in size, not located in a region with a small population, engaged in significant subcontracting and concentrated on provision at the sub-degree level, exhibited higher levels of technical efficiency. What this means for the long term improvement in efficiency for the polytechnic sector is discussed further in the conclusion.

A key factor in the continued operation of a polytechnic is its financial performance, given that a number of polytechnics have been disestablished over time as a result of their poor financial performance. So far, the analysis has focussed solely on the productive efficiency of a polytechnic. But an important question is how does the productive efficiency of polytechnics translate into financial performance? In other words, are polytechnics rewarded financially for their productive efficiency?

Table 3.10 compares the technical efficiency of the polytechnics to their return on income in 2006, where return on income is measured as the ratio of operating surplus/deficit to operating revenue.

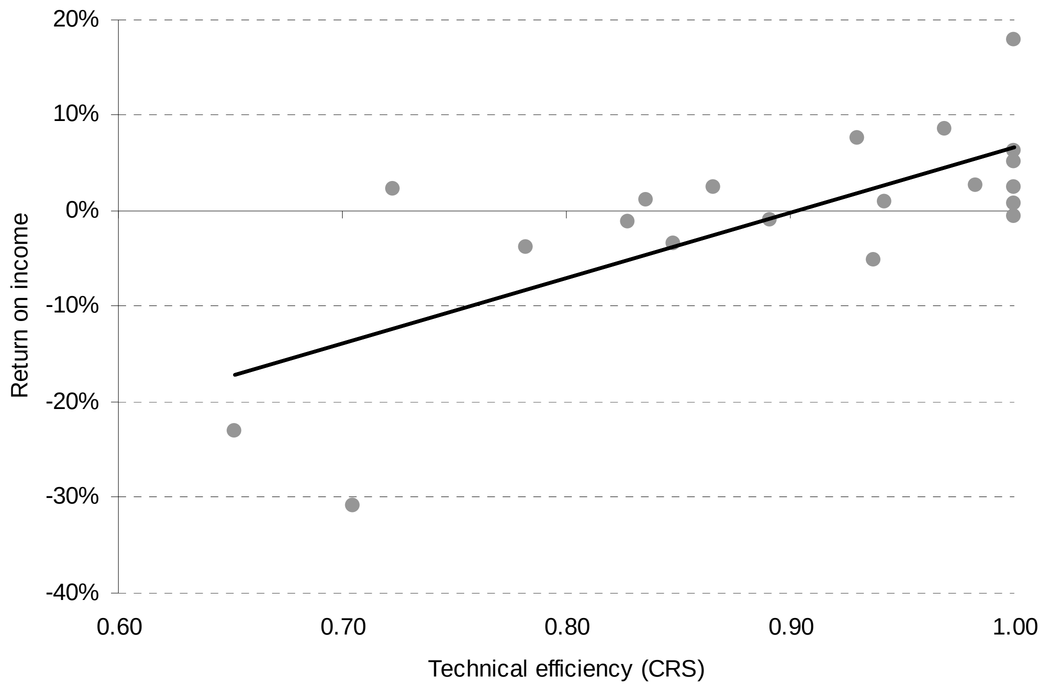
It is noticeable that two of the most inefficient polytechnics had very large negative returns on income. WITT with pure technical efficiency of 0.761 had a deficit of 23 percent, while Tairawhiti had a deficit of 31 percent and a pure technical efficiency value of 0.777.

Table 3.10, Technical efficiency vs return on income for New Zealand polytechnics 2006

Polytechnic	Technical efficiency		Return on income
	CRS	VRS	
Aoraki	0.930	1.000	7.6%
BOP	0.942	0.954	0.9%
CPIT	0.848	0.950	-3.4%
EIT	1.000	1.000	5.1%
MIT	0.828	0.955	-1.2%
NMIT	1.000	1.000	2.6%
Northland	0.866	0.902	2.5%
Otago	0.836	0.844	1.1%
SIT	0.969	1.000	8.6%
Tai Poutini	0.983	1.000	2.7%
Tairawhiti	0.705	0.777	-30.9%
Telford	1.000	1.000	18.0%
TOPNZ	1.000	1.000	6.3%
Unitec	1.000	1.000	-0.5%
UCOL	0.723	0.758	2.3%
Waiariki	0.937	1.000	-5.1%
WINTEC	0.891	0.915	-0.9%
WELTEC	1.000	1.000	0.8%
WITT	0.652	0.761	-23.0%
Whitireia	0.782	0.872	-3.7%
Mean	*0.895*	*0.934*	*0.1%*

The relationship between technical efficiency and return on income is illustrated in Figure 3.4, along with a line of best fit generated via ordinary least squares.

Figure 3.4, Technical efficiency vs return on income for New Zealand polytechnics 2006, assuming constant returns to scale



The least squares estimates are presented below with t values in parentheses:

Return on income = - 0.62 + 0.68 *Technical efficiency (CRS)*
(4.45) (4.45)

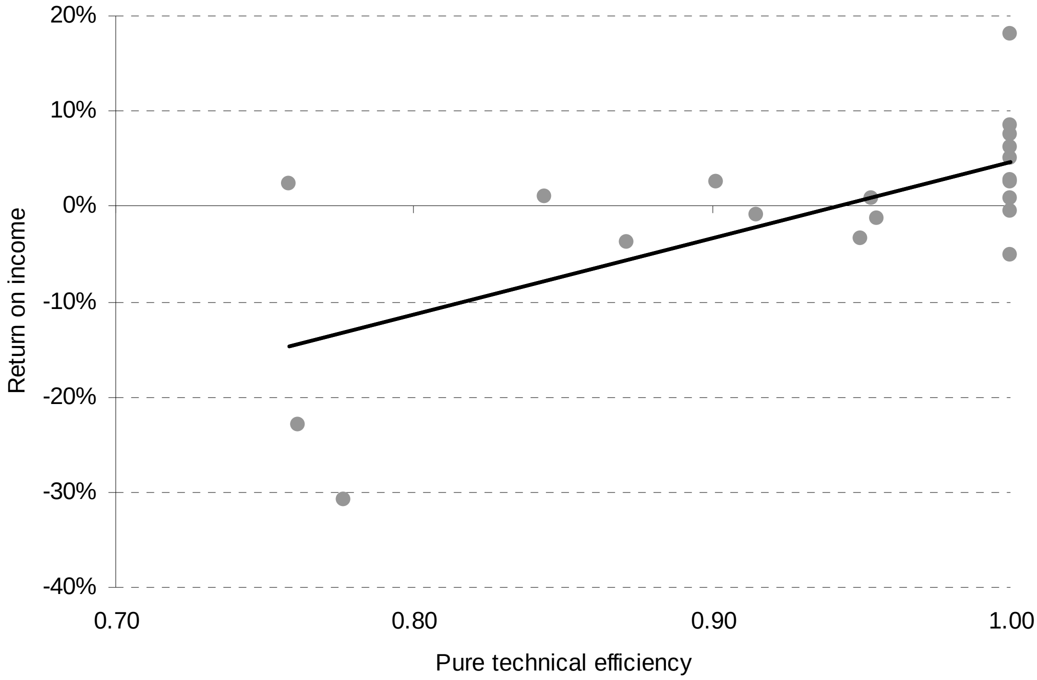
$R^2 = 0.52$

It is clear there is a positive association between return on income and technical efficiency (CRS). Specifically, the regression estimates show that on average, an increase of 1 percentage point in technical efficiency was associated with an increase of 0.68 percentage points in return on income.

If the data for the two outliers (WITT and Tairawhiti) in Figure 3.4 are omitted, then the positive association between return on income and technical efficiency (CRS) moderates slightly. An increase of 1 percentage point in technical efficiency is associated with an increase of 0.61 percentage points in return on income.

Figure 3.5 compares the pure technical efficiency of the polytechnics with their return on income in 2006.

Figure 3.5, Pure technical efficiency vs return on income for New Zealand polytechnics 2006, assuming variable returns to scale



Least squares estimates showing the association between return on income and pure technical efficiency are produced below, with t values in parentheses.

Return on income = - 0.75 + 0.80 *Pure technical efficiency*
(3.74) (3.73)

$R^2 = 0.44$

This time, the regression estimates show that in increase of 1 percentage point in pure technical efficiency is associated with an increase in return on income of 0.8 percentage points.[58] Or to break even, a polytechnic needed to achieve a pure technical efficiency value of around 0.94. This is a reasonably high level of technical efficiency required to break even and may illustrate one of the weaknesses of DEA – the technical efficiency estimates obtained are relative measures. Therefore, although

58 When the data for the two outliers are removed, a 1 percentage point increase in pure technical efficiency is associated with an increase of 0.66 percentage points in return on income.

a polytechnic may have a technical efficiency value of 1, it does not necessarily mean that it is efficient; simply that it is efficient compared to the others.

This is evident in the pure technical efficiency of Waiariki Polytechnic. Although the polytechnic achieved a pure technical efficiency value of 1,[59] it ran an operating deficit of over 5 percent of income in 2006. Similarly, Unitec, which also achieved a technical efficiency value of 1, ran a small operating deficit of 0.5 percent. Therefore, despite the apparent efficiency of these two institutions they did not run a surplus. This may suggest that they are not being funded at a high enough level, or the polytechnic system as a whole is relatively inefficient.

So far, this analysis has focussed on the efficiency of polytechnics in one year, 2006. In the next section, how the productive efficiency of polytechnics has changed over time is analysed using DEA.

3.4.4.3 Malmquist analysis

The analysis in the previous section examined the productive efficiency of polytechnics in 2006. However, this only provides a snapshot of their performance at one point in time. This section presents the results of a Malmquist analysis of New Zealand polytechnics between 1996 and 2006, which enables long term trends in productive efficiency to be examined.

The Malmquist analysis in this section uses a different model specification to that in section 3.4.4.2. Firstly, RESEARCH is excluded due to unavailability of data on research outputs for all polytechnics prior to 2006.[60] Also, to offset the impact of rising input prices, OTHEREXP is deflated using a post-school education producer price index (PPIQ.SPNN01410) calculated by Statistics New Zealand. The base year is set in 1996.

The mean values of the three inputs variables and one output variable over time are presented in Table 3.11. On average, OTHEREXP doubled between 1996 and 2006,

[59] Although there was an element of scale inefficiency at Waiariki.

[60] This model specification is similar to that used by Abbott and Doucouliagos (2007), which also used EFTS as the sole output variable in generating Malmquist indices for New Zealand polytechnics.

while ACADEMIC and GENERAL increased by much smaller amounts, 19 percent and 42 percent, respectively. On average, the number of equivalent full-time students increased by 64 percent during this time.

Table 3.11, Means of input and output variables used in the Malmquist analysis of New Zealand polytechnics 1996-2006

Variable	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	% change 96 - 06
ACADEMIC	183	186	186	190	188	204	213	223	221	222	218	19%
GENERAL	136	141	144	142	148	155	165	183	195	195	193	42%
OTHEREXP	7,548	8,076	8,538	9,342	9,880	11,028	12,277	15,251	16,527	16,136	15,606	107%
STUDENTS	2,540	2,632	2,715	2,781	2,849	3,205	3,718	4,596	4,835	4,631	4,154	64%

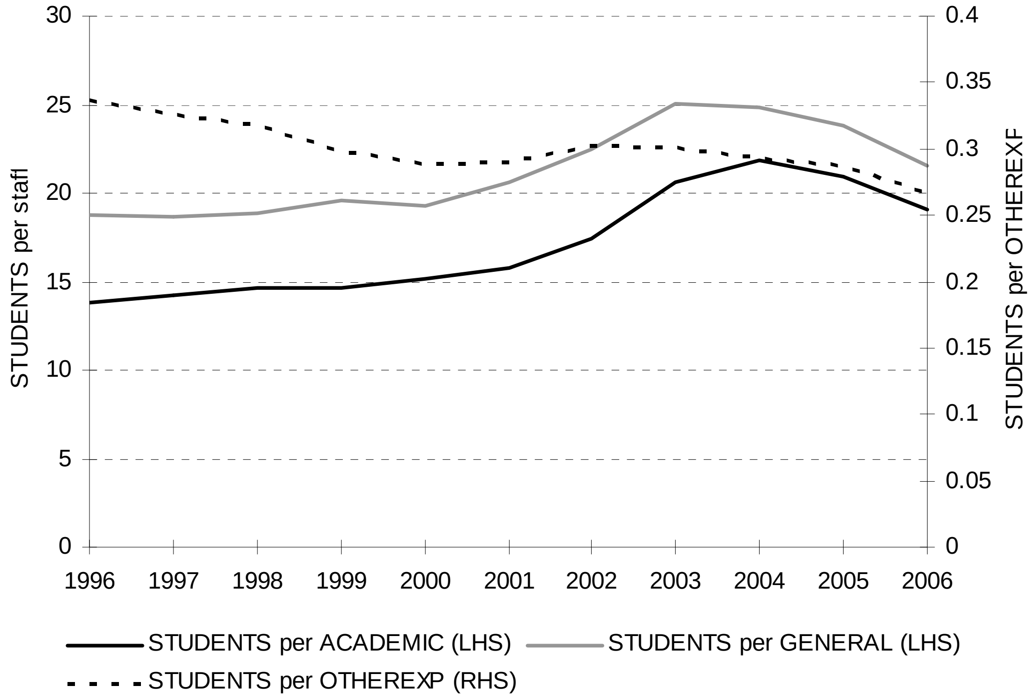
Note, ACADEMIC and GENERAL are in FTEs, OTHEREXP is in $000s and STUDENTS is in EFTS.

A clearer picture of the relationship between the input and output variables over time can be gained from examining the ratios of output to the various inputs. Figure 3.6 shows the overall ratio of STUDENTS per ACADEMIC, STUDENTS per GENERAL and STUDENTS per OTHEREXP.

The ratio of STUDENTS per ACADEMIC and STUDENTS per GENERAL display similar patterns. There was a steady increase during the 1990s, followed by faster growth in productivity of labour which peaked over the period 2003/2004. Since then, the ratio has been declining, suggesting a decrease in productivity as growth in enrolments slowed.

The ratio of STUDENTS per OTHEREXP, which captures the productivity of non-labour inputs, has shown a general trend of decline over time, apart from a slight increase in 2000/1.

Figure 3.6, Ratios of output to inputs for New Zealand polytechnics 1996-2006



The results of the Malmquist analysis of the New Zealand polytechnics are presented in Tables 3.12 to 3.16. These show the change in the five Malmquist indices from one year to the next, along with an indication if the indices are statistically significant (indicated by an *). For example, in Table 3.12, the value of 1.123 for Aoraki in 1996-1997 indicates that total factor productivity at this polytechnic increased by 12.3 percent between 1996 (the base year) and 1997 and was statistically significant at the 5 percent level. The value of 0.833 for Aoraki in 1997-1998 indicates that total factor productivity fell by 16.7 percent between 1997 (the base year) and 1998 and this change was also statistically significant.

On average in the polytechnic sector, there was total factor productivity growth of 1.9 percent per year. This was made up of 0.9 percent growth in technical efficiency and 1.0 percent growth in technology. The disaggregation of technical efficiency shows that pure technical efficiency grew by 0.8 percent on average per year, while scale efficiency grew by 0.1 percent.

Table 3.12, Total factor productivity change estimates for New Zealand polytechnics 1996-1997 to 2005-2006

Polytechnic	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	Mean
Aoraki	1.123*	0.833*	1.027	0.989	1.317*	1.280*	1.403*	1.022	0.901	0.778*	*1.049*
BOP	1.029	1.114	1.042	1.057	1.000	1.102*	1.028	0.948	0.937*	0.955	*1.019*
CPIT	1.018	1.026	0.994	0.987	1.044*	1.034	1.010	1.055	0.888*	1.020	*1.007*
EIT	1.034	1.081*	0.974	1.060*	1.103*	0.939*	1.016	0.890*	0.980	0.979	*1.004*
MIT	0.938*	0.936*	0.985	0.982	0.989	1.164*	0.955	1.014	0.914*	1.000	*0.986*
NMIT	0.979	0.968	1.066	1.126*	1.060*	1.115*	0.960	1.117*	1.305*	0.789*	*1.040*
Northland	1.170*	1.035	0.961	0.973	0.839*	1.090*	1.122*	1.028	1.069*	0.886*	*1.012*
Otago	1.027	1.056	1.065*	1.000	1.119*	0.966*	1.041	0.974	1.008	0.889*	*1.013*
SIT	1.049	1.114*	1.159*	0.944*	1.275*	1.165*	0.924	1.084*	0.876*	1.038	*1.056*
Tai Poutini	1.029	1.028	0.890*	1.034	1.151*	1.181*	1.521*	1.200	0.890	0.804*	*1.056*
Tairawhiti	0.946*	0.953	0.981	0.928*	1.190*	1.300*	1.492*	0.479*	1.025	1.012	*0.994*
Telford	0.872*	1.554*	1.402*	1.178	1.080	0.823*	2.790*	0.768	1.321*	0.981	*1.186*
TOPNZ	0.933	0.999	1.003	0.984	0.985	1.015	1.057	1.373*	0.891	0.875	*1.004*
Unitec	0.989	0.911*	0.999	0.899*	0.983	1.057	1.062	0.993	1.026	0.996	*0.990*
UCOL	1.060*	1.026	1.241*	0.953	1.197*	1.093*	0.924	0.961	0.947	0.848*	*1.018*
Waiariki	1.013	1.048	1.122*	0.832*	1.033	0.996	1.087*	0.887*	1.071*	0.901*	*0.995*
WINTEC	1.029	0.898*	0.908	1.055	1.008	1.090*	0.969	0.928	1.093*	0.841*	*0.978*
WELTEC	0.920	0.960	1.241*	0.972	0.826*	1.218*	1.062*	0.941*	0.961	0.948	*0.998*
WITT	1.097*	1.014	0.860*	0.918*	1.394*	0.968	1.017	0.849*	0.976	0.938*	*0.993*
Whitireia	1.005	1.229*	0.882*	1.010	1.145*	0.987	1.071	1.016	0.914	0.856*	*1.006*
Mean	*1.011*	*1.030*	*1.032*	*0.991*	*1.078*	*1.073*	*1.131*	*0.959*	*0.993*	*0.913*	*1.019*

Notes:
1. * significant at the 5 percent level.
2. Statistical significance derived from 2,000 bootstrapped replications.
3. All means are geometric means.
4. The indices represent change from one year to the next and the first year in each column is the base year.

Table 3.13, Technical efficiency change estimates for New Zealand polytechnics 1996-1997 to 2005-2006

Polytechnic	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	Mean
Aoraki	1.070*	0.882*	0.932	0.978	1.189*	1.045	1.000	0.991	1.009	0.930	*0.999*
BOP	1.132	1.061	0.981	1.098	0.972	1.100	1.022	1.167*	0.772*	1.220*	*1.045*
CPIT	1.052	1.040	0.926	1.046	0.982	0.985	0.920	1.317*	0.704*	1.327*	*1.015*
EIT	1.032	1.113*	0.892*	1.131*	1.045	0.885*	0.906*	1.120*	0.815*	1.231*	*1.009*
MIT	0.939	0.936	0.920	1.029	0.952	1.079	0.851	1.277*	0.775*	1.272*	*0.991*
NMIT	1.036	0.968	0.983	1.183*	0.995	1.046	0.864*	1.393*	1.030*	1.000	*1.042*
Northland	1.226*	1.064	0.878*	1.037	0.788*	0.995	0.955	1.373*	1.009	1.029	*1.024*
Otago	0.986	1.113	0.972	1.021	1.005	0.829*	0.916	1.223*	0.845*	1.092	*0.994*
SIT	1.121	1.118*	1.060*	0.990	1.173*	0.996	0.720*	1.466*	0.822*	1.178*	*1.046*
Tai Poutini	0.958	1.044	0.832*	1.019	1.030	1.050	0.903	1.208	1.000	0.983	*0.998*
Tairawhiti	0.989	0.952	0.923	0.981	1.156*	1.225*	1.000	0.649*	0.888	1.224*	*0.984*
Telford	0.960	1.496*	1.129*	1.000	1.000	0.823*	1.215*	1.000	1.000	1.000	*1.050*
TOPNZ	1.000	1.000	1.000	1.000	1.000	1.000	0.939	1.065	1.000	1.000	*1.000*
Unitec	1.044	0.931*	0.918*	0.920	0.917	0.933	0.931	1.243*	0.843*	1.232*	*0.983*
UCOL	1.092*	1.047	1.150*	0.959	1.096*	0.967	0.671*	1.245*	0.863*	1.005	*0.997*
Waiariki	1.108	1.044	1.000	0.907*	0.989	0.930*	0.985	1.106*	0.857	1.164	*1.005*
WINTEC	1.045	0.901*	0.860	1.102	0.984	1.065	0.916*	1.160*	0.963	0.993	*0.995*
WELTEC	0.965	1.053	1.143*	1.029	0.812*	1.148*	0.930	1.181*	0.826*	1.148*	*1.015*
WITT	1.176*	0.993	0.814*	0.958	1.315*	0.879*	0.896*	1.104	0.860*	1.103	*0.999*
Whitireia	1.108	1.214*	0.810*	1.058	1.076*	0.862	0.811	1.396*	0.836	0.988	*1.000*
Mean	*1.049*	*1.041*	*0.951*	*1.020*	*1.017*	*0.987*	*0.911*	*1.169*	*0.881*	*1.100*	*1.009*

Notes:
1. * significant at the 5 percent level.
2. Statistical significance derived from 2,000 bootstrapped replications.
3. All means are geometric means.
4. The indices represent change from one year to the next and the first year in each column is the base year.

Table 3.14, Technological change estimates for New Zealand polytechnics 1996-1997 to 2005-2006

Polytechnic	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	Mean
Aoraki	1.050	0.944	1.101*	1.011	1.107*	1.225*	1.403*	1.031	0.893*	0.836	*1.049*
BOP	0.909	1.050	1.062	0.963	1.029	1.002	1.006	0.812*	1.214*	0.782*	*0.976*
CPIT	0.967	0.987	1.074	0.944	1.063*	1.050*	1.098*	0.801*	1.261*	0.768*	*0.992*
EIT	1.001	0.971	1.092*	0.937	1.055	1.061*	1.122*	0.795*	1.202*	0.795*	*0.995*
MIT	0.999	1.000	1.071	0.955	1.039	1.079	1.121*	0.794*	1.179*	0.787*	*0.994*
NMIT	0.945	1.000	1.084*	0.952	1.066*	1.066*	1.111*	0.802*	1.266*	0.789*	*0.999*
Northland	0.954	0.973	1.094*	0.938	1.066*	1.096*	1.175*	0.749*	1.060	0.862*	*0.989*
Otago	1.041	0.949	1.096*	0.979	1.113*	1.165*	1.137*	0.797*	1.193*	0.814*	*1.019*
SIT	0.936	0.996	1.093*	0.954	1.088*	1.170*	1.283*	0.740*	1.065	0.881*	*1.010*
Tai Poutini	1.074	0.985	1.070*	1.015	1.118*	1.125*	1.685*	0.993	0.890	0.818	*1.058*
Tairawhiti	0.956	1.001	1.062	0.947	1.030	1.062*	1.492*	0.737*	1.155*	0.826*	*1.010*
Telford	0.908	1.038	1.242*	1.178	1.080	1.000	2.297*	0.768	1.321	0.981	*1.130*
TOPNZ	0.933	0.999	1.003	0.984	0.985	1.015	1.125	1.290*	0.891	0.875	*1.004*
Unitec	0.948	0.978	1.088*	0.978	1.072*	1.133*	1.141*	0.799*	1.218*	0.809*	*1.007*
UCOL	0.970	0.980	1.080*	0.994	1.092*	1.131*	1.377*	0.772*	1.098	0.844*	*1.022*
Waiariki	0.914*	1.004	1.122*	0.917	1.045	1.071*	1.104*	0.801*	1.250*	0.774*	*0.990*
WINTEC	0.985	0.997	1.055	0.957	1.023	1.023	1.057*	0.800*	1.136*	0.848*	*0.983*
WELTEC	0.954	0.911	1.086	0.944	1.018	1.061	1.142*	0.797*	1.163*	0.826*	*0.983*
WITT	0.933	1.021	1.057	0.958	1.060	1.100*	1.135*	0.769*	1.135*	0.850*	*0.995*
Whitireia	0.907	1.012	1.089	0.955	1.064*	1.145*	1.322*	0.728*	1.093	0.867*	*1.006*
Mean	*0.963*	*0.989*	*1.085*	*0.972*	*1.060*	*1.087*	*1.242*	*0.821*	*1.127*	*0.830*	*1.010*

Notes:
1. * significant at the 5 percent level.
2. Statistical significance derived from 2,000 bootstrapped replications.
3. All means are geometric means.
4. The indices represent change from one year to the next and the first year in each column is the base year.

Table 3.15, Pure technical efficiency change estimates for New Zealand polytechnics 1996-1997 to 2005-2006

Polytechnic	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	Mean
Aoraki	1.066	0.890*	0.949	0.977	1.167*	1.038	1.000	1.000	1.000	1.000	*1.006*
BOP	0.968	1.062	0.992	1.088	0.970	1.144*	0.982	1.160*	0.777*	1.228*	*1.030*
CPIT	0.983	1.088	1.021	1.004	1.044	0.979	1.112*	0.959	0.862	1.200*	*1.021*
EIT	1.052	1.096*	0.886*	1.158*	1.019	0.906*	0.885	1.126	0.868*	1.165*	*1.010*
MIT	0.968	0.975	0.998	0.987	1.016	1.162*	1.000	0.863*	0.971	1.137	*1.005*
NMIT	1.046	0.977	0.967	1.244*	0.947	1.062	0.852*	1.427*	1.000	1.000	*1.042*
Northland	1.144*	1.027	0.909*	1.025	0.769*	1.024	0.932	1.383*	1.156*	0.919*	*1.017*
Otago	1.030	1.110	0.992	1.106*	0.931	0.850*	0.931	1.093	0.969	1.021	*1.000*
SIT	1.104	1.095*	1.070*	1.032	1.097*	1.051	0.721*	1.387*	0.944	1.060	*1.044*
Tai Poutini	1.000	1.000	1.000	0.915	0.967	1.066	1.059	1.000	1.000	1.000	*1.000*
Tairawhiti	0.925	0.957	0.992	0.958	1.063	1.159*	1.000	0.675*	0.886*	1.299*	*0.979*
Telford	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
TOPNZ	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*1.000*
Unitec	1.006	1.000	1.000	1.000	1.000	1.000	1.000	0.909*	1.100*	1.000	*1.001*
UCOL	1.111*	1.043	1.170*	1.016	1.000	1.000	0.857*	0.947	0.996	0.927*	*1.003*
Waiariki	1.068	1.011	1.000	0.914*	0.985	0.953	0.964	1.132*	0.842	1.271*	*1.008*
WINTEC	1.043	0.930	0.977	0.999	1.022	1.038	1.088	0.925*	1.172*	0.895*	*1.006*
WELTEC	0.954	0.964	1.181*	1.000	0.797*	1.193*	0.892	1.180*	0.937	1.057	*1.007*
WITT	1.198*	0.982	0.840*	0.936	1.291*	0.885*	0.895*	1.117	0.881*	1.062	*0.999*
Whitireia	1.000	1.212*	0.803*	1.086	1.031	0.959	0.806*	1.372*	1.049	0.788*	*0.995*
Mean	*1.031*	*1.019*	*0.983*	*1.019*	*1.000*	*1.019*	*0.944*	*1.066*	*0.965*	*1.044*	1.008

Notes:
1. * significant at the 5 percent level.
2. Statistical significance derived from 2,000 bootstrapped replications.
3. All means are geometric means.
4. The indices represent change from one year to the next and the first year in each column is the base year.

Table 3.16, Scale efficiency change estimates for New Zealand polytechnics 1996-1997 to 2005-2006

Polytechnic	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	Mean
Aoraki	1.004	0.991	0.983	1.001	1.019	1.007	1.000	0.991	1.009	0.930	*0.993*
BOP	1.169	0.999	0.988	1.009	1.002	0.962	1.041	1.006	0.993	0.994	*1.015*
CPIT	1.071	0.956	0.907	1.042	0.940	1.005	0.827*	1.374*	0.817*	1.106	*0.994*
EIT	0.981	1.015	1.007	0.977	1.026	0.977	1.023	0.995	0.939	1.057	*0.999*
MIT	0.970	0.961	0.922	1.042	0.937	0.929	0.851	1.480*	0.798*	1.118	*0.987*
NMIT	0.990	0.991	1.016	0.951	1.050	0.985	1.014	0.976	1.030	1.000	*1.000*
Northland	1.072	1.036	0.966	1.012	1.025	0.972	1.024	0.992	0.872	1.119	*1.007*
Otago	0.958	1.003	0.980	0.923	1.079	0.976	0.984	1.119	0.871	1.069	*0.994*
SIT	1.015	1.020	0.991	0.959	1.069	0.947	0.999	1.057	0.872	1.111	*1.002*
Tai Poutini	0.958	1.044	0.832	1.113	1.065	0.984	0.853	1.208	1.000	0.983	*0.998*
Tairawhiti	1.069	0.995	0.931	1.024	1.087	1.056	1.000	0.961	1.002	0.943	*1.006*
Telford	0.960	1.496*	1.129	1.000	1.000	0.823	1.215	1.000	1.000	1.000	*1.050*
TOPNZ	1.000	1.000	1.000	1.000	1.000	1.000	0.939	1.065	1.000	1.000	*1.000*
Unitec	1.038	0.931	0.918	0.920	0.917	0.933	0.931	1.368*	0.766*	1.232	*0.983*
UCOL	0.983	1.004	0.983	0.943	1.096	0.967	0.784	1.314*	0.866	1.084	*0.994*
Waiariki	1.038	1.033	1.000	0.993	1.004	0.976	1.022	0.978	1.018	0.916	*0.997*
WINTEC	1.002	0.969	0.880	1.103	0.963	1.026	0.842*	1.253*	0.821*	1.109	*0.989*
WELTEC	1.012	1.093	0.967	1.029	1.019	0.962	1.043	1.001	0.882	1.086	*1.008*
WITT	0.982	1.011	0.969	1.023	1.019	0.994	1.001	0.988	0.976	1.039	*1.000*
Whitireia	1.108	1.002	1.008	0.974	1.043	0.899	1.006	1.018	0.797	1.253*	*1.004*
Mean	*1.018*	*1.023*	*0.967*	*1.001*	*1.017*	*0.968*	*0.965*	*1.097*	*0.912*	*1.054*	*1.001*

Notes:
1. * significant at the 5 percent level.
2. Statistical significance derived from 2,000 bootstrapped replications.
3. All means are geometric means.
4. The indices represent change from one year to the next and the first year in each column is the base year.

To illustrate how the productivity of polytechnics has changed and what has driven that change, the cumulative Malmquist indices for the overall polytechnic sector are presented in Figure 3.7. Total factor productivity grew steadily during the 1990s, and then accelerated between 2001 and 2003. However, since 2003, on average the total factor productivity of polytechnics has been on the decline.

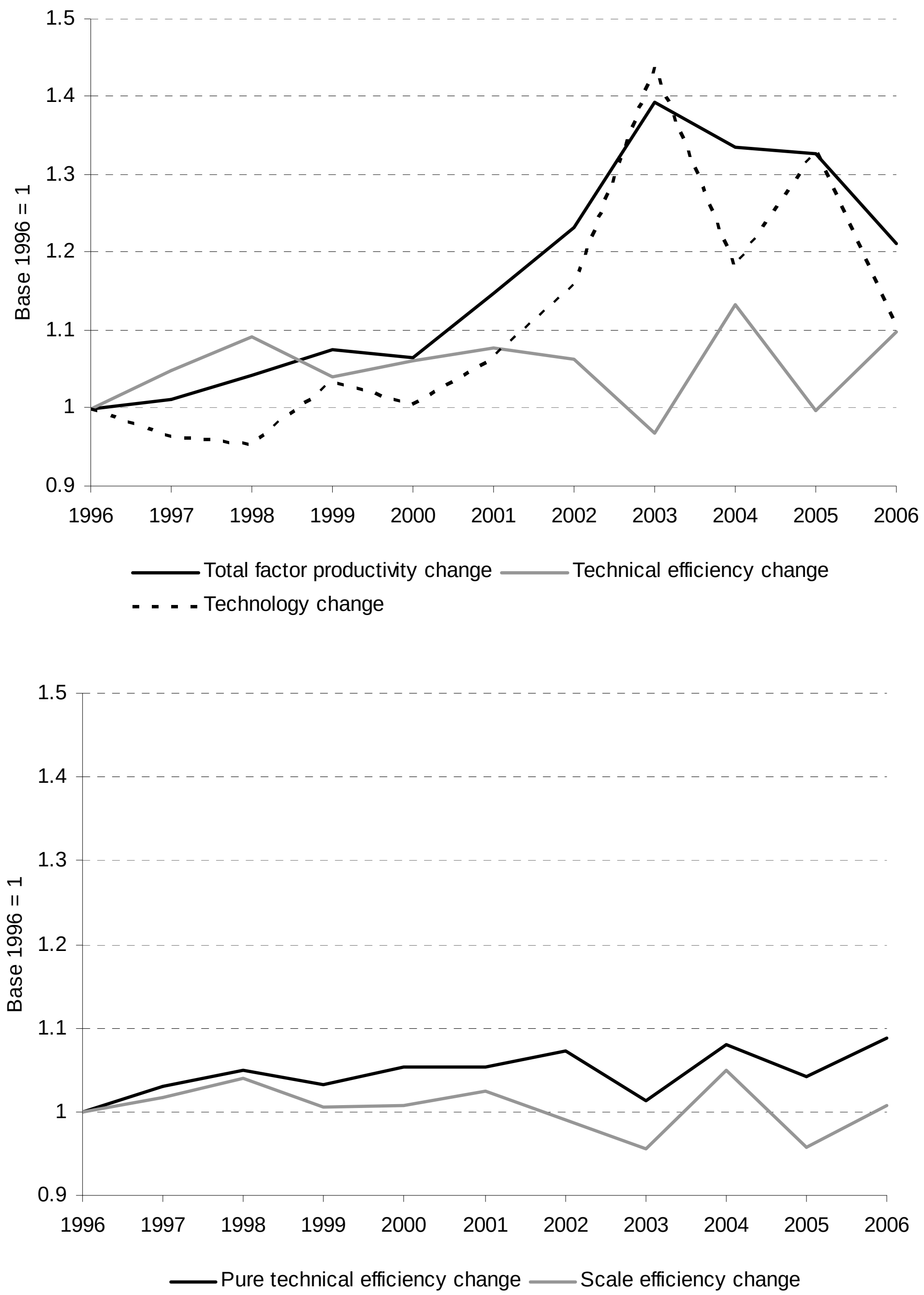
The key driver of change in productivity has been change in technology. There was a rapid increase in technology between 2001 and 2003, which was followed by a significant contraction in the production frontier in 2004. Then, technology rebounded strongly in 2005, before once again contracting in 2006.

A similar pattern of contraction and then expansion in the production frontier was observed by Flegg *et al*. (2004) in their study of United Kingdom universities. Although the authors of that study struggled to identify the causes of the contraction, the answer is more straightforward in this case. The outward shift in technology from 2001 reflects the increased delivery of community education programmes at many polytechnics. Many of these programmes are hobby courses and there is no requirement for formal assessment. Many of the programmes could be done via distance learning. In addition, the move to subcontracting delivery of some programmes to private training establishments would switch inputs from FTE academic staff to non-labour expenditure and effectively represent a change in technology.

Given there is no formal assessment in community education courses and many were delivered via a distance-learning platform, it is clear that the strong improvement in productivity at many polytechnics was driven by increased delivery of arguably lower-quality courses.

In addition, many polytechnics began to enter into subcontracting arrangements, whereby other providers (mostly private training establishments) would deliver the programmes under the auspices of the polytechnic. This means that instead of the delivery of the programmes being captured by the ACADEMIC variable, it was instead captured via OTHEREXP.[61]

Figure 3.7, Cumulative Malmquist indices for New Zealand polytechnics 1996-2006



The contraction of the frontier in 2004 followed the move by the government to restrict the number of community education programmes following a blowout in

[61] It is not possible to analyse the association between increased subcontracting of delivery and total factor productivity due to a lack of available subcontracting data prior to 2006.

tertiary education expenditure. There were further restrictions placed on the growth in sub-degree programmes and the types of programmes that could be delivered via subcontracting (such as First Aid courses). As the government restricted the types of programmes that polytechnics can deliver and especially the means of delivery, the productive frontier contracted.

When technical efficiency change is split into pure technical efficiency change and scale efficiency change, it shows that there has been little or no change in scale efficiency over the decade.

The role that government policy played in determining the trends in productivity growth merits closer attention. As can be seen in Figure 3.7, between 1996 and 1999 there was steady, albeit modest, growth of 2 percent per year in total factor productivity. This reflects the period when the government had a rolling cap on domestic enrolments at polytechnics. This had the advantage of creating certainty for the polytechnics, which should have made operational management easier. In addition, the per student funding from the government was decreasing, which would have created pressure for efficiency gains.

The relaxation of the enrolment cap in 1999 had little initial impact on total factor productivity. But from 2002, growing financial pressure on some polytechnics saw them take advantage of the new environment by increasing enrolments in community education courses. Although government funding for this type of course was relatively low, because they had a low cost of delivery they produced a relatively high profit margin. Between 1999 and 2003, total factor productivity increased by 6 percent per year on average in the polytechnics.

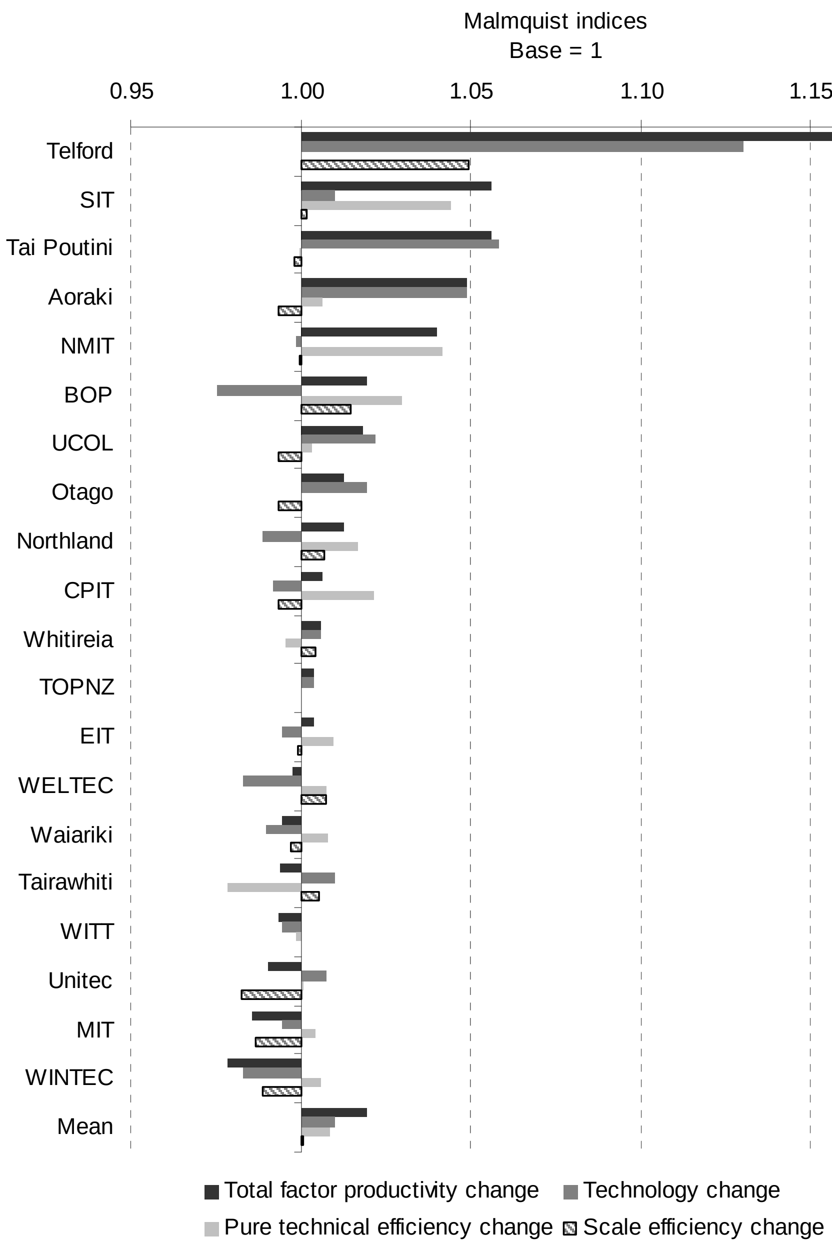
However, as the quality of these courses was questionable, the government capped funding for these enrolments from 2004.[62] In addition, the government introduced partial enrolment caps on sub-degree courses. This was the key factor in the contraction of the production frontier in 2004 and again in 2006. During this time, total factor productivity decreased by 4.6 percent per year in polytechnics on average. Therefore, the instability in the productive efficiency of polytechnics

[62] The ‘Managing Growth’ polices limited the volume of growth in sub-degree courses. Also, the government reduced the funding available for community education courses.

appears to have been due, in part, to changes in the government's funding policy in the tertiary education area.

The performance of the each of the individual polytechnics is summarised in Figure 3.8. This shows the mean change in the total factor productivity Malmquist index and its components for each polytechnic. The four components are: total factor productivity, technology change, pure technical efficiency change and scale efficiency change.

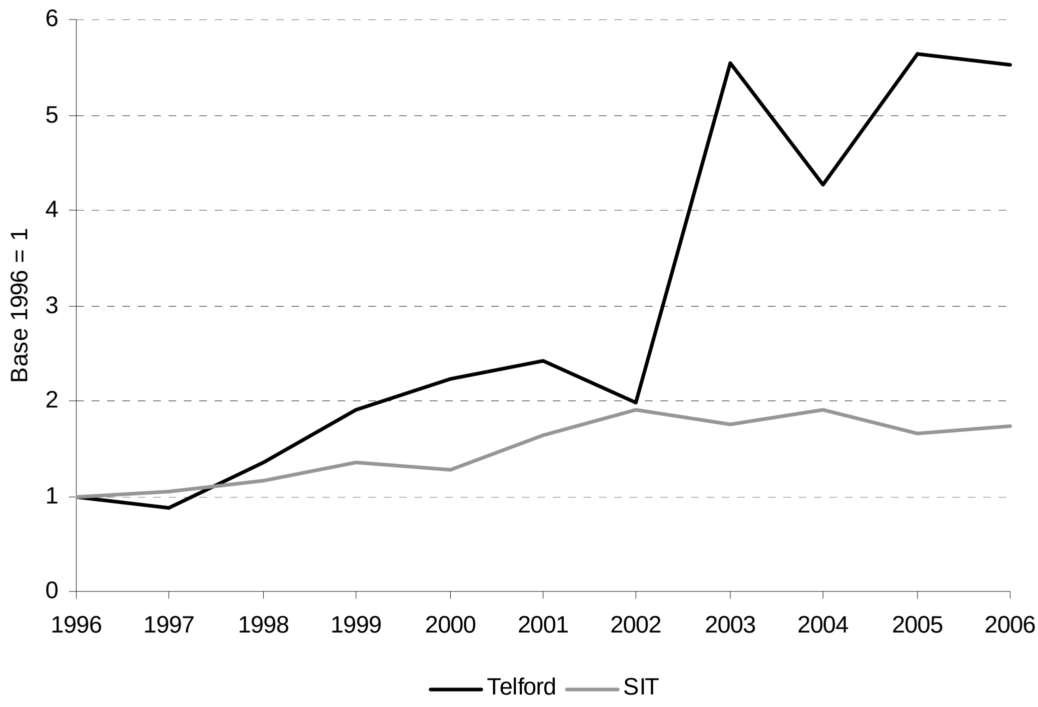
Figure 3.8, Mean Malmquist indices for New Zealand polytechnics 1996-1997 to 2005-2006



Telford achieved the largest average total factor productivity growth by some margin, with most of that increase occurring in one year (2003). Although there was some improvement in scale efficiency, the largest contribution to productivity growth at Telford came from an increase in technology. This is the result of the introduction of one large programme by Telford – Farmsafe. This programme involves teaching enrolled students about farm safety via a short course format. In addition a significant proportion of this course was also provided by other providers via subcontracting.

The experience of Telford compares with that of SIT. This polytechnic achieved the second highest rate of total factor productivity growth. However, the greatest contributor to productivity growth was a result of SIT moving closer to its production frontier, rather than through an outward shift in the frontier. The key factor in SIT's performance was a move to introduce zero fees in 2001. This had the effect of increasing enrolments and hence boosting pure technical efficiency.

Figure 3.9, Cumulative growth in total factor productivity at Telford Polytechnic and SIT



These two polytechnics were among the top performers in terms of total factor productivity growth, but what about the worst performers? The polytechnic with the lowest total factor productivity growth was WINTEC, which exhibited a fall in total factor productivity of 2.2 percent on average each year. Manukau Institute of Technology (MIT) and Unitec also exhibited falls in total factor productivity on average of 1.4 percent and 1.0 percent, respectively. The cumulative total factor productivity growth for these three polytechnics is illustrated in Figure 3.10 All of these polytechnics are relatively large in size, with significant elements of degree provision.

Figure 3.10, Cumulative growth in total factor productivity at WINTEC, MIT and Unitec

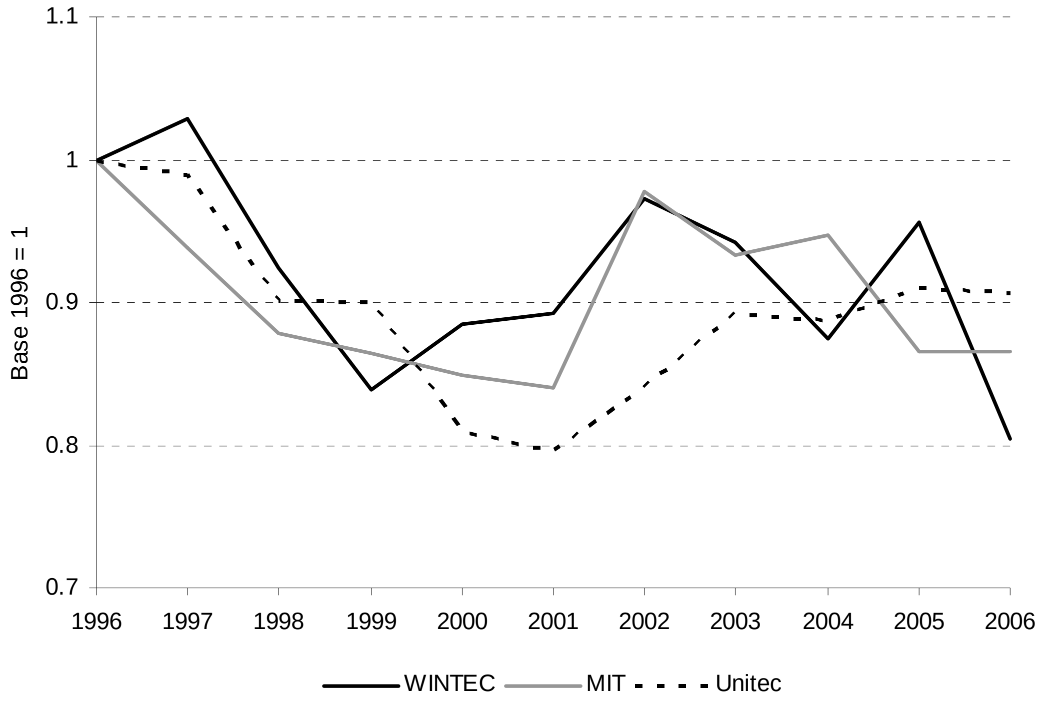
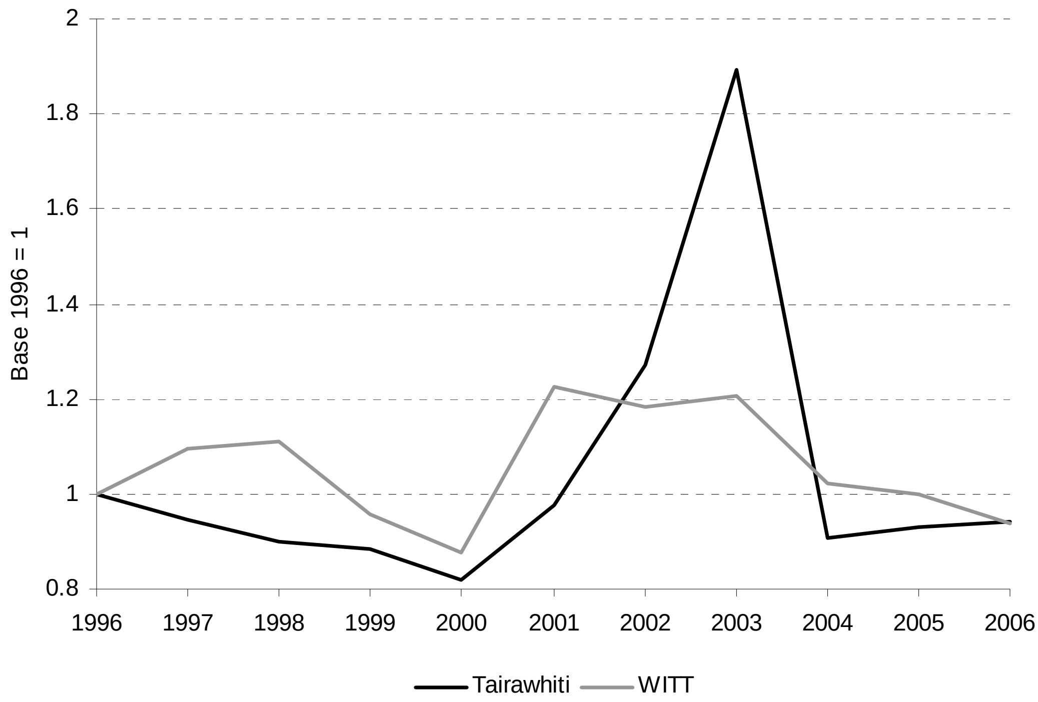


Figure 3.11 shows that average total factor productivity growth at WITT was negative (-0.7 percent) during the period, as was total factor productivity at Tairawhiti (-0.6 percent). These were two of the lowest performing polytechnics in terms of technical efficiency in 2006. Their general total factor productivity growth paths are similar, with the exception of 2003, where the massive increase in community education EFTS at Tairawhiti boosted their total factor productivity.

Figure 3.11, Cumulative growth in total factor productivity at Tairawhiti Polytechnic and WITT



Another factor that influenced the productivity growth of polytechnics is the impact of mergers. Two polytechnics, UCOL and WELTEC, have experienced mergers with other polytechnics during the period of analysis. WELTEC was merged with the Central Institute of Technology (CIT) in 2001, while UCOL absorbed Waiarapa Polytechnic in 2001 and Wanganui Polytechnic in 2002.

The cumulative change in total factor productivity at WELTEC and UCOL is illustrated in Figure 3.12. WELTEC exhibited an average decrease in total factor productivity of 0.2 percent. Although UCOL had positive average total factor productivity growth of 1.8 percent, this masks the apparent impact of these mergers on UCOL's productive efficiency.

As was discussed previously, one of the reasons for UCOL's low technical efficiency in 2006 was a result of the mergers with two regional polytechnics with a history of poor financial performance and hence efficiency. The merger with Waiarapa Polytechnic in 2001 appears to have had little detrimental effect on total factor productivity growth at UCOL. However, since UCOL absorbed Wanganui Polytechnic in 2002, total factor productivity has decreased by 8.1 percent on average each year. The fact that Wanganui was much larger than Waiarapa, and hence is a much larger drain on operations at UCOL, has meant the negative impact on productive efficiency has been greater.

The nature of the merger of WELTEC and CIT was of a different nature to the UCOL mergers. Whereas UCOL still delivers programmes using the old campuses of Wanganui and Waiarapa Polytechnics, WELTEC operates off two campuses in the Wellington area as the old CIT campus was sold. The impact of the merger is apparent in 2001, where total factor productivity fell by 17 percent. Since 2001, total factor productivity has increased by 2.1 percent on average, although total factor productivity has fallen in each of the last three years. This recent decline in total factor productivity at WELTEC has been driven by a fall in technology. Part of the reason for this could be a renewed focus on trades programmes at WELTEC. The delivery of these programmes usually involves significant investment in capital, which would tend to impact negatively on technology growth.

Figure 3.12, Cumulative growth in total factor productivity at UCOL and WELTEC

The fact that the absorption of other polytechnics has resulted in poor productive efficiency in the merged institutions and what the implications of this are is discussed further in the conclusion.

The analysis so far has assumed that all total factor productivity change was significant. However, tests of statistical inference suggest that the change in total factor productivity may have been less than indicated by the raw statistics in Table 3.11 to Table 3.15. The application of Wilson's (1999) Malmquist bootstrapping approach shows that 93 out of the 200 total factor productivity values in Table 3.11 are statistically significant at the 5 percent level. The comparable figure for the technical efficiency change estimates in Table 3.12 was 81 out of 200, for the technology change estimates in Table 3.13 it was 99 out of 200, for the pure technical efficiency change estimates in Table 3.14 it was 64 out of 200 and just 13 out of 200 for the scale efficiency change estimates in Table 3.15.

Therefore, the degree of change in the Malmquist index and its components may be overstated, especially in the case of scale efficiency. In addition, these results suggest that the significant changes in technology occurred in 1998-1999, reflecting the initial change to an uncapped enrolments system, and from 2000-2001 as polytechnics moved to increase enrolments in community education courses and increase the level of subcontracting.

There are a number of factors that may have influenced the change in total factor productivity of polytechnics over time. To analyse these factors, panel regression was applied to data for New Zealand polytechnics over the period 1996/97-2005/06.[63] The dependent variable in the regression analysis was the value of total factor productivity change at each polytechnic in each year. The explanatory variables that were included in the regression model are discussed in turn below.

The regression model includes a variable (LOSS) that captures the impact of the polytechnic running an operating deficit in one year on its productivity in the following year. Given that the TAMU guidelines suggest a minimum of a 3 percent

[63] A fixed-effects regression model was used to generate the coefficient estimates.

surplus on income, polytechnics should respond to a loss by seeking to improve efficiency. Several polytechnics have restructured following a loss.

Another explanatory variable in the analysis is COMMED. This is the change in the proportion of EFTS in community education programmes. Polytechnics that increase provision in these areas can increase their productivity as they take advantage of the lack of requirements for formal assessment and larger class sizes.

A variable is also included in the regression model (LEVEL) that captures the change in proportion of EFTS enrolled at the bachelors level or above. The cost of provision is greater at higher levels, due to lower class sizes compared with non-degree programmes.

The effect of the size of an institution on their productivity is captured by a variable (SIZE) that measures the total number of EFTS at the institution.

A variable is also included in the model to capture the effect of different government funding policies over time. This variable has three categories. These represent the period of a fully capped enrolment system between 1996 and 1998 (CAPPED1). Then, there is a category for the period when enrolments were uncapped (UNCAPPED). Finally, there is a category for the period when partial capping of enrolments was put in place again from 2004 onwards (CAPPED2). The reference category is CAPPED1. The definitions of these explanatory variables are summarized in Table 3.17.

Table 3.17, Definitions of explanatory variables used in the panel regression of total factor productivity of New Zealand polytechnics 1996-2006

Variable	Definition
LOSS	This is a dummy variable that takes a value of 1 if the polytechnic ran an operating deficit in the previous year.
COMMED	This is the change in the proportion of total EFTS enrolled in community education programmes.
LEVEL	This is the change in the proportion of total EFTS enrolled at the bachelors level or higher.
SIZE	This is the number of equivalent full-time students (EFTS) in thousands.
GOVT_POLICY	This represents different government policies toward enrolment. This has three categories: CAPPED1 = 1996-1998, UNCAPPED = 1999-2003, CAPPED2 = 2004-2006

Source: Ministry of Education.

The descriptive statistics of the three continuous variables in the regression model are presented in Table 3.18.

Table 3.18, Descriptive statistics of continuous explanatory variables in panel regression of the total factor productivity of New Zealand polytechnics 1996-2006

Variable	Mean	Std dev	Min	Max
COMMED	0.0012	0.0782	-0.4540	0.5141
LEVEL	0.0026	0.0249	-0.0667	0.0971
SIZE (000's EFTS)	3.6115	2.3771	0.1860	11.2450

The results of the panel regression analysis are presented in Table 3.19. Two model specifications are reported. The first includes Telford Polytechnic in the regression model, while the second omits Telford from the analysis. The very large increase in total factor productivity at Telford in 2003 may have a major impact on the coefficient estimates for the explanatory variables.

The results show that polytechnics that made a loss in the previous year attained an improvement in total factor productivity in the following year. On average, total factor productivity was 0.15 points higher the year following a loss. This suggests that at least in the short term, there was an effort by polytechnics to address their financial situation by improving efficiency.

The results also showed that large polytechnics enjoyed higher total factor productivity growth. An increase of 1,000 EFTS in size was associated with an increase in total factor productivity of 0.053 points.

The variable representing government funding policy suggests that there was no difference in total factor productivity growth between the period of fully capping enrolments and the period of uncapped enrolments. However, total factor productivity was 0.15 points lower during the period of partial capping that started in 2004, compared with the period of capping between 1996 and 1998. This is not surprising, as the restrictions put in place on enrolments such as community education programmes would have inhibited growth in areas where input costs are low. What is interesting is that the earlier period with full capping of domestic enrolments resulted in similar total factor productivity growth as the uncapped environment.

Similarly, an increase in the proportion of EFTS at the bachelors level or above resulted in a decrease in total factor productivity. A 1 percentage point increase in EFTS at the bachelors level or higher was associated with a drop in total factor productivity of 0.8 percentage points.

Although the change in proportion of community education EFTS is not significant in model 1, with the exclusion of Telford Polytechnic, there is a clear association between the change in proportion of community education EFTS and total factor productivity. The positive sign for the coefficient for COMMED in model 2 suggests that increasing provision in lower-quality courses was a factor in polytechnics improving their total factor productivity. An increase of 1 percentage point in the proportion of community education EFTS improved a polytechnic's total factor productivity by 0.42 points.

LEVEL was also not significant in model 1. However, with the exclusion of Telford, the variable becomes statistically significant. This shows that a 1 percentage point increase in the proportion of EFTS at the bachelors level or higher is associated with a decrease in total factor productivity of 0.85 points.

Table 3.19, Results of panel regression: Total factor productivity of New Zealand polytechnics 1996-2006

(Dependent variable = total factor productivity)

Variable	Model 1 (Including Telford)		Model 2 (No Telford)	
	Coefficient	Standard error	Coefficient	Standard error
LOSS	0.149**	0.034	0.075**	0.024
COMMED	0.117	0.175	0.423**	0.120
LEVEL	-0.628	0.328	-0.854*	0.353
SIZE	0.053**	0.016	0.029*	0.011
Govt_policy				
CAPPED1	Reference category		Reference category	
UNCAPPED	-0.007	0.033	-0.010	0.022
CAPPED2	-0.153**	0.047	-0.097**	0.032
CONSTANT	0.859**	0.053	0.931**	0.038
Prob>F	<0.0000		<0.0000	
N	200		190	

Notes,
1. *, ** significant at the 5 percent level and 1 percent level, respectively.
2. Fixed-effects regression was used to generate the coefficient estimates.

In section 3.4.4.2, the technical efficiency of polytechnics in 2006 was compared with their return on income to see if polytechnics were rewarded financially for their efficiency. Now we examine how total factor productivity growth impacted on the financial performance of the polytechnics. Table 3.20 compares the mean total factor productivity growth for each polytechnic with the percentage point change in their return on income between 1996 and 2006.

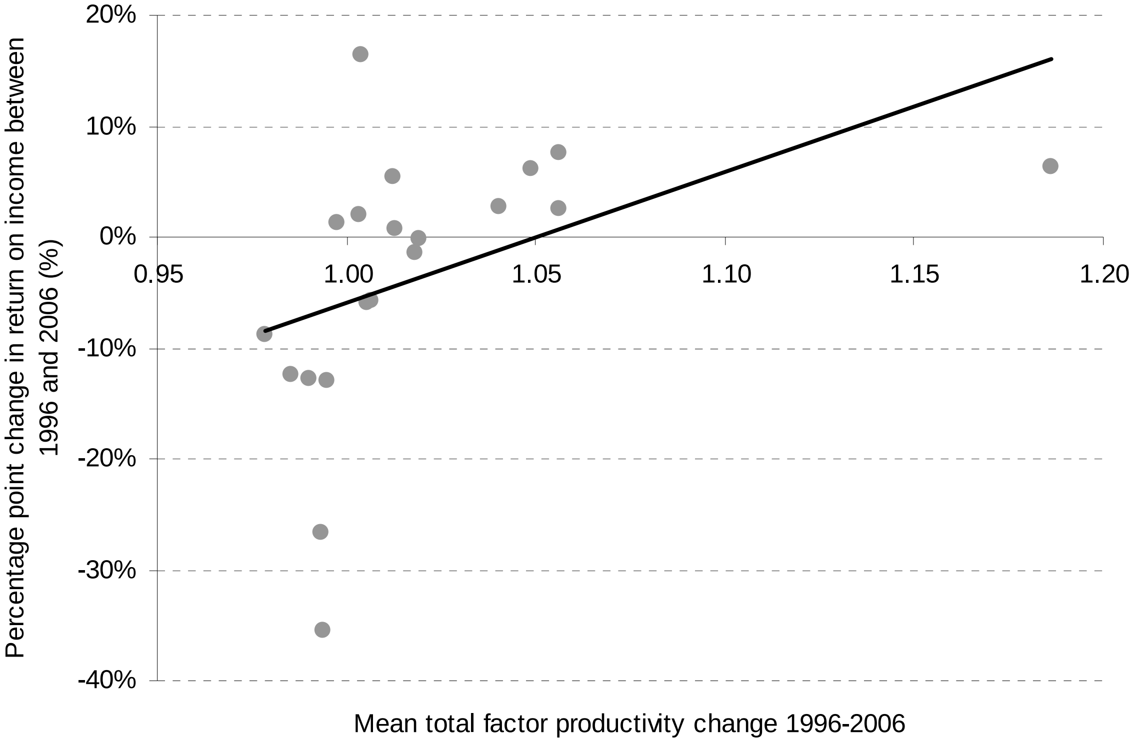
Generally, an improvement in total factor productivity was associated with an improvement in return on income. Eleven of 13 polytechnics with positive total factor productivity growth improved their return on income. Similarly, five of the six polytechnics with negative total factor productivity growth had deterioration in their financial performance.

Table 3.20, Mean total factor productivity growth vs percentage point change in return on income for New Zealand polytechnics 1996-2006

Polytechnic	Mean change in total factor productivity 1996-2006	Percentage-point change in return on income 1996-2006
Aoraki	1.049	6.1%
BOP	1.019	-0.1%
CPIT	1.007	-5.8%
EIT	1.004	1.9%
MIT	0.986	-12.5%
NMIT	1.040	2.7%
North	1.012	5.3%
Otago	1.013	0.8%
SIT	1.056	7.6%
Tai Poutini	1.056	2.5%
Tairawhiti	0.994	-35.6%
Telford	1.186	6.3%
TOPNZ	1.004	16.4%
Unitec	0.990	-12.8%
UCOL	1.018	-1.4%
Waiariki	0.995	-13.0%
WINTEC	0.978	-8.7%
WELTEC	0.998	1.3%
WITT	0.993	-26.7%
Whitireia	1.006	-6.0%

Figure 3.13 compares the mean total factor productivity change in the period 1996 to 2006 with the percentage point change in return on income between 1996 and 2006. The line of best fit generated using ordinary least squares regression in Figure 3.13 shows the positive association between higher total factor productivity growth and improved financial performance.

Figure 3.13, Mean total factor productivity vs change in return on income for New Zealand polytechnics 1996-2006



The least squares estimates are presented below with t values in parentheses:

$$\Delta \textit{Return on income} = -1.222 + 1.163\ \Delta \textit{Total factor productivity}$$
$$(2.17) \quad (2.11)$$

$R^2 = 0.20$

The regression estimates show that on average, an increase of 1 percentage point in total factor productivity was associated with an increase of 1.2 percentage points in return on income.[64]

[64] If the three polytechnics that appear to be outliers in Figure 3.13 are removed (Telford, WITT and Tairawhiti), then least squares regression shows that an increase of 1 percentage point in total factor productivity is associated with an increase of 1.74 percentage points in return on income.

3.4.5 Conclusion

A number of polytechnics list financial viability as one of their key objectives in their mission statements.[65] Given the positive association between efficiency and financial performance displayed in the previous sections, the maximisation of efficiency will help to achieve this objective of viability. Hence, there are strong incentives to maximise efficiency and ensure the continuing operation of the polytechnics free from intervention by government.

The application of DEA to the polytechnic sector has shown that, overall, there is no significant difference in the technical efficiency of around 75 percent of polytechnics. However, there are a number of polytechnics that have lower productive efficiency than others. Generally, institutions with lower technical efficiency also exhibited poor total factor productivity growth over time, suggesting that the issues inhibiting their efficiency have been around for some time.

This analysis in this section has also shown that higher technical efficiency and higher total factor productivity growth is rewarded financially. However, employing the factors identified as being associated with higher efficiency or higher total factor productivity growth, are not necessarily a feasible option for struggling polytechnics under the current government tertiary education priorities and within the current capped funding environment.

The current statement of tertiary education priorities lists as a key priority a focus on younger students enrolled in qualifications at level 4 on the qualifications framework or higher (Ministry of Education, 2006, p.30). Therefore, increasing enrolments in community education courses is not an option, neither is a substantial increase in enrolments given the existing cap on funding.

For polytechnics in isolated regional locations with smaller populations,[66] there is perhaps little that could be done to improve their efficiency. Merging these polytechnics with other institutions does not necessarily provide a solution, given that WELTEC and especially UCOL appear to be suffering from long-term negative

[65] Such as Bay of Plenty Polytechnic, Tairawhiti Polytechnic and WITT.
[66] In particular, Tairawhiti Polytechnic and WITT.

effects on their efficiency from merging with poorly-performing institutions. Whether there needs to be special consideration in the funding system given to the circumstances of these polytechnics, or if private training establishments may be better placed to provide tertiary education in these areas, may need to be considered by policy makers.

One potential area for an increase in efficiency in the polytechnics sector is for a decrease in bachelors-level provision with an associated increase in non-degree provision that may feed into degrees at universities.[67] However, given the substantial number of enrolments and the vocational nature of degrees at polytechnics, whether this is a feasible option for the sector is questionable.

Finally, it is clear that polytechnics operate most efficiently under a system of stable enrolments. Therefore, some element of government control over enrolments is warranted if the efficiency of polytechnics is to be maximised.

[67] A suggestion also made by the Tertiary Education Advisory Commission (see TEAC 2001).

3.5 Measuring the productive efficiency of New Zealand universities

3.5.1 Introduction

New Zealand universities are the largest providers of tertiary education in New Zealand – in 2006 around 125,000 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 2006, they attracted around $2.4 billion in revenue. Given its size, it is important that this resource is used efficiently.

This section uses DEA to analyse the productive efficiency of New Zealand universities and compare their performance to Australian universities. Specifically, the technical efficiency of Australasian universities in 2005 is estimated, along with Malmquist indices for the period 1997 to 2005.

New Zealand universities are already subject to more scrutiny of performance than other types of TEI. For example, their research quality is assessed via the Performance-Based Research Fund (PBRF) Quality Evaluations[68] and international rankings systems, such as the Times Higher Education Supplement and Shanghai Jiao Tong University rankings, attempt to measure performance across a number of dimensions and arrive at a weighted set of rankings.

However, these measures do not examine performance from a productive efficiency perspective. 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. Applying DEA to just the New Zealand universities is not feasible, given that the linear programming approach will end up with almost all the universities on

[68] Although a number of polytechnics and wānanga also participate in the PBRF, not all choose to do so. As a result, the vast majority of staff assessed in the Quality Evaluations were in the universities.

the frontier and hence assigns a 100 percent efficiency score. If DEA is to be used, it requires a wider coverage than just the New Zealand universities.

It is becoming increasingly common for the performance of New Zealand tertiary institutions to be benchmarked to their Australian counterparts. For example, 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.[69]

Although not using DEA, other studies have compared the performance of Australian and New Zealand universities. Dale and Goldfinch (2005) and Macri and Sinha (2006) analysed the performance of politics and economics departments in universities in New Zealand and Australia respectively across a number of bibliometric indicators. Smart and Weusten (2007b) also used bibliometric data to compare the performance of New Zealand universities with Australian universities across 10 broad subject areas.

In this study, 36 Australian public universities are added to the eight New Zealand universities to conduct DEA analysis. The application of DEA also allows for the identification of peer institutions. As the Australian higher education system is made up of several tiers of universities, it is possible to identify which tiers of Australian universities the individual New Zealand universities relate to.

The structure of this section is as follows. First, section 3.5.2 presents some 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 in section 3.5.3. Empirical estimates of technical efficiency and total factor productivity are presented and analysed in section 3.5.4. Finally, some conclusions are presented in section 3.5.5.

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[69] Coelli *et al*. (2004) also suggests combining the datasets of Australian universities with other countries, such as New Zealand.

3.5.2 Background[70]

Most of the 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.[71]

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. This is reflected in their lower scores in the PBRF Quality Evaluations.

There are essentially three tiers to the Australian public universities. 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.

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[70] A more detailed history of the New Zealand universities can be found in Chapter 4.

[71] 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.

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 research intensity, with more of a focus on bachelors level teaching. The members of the respective university groupings are listed in Table 3.21 below.

Table 3.21, 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

Not all Australian universities are included in this analysis. Data is not available for the whole of the 1997 to 2005 period for the following universities: University of Sunshine Coast, and the two private universities, Bond University and Notre Dame University.

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,[72] 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

[72] The purchasing power parity values used to convert the expenditure to a common currency was an average of the Big Mac index, and World Bank and OECD estimates. It could be argued that these measures will overstate the degree of apparent underfunding of New Zealand universities, given that the lower academic salaries in New Zealand are not reflected in the purchasing power parities used in the NZVCC study.

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 enrolled domestic students. 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 this area. The performance measures used for funding purposes include 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.

Both New Zealand and Australian universities experienced decreases in government funding per student over the period of this study.[73] This is likely to have provided some incentive for institutions on both sides of the Tasman to maximise their efficiency.

The Australian and New Zealand university systems also exhibited a significant increase in international student enrolments during the early 2000s. Abbott and

[73] 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.

Doucouliagos (2007) suggest that Australian universities exposed to greater competition for international students have higher levels of efficiency. They also found that international students appeared not to have impacted on the efficiency of New Zealand universities. The impact of international student enrolments on the technical efficiency of New Zealand and Australian universities is examined in section 3.5.4.

3.5.3 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.

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.[74]

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,[75] 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.[76]

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[74] The Australian staffing data includes actual casual staffing to ensure comparability with the New Zealand university data.

[75] 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.

[76] Note that STUDENTS is also used as a measure of teaching output in alternative specifications of the DEA model in section 3.5.4.

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.[77]

The output variables used in the DEA model include the number of undergraduate qualification completions (UNDERGRAD) and the number of postgraduate completions (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 much 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 leaves bibliometric databases as the best potential source of research output information. 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.[78]

This measure of research output has its limitations, which have been previously outlined in chapter 2. The key issue is the bias in the coverage of the Web of Science. Disciplines such as the social sciences and humanities, which disseminate research

[77] This also precludes the use of research contract income as a possible output variable.
[78] 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.

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.

This point, which is widely discussed in the literature, is acknowledged in this study by applying a weighting to the value of indexed articles and reviews in the social sciences and humanities area. A weighting of 2 is applied to indexed publications from these disciplines. Although somewhat subjective, this is the approach used in the Shanghai Jiao Tong University rankings to adjust for the subject bias of the Web of Science.[79] 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.

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.

The definitions of the input and outputs variables are presented in Table 3.22.

Table 3.22, 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.

[79] Use of weighted outputs is not without precedent in DEA analysis. Coelli *et al*. (2004) used a weighted value for equivalent full-time students.

3.5.4 Results

This section presents the results of the application of DEA to New Zealand and Australian universities. Firstly, technical efficiency estimates for 2005 are presented in section 3.4.5.1. This is followed by a presentation of the results of a Malmquist analysis over the period 1997 to 2005 in section 3.5.4.2.

3.5.4.1 Technical efficiency

Descriptive statistics of the input and output variables used in the DEA are presented in Table 3.23 below. They show there is a wide disparity in the operations of the universities. The largest university (Monash) has 3,319 full-time equivalent academic staff, while the smallest university (Lincoln) has 217.

Table 3.23, Descriptive statistics of input and output variables used in DEA analysis of Australasian universities 2005

Variables	Mean	Standard deviation	Min	Max
Inputs:				
ACADEMIC (FTEs)	1,118	738	217	3,319
GENERAL (FTEs)	1,389	852	181	3,504
OTHEREXP ($NZm)	125	88	31	409
STUDENTS (EFTS)	17,823	8,657	2,931	40,429
Outputs:				
UNDERGRAD (qualification completions)	3,876	2,034	415	8,728
POSTGRAD (qualification completions)	2,162	1,342	228	5,634
RESEARCH (indexed research outputs)	890	1,001	38	3,794

To obtain a parsimonious model and also test the robustness of the technical efficiency estimates, this study uses the approach of Johnes (2006) to help select the preferred model specification. This involves generating technical efficiency estimates using a saturated model and then comparing the results to models where one input/output variable has been removed to test for statistically significant changes in technical efficiency. The Pastor *et al*. (2002) *p*-value and Spearman's *r* statistic are presented in Table 3.24 and Table 3.25.

The results of the Pastor *et al*. (2002) test show that removing UNDERGRADUATE or RESEARCH resulted in a change to the technical efficiency estimates that were statistically significant. However, the Spearman's *r* statistic results are all below the value used to identify if the removal of any of the variables resulted in a significant change to the rankings of the universities (0.95). Therefore, all of the input/output variables in the original model specification are retained. This means that the model specification used in this study is similar to that of Flegg *et al*. (2004) and Worthington and Lee (2005) in their Malmquist analyses of United Kingdom and Australian universities, respectively.

Table 3.24, Testing alternative specifications of the DEA model applied to Australasian universities, assuming constant returns to scale

Variable	**Model**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
ACADEMIC		×	×	×	×	×	×
GENERAL	×		×	×	×	×	×
OTHEREXP	×	×		×	×	×	×
STUDENTS	×	×	×		×	×	×
UNDERGRAD	×	×	×	×		×	×
POSTGRAD	×	×	×	×	×		×
RESEARCH	×	×	×	×	×	×	
Pastor *et al*. (2002) *p*-value	0.97	0.91	0.97	0.97	0.00	0.97	0.00
Spearman's *r*	0.91	0.90	0.86	0.86	0.69	0.75	0.57

Table 3.25, Testing alternative specifications of the DEA model applied to Australasian universities, assuming variable returns to scale

Variable	**Model**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
ACADEMIC		×	×	×	×	×	×
GENERAL	×		×	×	×	×	×
OTHEREXP	×	×		×	×	×	×
STUDENTS	×	×	×		×	×	×
UNDERGRAD	×	×	×	×		×	×
POSTGRAD	×	×	×	×	×		×
RESEARCH	×	×	×	×	×	×	
Pastor *et al*. (2002) *p*-value	0.99	0.97	0.97	0.97	0.00	1.00	0.03
Spearman's *r*	0.92	0.90	0.84	0.84	0.66	0.89	0.60

This model specification means that a university will be efficient if they can maximise their number of graduates and the volume of their research output, given their mix of inputs.

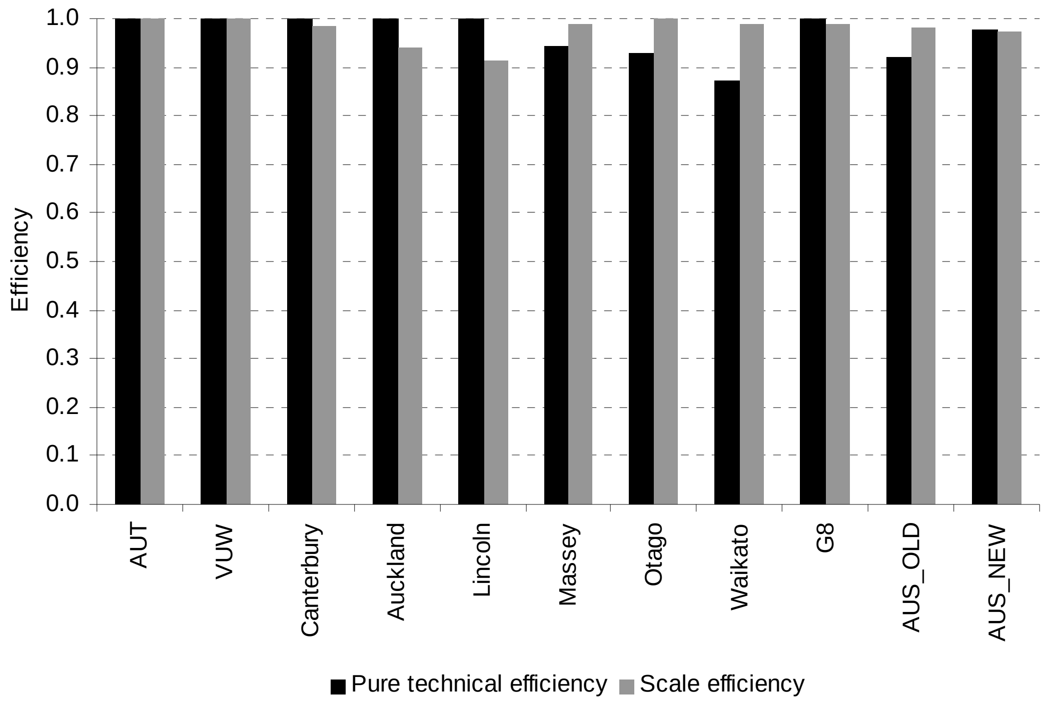
The results of the application of DEA to 2005 data for New Zealand and Australian universities are presented in Tables 3.26. The table contains the technical efficiency estimates under the assumptions of CRS and VRS, along with 95 percent confidence intervals. The pure technical efficiency and scale efficiency estimates of New Zealand universities are also illustrated in Figure 3.14.

Table 3.26, Results of DEA of Australasian universities 2005, completions specification

University	Technical efficiency		Scale efficiency	Returns to scale	Pure technical efficiency 95 % confidence intervals	
	CRS	VRS			Lower	Upper
AUT	1.000	1.000	1.000	-	0.923	1.049
Lincoln	0.914	1.000	0.914	IRS	0.923	1.049
Massey	0.932	0.943	0.989	DRS	0.919	0.964
Auckland	0.938	1.000	0.938	DRS	0.978	1.025
Canterbury	0.986	1.000	0.986	IRS	0.951	1.041
Otago	0.926	0.928	0.998	IRS	0.892	0.950
Waikato	0.862	0.871	0.990	IRS	0.840	0.892
VUW	1.000	1.000	1.000	-	0.954	1.040
Charles Sturt	1.000	1.000	1.000	-	0.924	1.050
Macquarie	1.000	1.000	1.000	-	0.951	1.042
Southern Cross	0.888	1.000	0.888	IRS	0.961	1.035
New England	0.948	0.989	0.959	IRS	0.965	1.010
NSW	1.000	1.000	1.000	-	0.954	1.040
Newcastle	0.830	0.831	0.998	IRS	0.809	0.851
Sydney	1.000	1.000	1.000	-	0.922	1.048
UTS	1.000	1.000	1.000	-	0.921	1.048
Western Sydney	1.000	1.000	1.000	-	0.924	1.049
Wollongong	1.000	1.000	1.000	-	0.923	1.049
Deakin	0.931	0.942	0.989	DRS	0.923	0.960
La Trobe	0.912	0.912	0.999	DRS	0.891	0.933
Monash	0.962	1.000	0.962	DRS	0.922	1.048
RMIT	0.807	0.838	0.963	DRS	0.806	0.858
Swinburne	0.906	0.930	0.974	DRS	0.903	0.951
Ballarat	1.000	1.000	1.000	-	0.924	1.047
Melbourne	1.000	1.000	1.000	-	0.943	1.043
VUT	0.898	0.905	0.992	IRS	0.883	0.924
CQU	1.000	1.000	1.000	-	0.924	1.049
Griffith	0.814	0.837	0.973	DRS	0.821	0.854
James Cook	0.843	0.901	0.936	IRS	0.879	0.921
QUT	0.937	1.000	0.937	DRS	0.970	1.030
Queensland	0.980	1.000	0.980	DRS	0.962	1.032
South Queensland	1.000	1.000	1.000	-	0.924	1.048
Curtin	0.918	0.983	0.934	DRS	0.957	1.001
Edith Cowan	0.967	0.972	0.995	IRS	0.944	0.994
Murdoch	0.857	0.873	0.982	IRS	0.855	0.891
Western Australia	1.000	1.000	1.000	-	0.935	1.047
Flinders	1.000	1.000	1.000	-	0.925	1.051
Adelaide	0.970	0.992	0.978	IRS	0.957	1.015
South Australia	0.977	0.979	0.998	DRS	0.955	1.002
Tasmania	0.835	0.856	0.975	IRS	0.844	0.870
NTU	0.900	1.000	0.900	IRS	0.922	1.048
ANU	1.000	1.000	1.000	-	0.926	1.050
Canberra	0.991	1.000	0.991	-	0.922	1.049
Catholic	1.000	1.000	1.000	-	0.924	1.049
Mean	*0.946*	*0.965*	*0.980*		*0.918*	*1.000*

The results in Table 3.26 show that the degree of variation in pure technical efficiency between New Zealand universities is relatively small. Five of the eight universities[80] have a pure technical efficiency value of 1, with the lowest being 0.871 by the University of Waikato. Overall, the average pure technical efficiency for New Zealand universities was reasonably high at 0.968. In other words, outputs could be increased by 3.2 percent, while keeping inputs constant. This compares with an average pure technical efficiency of 0.999 for G8 universities, 0.922 for AUS_OLD universities and 0.977 for AUS_NEW universities.[81]

Figure 3.14, Pure technical efficiency and scale efficiency estimates of Australasian universities 2005, completions specification



Among the New Zealand universities, scale inefficiency affected more institutions than pure technical inefficiency. Six of the eight universities had a scale efficiency value of less than 1. Overall, the average scale efficiency value for New Zealand universities was 0.977. In other words, if the universities improved their scale of operations, outputs could be boosted by 2.3 percent.

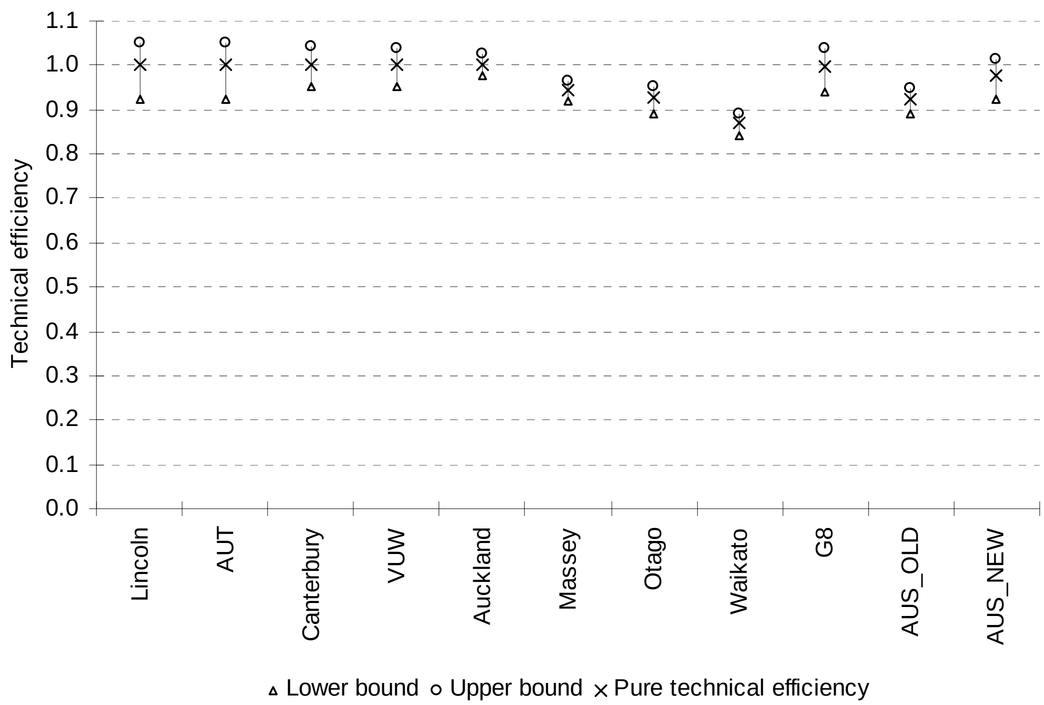
[80] These are the Universities of Auckland and Canterbury, Victoria University of Wellington, Lincoln University and AUT.
[81] The lowest pure technical efficiency was exhibited by the University of Newcastle (0.831).

The university with the lowest scale efficiency in 2005 was Lincoln (0.914), which could improve efficiency by increasing its scale. The University of Auckland (0.938) was another New Zealand university to exhibit scale inefficiency. In this case, Auckland could benefit from decreasing in size.

The average scale efficiency of 0.977 for New Zealand universities compares with values of 0.990 for G8 universities, 0.983 for AUS_OLD universities and 0.975 for AUS_NEW universities.

Confidence intervals for the pure technical efficiency estimates are presented in Figure 3.15.

Figure 3.15, Estimates of pure technical efficiency of Australasian universities and their associated 95 percent confidence intervals 2005, completions specification



The University of Waikato exhibits pure technical efficiency that is clearly below the other New Zealand universities. In addition, it appears to have lower pure technical efficiency than the G8 and AUS_NEW groups of universities. The University of Waikato is located in a regional centre (Hamilton) that has a limited geographical population to draw from, compared with the other eight universities. It also arguably lacks a specific area of specialised focus that might draw students from other regions, although its Management School is well regarded.

Another of the New Zealand universities exhibiting a pure technical efficiency of less than 1 was Massey University. Although Massey University has its main campus located in a regional centre (Palmerston North), it is a significant provider of extramural education, and has campuses in Auckland and Wellington. The Wellington campus of Massey University was originally the Wellington Polytechnic. Massey University absorbed the polytechnic in 1999. As will be seen in the Malmquist analysis, the merger with Wellington Polytechnic appears to have been problematic for Massey.

The University of Otago also exhibits a pure technical efficiency value of less than 1. Although Otago is located in a city with a limited population, a significant proportion of its student population come from other regions. The presence of a medical school may be one factor impacting on the performance of Otago, given the higher costs of running medical schools.

A useful way of examining the performance of the universities over time is to compare the efficiency of the institutions in 1997 and 2005. Although the measures of technical efficiency between time periods are not strictly comparable, they nevertheless provide some insight into the relative performance of the New Zealand universities at the start and end of the period under review.

Table 3.27 shows the pure technical efficiency and scale efficiency estimates derived from applying DEA to data from 1997 and 2005. The relative performance of Massey University, the University of Otago and University of Waikato deteriorated by moving away from the production frontier, compared to the other universities. However, the University of Auckland and VUW both improved their pure technical efficiency relative to the other universities. Table 3.27 also shows that significant improvement was exhibited by AUS_NEW universities, which improved their technical efficiency measures between 1997 and 2005.[82]

[82] How the productive efficiency of the universities has changed over the time period is examined in more depth in the Malmquist analysis in the following section.

Table 3.27, Pure technical efficiency and scale efficiency estimates of Australasian universities 1997 and 2005, completions specification

University	Pure technical efficiency		Scale efficiency		Returns to scale	
	1997	2005	1997	2005	1997	2005
AUT	1.000	1.000	1.000	1.000	-	-
Lincoln	1.000	1.000	0.742	0.914	IRS	IRS
Massey	1.000	0.943	0.975	0.989	DRS	DRS
Auckland	0.949	1.000	0.959	0.938	DRS	DRS
Canterbury	1.000	1.000	1.000	0.986	-	IRS
Otago	1.000	0.928	1.000	0.998	-	IRS
Waikato	0.914	0.871	0.998	0.990	IRS	IRS
VUW	0.917	1.000	0.999	1.000	DRS	-
NZ	*0.973*	*0.968*	*0.959*	*0.977*		
G8	1.000	0.999	0.968	0.990		
AUS_OLD	0.927	0.922	0.972	0.983		
AUS_NEW	0.924	0.977	0.904	0.975		
Australia	*0.942*	*0.965*	*0.939*	*0.981*		

Note, Unweighted means are presented in this table.

The disparity in pure technical efficiency among the universities in this study is examined further through second-stage analysis. This applies bootstrapped truncated regression to data for the universities to provide robust tests of statistical significance of the effect of various explanatory variables.

The explanatory variables included in the regression model include the proportion of international students (INTERNATIONAL). This variable in included in the model as increased competition for international students has been identified as a factor in promoting efficiency in Australian universities (Abbott and Doucouliagos 2007).

Also included is a dummy variable (MEDSCHOOL) that takes a value of 1 if the university has a medical school and 0 if it does not. This variable is included to capture the impact of the presence of a medical school. There is no assumption made a priori about the impact of a medical school on efficiency. Although the costs of delivery are higher with a medical school universities with medical schools also tend to be more research intensive (Marginson 2007).

The size of a university in terms of equivalent full-time students (in thousands) is included in the model (SIZE). A variable with multiple categories that captures the grouping a university belongs to is also included in the regression model. The five categories are: G8, AUS_OLD, AUS_NEW, NZ_NEW (AUT) and NZ_OLD (the remaining New Zealand universities). The reference category is NZ_OLD universities.

The definitions of the explanatory variables in the truncated regression analysis are presented in Table 3.28.

Table 3.28, Definitions of explanatory variables used in the truncated regression analysis of the pure technical efficiency of Australasian universities

Variable	Definition
INTERNATIONAL	This is the proportion of equivalent full-time students that are international students.
MEDSCHOOL	This is a dummy variable that takes a value of 1 if the university has a medical school and 0 if it doesn't.
SIZE	This is the number of equivalent full-time students in thousands.
UNI_GROUPING	This is a variable with multiple categories. The categories are: NZ_OLD, NZ_NEW, G8, AUS_OLD, AUS_NEW.

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

The descriptive statistics of the continuous variables in the regression model are presented in Table 3.29.

Table 3.29, Descriptive statistics of continuous explanatory variables used in the truncated regression analysis of the pure technical efficiency of Australasian universities

Variable	Year	Mean	Standard deviation	Min	Max
INTERNATIONAL	1997	0.095	0.053	0.028	0.223
	2005	0.244	0.113	0.053	0.602
SIZE (000s EFTS)	1997	13.891	6.866	2.790	31.072
	2005	17.823	8.657	2.931	40.429

The results of the bootstrapped truncated regression are presented in Table 3.30. These show the factors associated with the estimates of pure technical efficiency of Australasian universities in 1997 and in 2005. The only variable with a statistically significant association with pure technical efficiency was UNI_GROUPING. In 1997, the pure technical efficiency of new Australian universities was 5.2 percentage points lower than New Zealand universities (excluding AUT). However, in 2005, there was no statistically significant difference in the pure technical efficiency of New Zealand universities (excluding AUT) and the new Australian universities. Also, the pure technical efficiency of G8 universities was now 5.5 percent higher than the New Zealand universities (excluding AUT).

This suggests that between 1997 and 2005 New Zealand universities have lost ground to their Australian counterparts. This issue is examined in more depth in the Malmquist indices analysis in section 3.5.4.2.

Table 3.30, Results of truncated regression analysis: Pure technical efficiency of Australasian universities 1997 and 2005, completions specification

(Dependent variable = pure technical efficiency)

Variable	1997			2005		
	Coefficient	95 % confidence intervals		Coefficient	95 % confidence intervals	
		Lower	Upper		Lower	Upper
INTERNATIONAL	-0.280	-0.741	0.150	-0.011	-0.136	0.109
MEDSCHOOL	-0.049	-0.105	0.005	-0.021	-0.059	0.017
SIZE	0.001	-0.002	0.003	-0.001	-0.002	0.001
UNI_GROUPING						
AUS_NEW	-0.052*	-0.101	-0.006	0.009	-0.026	0.043
AUS_OLD	-0.037	-0.096	0.025	-0.040	-0.081	0.001
G8	0.063	-0.008	0.133	0.055*	0.006	0.104
NZ_NEW	0.015	-0.124	0.153	0.030	-0.064	0.126
NZ_OLD	Reference category			Reference category		
CONSTANT	0.998*	0.929	1.068	0.983*	0.944	1.022
SIGMA	0.655	0.399	0.783	0.453	0.285	0.558
N	44			44		

Notes:
1. * denotes significant at the 5 percent level.
2. The 95 percent confidence intervals were generated from 2,000 bootstrapped replications.

The DEA output also identifies peer institutions. Identifying peer institutions serves two purposes in this analysis of productive efficiency. First, it can identify the institution that an inefficient university may look to for ways in which to improve their efficiency. Second, the peer institutions can help identify where the New Zealand universities are situated within the Australian tiers of universities.

The peer institutions for the New Zealand universities are presented in Table 3.31. Note that peer institutions for two DEA model specifications are presented. One model specification uses qualification completions as the measure of teaching output, while the other uses STUDENTS as an output variable, instead of UNDERGRAD and POSTGRAD, which are excluded from the model. This gives a specification closer to what the New Zealand universities are funded on.

Of the New Zealand universities that exhibit pure technical inefficiency, Massey University has two New Zealand universities that are peers. These are AUT, and the University of Canterbury. Given that AUT's high pure technical efficiency is partly due to its significant provision of sub-degree programmes, mirroring the operational structure of AUT is not a viable option. Looking at the operation of the University of Canterbury in order to attempt to improve efficiency is a much more likely option.

The University of Otago has Lincoln University as a peer institution, as does the University of Waikato. The University of Waikato also has the University of Canterbury as a peer institution. Given the specialised nature of Lincoln University, its management of operations is unlikely to provide obvious solutions for the University of Otago and the University of Waikato to improve their efficiency.

Table 3.31, Peer institutions of New Zealand universities 2005, New Zealand peers

University	Peer institutions
AUT	Massey*
Lincoln	Otago*, Waikato*
Massey	AUT*, Canterbury+
Auckland	n/a
Canterbury	Massey+, Waikato+
Otago	Lincoln*
Waikato	AUT*, Lincoln*, Canterbury+
VUW	n/a

Note, * denotes peer from completions specification, + denotes peer from enrolments specification.

The peer institutions can also show which Australian universities are peers of the New Zealand institutions. These are identified in Table 3.32. AUT has 10 Australian universities that are peer institutions. AUT has the greatest number of peers from the AUS_NEW grouping. These are the University of Western Sydney, RMIT, Australian Catholic University and Swinburne. This indicates that AUT is similar to the younger teaching intensive universities in Australia.[83]

[83] Although AUT is also a peer of a number of AUS_OLD universities, the large number of sub-degree qualifications offered at AUT means that these results should be treated with caution.

A number of New Zealand universities have peers that are predominantly from the AUS_OLD grouping. These include Lincoln University, the University of Canterbury[84] and VUW.

Massey University, the University of Auckland and the University of Otago all have more than one G8 peer institution. They also have peers from the AUS_NEW grouping.

Table 3.32, Peer institutions of New Zealand universities 2005, Australian peers

University	Peer groupings		
	G8	AUS_OLD	AUS_NEW
AUT		Newcastle*, Deakin*, La Trobe*, Edith Cowan*, Murdoch*, Tasmania*	Western Sydney^{+}, RMIT^{+}, Catholic^{+}, Swinburne*
Lincoln		New England*+, James Cook*$^{+}$, Edith Cowan*, Murdoch*$^{+}$, Tasmania*, Flinders^{+}	Southern Cross^{+}
Massey	Sydney^{+}, Melbourne*		Charles Sturt*$^{+}$, Western Sydney*$^{+}$
Auckland	Sydney^{+}, Monash^{+}		RMIT^{+}
Canterbury	Adelaide*$^{+}$	James Cook*$^{+}$, New England^{+}, Newcastle^{+}, La Trobe^{+}, Edith Cowan^{+}, Murdoch^{+}, Flinders^{+}, Tasmania^{+}	South Australia^{+}
Otago	Western Australia*$^{+}$, Sydney^{+}		Charles Sturt*, CQU^{+}
Waikato		Flinders*	Western Sydney^{+}, Southern Queensland^{+}
VUW		La Trobe^{+}	

Note, * denotes peer from completions specification, $^{+}$ denotes peer from enrolments specification.

Although the analysis of New Zealand polytechnics in section 3.4.4.1 showed a clear relationship between higher technical efficiency and better financial performance, the association is more tenuous for Australasian universities. Figure 3.16 and Figure 3.17 show the relationship between the technical efficiency estimates under the completions specification and the return on income for the universities in this study.

[84] The University of Canterbury does have one G8 peer – the University of Adelaide.

It is apparent that the financial situation of the universities in this study is much stronger than the New Zealand polytechnic sector. Just three of the 44 universities exhibited an operating deficit in 2005. But the correlation between technical efficiency and return on income is much lower. The Pearson's correlation coefficient between technical efficiency and return on income for all universities in this study was 0.31. For New Zealand universities the figure was 0.42 and for Australian universities 0.30. The correlation coefficient for pure technical efficiency and return on income was 0.22 for all universities, 0.26 for New Zealand universities and 0.22 for Australian universities.

Figure 3.16, Technical efficiency vs return on income for Australasian universities 2005, completions specification

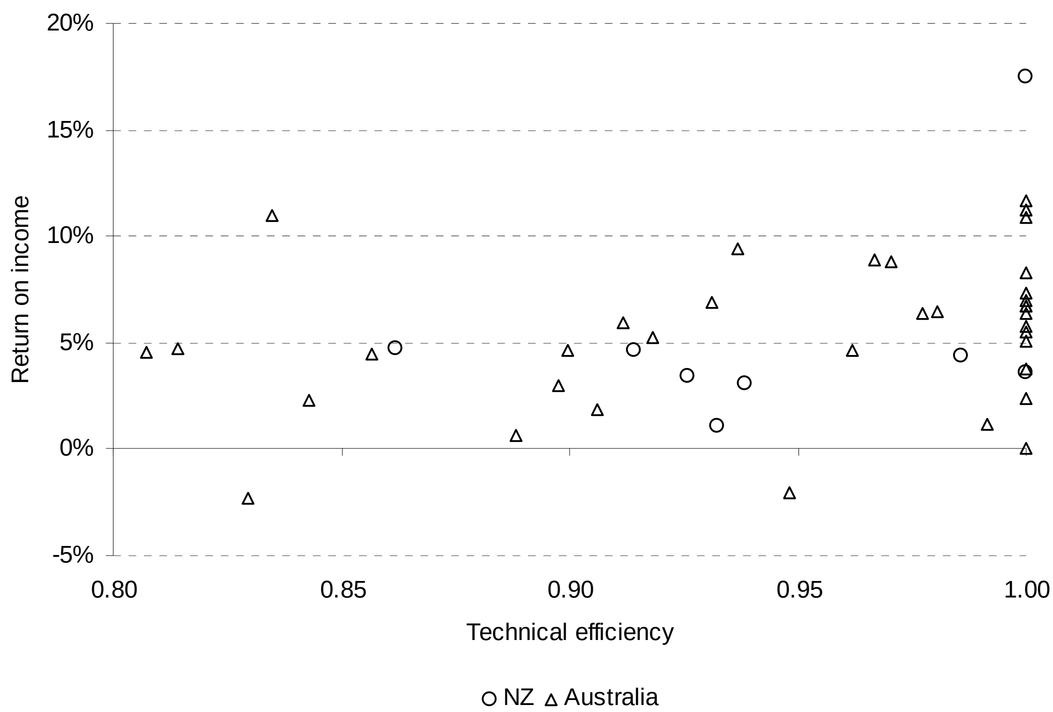
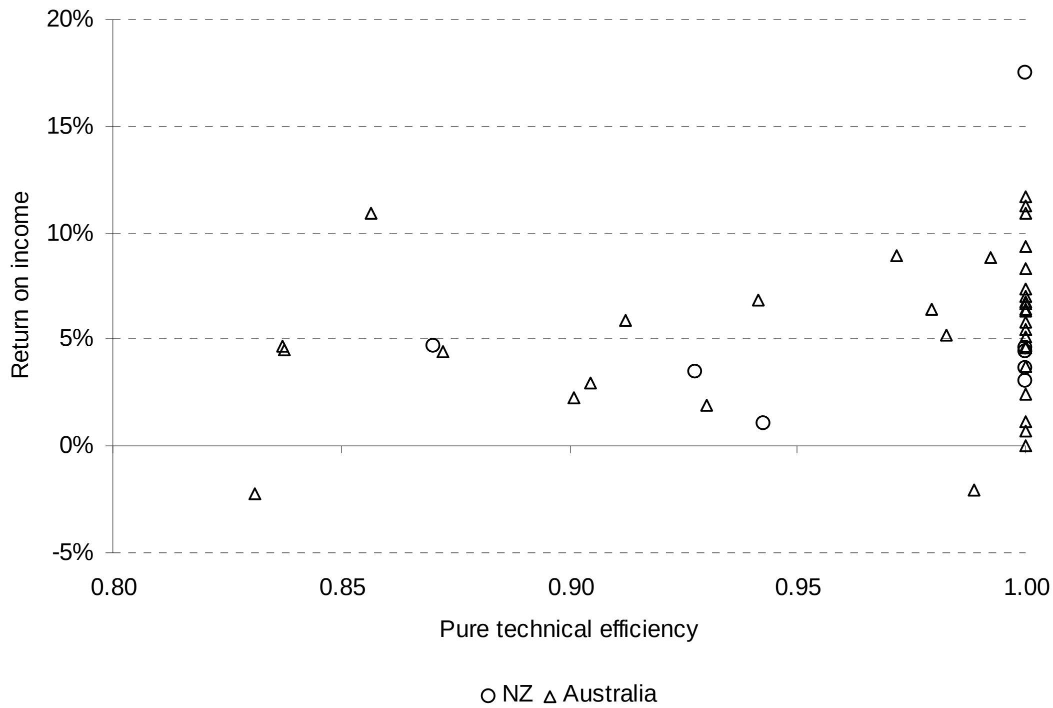


Figure 3.17, Pure technical efficiency vs return on income for Australasian universities 2005, completions specification



To further analyse the association between technical efficiency and return on income, the technical efficiency estimates from the enrolments specification are compared with return on income. As government funding for universities is more strictly tied to enrolments rather than completions, there may be a clearer association between efficiency and financial performance.

However, it appears that the relationship between technical efficiency and return on income is less clear under the enrolments specification. Figure 3.18 compares the technical efficiency estimates with return on income, while Figure 3.19 compares the pure technical efficiency estimates with return on income.

The Pearson's correlation coefficient between technical efficiency and return on income for all universities was 0.29, for New Zealand universities 0.41 and 0.25 for Australian universities. The correlation coefficient between pure technical efficiency was 0.21 for all universities, 0.23 for New Zealand universities and 0.20 for Australian universities. So overall, the association between technical efficiency and financial performance is relatively weak, although it is stronger for New Zealand universities than their Australian counterparts.

Figure 3.18, Technical efficiency vs return on income for Australasian universities 2005, enrolments specification

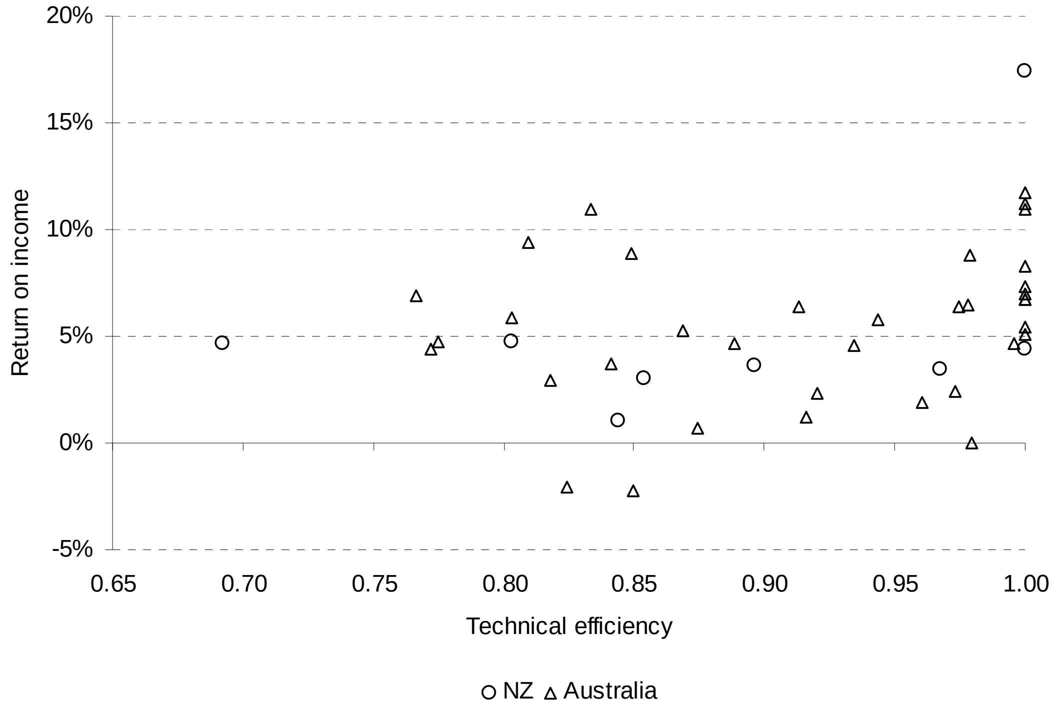
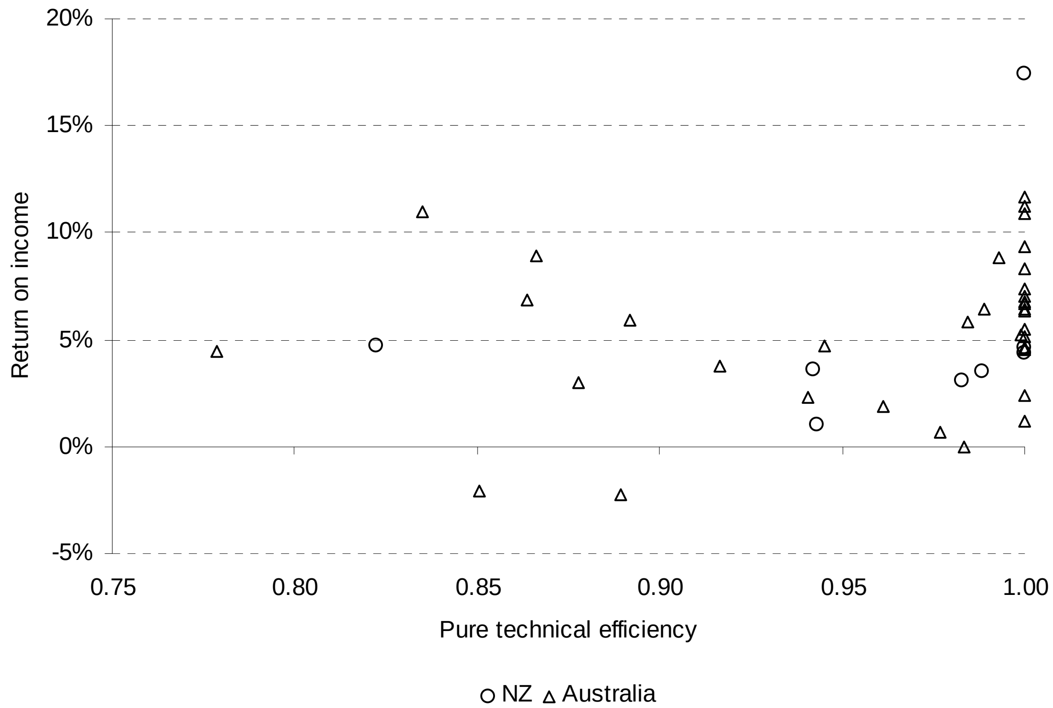


Figure 3.19, Pure technical efficiency vs return on income for Australasian universities 2005, enrolments specification



3.5.4.2 Malmquist analysis

This section presents the results of the Malmquist analysis of Australasian universities between 1997 and 2005. The means of the input and output variables in each year of the analysis are presented in Table 3.33. 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 3.33, Mean values of inputs and outputs in Malmquist analysis of Australasian universities 1997-2005

Variables	1997	1998	1999	2000	2001	2002	2003	2004	2005	% change 1997-2005
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 3.34, while the raw Malmquist indices are presented in Tables 3.35 to 3.39.

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 3.34 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.[85]

Table 3.34, 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.

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

Table 3.35, Total factor productivity change estimates for Australasian universities 1997-1998 to 2004-2005, completions specification

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. * significant at the 5 percent level.
2. Statistical significance derived from 2,000 bootstrapped replications.
3. All means are geometric means.
4. The indices represent change from one year to the next and the first year in each column represents the base year.

Table 3.36, Technical efficiency change estimates for Australasian universities 1997-1998 to 2004-2005, completions specification

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. * significant at the 5 percent level.
2. Statistical significance derived from 2,000 bootstrapped replications.
3. All means are geometric means.
4. The indices represent change from one year to the next and the first year in each column represents the base year.

Table 3.37, Technological change estimates for Australasian universities 1997-1998 to 2004-2005, completions specification

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. * significant at the 5 percent level.
2. Statistical significance derived from 2,000 bootstrapped replications.
3. All means are geometric means.
4. The indices represent change from one year to the next and the first year in each column represents the base year.

Table 3.38, Pure technical efficiency change estimates for Australasian universities 1997-1998 to 2004-2005, completions specification

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. * significant at the 5 percent level.
2. Statistical significance derived from 2,000 bootstrapped replications.
3. All means are geometric means.
4. The indices represent change from one year to the next and the first year in each column represents the base year.

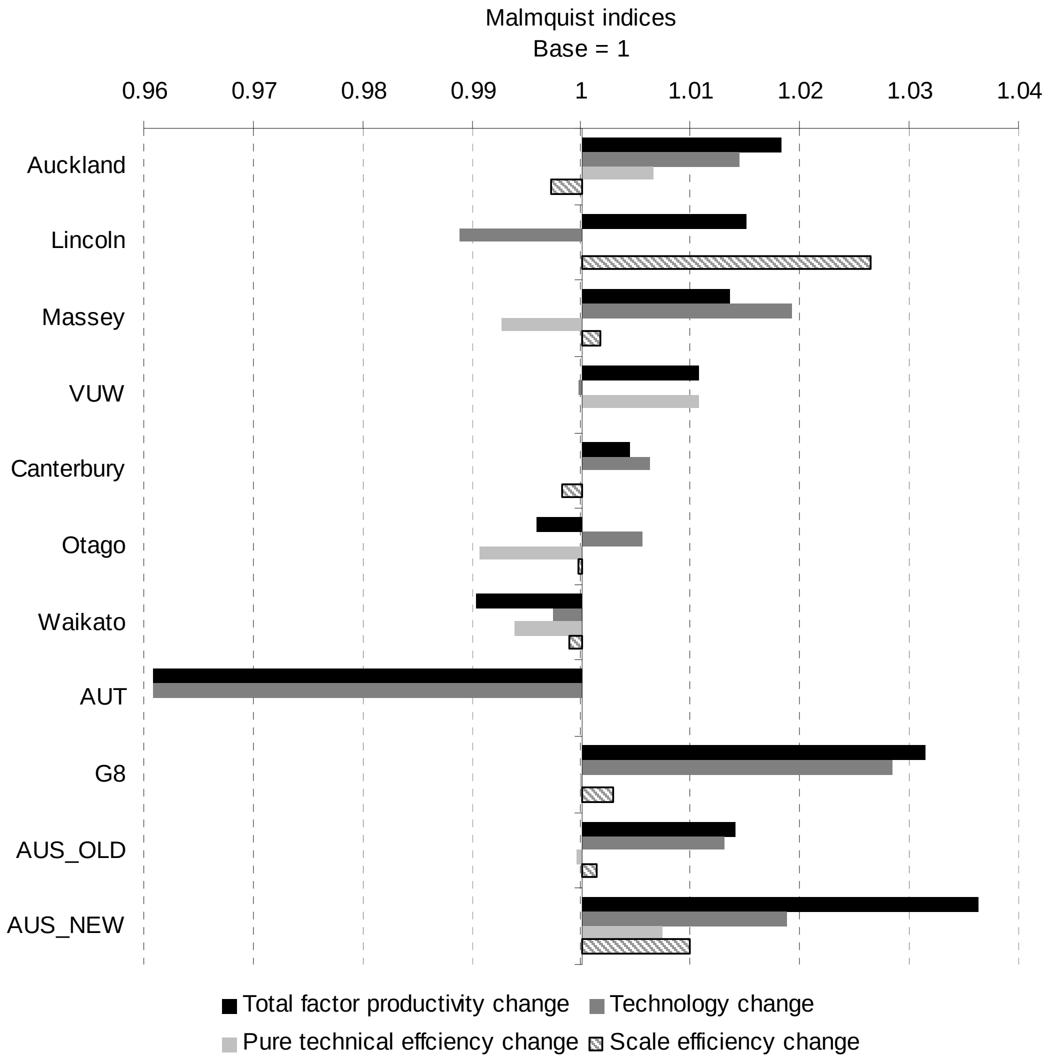
Table 3.39, Scale efficiency change estimates for Australasian universities 1997-1998 to 2004-2005, completions specification

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. * significant at the 5 percent level.
2. Statistical significance derived from 2,000 bootstrapped replications.
3. All means are geometric means.
4. The indices represent change from one year to the next and the first year in each column represents the base year.

The performance of each of the New Zealand universities is summarised in Figure 3.20, 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 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 3.20, Mean Malmquist indices for Australasian universities 1997-1998 to 2004-2005, completions specification



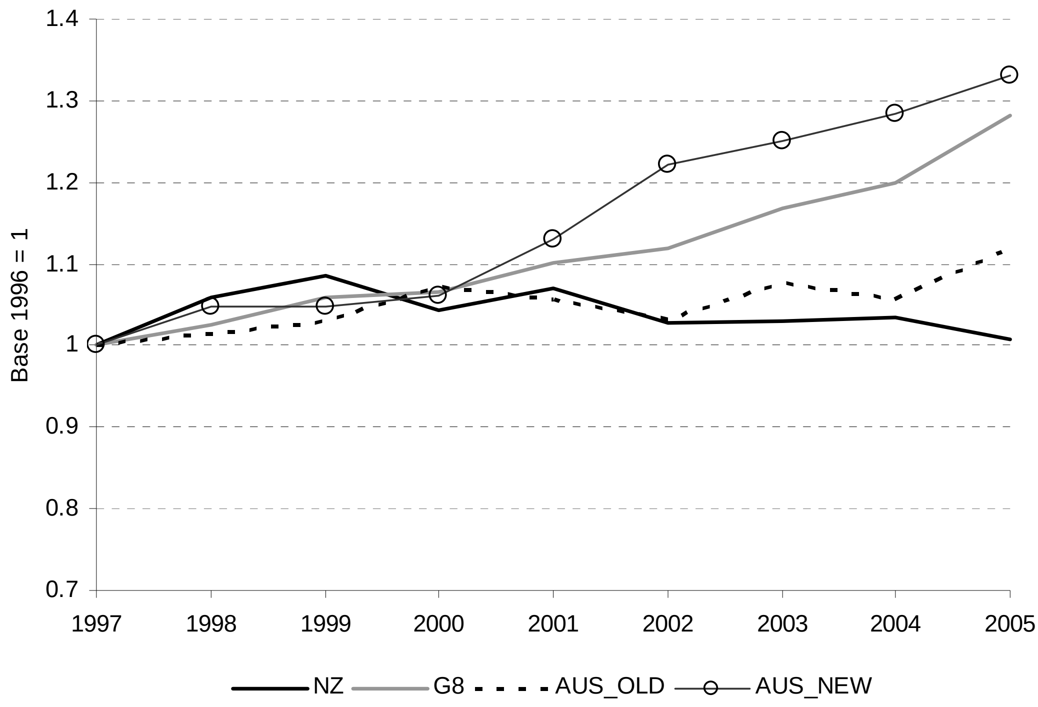
Improvement in technology was the key driver of total factor productivity growth at the University of Auckland. This was also the case at Massey University and the University of Canterbury.

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 dramatic 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 3.21.

Figure 3.21, Cumulative total factor productivity growth by Australasian university grouping 1997-2005, completions specification



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 3.22. 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 3.22, Cumulative technology growth by Australasian university grouping 1997-2005, completions specification

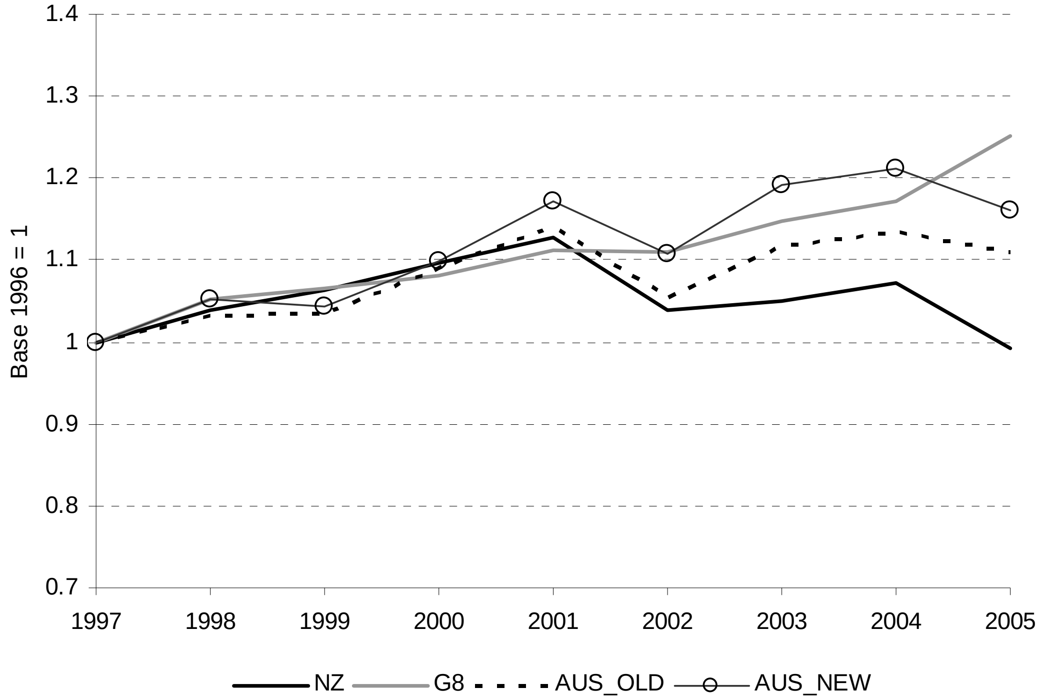
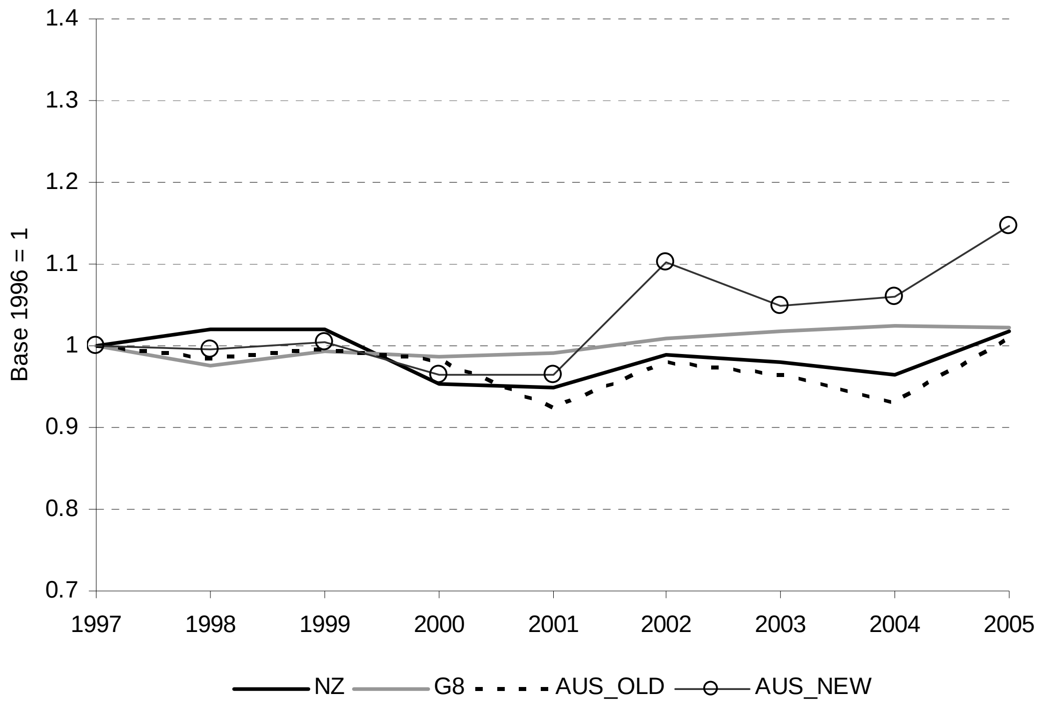


Figure 3.23 presents the cumulative technical efficiency growth for the groupings of Australasian universities. On average, technical efficiency growth in New Zealand, G8 and AUS_OLD universities has been sluggish. Only in the case of the AUS_NEW universities was there a significant rise in cumulative 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,[86] this result is not surprising.

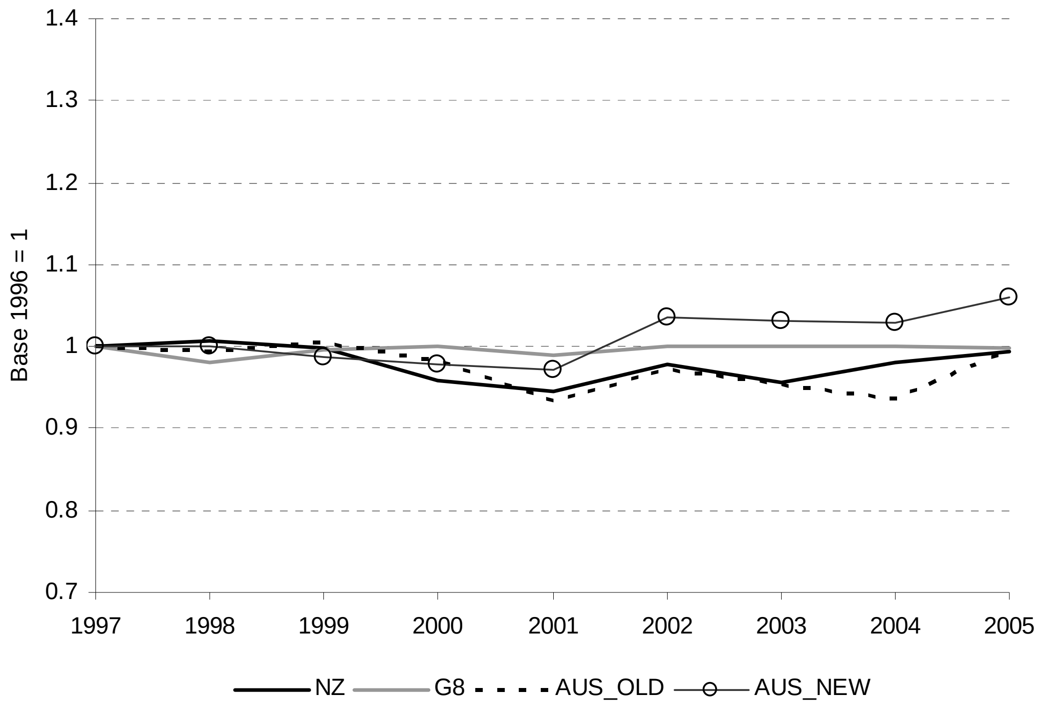
[86] A new university would be unlikely to begin in a position of high technical efficiency. There is likely to be some 'learning' required by the management of the institution before a new university begins to improve their mix of inputs and outputs.

Figure 3.23, Cumulative technical efficiency growth by Australasian university grouping 1997-2005, completions specification



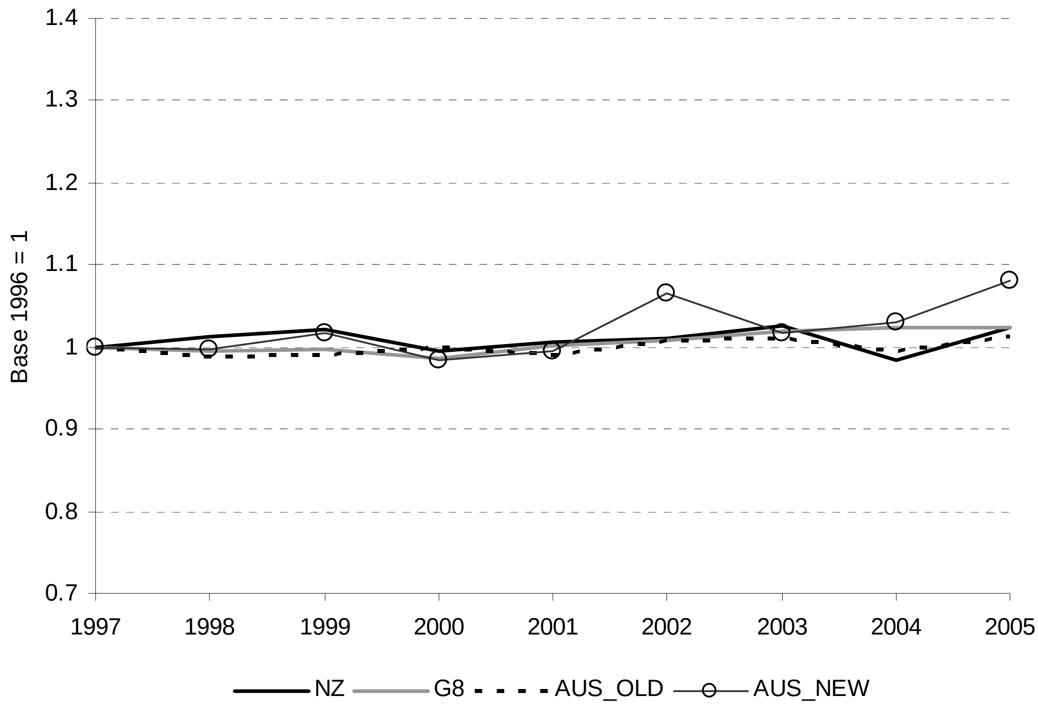
Technical efficiency growth can be disaggregated into pure technical efficiency and scale efficiency growth. Figure 3.24 shows the cumulative pure technical efficiency growth for the four groupings of Australasian universities. Between 1997 and 2001, all four of the university groupings exhibited deterioration in cumulative pure technical efficiency. Since then, only AUS_NEW universities achieved significant pure technical efficiency growth.

Figure 3.24, Cumulative pure technical efficiency growth by Australasian university grouping 1997-2005, completions specification



The cumulative scale efficiency change for the four Australasian groupings of universities is presented in Figure 3.25. 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.

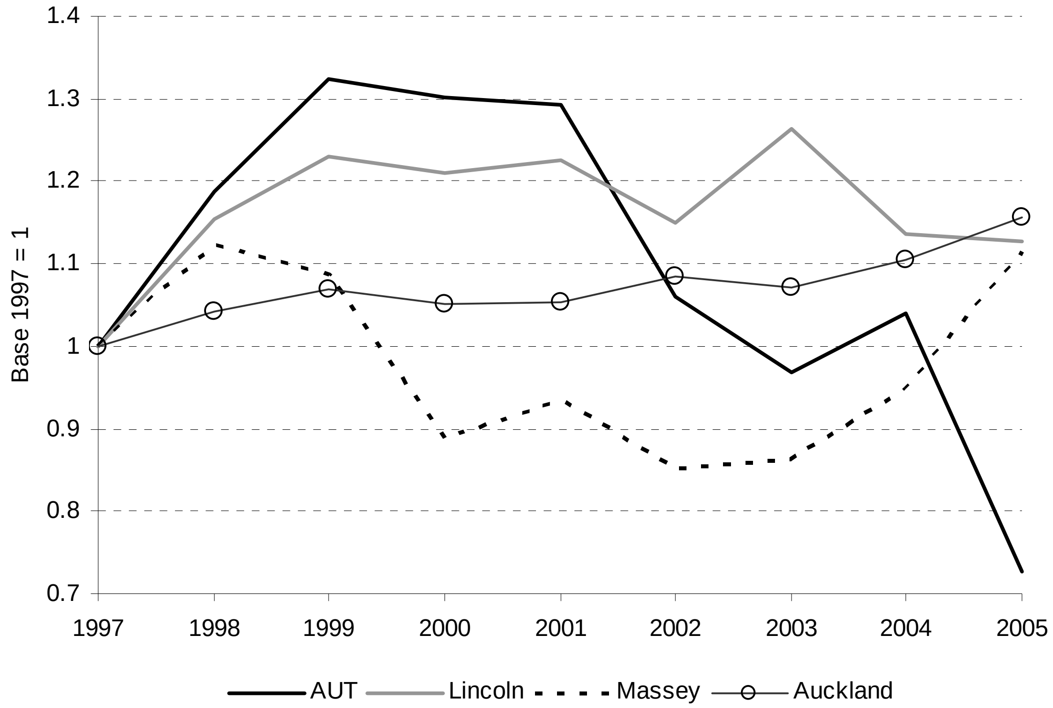
Figure 3.25, Cumulative scale efficiency growth by Australasian university grouping 1997-2005, completions specification

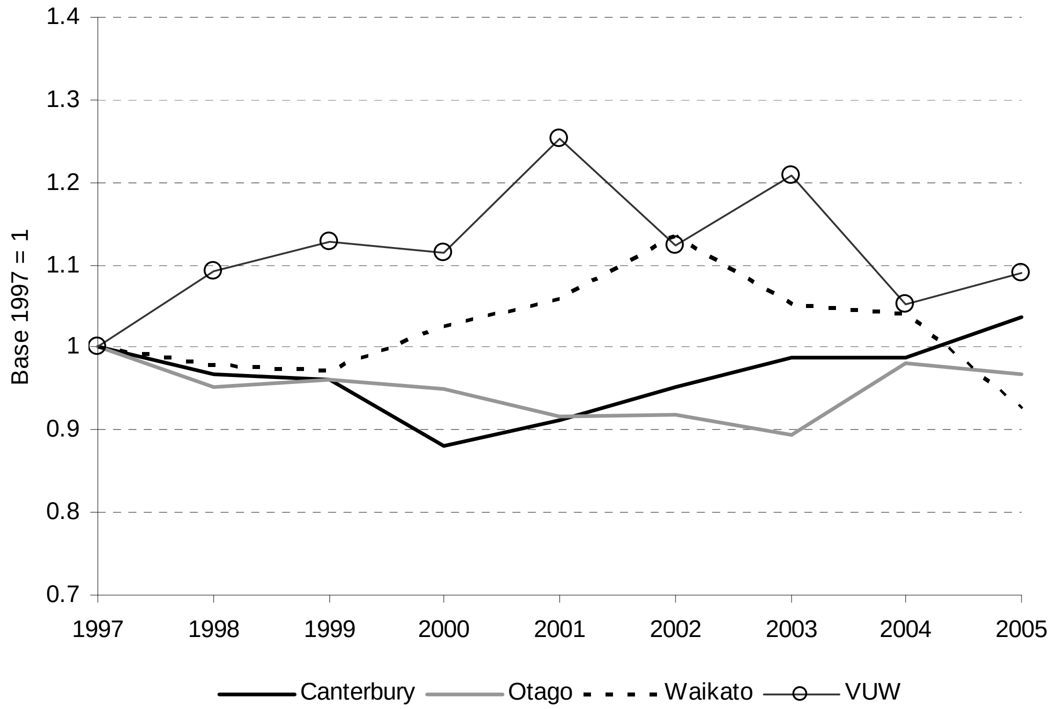


The mean total factor productivity growth presented in Figure 3.21 masks trends in the performance of the individual New Zealand universities. In particular, the strong growth at AUT while it was still a polytechnic and then fall in total factor productivity following it becoming a university impact on the overall New Zealand average. Figure 3.26 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 3.26, Cumulative total factor productivity growth by individual New Zealand universities 1997-2005, completions specification





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.

The performance of the University of Waikato is concerning, given that is displayed the lowest technical efficiency of the New Zealand universities in the analysis in section 3.5.4.2. Although there was steady growth in total factor productivity between 1997 and 2002, since then total factor productivity has fallen significantly.[87]

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 factors analysed include some of the previously identified key drivers of productivity growth, such as increased numbers of international students. The financial performance of the universities is also examined for signs that poor financial performance in one year is followed by an increase in productivity the following year.

For the purposes of this analysis, the regression analysis is run for two model specifications, each with a different dependent variable. The two dependent variables are the total factor productivity estimates derived from the completions model specification and the total factor productivity estimates from the enrolments model specification.

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[87] 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.

In addition, the regression is 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.

A variable (INTERNATIONAL) is included in the regression analysis that measures the change in proportion of international students enrolled at a university.[88] 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 is 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 will capture if poor financial performance is responded to by moves to improve productive efficiency.

A variable to capture the impact of time (TIME) is 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 is 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.

The explanatory variables included in the regression analysis are defined in Table 3.40.

[88] Mean = 0.019, standard deviation = 0.025, minimum = -0.115, maximum = 0.161.

Table 3.40, 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 3.41 and Table 3.42.

Table 3.41, Results of panel regression: Total factor productivity of Australasian universities 1997-2005, completions specification

(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.

Table 3.42, Results of panel regression: Total factor productivity of Australasian universities 1997-2005, enrolments specification

(Dependent variable = total factor productivity)

Variable	All		New Zealand		Australian	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
LOSS	0.025*	0.011	0.076**	0.029	0.019	0.011
INTERNATIONAL	0.636**	0.151	0.227	0.306	0.686**	0.170
TIME	< 0.000	0.001	0.003	0.003	< 0.000	0.002
UNI_GROUPING						
AUS_NEW	0.019	0.010	n/a		-0.014	0.008
AUS_OLD	0.010	0.010	n/a		-0.023*	0.009
G8	0.033**	0.010	n/a		Reference category	
AUT_OLD	0.058**	0.020	0.066**	0.020	n/a	
AUT_NEW	-0.028*	0.013	-0.022	0.013	n/a	
NZ	Reference category		Reference category		n/a	
CONSTANT	0.986**	0.010	0.974**	0.016	1.018**	0.010
R^2	0.11		0.23		0.08	
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.[89] These powers have never been used in the

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

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.[90] 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 3.40 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 AUS_NEW universities 3.1 percentage points higher than the New Zealand universities (excluding AUT).

The results in Table 3.41, which uses the enrolments specification, shows that the G8 universities achieved total factor productivity growth that was 3.3 percentage points higher than New Zealand universities (excluding AUT). However, there was no statically significant difference in total factor productivity growth of AUS_NEW universities and New Zealand universities under this specification.

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

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.

Table 3.34 to Table 3.38 also include an indication if the Malmquist indices were statistically significant using Simar and Wilson's (1999) bootstrapping approach to generate 95 percent confidence intervals. The results suggest that the changes in productivity may be overstated, especially in the case of changes in scale efficiency indices. For the New Zealand universities, 33 percent of the total factor productivity indices were statistically significant, 17 percent of technology, 22 percent of technical efficiency, 11 percent of pure technical efficiency and 0 percent of scale efficiency indices.

Overall, the association between improved productivity and improved financial performance is weak. Figure 3.27 compares the mean total factor productivity change between 1997 and 2005 with the percentage point change in return on income over the same period. Generally, New Zealand universities that improved their productivity improved their financial position. Three of the four New Zealand universities with positive mean total factor productivity growth exhibited a positive percentage point change in return on income between 1997 and 2005. However, a similar relationship is not apparent for the Australian universities, where 17 out of 33 universities with positive total factor productivity growth had a percentage point decrease in return on income between 1997 and 2005.[91]

[91] The Pearson's correlation coefficient for the value of mean total factor productivity and the percentage point change in return on income was 0.28 for the New Zealand universities and 0.23 for the Australian universities.

Figure 3.27, Mean total factor productivity vs percentage point change in return on income of Australasian universities 1997-2005, completions specification

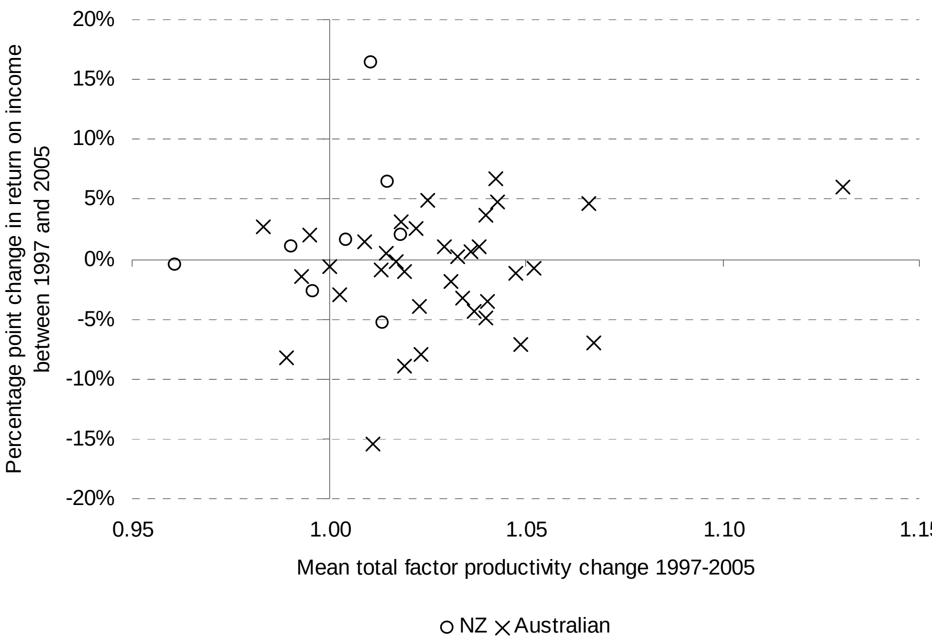
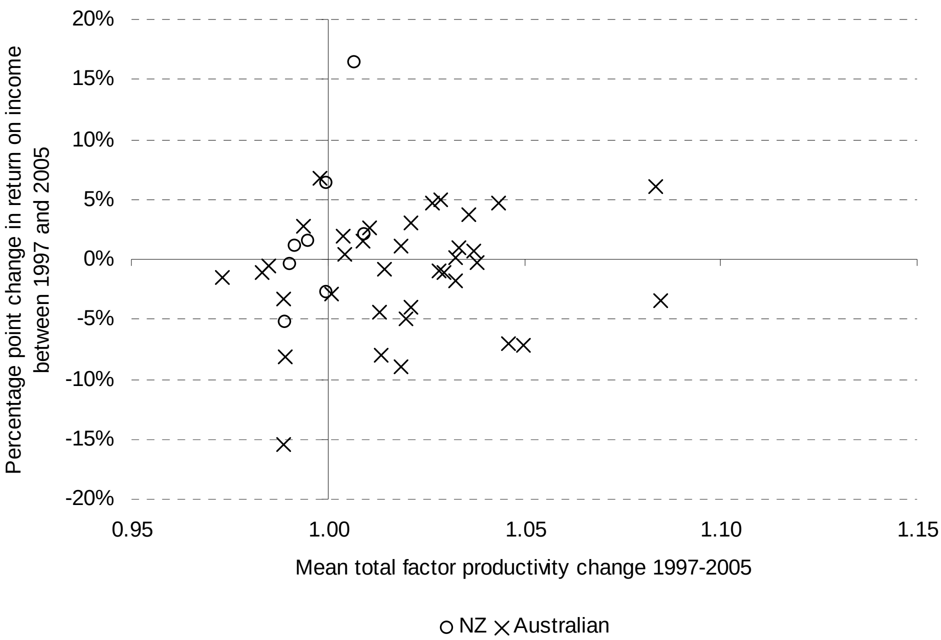


Figure 3.28 compares mean total factor productivity growth in the alternate enrolments specification with the change in return on income. This may show a stronger relationship between productivity growth and financial performance, given that funding is more aligned with enrolments rather than qualification completions.

The correlation between total factor productivity growth and the percentage point change in return on income is stronger for New Zealand universities in this enrolments specification, compared with the completions specification.[92] However, it shows that three of the six New Zealand universities with negative mean total factor productivity growth managed to achieve an improvement in financial performance between 1997 and 2005. This compares with 13 out of 28 Australian universities with positive mean total factor productivity growth exhibiting a percentage point fall in return on income between 1997 and 2005.

[92] The Pearson's correlation coefficient for the value of mean total factor productivity and the percentage point change in return on income 0.64 for New Zealand universities and 0.19 for Australian universities.

Figure 3.28, Mean total factor productivity vs percentage point change in return on income of Australasian universities 1997-2005, enrolments specification



Although this study is focused on the performance of New Zealand universities, the weaker association between positive productivity growth and improved financial performance in Australian universities would be a concern for policymakers. A possible explanation for this result would be that funding levels are not rewarding this improved productivity and/or the cost of some of the inputs into the productive process may be increasing faster than improvements in productivity.

3.5.5 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 section has examined the ability of the universities to achieve these objectives efficiently.

The analysis of the efficiency and productivity growth of New Zealand universities has identified some key trends in their performance. Although in many cases New Zealand universities are as efficient as Australian universities, their relative performance has been eroding over time. 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.

3.5.6 Appendix

Table 3.43, Results of DEA of Australasian universities 2005, enrolments specification

University	Technical efficiency		Scale efficiency	Return to scale	Pure technical efficiency 95 % confidence intervals	
	CRS	VRS			Lower	Upper
AUT	0.896	0.942	0.951	DRS	0.916	0.958
Lincoln	0.693	1.000	0.693	IRS	0.913	1.053
Massey	0.844	0.943	0.895	DRS	0.925	0.957
Auckland	0.854	0.983	0.869	DRS	0.953	1.003
Canterbury	1.000	1.000	1.000	-	0.931	1.047
Otago	0.968	0.988	0.979	DRS	0.956	1.007
Waikato	0.803	0.822	0.977	DRS	0.791	0.840
VUW	1.000	1.000	1.000	-	0.942	1.042
Charles Sturt	1.000	1.000	1.000	-	0.932	1.047
Macquarie	0.975	1.000	0.975	DRS	0.973	1.025
Southern Cross	0.874	0.977	0.895	IRS	0.946	1.000
New England	0.825	0.851	0.969	IRS	0.835	0.862
NSW	0.980	0.983	0.996	DRS	0.953	1.002
Newcastle	0.849	0.890	0.955	DRS	0.867	0.907
Sydney	1.000	1.000	1.000	-	0.927	1.052
UTS	0.841	0.916	0.918	DRS	0.899	0.931
Western Sydney	0.973	1.000	0.973	DRS	0.953	1.039
Wollongong	1.000	1.000	1.000	-	0.930	1.047
Deakin	0.766	0.864	0.887	DRS	0.849	0.878
La Trobe	0.803	0.892	0.901	DRS	0.876	0.906
Monash	0.889	1.000	0.889	DRS	0.913	1.051
RMIT	0.934	1.000	0.934	DRS	0.935	1.045
Swinburne	0.961	0.961	0.999	DRS	0.924	0.981
Ballarat	1.000	1.000	1.000	-	0.914	1.054
Melbourne	1.000	1.000	1.000	-	0.940	1.030
VUT	0.818	0.878	0.932	DRS	0.855	0.893
CQU	1.000	1.000	1.000	-	0.913	1.052
Griffith	0.775	0.945	0.820	DRS	0.931	0.956
James Cook	0.920	0.941	0.979	IRS	0.913	0.959
QUT	0.809	1.000	0.809	DRS	0.982	1.018
Queensland	0.978	1.000	0.978	DRS	0.956	1.025
South Queensland	1.000	1.000	1.000	-	0.918	1.051
Curtin	0.869	0.999	0.870	DRS	0.981	1.014
Edith Cowan	0.849	0.866	0.980	DRS	0.830	0.882
Murdoch	0.772	0.779	0.992	IRS	0.755	0.793
Western Australia	1.000	1.000	1.000	-	0.932	1.047
Flinders	0.943	0.984	0.958	IRS	0.933	1.005
Adelaide	0.979	0.993	0.985	IRS	0.962	1.013
South Australia	0.913	0.989	0.923	DRS	0.971	1.003
Tasmania	0.833	0.835	0.998	IRS	0.821	0.847
NTU	0.996	1.000	0.996	IRS	0.912	1.056
ANU	1.000	1.000	1.000	-	0.946	1.038
Canberra	0.916	1.000	0.916	IRS	0.954	1.036
Catholic	1.000	1.000	1.000	-	0.910	1.053
Mean	*0.911*	*0.960*	*0.950*		*0.915*	*0.989*

Table 3.44, Mean Malmquist indices for Australasian universities 1997-2005, enrolments specification

University	Total factor productivityΔ	Technical efficiencyΔ	TechnologyΔ	Pure technical efficiencyΔ	Scale efficiencyΔ
AUT	0.990	0.986	1.004	0.993	0.994
Lincoln	1.000	0.988	1.012	1.000	0.988
Massey	0.989	0.985	1.005	0.993	0.992
Auckland	1.009	0.996	1.013	0.999	0.997
Canterbury	0.995	1.000	0.995	1.000	1.000
Otago	1.000	0.996	1.004	0.999	0.997
Waikato	0.992	0.995	0.997	0.993	1.002
VUW	1.007	1.001	1.006	1.000	1.001
Charles Sturt	1.030	1.009	1.021	1.005	1.003
Macquarie	1.029	1.017	1.012	1.007	1.010
Southern Cross	0.989	0.987	1.002	0.997	0.989
New England	1.001	0.988	1.013	0.988	1.000
NSW	1.050	1.023	1.026	1.006	1.017
Newcastle	1.019	1.017	1.002	1.003	1.014
Sydney	1.036	1.008	1.028	1.000	1.008
UTS	0.989	0.985	1.003	0.989	0.996
Western Sydney	1.020	1.017	1.003	1.000	1.017
Wollongong	1.043	1.027	1.016	1.026	1.000
Deakin	0.983	0.967	1.016	0.982	0.985
La Trobe	0.973	0.973	1.000	0.986	0.987
Monash	1.033	1.003	1.029	1.000	1.003
RMIT	1.038	1.017	1.021	1.001	1.016
Swinburne	1.013	0.995	1.018	0.995	1.000
Ballarat	1.046	1.022	1.024	1.000	1.022
Melbourne	1.037	1.003	1.035	1.000	1.003
VUT	0.985	0.975	1.010	0.984	0.991
CQU	1.083	1.018	1.064	1.009	1.009
Griffith	1.013	1.002	1.011	1.010	0.992
James Cook	1.033	1.025	1.008	1.021	1.003
QUT	1.004	0.988	1.017	1.000	0.988
Queensland	1.032	1.011	1.021	1.000	1.011
South Queensland	1.027	1.009	1.018	1.008	1.001
Curtin	1.028	1.017	1.011	1.017	1.001
Edith Cowan	0.998	0.991	1.007	0.985	1.006
Murdoch	0.989	0.999	0.989	0.991	1.008
Western Australia	1.021	1.000	1.021	1.000	1.000
Flinders	1.009	1.006	1.003	1.006	1.000
Adelaide	1.021	0.997	1.024	0.999	0.998
South Australia	1.019	1.015	1.003	1.007	1.008
Tasmania	1.004	0.997	1.007	0.997	1.000
NTU	1.085	1.059	1.024	1.000	1.059
ANU	1.011	1.000	1.011	1.000	1.000
Canberra	1.014	1.015	1.000	1.023	0.992
Catholic	0.994	1.000	0.994	1.000	1.000
Mean	*1.015*	*1.003*	*1.012*	*1.000*	*1.002*

Note, All means are geometric means.

Table 3.45, Peer institutions of Australasian universities 2005

	University	Model	
		Completions	Enrolments
1	AUT	n/a	17, 22, 44
2	Lincoln	n/a	n/a
3	Massey	1, 9, 15, 17, 25	5, 9, 15, 17
4	Auckland	n/a	15, 21, 22
5	Canterbury	n/a	n/a
6	Otago	2, 9, 36	15, 27, 36
7	Waikato	1, 2, 37	5, 17, 32
8	VUW	n/a	n/a
9	Charles Sturt	n/a	n/a
10	Macquarie	n/a	n/a
11	Southern Cross	n/a	2, 5, 24, 43, 44
12	New England	2, 9, 16, 25, 42, 43	2, 5, 24, 27
13	NSW	n/a	15, 27, 36
14	Newcastle	1, 9, 15, 36, 37	5, 9, 15, 17
15	Sydney	n/a	n/a
16	UTS	n/a	9, 15, 17, 22
17	Western Sydney	n/a	n/a
18	Wollongong	n/a	n/a
19	Deakin	1, 9, 16, 17, 25	9, 15, 22, 27
20	La Trobe	1, 9, 15, 16, 37	5, 8, 15, 17
21	Monash	n/a	n/a
22	RMIT	10, 16, 17, 21	n/a
23	Swinburne	1, 18, 41, 44	18, 24, 27
24	Ballarat	n/a	n/a
25	Melbourne	n/a	n/a
26	VUT	9, 16, 17, 24, 44	22, 24, 27
27	CQU	n/a	n/a
28	Griffith	9, 15, 16, 17, 25	9, 15, 17, 22
29	James Cook	2, 5, 9, 36	2, 5, 27, 36
30	QUT	n/a	n/a
31	Queensland	n/a	n/a
32	Southern Queensland	n/a	n/a
33	Curtin	9, 15, 17	9, 15, 17, 22
34	Edith Cowan	1, 2, 9, 16, 37, 43	5, 9, 17, 32
35	Murdoch	1, 2, 9, 36, 37	2, 5, 24, 27, 36
36	Western Australia	n/a	n/a
37	Flinders	n/a	2, 5
38	Adelaide	5, 15, 36, 37, 41	5, 15, 18,36, 41
39	South Australia	9, 15, 16, 17, 18	5, 15, 17
40	Tasmania	1, 2, 9, 15, 36, 41	5, 15, 18, 27, 36
41	NTU	n/a	n/a
42	ANU	n/a	n/a
43	Canberra	n/a	n/a
44	Catholic	n/a	n/a

3.6 Measuring the productive efficiency of New Zealand tertiary education institutions

3.6.1 Introduction

In this section, Data Envelopment Analysis (DEA) is used to measure the efficiency of all four types of tertiary education institution (TEI) – universities, polytechnics, colleges of education and wānanga. The institutions chosen for this analysis were those that participated in the 2006 Performance-Based Research Fund (PBRF) Quality Evaluation.[93] This included: all universities, half of the polytechnics (10), two of the three wānanga and two colleges of education. As such, there is an element of bachelors degree provision and research at each of these institutions. In addition, there is an element of fluidity between the subsectors. One polytechnic (Auckland Institute of Technology) has become a university, while another polytechnic (Wellington) and all of the colleges of education have been absorbed by universities. Therefore, there is arguably a degree of homogeneity between the TEIs which makes a comparison of their efficiency meaningful.[94]

An analysis of this nature is important as the provision of degree-level teaching by non-university TEIs has proved somewhat controversial over time. There have been allegations that degrees from non-university TEIs have a lack of parity of esteem with university degrees (OECD 1997, TEAC 2001).[95] In addition, given the drain that the requirement for research places on TEIs offering degrees, it is questionable whether smaller regional polytechnics in particular should be engaging in degree provision.

A previous study by Yahanpath and Wang (2003) used DEA to compare the performance of TEIs across New Zealand TEI subsectors. Specifically, they compared the technical efficiency of universities and polytechnics in 1999 and found that polytechnics had higher levels of technical efficiency than universities.

[93] Not all polytechnics and wānanga participated in the 2006 PBRF Quality Evaluation. Ten out of 20 polytechnics participated and two out of three wānanga participated.
[94] The inclusion of all participating TEIs also increases the number of decision making units (DMUs) in the analysis.
[95] This issue is the subject of analysis in the next chapter.

However, their analysis did not include an output measure to capture research output and so the finding must be viewed with caution.[96]

This study takes a more balanced approach in comparing the efficiency of TEI subsectors by including a measure of research output – the sum of the Performance-Based Research Fund (PBRF) quality scores achieved by staff at participating TEIs. Although the quality scores measure the *quality* of research, rather than the *quantity*, this measure is one of the key drivers of funding allocated for research purposes by the government.[97] In addition, the quality scores are made publicly available, adding to the incentive for TEIs to maximise their research quality. The other key determinant of TEI funding is the number of students they enrol.

Therefore, analysing the efficiency of TEIs in producing these two outputs will provide an indication to policy makers about the appropriate use of resources in achieving the government's objectives in tertiary education.

The structure of this section is as follows. First, some background on the four subsectors is presented in section 3.6.2. Then, the data used in the DEA is presented in section 3.6.3. This is followed in section 3.6.4 by the results of the application of DEA to the 22 TEIs in this study. Finally, in section 3.6.5 some conclusions are presented.

3.6.2 Background

As was outlined in section 3.5.2, most of the eight universities can trace their history back well into the 19th century. They are among the largest providers of tertiary education in New Zealand and have the greatest research capability.

The history of polytechnics as autonomous institutions dates back to the early 1960s. They are mostly providers of vocational education and generally have a limited

[96] To be fair to the authors, a comparable measure of research output across the TEI subsectors was not available at that time.
[97] Hazeldine and Kurniawan (2006) use PBRF scores as a measure of output in their analysis of productivity of New Zealand universities.

research capability, given that they have only been offering degrees since the early 1990s.[98]

The first of the colleges of education was established in 1876.[99] However, it was not until the late 1990s that they began to offer degrees in their own right. As a result, the research capability of the colleges of education is much lower than the universities.

By 2006, just two colleges of education remained as autonomous TEIs. These were the Christchurch College of Education (CCE) and the Dunedin College of Education (DCE).[100] In 2004, the University of Auckland absorbed the Auckland College of Education. Then, in 2005, the Wellington College of Education was absorbed by Victoria University of Wellington (VUW).[101]

The two wānanga in this study are among the most recent institutions to become TEIs. Te Wānanga o Aotearoa (TWoA) became a TEI in 1993 and Te Whare Wānanga o Awanuiarangi (TWWoA) became a TEI in 1997. Wānanga were established to offer programmes mainly to Māori students, although the scope of provision has ended up somewhat wider than that. One of the wānanga, TWoA, was only established in the mid 1990s, but expanded quickly to become the largest TEI, in terms of enrolments, in 2003. Since then, TWoA has reduced in size as a result of financial difficulties and restrictions on the programmes funded by the government. Although generally having limited involvement in degree provision, one of the wānanga, TWWoA, does offer degrees at the PhD level.

3.6.3 Data

The inputs available for this study of TEI efficiency are similar to those used in previous sections. The number of full-time academic (ACADEMIC) and general staff (GENERAL) are available for inclusion in the model specification. Also available are the value of fixed assets (ASSETS) and non-labour operating expenditure (OTHEREXP).

[98] More detail on the history of polytechnics can be found in section 3.4.2.
[99] Dunedin College of Education.
[100] However, in 2007, CCE was absorbed by the University of Canterbury and DCE was absorbed by the University of Otago.
[101] Previously, Palmerston North College of Education was absorbed by Massey University in 1996 and Hamilton Teachers College was absorbed by the University of Waikato in 1990.

To measure the teaching output of the TEIs the number of equivalent full-time students is used (STUDENTS). The use of qualification completions is not appropriate in this analysis, as there is a significant amount of teaching provision at polytechnics that does not result in the conferring of formal qualifications.[102]

To measure research output, the total quality score achieved by each of the TEIs is used (RESEARCH). Although this is not strictly a measure of the quantity of research, it is the key measure that the government uses to fund research activities at TEIs. Therefore, achieving the maximum quality as efficiently as possible should be a key objective of the TEIs. The inputs and outputs used in the DEA are summarised in Table 3.46 below.

Table 3.46, Definitions of input and output variables used in the DEA of tertiary education institutions

Variables	Definition
Inputs:	
ACADEMIC	Total number of full-time equivalent academic staff.
GENERAL	Total number of full-time equivalent general staff.
OTHEREXP	Total operating expenditure on non-labour items ($000s).
ASSETS	Total fixed assets ($000s).
Outputs:	
STUDENTS	Total number of equivalent full-time students.
RESEARCH	Total PBRF quality score.

Source, Ministry of Education, Tertiary Education Commission and annual reports of New Zealand tertiary education institutions.

The summary statistics of the input and output variables are presented in Table 3.47.

Table 3.47, Descriptive statistics of input and output variables used in the DEA of New Zealand tertiary education institutions

Variables	Mean	Standard deviation	Min	Max
Inputs:				
ACADEMIC (FTEs)	493	408	63	1,597
GENERAL (FTEs)	642	684	82	2,468
OTHEREXP ($000s)	60,607	67,817	6,523	287,268
ASSETS ($million)	281	356	10	1,168
Outputs:				
STUDENTS (EFTS)	9,323	7,577	908	29,451
RESEARCH (Quality score)	1,086	1,792	7	6,316

[102] Such as Training Opportunities Programmes (TOPs).

3.6.4 Results

As there are only 22 TEIs in this analysis, it is important to arrive at a model that is as parsimonious as possible. Therefore, the Pastor *et al*. (2002) test and Spearman's rank coefficient are used to identify if any of the input or output variables could be removed from the model.

The results of the Pastor *et al*. (2002) test and Spearman's rank test in Table 3.48 and Table 3.49 show that the removal of GENERAL and ASSETS had little impact on the technical efficiency estimates produced by the DEA. Therefore, the parsimonious model selected for this analysis removes both of these input variables. This leaves two inputs and two outputs in the DEA.

Table 3.48, Testing alternative specifications of the DEA model applied to New Zealand tertiary education institutions, assuming constant returns to scale

Variable	Model					
	1	2	3	4	5	6
ACADEMIC		×	×	×	×	×
GENERAL	×		×	×	×	×
OTHEREXP	×	×		×	×	×
ASSETS	×	×	×		×	×
STUDENTS	×	×	×	×		×
RESEARCH	×	×	×	×	×	
Pastor *et al*. (2002) *p*-value	0.86	0.97	0.00	0.97	0.00	0.00
Spearman's *r*	0.96	0.98	0.78	0.99	0.41	0.19

Table 3.49, Testing alternative specifications of the DEA model applied to New Zealand tertiary education institutions, assuming variable returns to scale

Variable	Model					
	1	2	3	4	5	6
ACADEMIC		×	×	×	×	×
GENERAL	×		×	×	×	×
OTHEREXP	×	×		×	×	×
ASSETS	×	×	×		×	×
STUDENTS	×	×	×	×		×
RESEARCH	×	×	×	×	×	
Pastor *et al*. (2002) *p*-value	0.86	0.97	0.00	0.97	0.00	0.04
Spearman's *r*	0.85	0.98	0.82	0.98	0.62	0.37

This model specification means that a TEI will be efficient if they can maximise the delivery of education and the quality of their research, given their mix of inputs.

The results of the DEA are produced in Table 3.50. The results include the technical efficiency estimates, for both the CRS and VRS assumptions, and their associated 95 percent confidence intervals.

Overall, the mean pure technical efficiency was 0.913. In other words, outputs could be increased by 8.7 percent with the existing set of inputs. Although Yahanpath and Wang (2003) found that polytechnics were more efficient than universities in 1999, this is clearly not the case in 2006 once research output is taken into consideration. The average pure technical efficiency for polytechnics was 0.871, compared with 0.973 for universities. The mean pure technical efficiency for the two wānanga was highest at 1, while the two colleges of education had mean pure technical efficiency of 0.795.

Table 3.50, Results of DEA of New Zealand tertiary education institutions 2006

Subsector	TEI	Technical efficiency		Scale efficiency	Returns to scale	Pure technical efficiency 95 % confidence intervals	
		CRS	VRS			Lower	Upper
Polytechnic	CPIT	0.850	0.889	0.957	DRS	0.861	0.911
	EIT	0.915	0.917	0.997	DRS	0.856	0.969
	MIT	0.853	0.895	0.953	DRS	0.867	0.920
	NMIT	1.000	1.000	1.000	-	0.945	1.100
	North	0.799	0.815	0.981	DRS	0.779	0.850
	Otago	0.748	0.766	0.977	DRS	0.742	0.789
	TOPNZ	1.000	1.000	1.000	-	0.905	1.131
	Unitec	0.924	0.967	0.956	DRS	0.934	1.003
	WINTEC	0.772	0.785	0.983	DRS	0.752	0.817
	Whitireia	0.666	0.672	0.990	DRS	0.647	0.703
	Mean	*0.853*	*0.871*	*0.979*		*0.829*	*0.919*
University	AUT	0.781	0.828	0.943	DRS	0.777	0.876
	Lincoln	0.777	0.955	0.813	IRS	0.898	1.011
	Massey	0.858	1.000	0.858	DRS	0.955	1.069
	Auckland	0.932	1.000	0.932	DRS	0.888	1.138
	Canterbury	0.996	0.997	0.998	IRS	0.941	1.059
	Otago	1.000	1.000	1.000	-	0.925	1.118
	Waikato	1.000	1.000	1.000	-	0.941	1.106
	VUW	0.941	1.000	0.941	DRS	0.961	1.069
	Mean	*0.911*	*0.973*	*0.936*		*0.911*	*1.056*
Wānanga	TWoA	1.000	1.000	1.000	-	0.887	1.134
	TWWoA	0.891	1.000	0.891	IRS	0.949	1.090
	Mean	*0.946*	*1.000*	*0.946*		*0.918*	*1.112*
College of education	CCE	0.550	0.589	0.933	IRS	0.554	0.627
	DCE	0.531	1.000	0.531	IRS	0.892	1.143
	Mean	*0.541*	*0.795*	*0.732*		*0.723*	*0.885*
Mean		0.854	0.913	0.938		0.857	0.983

Because of a lack of available data for explanatory variables, a nonparametric test – the Mann Whitney rank sum test – rather than truncated regression is used to determine if the pure technical efficiency of each subsector is significantly different from one other. As can be seen in Table 3.51, the results of the Mann-Whitney tests confirm that the pure technical efficiency of polytechnics was lower than that of universities. None of the other subsectors exhibited pure technical efficiency that was significantly different from each other, although the relatively small number of DMUs in the college of education and wānanga subsector is a factor in this finding.

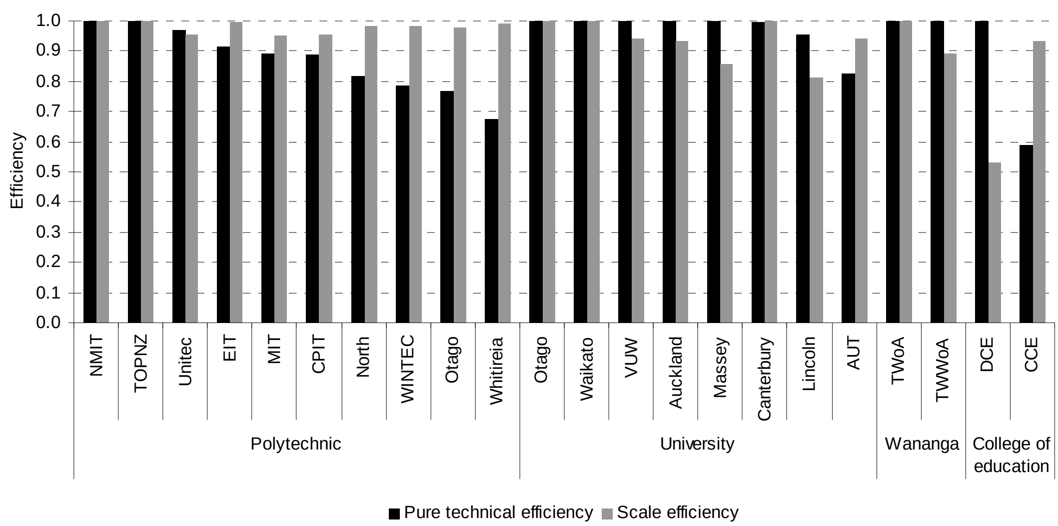
Table 3.51, Mann Whitney rank sum test results: Pure technical efficiency

TEI being compared	P>|z|
Polytechnic vs university	0.02*
Polytechnic vs wānanga	0.08
Polytechnic vs CoE	0.83
University vs CoE	0.34
University vs wānanga	0.46
CoE vs wānanga	0.32

Note, * significant at 5 percent level

The pure technical efficiency and scale efficiency estimates of individual TEIs are presented in Figure 3.29 below, with each TEI ranked from highest to lowest pure technical efficiency within each of their respective subsectors.

Figure 3.29, Pure technical efficiency estimates and scale efficiency estimates of New Zealand tertiary education institutions 2006



In terms of the performance of individual TEIs, the University of Waikato achieved a pure technical efficiency of 1 in 2006. This compares with the relatively high degree of inefficiency exhibited by this university in the DEA in the previous section. Although not strictly comparable as the analysis involves different DMUs and a different variable to capture research output, this suggests that Waikato seems to have improved its pure technical efficiency within the space of a year. An examination of the full-time equivalent (FTE) staffing of the University of Waikato suggests that they engaged in a restructuring exercise in 2006. Between 2005 and 2006, FTE academic staff decreased by nine percent, while the number of EFTS reduced by four percent. As a result, the number of EFTS per academic staff member rose from 15.1 to 15.6.

The relatively low pure technical efficiency exhibited by AUT in Table 3.50 is in contrast to its performance in section 3.5.5. However, in the enrolments specification in Table 3.43, AUT achieved a pure technical efficiency of 0.942 in 2005. Given the rate of decline in total factor productivity shown in Figure 3.26, it is perhaps not surprising that AUT has fallen further behind the other universities as it continues to readjust from operation as a polytechnic to operation as a university.

The pure technical efficiency of the polytechnics in Table 3.50 show a similar relationship to those generated in the analysis of polytechnic efficiency in section 3.4.4.1. The Pearson's correlation coefficient between the two sets of pure technical efficiency estimates is 0.92.

Among the polytechnics, the top placing of TOPNZ and NMIT with a pure technical efficiency value of 1 reflects the extramural status of the former, and a relatively high degree of subcontracting in the latter. The polytechnics with the lowest pure technical efficiency were Whitireia (0.672), Otago (0.766) and WINTEC (0.785).

The two colleges of education exhibit vastly different pure technical efficiency estimates. CCE has a pure technical efficiency of 0.589, the lowest of the TEIs in this analysis. DCE on the other hand exhibited a pure technical efficiency value of 1. Given that 2006 was the last year before these two colleges of education were absorbed by universities, this might explain some of the low efficiency by CCE.

The two wānanga both exhibited a pure technical efficiency value of 1. Part of the reason for this is due to the mix of courses, some of which included distance learning.

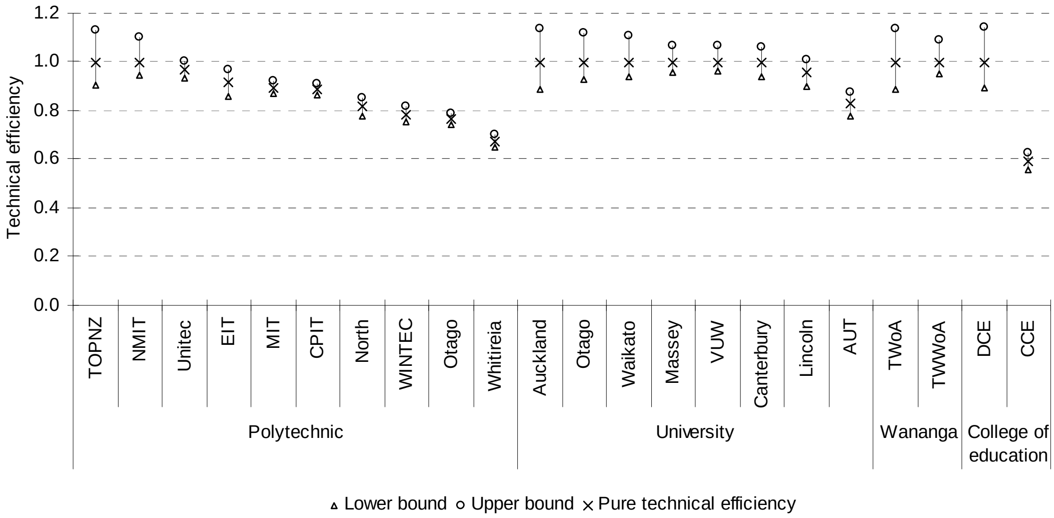
The returns to scale results in Table 3.50 shows that DRS dominate in the polytechnic sector – eight out of ten polytechnics have a scale efficiency value of less than 1. Nevertheless, the mean scale efficiency of 0.979 was the highest of the four TEI subsectors. Although the polytechnics could benefit from a reduction in scale, it is questionable whether they could do so and remain viable.

In 2007, the CCE was absorbed by the University of Canterbury and the DCE was absorbed by the University of Otago. The results in Table 3.50 provide some support for this move, given that the University of Canterbury, CCE and DCE all exhibited IRS in 2006.

However, the evidence on mergers is mixed as the University of Auckland and VUW exhibit DRS. This would suggest that their absorption of the Auckland College of Education and Wellington College of Education, respectively, may have been detrimental to the scale efficiency of these institutions. Massey University also exhibits significant DRS, which suggest that the merger with Wellington Polytechnic in 1999 and the operation of multiple campuses is detrimental to scale efficiency.

The pure technical efficiency estimates and their associated 95 percent confidence intervals are illustrated in Figure 3.30, ranked in order within their respective subsectors.

Figure 3.30, Estimates of pure technical efficiency of New Zealand tertiary education institutions and their associated 95 percent confidence intervals 2006



Among the universities, there is no statistically significant difference in the pure technical efficiency estimates exhibited by seven of the eight universities. The one university with lower pure technical efficiency was AUT.

The pure technical efficiency of EIT, Northland Polytechnic, WINTEC, Otago Polytechnic and Whitireia Polytechnic is well below that of the majority of universities. Finally, the performance of CCE was clearly below that of all other TEIs.

The association between technical efficiency and the financial performance of the TEIs is now examined. To do this the technical efficiency of the 22 TEIs is compared with their return on income in 2006. This will show if higher levels of efficiency is rewarded in better financial performance.

Figure 3.31 compares the technical efficiency under the CRS assumption with the return on income for the 22 TEIs. It shows that a higher level of technical efficiency was generally associated with a higher level of return on income. The two wānanga and one of the colleges of education (CCE) appear to be outliers.

Figure 3.31, Technical efficiency vs return on income for New Zealand tertiary education institutions 2006

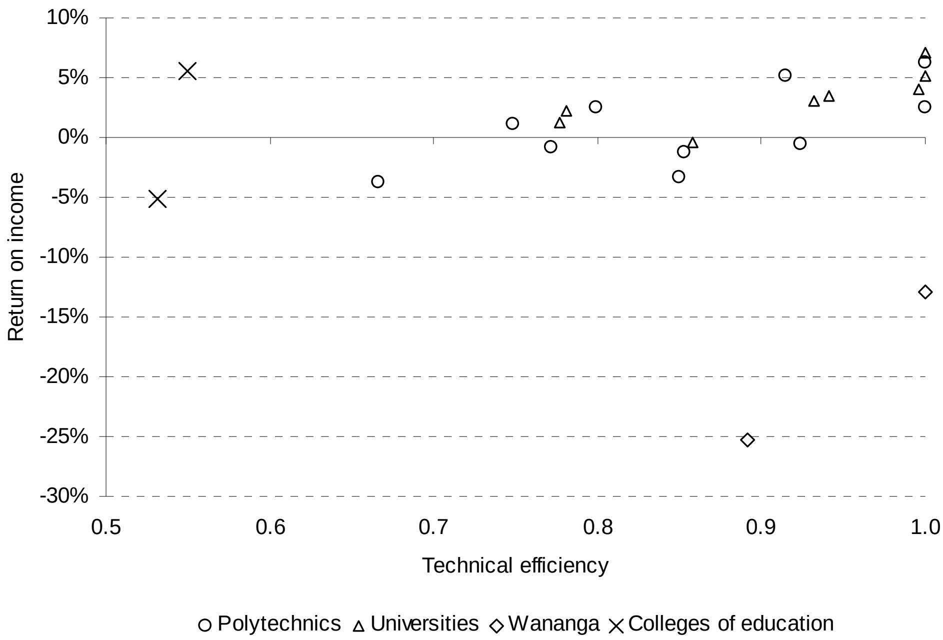
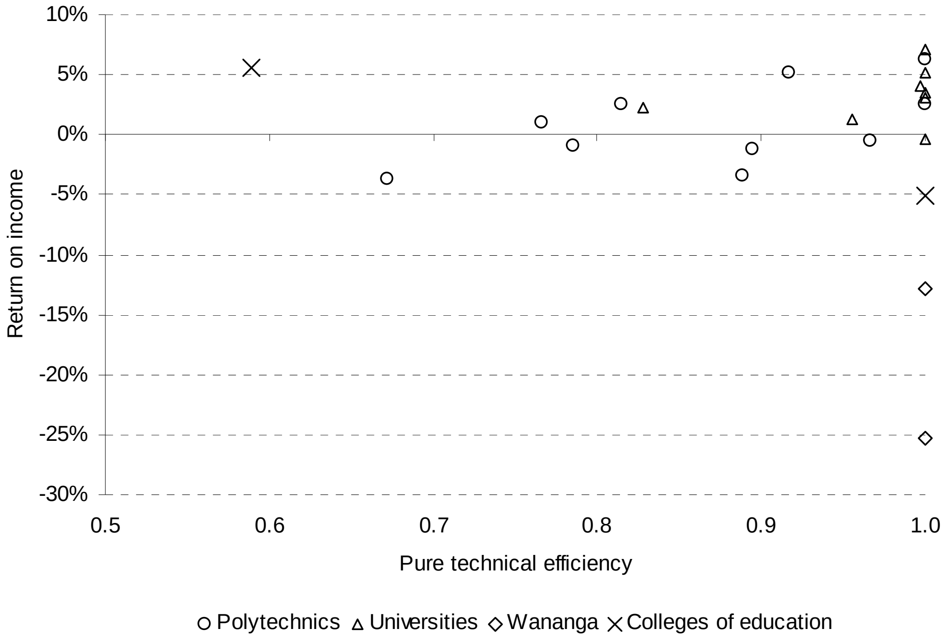


Figure 3.32 compares pure technical efficiency with the return on income of the 22 TEIs. It also displays a positive association between higher pure technical efficiency and higher return on income, but to a lower level than in Figure 3.31. Once again, the two wānanga and CCE appear to be outliers.

Figure 3.32, Pure technical efficiency vs return on income for New Zealand tertiary education institutions 2006



Least squares regression was used to determine the nature of the association between technical efficiency and return on income and whether it was statistically significant. In this case the dependent variable is the return on income, while the independent variables are technical efficiency and a variable with multiple categories representing subsector. The results of the regression are presented in Table 3.52. Model 1 uses technical efficiency as the key independent variable, while in model 2, pure technical efficiency is used as the key independent variable.

Table 3.52, Results of least squares regression: Return on income for New Zealand tertiary education institutions 2006

(Dependent variable = return on income)

Variable	Model 1		Model 2	
	Coefficient	Standard error	Coefficient	Standard error
Technical efficiency	0.231**	0.077	n/a	
Pure technical efficiency	n/a		-0.006	0.086
TEI_TYPE				
University	Reference category		Reference category	
Polytechnic	-0.011	0.016	-0.025	0.021
College of education	0.055	0.038	-0.032	0.035
Wānanga	-0.232**	0.026	-0.223**	0.032
CONSTANT	-0.177*	0.071	0.038	0.085
R^2	0.80		0.69	
N	22		22	

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

The results show a clear association between higher technical efficiency and higher financial returns. An increase of 1 percentage point in technical efficiency was associated with a 0.2 percentage point increase in return on income.

There was no statistically significant association between pure technical efficiency and financial performance. However, if the colleges of education and wānanga are removed from the analysis, then there was a statistically significant positive association between pure technical efficiency and return on income.[103]

Notable is the poor financial performance of the two wānanga after controlling for technical efficiency. Both of these TEIs had significant operating deficits in 2006 following significant drops in enrolments from the previous year. In addition, many of the courses at wānanga have zero fees, therefore, the return will be lower on enrolments in this subsector than in others.

[103] A 1 percentage point increase in pure technical efficiency was associated with an increase in return on income of 0.19 percentage points.

3.6.5 Conclusion

The move by the government to allow the provision of degree-level programmes by non-universities has proved somewhat controversial. Over an extended period of time, questions have been raised about the parity of esteem between university and non-university degrees. The analysis of TEI performance in this section suggests that from an efficiency point of view, there is also a lack of parity between universities and polytechnics in particular. The lower efficiency of polytechnics relative to universities may also suggest that polytechnics are not generally efficient overall, hence answering a question posed in the DEA study of New Zealand polytechnics in section 3.4.

The provision of degrees at polytechnics, with the possible exception of Unitec, appears to be a major cause of technical inefficiency in the tertiary system. This in turn places a financial burden on polytechnics – they have been among the poorest performers financially of the TEIs. Therefore, efficiencies could be gained by reducing the degree provision at non-universities, especially those that are smaller in size.

Another key finding from the analysis of TEI efficiency is the outcome of the rationalisation of the TEIs over the last decade. In 1999, there were 39 TEIs (7 universities, 25 polytechnics, 4 colleges of education and 3 wānanga), but by 2006 there were 33, reducing to 31 in 2007.

The outcome of the rationalisation appears mixed. The merger of CCE with the University of Canterbury and DCE with the University of Otago would appear to have been warranted, given that increasing returns to scale were a feature at three of those TEIs in 2006, the year prior to their merger. However, among the three universities which had merged with other TEIs within the last decade, there was a significant degree of decreasing returns to scale, indicating that the mergers may have impacted negatively on the scale of these three universities.

Finally, an issue of concern for policy makers must be the fact that despite some TEIs exhibiting high technical efficiency, they suffered from poor financial performance. Wānanga in particular were examples of this. This suggests that the operational structure, as it existed in 2006 for these TEIs, is unsustainable in the long term.

3.7 Appendix

3.7.1 Pastor *et al.* (2002) test

The notation describing the Pastor *et al.* (2002) test procedure presented below is adapted from Johnes (2006, p.286).

In order to generate the Pastor *et al.* (2002) test statistic first denote the vector of *s* outputs used by DMU *j* ($j = 1,\ldots,n$) by y_j and the vector of *m* inputs used by DMU *j* by x_j. The test works by comparing the ratio of the efficiency score for each DMU ($j = 1,\ldots,n$) for the full model (denoted by $\hat{D}(x'_j, y'_j), 0 \leq \hat{D}(x'_j, y'_j) \leq 1$), to the efficiency for the reduced model (denoted by $\hat{D}(x_j, y_j), 0 \leq \hat{D}(x_j, y_j) \leq 1$), where the reduced model must be nested within the full model.

Let $\rho_j = \hat{D}(x'_j, y'_j) / \hat{D}(x_j, y_j)$ ($j = 1,\ldots,n$) be observed values of a random sample $\Gamma_1,\ldots, \Gamma_j$ drawn form a population $\Gamma \sim (1,F)$ (where *F* is a cumulative density function on $[1,\infty)$) and define

$$T_j = \begin{cases} 1 & \text{if } \Gamma_j > \overline{\rho}, \\ 0 & \text{otherwise,} \end{cases} \qquad j = 1,\ldots n,$$

where $\overline{\rho} > 1$. The impact of the variable(s) excluded from the full model is considered relevant if $P(\Gamma > \overline{\rho}) > p_0$ where $0 < p_0 < 1$. In order to test the null hypothesis that $H_0 : P(\Gamma > \overline{\rho}) \leq p_0$ the value of *p* is calculated as $p = P(T > T_0) = 1 - F^B(T_0 - 1)$, where $T = \sum_{j=1}^{n} T_j$, T_0 is the observed value of *T*, and, under H_0, $T \sim$Binomial $(n\text{-}1, p_0)$ and F^B is the cumulative density function of the Binomial $(n - 1, p_0)$.

A small *p*-value suggests the null hypothesis should be rejected. In other words, the removal of the variable results in a statistically significant change in the technical efficiency estimate and so should be retained in the model specification. Pastor *et al.* (2002) suggests that the test performs well for the values of $\overline{\rho} = 1.1$ (a significance level of 10 percent) and $p_0 = 0.15$.

3.7.2 Deriving confidence intervals for technical efficiency estimates

The process for deriving the confidence intervals for estimates of technical efficiency is based on the method developed by Simar and Wilson (2000). The notation presented below is adapted from Johnes (2006, pp.286-287).

To generate the 95 percent confidence intervals first denote the vector of s outputs used by DMUj (j=1,…,n) by y_j and the vector of m inputs used by DMUj by x_j. The steps to then follow are:

1. Apply DEA to the given data on inputs and outputs to obtain an estimate of efficiency for each DMU in the set. This is denoted by $\hat{D}(x_j, y_j)$.

2. Then to derive the bootstrap values you:

   2.1 Set a bandwidth h for use in the drawing of the bootstrap values (see Simar and Wilson (1998) for further details on setting the bandwidth).

   2.2 Draw n independently and identically distributed probability density function used as the kernel distribution (the uniform distribution in this case).

   2.3 Draw n values (denoted by d_j, j = 1,…,n) independently and uniformly from the set of 2n reflected distance function estimates. From these, calculate the mean:

$$\bar{d} = \sum_{j=1}^{n} d_j / n$$

   and

$$d_j^* = \bar{d} + (1 + h^2 / s^2)^{-1/2} (d_j + h\varepsilon_j - \bar{d})$$

   where s^2 is the sample variance of $\upsilon_j = d_j + h\varepsilon_j$.

   2.4 Calculate the bootstrap values ($\hat{D}_j^*$) as

$$\hat{D}_j^* = \begin{cases} d_j^* & \text{if } d_j^* \leq 1, \\ 2 - d_j^* & \text{otherwise.} \end{cases}$$

3. The next step is to define the pseudo-data and obtain the bootstrap estimates of the efficiencies. This is done by defining a pseudo-data set with input and output vectors (denoted by (x_j^*, y_j^*)) as

$$y_j^* = D_j^* / \hat{D}(x_i, y_i),$$

$$x_j^* = x_j.$$

Then obtain a value of *B* (*B* = 2,000 is used in this analysis) bootstrap estimates of the efficiency score for each DMU *j* (*j*=1,…,*n*) by applying DEA to the pseudo-data *B* times. These bootstrap estimates can be denoted for DMU *k* by $\{\hat{D}_b^*(x_k, y_k)\}_{b=1}^{B}$.

4. Then compute estimated confidence intervals for the efficiency scores. The 100(1−α)% confidence intervals for the true efficiency for DMU *k* is calculated by finding the values b_α, a_α such that

$$Pr(-b_\alpha \le \hat{D}(x_k, y_k) - (Dx_k, y_k) \le -a_\alpha) = 1 - \alpha$$

In this analysis a value of $\alpha = 0.05$ is used to generate 95 percent confidence intervals. The values b_α, a_α are not known but are estimated from the bootstrap estimates $\{\hat{D}_b^*(x_k, y_k)\}_{b=1}^{B}$ by sorting the values $\hat{D}_b^*(x_k, y_k) - \hat{D}(x_k, y_k)$ in increasing order and deleting (100 α/2)% of the observations at each end of this list. Thus, estimates of $-b_\alpha$ and $-a_\alpha$ (denoted by $-\hat{b}_\alpha$ and $-\hat{a}_\alpha$) are the endpoints of the remaining array of values such that $\hat{a}_\alpha \le \hat{b}_\alpha$.

In other words, the bottom 2.5 percent and top 2.5 percent of bootstrapped technical efficiency estimates are removed to leave us with the limits of the lower and upper bound to the 95 percent confidence interval $[\hat{D}(x_k, y_k) + \hat{a}_\alpha, \hat{D}(x_k, y_k) + b_\alpha]$.

3.7.3 Second-stage regression

The process for generating robust second-stage estimates using bootstrapping and truncated regression described below is adapted from Simar and Wilson (2007, pp.37-40). This particular method described below uses the actual technical efficiency estimates as the dependent variable instead of the alternate finite sample size adjusted estimates. The steps to generate the confidence intervals for the truncated regression coefficients are as follows:

1. First, using the data in $\mathscr{S}_n$, compute $\hat{\delta}_i = \delta(x_i, y_i|\hat{\mathscr{P}}) \forall i = 1,\ldots,n$ using

$$\widehat{\delta}_0 = \delta(\boldsymbol{x}_0, \boldsymbol{y}_0|\widehat{\mathscr{P}}) = \max\{\theta > 0 \mid \theta \boldsymbol{y}_0 \leqslant \boldsymbol{Yq},\ \boldsymbol{x}_0 \geqslant \boldsymbol{Xq},\ \boldsymbol{i}'\boldsymbol{q} = 1,\ \boldsymbol{q} \in \mathbb{R}^n_+\}$$

2. Then use the method of maximum likelihood to obtain an estimate $\hat{\beta}$ of β as well as an estimate $\hat{\sigma}_\varepsilon$ of σ_ε in the truncated regression of $\hat{\delta}_i$ on z_i in

$$\widehat{\delta}_i = \boldsymbol{z}_i\boldsymbol{\beta} + \xi_i \geqslant 1$$

using the $m < n$ observations where $\hat{\delta}_i > 1$.

3. This next step derives the bootstrapped estimates of the truncated regression coefficients. To do so loop over the next three steps (3.1-3.3) L times to obtain a set of bootstrap estimates $\mathscr{A} = \{(\hat{\beta}^*, \hat{\sigma}_\varepsilon)_b\}_{b=1}^{L}$:

   3.1 For each $i = 1,\ldots,m$, draw ε_i from the $N(0, \hat{\sigma}_\varepsilon^2)$ distribution with left-truncation at $(1 - z_i\hat{\beta})$.

   3.2 Again for each $i = 1,\ldots,n$, compute $\delta_i^* = z_i\hat{\beta} + \varepsilon_i$.

   3.3 Use the maximum likelihood method to estimate the truncated regression of δ_i^* on z_i yielding estimates $(\hat{\beta}^*, \hat{\sigma}_\varepsilon^*)$.

4. Use the bootstrap values in $\mathscr{A}$ and the original estimates $\hat{\beta}, \hat{\sigma}_\varepsilon$ to construct estimated confidence intervals for each element of β and for σ_ε as described below.

Once the bootstrap values of $\mathscr{A}$ or $\mathscr{C}$ have been obtained the following confidence interval can be constructed:

$$\Pr[-b_\alpha \leq (\widehat{\widehat{\boldsymbol{\beta}}}^*_j - \widehat{\widehat{\boldsymbol{\beta}}}_j) \leq -a_\alpha^*] \approx 1 - \alpha,$$

Which leads to an estimated confidence interval:

$$[\hat{\hat{\beta}}_j + a^*_\alpha , \hat{\hat{\beta}}_j + b^*_\alpha]$$

For the purposes of this study α = 0.05 which generates a 95 percent confidence interval for the coefficients of the explanatory variables in the truncated regression analysis. If the confidence interval contains the value of 0, then the variable does not have a statistically significant association with technical efficiency.

3.7.4 Statistical inference of Malmquist indices

The process developed to generate confidence intervals for Malmquist indices is presented below and is adapted from Simar and Wilson (1999, pp.459-471). The process involves ranking bootstrapped estimates of the Mamquist indices in order from highest to lowest. The steps to generate the confidence intervals are:

1. First, given a sample $\ell = \{(x_{it}, y_{it}) \mid i = 1,...,N; t = 1,2\}$ of observations on N firms in two time periods and the bootstrap estimates of the Malmquist index for firm *i*: $\{M^*_i(t_1,t_2)(b)\}^B_{b=1}$, these bootstrap values can be used to find the values of a^*_α, b^*_α such that the statement

$$\Pr(-b^*_\alpha \le \hat{M}^*_i(t_1,t_2) - \hat{M}_i(t_1,t_2) \le -a^*_\alpha \big| \ell)$$
$$= 1 - \alpha$$

is true with high probability.

2. Then, rearranging terms yields an estimated $(1-\alpha)$-percent confidence interval

$$\hat{M}_t(t_1,t_2) + a^*_\alpha \le M_i(t_1,t_2) \le \hat{M}_i(t_1,t_2) + b^*_\alpha$$

and if the confidence interval does not include 1 then the change in productivity is statistically significant. For the purposes of this study α = 0.05 which generates 95 percent confidence intervals for the Malmquist indices.

4 Parity of esteem and the demand for bachelors degrees in New Zealand

4.1 Introduction

Ensuring equity of access to tertiary education is a key objective of most developed societies. In striving to reach this objective, a large body of research has been produced analysing the decision-making-process of tertiary education students. Most of this research has focused on identifying the factors associated with participation in tertiary education, with much less attention directed to identifying the factors associated with the choice of which tertiary institution to attend (Chapman 1981).

In New Zealand, research in the latter category has examined the factors associated with the broad type of tertiary institution selected (see Maani 2006) or the factors associated with the level of tertiary qualification enrolled in (see Ussher 2008). However, the factors associated with the type of tertiary education institution selected by students at the *same level of qualification* have not been examined in the New Zealand context.

This distinction is important, given there have been claims of a lack of parity of esteem between bachelors degrees conferred by New Zealand universities and those conferred by New Zealand polytechnics. These claims, which have most notably appeared in submissions to reviews of the New Zealand tertiary education system by the Organisation for Economic Cooperation and Development (OECD) in 1997 and the Tertiary Education Advisory Commission (TEAC) in 2001, are based on a perception that domestic students who receive a bachelors degree from a polytechnic are disadvantaged in the labour market (OECD 1997; TEAC 2001). It has also been claimed that international students perceive that degrees from polytechnics in New Zealand are not of the same quality as university degrees (TEAC 2001).

A lack of parity of esteem between university and polytechnic degrees, whether real or perceived, could restrict the ability of the polytechnics to recruit domestic and international students. This in turn could affect the financial viability of those polytechnics with significant levels of bachelors degree provision.

The seriousness of the problem is illustrated by the nature of the ongoing attempts by polytechnics to find a solution. These solutions have included attempts by two polytechnics to become universities, one of which resulted in legal action against the government when unsuccessful. Further suggestions have included a proposal for a creation of a new class of university, the university of technology, through an amendment to the Education Act, and the creation of an overarching degree-granting body for the polytechnic sector.

Clearly, these actions indicate there is, at the very least, a perception of a lack of parity of esteem between university and polytechnic degrees. Yet, until now, no research has specifically examined the enrolment decisions of degree students for evidence that a lack of parity of esteem exists, and if it does, what the scale of it may be.

This study examines the issue of parity of esteem between university and polytechnic degrees by identifying the factors that are associated with the choice of tertiary education provider at the bachelors degree level. Specifically, logistic regression is applied to a dataset containing the administrative enrolment records of over 20,000 domestic students starting a bachelors degree in 2006 to identify the demographic and study-based characteristics of these students associated with enrolling at a university instead of a polytechnic. In particular, this study focuses on characteristics that may provide evidence of a lack of parity of esteem between university and polytechnic degrees.

An analysis such as this depends on students making choices of institution which assumes that spaces are available to them. A number of university courses have limited spaces available, such as medicine. But the vast majority do not have limitations on enrolments. Some polytechnic degree courses also face restrictions, such as nursing and some design courses. However, courses in business and computing, which are a significant part of polytechnic offerings at the degree level, have no limitations in terms of places. Therefore, there was likely to be extra capacity in the polytechnic sector for university degree students if they had wanted to enrol with them and vice versa.

This study also examines if parity of esteem plays a role in the decisions of university students by identifying the factors associated with the choice of a particular type of university. For those students that choose to study at a university, parity of esteem may also play a role in their choice of a particular type of university, given that universities in New Zealand vary considerably in terms of their history and research profile. For example, the Universities of Auckland and Otago both have medical schools and can trace their history back to the 19^{th} century. In comparison, institutions such as Massey University and the University of Waikato are newer in age and mostly regionally based, while the Auckland University of Technology was only granted university status in 2000.

Although the administrative dataset used in this study lacks the richness of information that can be provided from survey-based datasets,[104] it has the advantage of containing information on almost all domestic students aged between 16 and 27 who started a bachelors degree at a university or polytechnic in 2006. This level of coverage of domestic bachelors degree starters is an advance on previous studies and increases the robustness of any findings from the logistic regression analysis. Importantly, it also allows for an analysis of the association between the geographical mobility of students and their choice of tertiary education provider.

The structure of this chapter is as follows. Firstly, a brief history of bachelors degree provision in New Zealand is presented in section 4.2. This section also includes a discussion on the issue of parity of esteem. Then, a literature review of studies that examine the choice of tertiary education provider by students is presented in section 4.3. This is followed by a discussion of the data and the theoretical framework used to analyse the demand for degree-level education in polytechnics and universities in sections 4.4 and 4.5, respectively. In section 4.6, the characteristics of the datasets are further explored. The logistic regression results are presented in section 4.7. As well as examining the choice of a university or a polytechnic across all bachelors

[104] Such as the Christchurch Health and Development Study used by Maani (2006).

degree starters, this section also takes a narrower focus on the choice of provider for those students studying a nursing degree. Also in section 4.7, the results of the application of multinomial logistic regression analysis to the choice of selected groupings of universities are presented. Finally, some conclusions are presented in section 4.8.

4.2 Background

This section presents a short history of bachelors degree provision in New Zealand, with a focus on when universities and polytechnics began offering degree programmes. Then, the debate that has evolved around the issue of a lack of parity of esteem between university and polytechnic degrees is examined.

4.2.1 A history of bachelors degree provision in New Zealand

The history of bachelors degree provision in New Zealand spans back well over a century, with the universities the first tertiary institutions to begin offering bachelors degrees. The University of Otago was the first tertiary institution to offer bachelors degrees in New Zealand in 1869, but its life as an autonomous degree-granting body was short lived. In 1870, a federal University of New Zealand, comprised of affiliated colleges, was established by statute and became the sole examining and degree-granting body for New Zealand.

Although the establishment of the University of New Zealand was partly related to regional frictions between the education authorities in Otago and Canterbury, a strong desire to ensure that bachelors qualifications awarded in New Zealand were held in the appropriate level of esteem was also a key factor (Parton 1979). The 1878 Royal Commission reviewing the University of New Zealand stated that '…degrees granted by a university so governed [as an federal university with affiliated colleges] would be more highly esteemed that any that might have been granted by the individual colleges…' (Parton 1979, p.20).

The first colleges to be affiliated to the University of New Zealand were South Island based, reflecting the population concentrations that existed in New Zealand at that time. Canterbury College, the predecessor to the University of Canterbury, was the first institution to be affiliated to the University of New Zealand in 1873 and was followed by the University of Otago in 1874.

More colleges were affiliated over the following decades as new population centres developed and required tertiary education provision. Auckland University College, later to become the University of Auckland, was affiliated to the University of New

Zealand in 1883. In 1896, Canterbury Agricultural College, which had been part of Canterbury College, was granted its own governing body and was affiliated as a separate entity to the University of New Zealand. This institution would later become Lincoln University. Victoria College, later to become Victoria University of Wellington, was founded in 1897 and began teaching operations in 1899. In 1928, Massey Agricultural College, later to become Massey University, was formally opened following the passing of the 1925 New Zealand Agricultural College Act.

Despite the increasing number of affiliated colleges, the operation of the University of New Zealand was fraught with difficulties. One of main problems was the clumsiness of its administrative system, which restricted the ability of member colleges to ensure that their programmes of learning were able to meet the changing requirements of the stakeholders in the tertiary education system (Parton 1979). Following the recommendation of the Hughes Parry Committee in 1959, the University of New Zealand was disestablished in 1961 and the power to grant degrees devolved to the individual universities (Parton 1979). [105]

In 1964, two more tertiary institutions were granted the power to confer degrees. Massey University was created from a merger of Massey Agricultural College and part of Victoria University of Wellington that operated in Palmerston North. In addition, the University of Waikato was opened in Hamilton in 1964. This took the total number of degree-granting institutions to six, all of them universities.[106] This was to remain the status quo for the next 25 years.

It was during the 1960s that polytechnics (or technical institutes as they were then known) first began to offer programmes as stand-alone institutions.[107] Prior to this, they had operated as technical divisions attached to high schools.

In 1960, the first technical institute, the Central Institute of Technology, was established and was followed by the Auckland Technical Institute in 1961. Thereafter, technical institutes were established in all the main centres. A further

[105] At this time Lincoln College became a constituent college of the University of Canterbury.
[106] These were: Massey University, University of Auckland, University of Waikato, University of Otago, University of Canterbury and Victoria University of Wellington.
[107] These programmes were vocational in nature and at the sub-degree level.

expansion of vocational tertiary institutions occurred in the 1970s, with the establishment of community colleges in many provincial centres. In the 1980s, the various technical institutes and community colleges were rebranded as polytechnics.[108]

Although other countries had vocational tertiary institutions engaging in degree-level teaching, when the idea was raised in New Zealand in the early 1970s it did not gain much traction (Dougherty 1999). A report presented to the Minister of Education in 1974, Directions for Educational Development, recommended that New Zealand should not allow technical institutes to offer degrees to avoid the issue of academic drift, whereby they would attempt become alternative universities. As a result, the polytechnics continued to focus on sub-degree vocational education during the 1970 and 1980s (Abbott 2000, p.100).

By the late 1980s, the New Zealand tertiary education system was perceived as elitist and with low participation (McLaughlin 2003). In addition, a shift in the nature of university education towards more vocational areas was beginning to blur the boundaries between university and polytechnics (Abbott 2000).

A series of reviews of the tertiary education system during this time presented contrasting views on how to tackle these issues. For example, a committee set up by the universities to review their performance found that overall the universities were performing well and were adaptive to demand pressures (The Watts Report 1988). However, these findings were criticised by Boston (1988) and Snook (1991) as lacking analytical rigour and failing to provide a robust counter to the views of others such as the New Zealand Treasury. The Treasury (1987) was of the opinion that the introduction of a greater degree of market forces into the tertiary education sector was warranted and would make the universities more receptive to the needs of their stakeholders and improve their efficiency.

It was in this environment of contrasting views that the government commissioned a review of the provision of tertiary education in New Zealand in 1988. This was

[108] Although some individual institutions chose not to include the term polytechnic in their title.

carried out by the Working Group on Post Compulsory Education and Training (PCET), which was convened by Professor Gary Hawke. The PCET Working Group drew on the findings of the various reviews of the tertiary system and held discussions with key stakeholders. After four months of deliberations, the PCET Working Group presented their recommendations to the government.

The PCET Working Group saw no reason why degree-level teaching should be restricted to the universities and believed that an environment with more competition would improve the efficiency of tertiary providers (Hawke 1988, p.24) and make them more responsive to the requirements of stakeholders such as students and employers (Hawke 1988, p.76).[109]

Although the government did not accept all of the recommendations by the PCET Working Group,[110] it did accept the proposal to allow non-university institutions to offer degrees. However, it did so with the expectation that only a small proportion of the programmes offered by non-universities would be at the degree level (Department of Education 1989).[111]

The legislation which contained the removal of the university monopoly on degree provision, the Education Amendment Act, took effect from 1990. The Act included a provision that degrees were 'primarily taught by those active in research'.[112] Also, the term 'university' was protected and universities were characterised as institutions whose '…research and teaching are closely interdependent and most of their teaching is done by people who are active in advancing knowledge [and meeting]…international standards of research and teaching…'.[113]

Polytechnics were characterised in the Education Amendment Act as institutions that display '…a wide diversity of continuing education, including vocational training, that contributes to the maintenance, advancement, and dissemination of knowledge

[109] Abbott (2000) noted there had been an increase in full-time diploma students at polytechnics which would suggest they may have preferred to study at the degree level if possible.
[110] For example, the government did not introduce a student loan scheme for students as recommended by the Working Group.
[111] The government also decided that Lincoln College would become an autonomous degree granting institution in its own right and became Lincoln University in 1990.
[112] Education Act 1989, Section 256.
[113] Education Act 1989, Section 162(4).

and expertise and promotes community learning, and by research, particularly applied and technological research, that aids development'.[114]

Clearly, the threshold of research is lower for polytechnics than universities in the above characterisations. However, polytechnics choosing to offer degree programmes were bound by the requirements that degree teaching was done primarily by staff active in research. The ability of polytechnics to meet this requirement has been questioned (TEAC 2001), with the subsequent release of the results of the Performance-Based Research Fund (PBRF) Quality Evaluations, which highlighted the gulf in research performance between the universities and polytechnics, doing little to dispel these concerns.

Following the passing of the Education Amendment Act, the two largest polytechnics, Auckland Technical Institute (ATI) and Carrington Polytechnic (later to become Unitec New Zealand) responded by quickly moving to offer degrees and reduce their involvement in teaching at the sub-degree level (Abbott 2000). The first bachelors degree was offered by ATI in 1991 and the first at Carrington Polytechnic in 1992 (Dougherty 1999).[115] The subject areas of the early degrees (management, nursing, design, computing and construction) illustrated their vocational nature.

Over time, other medium-sized polytechnics and even some smaller regional polytechnics moved to offer their own degrees as part of a general academic drift towards university-like programmes (OECD 1997). By 2007, 17 out of 20 polytechnics had students enrolled at the bachelors degree level or higher.[116] Nineteen percent of equivalent full-time students (EFTS) at polytechnics in 2007 were at the bachelors level or higher[117] with the highest proportion at Unitec New Zealand (42 percent).[118] This is a level of degree provision well beyond what was

[114] Education Act, Section 162(4).
[115] Otago Polytechnic had offered a conjoint physiotherapy degree with the University of Otago in 1990, but this was awarded under the auspices of the university (Dougherty 1999).
[116] All the enrolment statistics in this section are sourced from the Tertiary Education Commission. The data can be found at: http://www.tec.govt.nz/templates/standard.aspx?id=1216.
[117] Compared with 93 percent for universities.
[118] The lowest percentage of bachelors or higher students enrolled at a university is Auckland University of Technology (69 percent).

originally envisaged by the government at the time the university monopoly on degree provision was removed.[119]

Even so, the provision of bachelors or higher education is still dominated by the universities. In 2007, 87 percent of bachelors or higher EFTS at tertiary education institutions were enrolled in universities, 12 percent in polytechnics and 1 percent in wānanga.

While polytechnics focused on increasing the number of students enrolling in their degrees following the passing of the Education Amendment Act, the universities focused on repositioning themselves by concentrating on postgraduate qualifications and research (Barrowman 1999). This repositioning continues to be an ongoing exercise, with the University of Auckland recently announcing a move to extend restrictions on the number of undergraduate places in order to increase the proportion of postgraduate students (McNaughton 2007).

4.2.2 Parity of esteem[120]

With the majority of the universities having a relatively long history of degree provision and extensive postgraduate programmes, compared with the more recent history of degree teaching by polytechnics, it is perhaps not surprising that the worth of the degrees offered by polytechnics have been questioned, albeit sometimes indirectly.

In 1997, a thematic review of New Zealand's tertiary education system by the OECD received submissions asserting that students graduating with newer degrees were disadvantaged in the labour market. The OECD received anecdotal evidence that '…students simply "do not trust" the new degrees [from polytechnics] because they believe the labour market is not rewarding such qualifications' and that "…although the new degrees look practical, they will be obsolete"' (OECD 1997, p.10). However, it was the view of the OECD that the issue was more that the providers

[119] Dougherty (1999) noted this point as well.
[120] The term 'parity of esteem' was also used in a 1957 report that examined the split of vocational training institutions from secondary schools. There was a concern that as the vocational institutions were providing training for blue collar occupations, there would be a lack of parity of esteem with students studying in more academically orientated subjects at secondary school (Dougherty 1999).

were new to degree provision rather than the newness of the degrees per se (OECD 1997, p.10).

In 2001, the issue of parity of esteem was examined in some depth in a review of the New Zealand tertiary education system by the Tertiary Education Advisory Commission (TEAC). The TEAC review found that although polytechnics maintained that their degrees were of a comparable standard to universities, there was a perception that polytechnic degrees did not have a parity of esteem with university degrees. The outcome of this was that "…polytechnic students would not fare as well as their university counterparts in the labour market". Also, the polytechnics faced difficulties in attracting international students to their degrees (TEAC 2001, p.77).

The issue of whether students with a degree from a polytechnic are disadvantaged in the labour market merits closer attention. The submissions to the OECD and TEAC reviews asserting polytechnic students were disadvantaged were anecdotal in nature, but what does the available quantitative evidence show?

The premium on earnings from attending different types of tertiary institutions is one labour market outcome that can be examined for evidence of any lack of parity of esteem between university and polytechnic degrees. Higher earnings by graduates from one particular type of tertiary provider may indicate the labour market values their skills more highly.

Overseas research suggests that the returns from attending a prestigious institution can be significant. Chevalier and Conlon (2003) examined if there is a higher return on wages for students who graduate from prestigious institutions in the United Kingdom. They examined graduating cohorts from 1984, 1990 and 1995 and, after controlling for pre-university study personal and academic characteristics to address the problem of selectivity, they found that wages from a Russell Group institution (which include older more research intensive universities) adds up to 6 percent to the income earned by men and 2.5 percent to income earned by women, compared to those students graduating from institutions that were more recently granted university status (Chevalier and Conlon 2003, p.iii). However, they were unable to say whether this income advantage persists over time or is a momentary advantage.

In New Zealand, the Ministry of Education has made use of a dataset linking the education history and post-study earnings of New Zealand students to analyse the impact of provider type on the earnings premium of students three and five years post-study.[121] Smyth *et al.* (2009) examined how the post-study income of students who study at the bachelors level at universities and polytechnics compare over time. They found that new graduates from each type of provider generally start off on a similar footing in terms of income, suggesting at the time of graduation a degree from a university and a polytechnic were equally valued in the labour market. However, over time the incomes of university graduates increased at a faster rate than polytechnic students.

The study also used generalised logistic regression to examine the earnings premium associated with various levels and fields of study at different types of tertiary institutions. They found that after controlling for other factors, the post-study income of students who studied at polytechnics and universities was similar in areas such as commerce and information technology. However, in subjects such as health, university graduates received a significant income premium. Given that most university graduates in the health area at universities would be medical doctors and graduates from polytechnics nurses, this result is not unexpected.

Another factor that may influence the esteem with which an institution is perceived is how they rank in various performance measures. These include international rankings systems of tertiary institutions, such as the Times Higher Education Supplement rankings and the Shanghai Jiao Tong University rankings.

The 2008 Shanghai Jiao Tong University rankings show that the highest ranked universities were Auckland and Otago (ranked between 201 and 302), followed by

[121] Studies such as Maani (1999) and Penny (2005) in their analyses of the returns to educational qualifications focused on the level of qualification rather than the type of provider. Although Maani and Maloney (2004) do split qualifications into polytechnic and university diplomas/certificates, they do not differentiate between provider type at the bachelors and higher level.

Massey University (ranked between 303 and 401), and the University of Canterbury and Victoria University of Wellington (both ranked between 402 and 503).[122]

The 2008 Times Higher Education Supplement rankings show that the University of Auckland was the highest ranked New Zealand university (ranked 65th), followed by the University of Otago (124th), University of Canterbury (186th), Victoria University of Wellington (227th), Massey University (283rd) and the University of Waikato (378th).[123] Clearly, the Universities of Auckland and Otago perform the best in these rankings, with the presence of medical schools likely to be contributing to their relatively higher ranking. [124]

The research performance of New Zealand tertiary institutions can also be compared using the results of the 2003 and 2006 Performance-Based Research Fund (PBRF) Quality Evaluations. The PBRF Quality Evaluations use a process of peer review to measure the quality of research by staff teaching at the degree level in participating tertiary education organisations. Although this exercise is carried out for funding purposes, the results are then published by the government at the institutional subject level.

The results of the two Quality Evaluations show that there is a significant gap in research performance between polytechnics and universities. In 2003, just two of the 17 eligible polytechnics, Unitec New Zealand and Wintec, chose to participate in the Quality Evaluation, despite the cut in government funding that resulted from non-participation. In comparison, all eight universities participated in the 2003 Quality Evaluation.

The results of the 2003 Quality Evaluation showed that the average quality of research carried out by polytechnic staff was well below that of the universities. The

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[122] Not all New Zealand universities participate in the rankings. The full results can be found at: http://www.arwu.org/rank2008/EN2008.htm.

[123] The full results can be found at: http://www.topuniversities.com/worlduniversityrankings/results/2008/overall_rankings/fullrankings/

[124] These two international ranking systems are compiled with a reliance on indicators of research performance, given their greater availability compared with other facets of university performance. As a result, universities with medical schools tend to perform at a higher level than other universities due to their research intensive nature and their associated publication of research in journals (Marginson 2007).

average combined quality score of Unitec New Zealand and Wintec was 0.62 out of a maximum of 10. This was less than a quarter of the combined average research score of 2.98 achieved by the eight universities.[125]

There was also variation in the performance of the universities. The University of Auckland achieved the highest average quality score (3.96), followed closely by the University of Canterbury (3.83). There is then a cluster of universities with average quality scores between 3.39 and 2.98 (Victoria University of Wellington, University of Otago and the University of Waikato, respectively). They were followed by Lincoln University (2.56), Massey University (2.11) and the Auckland University of Technology (AUT) (0.77).

Although more polytechnics participated in the 2006 Quality Evaluation, the peer-assessed quality of research by those institutions remained well below that of the universities. In 2006, the 10 participating polytechnics achieved a combined average quality score of 0.57, compared with a university average of 3.72. The best performing polytechnic was Unitec, with an average score of 0.96, which was still well below that of the average score of 3.72 achieved by the eight universities, but closer to the quality score achieved by the newest university, AUT (1.86). The worst performing polytechnic was Whitireia, with an average research score of just 0.13.[126]

In the 2006 Quality Evaluation, the gap in performance between the universities reduced. The top average quality score was achieved by the University of Otago (4.23), with the lowest score achieved by AUT (1.86). However, the older metropolitan universities still outperformed the other universities.

That a significant gulf exits between the quality of research carried out by university and polytechnic staff is not that surprising, given that universities have been offering degrees and engaging in research for a much longer time period than the polytechnics. However, it raises the issue of how publication of the PBRF Quality Evaluation results may have influenced the choices of bachelors students, especially

[125] These 2003 PBRF Quality Evaluation results are sourced from Tertiary Education Commission (2004).
[126] These 2006 PBRF Quality Evaluation results are sourced from Tertiary Education Commission (2007).

as one of the reasons given for publication of the PBRF Quality Evaluation results was to inform student decision making.[127] However, this is an issue outside of the scope of this study, given that the analysis is restricted to just one year of enrolments.

Over time, polytechnics have proposed various solutions to address the parity of esteem issue. The most direct course of action has been the attempt by two polytechnics to be granted university status. Of the two attempts, just one, by Auckland Institute of Technology, has proved successful. This institution was granted university status in 2000 and became the Auckland University of Technology (AUT). However, the research performance and the proportion of students in postgraduate study at AUT remain much lower than the other seven universities, even after eight years as a university.[128]

Unitec New Zealand also pursued university status in the late 1990s, but the government expressed a reluctance to increase the number of universities beyond the current number of eight and finally turned down Unitec New Zealand's application for university status in 2006.[129]

Unitec New Zealand has also been at the forefront of pushing for the creation of a new classification of tertiary institution – the university of technology. This solution was suggested by Unitec New Zealand in its submission to the TEAC review in 2001 and proposed that a university of technology would have lesser research requirements than full-universities, but would recognise the scale of degree teaching and the applied research taking place at these institutions (TEAC 2001). Importantly it would contain the word 'university' in the title.

The TEAC's response to the submission was that they believed it could cause confusion about what exactly constituted a university in New Zealand and also that it would potentially lead to two classes of universities, the full universities and the universities of technology. In addition, the TEAC indicated they thought it would not

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[127] See Ministry of Education and Transition Tertiary Education Commission (2002, p.22).
[128] AUT's 2006 PBRF average quality score was 1.86, compared with the university average of 3.72. Also, in 2007, just 6.9 percent of EFTS at AUT were at the postgraduate level. This compares with 16 percent for the other seven universities.
[129] The time taken for the government to make this decision ultimately led to Unitec New Zealand taking legal action against the process used by the government to deny them university status.

solve the underlying issue of parity of esteem – which they felt would be better dealt with through more collaboration and increased linkages with the universities (TEAC 2001).

Although rejected as a solution to the parity of esteem issue by the TEAC, the creation of a university of technology classification was proposed once again in a 2008 Private Member's Bill. However, it appears unlikely that such an institution type will be created, given the degree of opposition from various stakeholders, including the eight current universities (Gerritson 2008).

The creation of an over-arching degree-granting body for polytechnics was another proposed solution to a perceived lack of parity of esteem for polytechnics degrees. This was first proposed during the late 1990s and had echoes of the reasoning behind the creation of the University of New Zealand as the overarching degree-granting body of universities (Dougherty 1999). However, this proposal gained little traction at the time as Unitec New Zealand and Auckland Institute of Technology were focussed on achieving university status (Dougherty 1999).

Nevertheless, the proposed creation of an overarching degree-conferring body was included in a submission to the TEAC review by the Association of Polytechnics of New Zealand (APNZ) as a way of dealing with the parity of esteem issue. However, the TEAC was sceptical it would solve the parity of esteem problem and felt it would simply duplicate the current role of the New Zealand Qualifications Authority and not deal with the issue of institutional drift (TEAC 2001).

With the likelihood of the current University of Technology Bill not progressing, the creation of an overarching degree-granting body has once again been mooted by ITPNZ, the organisation superseding APNZ. The reaction of the government to this proposal is unclear at this time.

What is clear is that the attempts by the polytechnic sector to solve the parity of esteem issue have persisted over time. This implies that the issue is real and of great concern to those polytechnics involved in teaching at the bachelors level.

4.3 Review of the literature

There are three key themes in the literature analysing the choice of tertiary education provider by students. The first of these themes involves the modelling of the various stages in the decision making process by potential participants in tertiary education. The second theme uses a marketing-based approach of qualitative surveys and interviews of potential or current students to identify the factors that influence their tertiary education decisions. The third theme in the literature uses statistical modelling to identify the factors associated with the tertiary education choices of students.

Although this study fits within the third theme of research, it is useful to also examine the literature of the other two in order to provide some important context to the decisions made by bachelors degree students when selecting a tertiary provider and help identify potential factors that may influence student choices.

4.3.1 Modelling the decision making process of tertiary students

The decision-making-process that students go through in choosing to participate in tertiary education and then selecting an appropriate provider is a complex process (HEFCE 2008) that can start at an early age (Leach and Zepke 2005).

In terms of the process itself, Hossler and Gallagher's (1987) three-stage model of the decision making process is the one most commonly referenced in the literature. This model divides the decision making process into three stages: *predisposition*, *search* and *choices*.

The *predisposition* stage considers the background of the student, including parental attitudes to tertiary education and the nature of school attended. In the *search* stage the student is seeking out information on possible career outcomes. In the *choices* stage, the student makes the decision of the actual course to enrol in and the provider.

Table 4.1 is adapted from Leach and Zepke (2005, p.14) and summarises the factors that are of influence at the three stages of decision making. In the *predisposition* stage the factors that influence decision making are the family and school environment of the student. At the *search* stage the potential student places much greater attention on the options they have for tertiary study and gathers information that will help to determine their decision. During the *choice* stage the student makes the final decision and appraises the merits of the various options they have.

Table 4.1, Working model for decision making

Decision making stage	Factors influencing choice of students
Predisposition	• Socio-economic status • Parental disposition • Self belief in ability • School
Search	• Career outlook/aspirations • Academic achievement • Subject area interest • Institutional profile - *location* - *courses offered* - *reputation/ image* • Costs and financial aid
Choice	• Right courses/degrees • Admission • Social fit

Source, Leach and Zepke (2005, p.14)

The large number of potential factors impacting on tertiary education decisions by students emphasises the complex nature of the decision making process. The factors identified as key to the choice of tertiary institution are identified in the next section.

4.3.2 Marketing-based analysis of student preferences of tertiary education provider

The second theme in the literature uses a marketing-based approach to identify the factors that influence the tertiary education decisions of students. This involves surveying potential and existing students for the reasons they selected the tertiary institution they are at or intend to enrol in. In many cases this involves ranking the factors influencing their decision in order of preference.

Some of the first analyses of student choices using this marketing-based framework originated in the United States, where competition to attract students is perhaps more overt than in other countries (see Krampf and Heinlein 1981; Hooley and Lynch 1981). These studies found that the subject choices available, the reputation of the institution and the location of the campus were important factors influencing the decision of students when selecting a tertiary provider.

A number of Australian studies have examined the choice of provider by students intending to study at university. A study by James *et al*. (1999) analysed the factors influencing the choices of undergraduates in the Australian higher education system. This study used a mail out survey of 937 and 538 students, respectively, followed by telephone interviews with 12 of the respondents.

The study asked students to rank the factors that had the greatest influence on their choice of university and then examined the responses by the type of university applied to. The two types of university that are relevant to the New Zealand context are 'research focussed' universities (such as the University of Melbourne) and what the authors labelled 'technical universities' (such as Queensland University of Technology). The 'technical universities' are roughly the most comparable to the larger degree-granting polytechnics in New Zealand and the New Zealand universities, with the exception of Auckland University of Technology, are arguably more comparable to the 'research focussed' universities.

The strongest influences for those students applying to 'research focussed' universities compared with other applicant groups were: prestige/image, employment/salaries, international character, research reputation, opportunity for higher degrees, atmosphere on campus, kind of student, social and cultural life clubs and societies, sporting and recreation facilities, parent's views and employer views.

For students enrolling in 'technical universities', the strongest influences were: employment rates/salaries, IT used in teaching, flexible study options, easy to get to from home, classes outside working hours, easy to get to from work, employer's views.

As was noted by the authors of the study, the divergent lists indicate that applicants to the 'research focussed' universities were the most likely to be influenced by the institutional status. The study also found that applicants from a higher socioeconomic background are '….more influenced than the lower socioeconomic group by the prestige of the university and the social and cultural life on campus' (James *et al*. 1999, p.42). In terms of gender, the study found that women tended to place a lower priority on the status of the instituttion, although the difference was not statistically significant.

A study by Suitar and Turner (2002) used conjoint analysis to examine the choice of tertiary education provider by Western Australian secondary school students. The authors surveyed 259 students and found that there were four key factors driving the decisions of students. They were in order of importance: course suitability, academic reputation, job prospects and teaching quality. These are similar factors to those identified by James *et al*. (1999), reinforcing that reputation and the likelihood of enhancing employment prospects are key deciding factors.

A number of New Zealand studies have examined the intentions of prospective degree students and the reasons for their choice of tertiary institution. Chalmers (2001) found that children from professional, managerial and highly educated parental backgrounds tended to assume they would study at university.

Holdsworth and Nind (2006) examined the choice of tertiary institution by 500 prospective students from various secondary schools around New Zealand. Their research showed that the quality and flexibility of the qualification/courses were the most important factor in student choice. This was followed by the likelihood that employers would recruit from the institution. The students also indicated a preference that they would not like to attend an institution without sufficient accommodation available.

Similar results were found in a recent survey of New Zealand university and polytechnic students (NZUSA 2008).[130] This study also ranked the factors influencing the decision of students when choosing an institution. The majority of students surveyed identified that the key reason for choosing an institution was that it offered the courses they were interested in. This was followed by the institution

[130] Note that the students in this survey included international as well as domestic students.

being close to where the student was located and thirdly that the institution had a good reputation.

On this latter point, the survey identified that students who: studied at the University of Auckland, were full-time, with parental income between $20,000 to $60,000, Asian, and aged between 20 and 22 years were the most likely to take into account the reputation of an institution when making a decision (NZUSA 2008).

The issue of how large a role the prestige or reputation of a tertiary institution plays in the decision of students was the subject of a recent study by the Higher Education Funding Council for England (HEFCE). They surveyed the literature to identify which students were the most likely to take into account league tables when deciding on the appropriate tertiary education provider (HEFCE 2008). The survey found that the students most likely to look at league tables were: younger students, men, students of higher academic ability, students from higher social classes, international students and students who travel long distances for study. However, the study noted that although many students look at league tables, it is only a major factor for a small proportion of students and the choice of provider remains a complex process.

The way in which some of the New Zealand universities spent considerable effort advertising their performance in the PBRF Quality Evaluations, along with the sparring over the interpretation of the results that occurred in the press between institutions[131] indicates the universities themselves consider that the esteem of an institution plays a role in student decision making.

In summary, although the decision-making-process of tertiary students is complex and varies between individuals, there is a common theme in the marketing-based literature that the suite of courses offered, the likelihood of employment and the reputation of the institution are important factors influencing the selection of tertiary education provider.

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[131] The Universities of Otago and Auckland sparred in the press over Auckland's way of presenting the Quality Evaluation results. Auckland presented the total amount earned via the PBRF as indicating that the University of Auckland was the top research university in New Zealand. However, the University of Otago achieved the highest average quality score, which is generally the acknowledged way of comparing performance.

4.3.3 Quantitative analysis of student choices

The third theme in the literature uses quantitative methods to identify the factors associated with the decisions of students. Rather than survey students directly to identify the factors that influence their decisions, these studies mainly use background information on the educational achievement and family characteristics of students to draw conclusions on their decision making process.

There is a mix of overseas and New Zealand research which has examined this area. Knighton and Mirza (2002) analysed the impact of parental education and income on the choice of attending university or college for a sample of Canadian students. The study used logistic regression analysis to control for other factors and found that parental education was a key factor associated with choice of provider. The results showed that students whose parents had higher qualifications were more likely to attend university. Rahman *et al*. (2005) updated this study using an additional cohort of students and also found that parental education and family structure were important factors associated with the decision of students to enroll in a university instead of a college.

In terms of New Zealand research, Choat (1998) analysed the impact of socioeconomic status on the decisions of school leavers and found that students from high decile schools were more likely to attend university than polytechnics. Similarly, a report by the University of Auckland Taskforce (University of Auckland 1999) examined trends in attendance at tertiary institutions by students from schools with a decile rating between 1 and 3. The Taskforce found that during the late 1990s there was a decline in the number of students from the low decile schools attending the University of Auckland and Manukau Institute of Technology.

Maani (2000, 2006) applied multinomial probit regression to the Christchurch Health and Development Study dataset to examine the factors associated with four post-compulsory outcomes for a cohort born in Christchurch in 1977. The four post-study outcomes included university study, polytechnic study, employed and unemployed/not in the labour force.

The dataset used by Maani contained variables on a participant's background not normally available for studies of this type. However, although the dataset was rich in that sense, it had the limitations of a relatively small sample size (694 and 580, respectively) along with the fact that all of the participants were born in Christchurch.

Maani found that after controlling for other factors, the higher the income decile of the parents of a student when they were aged 18, the higher was the likelihood of the student attending university. However, the opposite case was found for polytechnic attendance, with a higher parental income decile resulting in a lower likelihood of attending a polytechnic. Maani also found that the better the scholastic performance of the student at school certificate level the greater was the likelihood of attending university, while the opposite relationship was true for polytechnic attendance – a higher level of academic achievement at the school certificate level was associated with a lower likelihood of attendance.

However, the studies by Choat (1998), the University of Auckland Taskforce (1999) and Maani (2000, 2006) may simply reflect the factors associated with attendance at different *levels* of tertiary education, as the majority of university students are enrolled at the bachelors level or higher and the majority of students enrolled at polytechnics study at the non-degree level.

A study by Ussher (2008) partly addressed this issue by using multinomial logistic regression to identify the characteristics of students associated with the level of tertiary education selected by a cohort of New Zealand school leavers from 2004. The two levels of provider-based tertiary study were at the bachelors-level and non-degree level. Ussher found that the highest school qualification of students was a key factor associated with the choice of New Zealand students, especially those choosing to study at the bachelors level. Students with higher school qualifications were more likely to study at the bachelors or higher level. Another finding was that the decile of the last secondary school attended did not have much impact on the choice of tertiary study. However, Ussher included another measure closely associated with school decile (peer impact) in the model that may have masked the impact of this variable.[132]

Although the study by Ussher examined the factors associated with the choice of enrolment in different levels of tertiary education, it did not analyse the choice of bachelors study at different types of provider. Therefore, although Ussher examined tertiary education choices from a different angle to Maani (2006), it still did not address the issue of what factors are associated with the choice of tertiary provider type at the same level of qualification.

It is clear from this examination of the literature that although several studies have examined the factors associated with the choice of type of provider or the level of tertiary education in New Zealand, none of them examined the choice of type of tertiary provider at the same level of qualification. Without doing so, a clear picture of the factors influencing the choice of type of provider to study a degree in New Zealand cannot accurately be determined. Hence no insight into the parity of esteem issue can be gained from existing studies. This is the gap in the literature that this study aims to fill.

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[132] The peer impact variable was calculated as the proportion of students from a school that enrolled in a similar type of tertiary education. This has the potential to be highly correlated with school decile.

4.4 Data

The data used in this analysis is derived from the administrative enrolment information recorded by tertiary institutions at the time that students enrolled in a bachelors degree qualification for the first time. This data was provided to the Ministry of Education for funding and monitoring purposes. The Ministry of Education has then made this information available to the author for analytical purposes.

The full dataset contains the unit record information of 20,628 domestic students aged between 16 and 27 who commenced a bachelors degree at a university or polytechnic in 2006.[133] This is around 70 percent of all domestic degree starters in 2006 and therefore represents a reasonable coverage of degree starters in New Zealand.

The information available for each student includes demographic details such as age, gender, and the ethnic group of the student. It also contains historical information on the student, such as their highest secondary school qualification, the decile of the last secondary school they attended and their main activity in the period prior to commencing degree studies. Information on the type of school attended (public vs private) is also available.

The tertiary-study related variables in the dataset include information on the study load of the student, the broad subject area of the qualification the student is enrolled in and whether the student studied on an intramural or extramural basis.

The dataset also contains information on whether the student studied at a tertiary provider in the same district council area as they attended secondary school. This variable is derived at the campus level – which is important for identifying students that are studying at campuses outside of the main location of the tertiary institution.

[133] Although the issue of parity of esteem also potentially applies to international students, this study focuses solely on domestic students. There is no detailed information available on the school performance or socioeconomic status of international students, which are expected to be important factors in determining the choice of tertiary provider.

The Albany and Wellington campuses of Massey University are the most prominent examples of this.

Because of the interest in the student characteristics associated with choice of tertiary provider that require information on the last secondary school attended, such as school decile, the dataset used in this study does not include degree starters who were enrolled in schools not recognised by the Ministry of Education, home schooled, enrolled in the correspondence school or who never attended a secondary school.

The reason for restricting the dataset to those aged between 16 and 27 at time of first enrolment in a bachelors degree is that a key variable in this study, decile of last secondary school attended, was first calculated in 1995. Therefore, students aged over 27 in 2006 would have attended a secondary school prior to the period that deciles were allocated. Given that deciles can and do change over time, students aged over 27 are excluded from the study.

In addition, as the official school leaving age is 16, the dataset is limited to those students aged at least 16 years of age at time of first enrolment. Students enrolled in degree study under the age of 16 are likely to be exceptions to the rule – and exhibit a significantly different profile to the vast majority of students who start a bachelors degree.

The logistic regression analysis in this chapter is applied to a number of subgroups of the overall dataset. These subgroups are described in Table 4.2 and range in size from the 20,628 domestic students aged between 16 and 19 who enrolled in a bachelors degree at a university or polytechnic, to the 375 students in the dataset of school leavers who enrolled on an intramural basis in a bachelors degree in nursing at a university or polytechnic.

The reasons for examining different groups of students are three-fold. Firstly, determining if a student has travelled to enrol in bachelors study can only be achieved by comparing the location of the last secondary school attended with the location of the tertiary campus they have enrolled at. Therefore, only in the case of school leavers (School Leavers) can it be accurately determined if the student travelled for the purposes of study.

Secondly, the analysis of all domestic degree starters (All Students) examines if the association between selected variables, such as highest secondary school qualification and decile of last secondary school attended, changes with age. Also, the impact of the prior activity on the choice of tertiary education provider is analysed using this dataset, a factor excluded from the School Leaver dataset.

Finally, by examining specific degrees, such as nursing, the issue of parity of esteem can be explored in areas which have been predominantly the domain of polytechnics.

Table 4.2, Descriptions of datasets used in analysis of student choices

Analysis	Dataset	Definition	Size
University vs polytechnic	All Students	Students enrolled in bachelors degrees in universities and polytechnics.	20,628
	All Students - Nursing	Students enrolled in a bachelor of nursing in universities and polytechnics.	721
	School Leavers	Intramural students enrolled in bachelors degrees in universities and polytechnics directly from school.	13,775
	School Leavers - Nursing	Intramural students enrolled in a bachelor of nursing in universities and polytechnics directly from school.	375
University grouping	All Students	Students enrolled in bachelors degrees in universities.	17,582
	All Students – Teacher education	Students enrolled in a bachelors degree in the teacher education area.	626
	School Leavers	Intramural students enrolled in bachelors degrees in universities directly from school.	12,645
	School Leavers – Teacher education	Intramural students enrolled in bachelors degrees in universities directly from school in the teacher education area.	401

4.5 Theoretical framework and method

The theoretical framework for this analysis is adapted from Maani (2006) and assumes that a student's choice of tertiary education provider is influenced by a desire to maximise their future economic returns.[134] The choice of provider is also assumed to be affected by environmental factors such as the influence of parents and peers, lifestyle choices and subject interests.

Assuming that the choice of institution is between a university and polytechnic, then Y_{i0} is the stream of potential life-time earnings net of education costs for the i^{th} individual if the student decides to study a bachelors degree at a polytechnic, and Y_{ij} is the stream of life-time earnings if the student decides to study at a university.

$$Y_{ij} = E_j (S_i), \quad j = 0, 1 \tag{1}$$

Then potential life-time earnings at that type of provider will depend on the educational achievement at each type of provider (E_j), as influenced by the individual characteristics and ability of the individual (S_i). The net present value of choosing the j^{th} type of tertiary provider for the i^{th} individual is denoted by V_{ij}:

$$V_{ij} = V \{E_j (S_i), X_i, u_i\}, j = 0, 1 \tag{2}$$

where V_{ij} is the utility of the expected lifetime earnings at that type of provider; X_i represents observable background characteristics and u are the unobservables. A student will choose to study at university if the utility of the expected present value of lifetime earnings from studying a degree at this type of institution exceeds that of studying at a polytechnic.

As the choice of enrolling in a university or polytechnic is binary in nature, the use of ordinary least squares is not appropriate as the error term is heteroscedastic and not normally distributed and the predicted probabilities can be either greater than one or less than zero (Ramanathan 1998).

[134] Who adapted her framework from that developed by Willis and Rosen (1979) in estimating the factors influencing university participation.

Therefore, binary logistic regression, which uses a maximum likelihood procedure to generate estimates of the logits is used. The logistic regression model is presented in equation 3, where $P_{university}$ represents the probability of a student choosing a university to study a bachelors degree:

$$\ln\left[\frac{P_{university}}{P(1-P_{university}))}\right] = \alpha + X_i\beta + \mu \tag{3}$$

Where the dependent variable is the natural logarithm of the odds of a student selecting a university to study a degree, X is a vector of explanatory variables, β is the coefficient of the explanatory variables in logit form, μ is an error term and i = 1 to n observations.

The suite of explanatory variables available for the logistic regression analyses includes demographic, background and tertiary study-related factors. Each of these variables is discussed in turn below.

The age of a student at the time of their initial enrolment in a bachelors degree is included as an explanatory variable (AGE), with different specifications for age in the School Leaver and All Students analyses. In the School Leaver analysis, age is a continuous variable that ranges from 16 to 19. However, for the All Students analysis, the age of a student at their initial enrolment is specified by a dummy variable that takes a value of 0 if the student is aged between 16 and 19 and a value of 1 if the student is aged between 20 and 27. A categorical variable is used to represent age as students aged under 20 face different academic entry requirements to those aged 20 and over. There is open entry for students aged 20 and over and restricted entry dependent on secondary school performance for students aged under 20. Therefore, specifying age as a dummy variable more accurately reflects the different entry requirements on tertiary choices for these respective age groups.

It is expected that older students would be more likely than younger students to want to acquire skills that are more vocationally orientated for employment purposes and therefore may be more likely to attend a polytechnic where the degrees are more vocational in nature.

The gender of the student is represented in the regression model by a dummy variable (GENDER) which takes a value of 1 if the student is male and 0 if the student is female. There is no a priori expectation as to the sign of this variable. However, given the broad subject categories used in this analysis, it is likely that subject choice will vary significantly by gender.

A variable with multiple categories (ETHNIC GROUP) is used to capture the association between ethnic group and the likelihood of selecting a university to enrol in bachelors study. As students have to ability to specify multiple ethnicities on their enrolment forms the ethnic groups have been specified on a prioritised basis. The ethnic groups in the analysis are: European, Māori, Pasifika, Asian and 'Other'. The reference category is European. The order of prioritisation is Māori, Pasifika, Asian, Other and then European.

Given that Asian students are more influenced by league tables and the prestige of a tertiary institution, they may be more likely than other ethnic groups to select a university instead of a polytechnic to start a bachelors degree.

The decile of the last secondary school attended by the student is included as an explanatory variable (SCHOOL DECILE) in the model. A decile value is constructed for primary, intermediate and secondary schools in New Zealand for government funding purposes.[135] Census data is used to construct a profile of the area that students are drawn from to attend the school. It takes into account five factors: household income, occupation, parental education qualifications, household crowding (number of people in a household divided by number of bedrooms), and income support. Decile values are assigned by ranking the weighted average of the combined measures and splitting the schools into ten equal groups. The schools with

[135] See http://www.minedu.govt.nz/educationSectors/Schools/SchoolOperations/Resourcing/OperationalFunding/Deciles/HowTheDecileIsCalculated.aspx.

the most well-off catchments are assigned a decile value of 10, the schools with the least well-off a decile of 1.

For the purposes of this study a variable with multiple categories is used to capture the association between school decile and the type of tertiary providers selected by students. This approach is used as non-secondary schools are used in the ranking process used to generate the deciles. Therefore, there is not a clear linear relationship between the decile of each secondary school to the next. In addition, not all private schools are assigned a decile.[136]

In the logistic regression analysis SCHOOL DECILE is represented by 11 categories which range from decile 1 to decile 10. There is also a category for private schools that are not assigned a decile. The reference category is a decile 10 school.

Although previous studies have used school decile as a proxy for the socioeconomic status of students (see Choat 1998, University of Auckland Taskforce 1999), a drawback of using school decile in this way is that it is linked to the school a student attends and not the circumstances of that individual. In other words, a student who attends a low decile school may come from a household that is highly educated and of high income, and vice versa. Nonetheless, given the lack of alternative measures of socioeconomic status of students, decile is the best variable available, despite is limitations.

It is expected that students that choose to enrol in a university are more likely to come from high decile schools compared with students who enrol in a polytechnic. Similarly, students from higher-decile schools may be more likely to attend universities that are perceived as having higher esteem.

To capture the association between the various pathways into bachelors degree study and choice of tertiary institution, a variable with multiple categories (PRIOR ACTIVITY) is included in the All Students regression model. This is the main activity of a student in October in the year preceding enrolment. The categories are:

[136] In the School Leaver dataset around 38 percent of private schools are assigned a decile.

school student, university student, polytechnic student, other tertiary student (which includes attendance at a college of education, wānanga and private training establishment), employed (including self-employed), unemployed, houseperson (including retired) and overseas. The reference category in the regression models is school leavers.

It is likely that students that have had previous exposure to study at a certain provider type will continue on to further study at that same provider. It is also possible that students that were employed will enrol in a degree course that will help their current or future employment prospects. Therefore, they may be more likely to enrol in a vocational degree at a polytechnic where the degrees are vocationally focused.

A variable with multiple categories (SCHOOL QUALS) is used in the regression models to capture the highest school qualification achieved by the bachelors degree starters. These categories are: students with a year 11 qualification or lower (includes students with no school qualifications or School Certificate and NCEA level 1), year 12 (includes students with University Entrance and NCEA level 2), and year 13 or higher (includes scholarship, bursary and NCEA level 3). There is also a category that represents students who indicated a highest qualification of an overseas nature. These are overseas qualifications received by domestic students in New Zealand as an alternative to the national system, such as Cambridge Exams or International Baccalaureate qualifications. A drawback of the overseas qualification category is that the level of the qualification is not indicated in the enrolment data used in this analysis. The reference category in the regression models is students with a year 12 qualification.

If there is a perception that university degrees are ‘better’ than polytechnic degrees, then more academically-able students are expected to have a greater likelihood of choosing university study to maximise their future incomes. The limited opportunities for postgraduate study at polytechnics are also likely to be an influence on the decision of the more academically able students.

It should be noted that the highest school qualification reported in this study is at the time the student completed their enrolment form. In the case of students who are school leavers and who may not have received their exam results when filling out the enrolment forms this may lead to situations where their highest school qualification is understated. Therefore, this group may have attained higher school qualifications than indicated at time of enrolment.[137]

The study load of a student is measured by a dummy variable (STUDY LOAD) that takes a value of 1 if the student is part time and a value of 0 if the student is full-time. If the student had a 1 EFTS load for the entire year or were enrolled for one semester but were full-time they are considered to be in full-time study. Otherwise they are considered to be enrolled on a part-time basis.

Students who study on a part-time basis are likely to be doing so because they have commitments elsewhere that preclude a full-time commitment to study. For example, they may be working and are studying to attain specific work-related skills. These students may be more likely to seek to study degrees that will help their employment prospects and hence enrol in the more applied degrees that are offered by the polytechnics.

The choice of subject area for tertiary study is an important factor in student decision making. In those areas where the polytechnics may be new to offering degrees outside of their areas of specialisation, there is likely to be lower demand. In other areas, where polytechnics are perceived to be providing relevant degrees that will result in good labour market outcomes there may well be higher demand for their degree programmes.

The subject area that the student enrols in is represented by a variable (SUBJECT) with eight categories. The categories are based on 2-digit broad New Zealand Standard Classification of Education (NZSCED) categories assigned to the qualification the student has enrolled in. The categories are: Science (which includes Information Technology), Engineering, Architecture, Agriculture, Health, Commerce (including food and hospitality), Society and culture (including education and mixed field) and Creative arts.

[137] This is why students who are school leavers with less than year 12 qualifications appear in the database as having enrolled in bachelors study.

There have been a number of areas where subject areas have been combined due to issues with the specification of the various subject areas. For example, Information technology is combined with Science given that a number of universities offer their computer qualifications under a bachelor of science. Also, a small number of hospitality enrolments are included in the Commerce enrolments. In addition, Architecture students have been included in the Engineering subject area. Similarly, enrolments in the Education field have been combined with Society and culture, given that enrolments in this area at polytechnics have only just begun in small numbers in 2006. The reference category in the regression models is Creative arts.

For the All Students regression analysis a dummy variable (STUDY TYPE) is used to capture the nature of attendance of the student. This variable takes a value of 1 if the student was enrolled extramurally and 0 if enrolled intramurally. The majority of extramural bachelors level education in New Zealand is provided through two tertiary institutions: the Open Polytechnic of New Zealand and Massey University.

A variable with two categories (MOBILITY) is included in the School Leaver regression analysis to capture the association between the likelihood of travelling for tertiary study and enrolment in a university. The first category represents those students that enrol in a tertiary institution in the same district council area where they went to school. The second category represents those students that travelled to undertake degree study. The reference category is students who did not travel.

Access to tertiary education would appear to play a key role in the decision making of students (Ussher 2007). For example, some students will be unable to travel given their financial or family circumstances. As polytechnics have a wider geographical coverage due to the regional location of a number of polytechnics, it would be expected that the likelihood of students attending a polytechnic for bachelors study will be higher for this group. In addition, students may travel to study at tertiary providers outside of their current geographical location in order to study specific subjects or appreciate a certain student lifestyle.

The explanatory variables used in both models are summarised in Table 4.3 where SL represents the variables included in the School Leaver regression analysis and AS represents the variables included in the All Students regression analysis.

Table 4.3, Definitions of explanatory variables in logistic regression analysis of student choices

Variable	Student group	Definition	Categories
AGE	SL AS	Age at time of first enrolment in bachelors degree	n/a 16-19 (reference) & 20-27
GENDER	SL&AS	Gender of student	Male, female (reference)
ETHNIC GROUP	SL&AS	The prioritised ethnic group of students	European (reference), Māori, Pasifika, Asian, Other
SCHOOL QUALS	SL&AS	The level of highest secondary school qualification	Year 11 or lower, year 12 (reference), year 13, overseas
SCHOOL DECILE	SL&AS	The decile of last secondary school attended	1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (reference) and private school – no decile
PRIOR ACTIVITY	AS	The main activity at 1 October in year prior to enrolment	School student (reference), university student, polytechnic student, other tertiary student, employed, unemployed/beneficiary, houseperson, overseas,
SUBJECT	SL&AS	The broad subject area of the bachelors qualification enrolled in	Science, Engineering, Agriculture, Health, Commerce, Society and culture, Creative arts (reference)
STUDY LOAD	SL&AS	This indicates whether the student was enrolled on a full-time or part-time basis	Full-time (reference), part-time
STUDY TYPE	AS	This indicates whether a student was enrolled on an intramural or extramural basis	Intramural (reference), extramural
MOBILITY	SL	This indicates whether the student travelled to enrol in tertiary study	Did not travel (reference), travel

Although the list of variables in Table 4.3 is reasonably comprehensive, one potentially important explanatory variable, the cost of tuition fees, is excluded from this study.[138] However, tuition fees charged by polytechnics and universities in the same field of study do not show significant variation, especially between institutions in the same regional area.

Table 4.4 below presents the domestic fees for a full-time student in the commerce area at the bachelors level for seven New Zealand universities and nine polytechnics in 2007.[139] The average fee at the universities of $4,078 is very similar to the average fee of $3,995 charged at the polytechnics. When the fees at providers are examined by region, there is little difference in fees charged, with the greatest variation between the University of Auckland and Unitec New Zealand and MIT.

Table 4.4, Domestic tuition fees for bachelors degree in commerce 2007

Region	**Universities**		**Polytechnics**	
Auckland	AUT Auckland	$4,185 $4,526	Unitec NZ MIT	$3,950 $3,909
Waikato	Waikato	$4,127	WINTEC	$4,270
Manawatu	Massey	$3,787	UCOL	$3,969
Wellington	VUW	$4,170	WELTEC	$4,302
Canterbury	Canterbury	$4,164	CPIT	$4,000
Otago	Otago	$3,585	Otago	$3,568
Mean		**$4,078**		**$3,995**

In any event, tuition fees may not be a major factor in student decision making for bachelors students. Holdsworth and Nind (2006) found that students may not be particularly sensitive to differences in the price of bachelors programmes. The availability of student loans to pay for course fees may be a contributing factor to the lack of price sensitivity for tertiary education.

[138] This information is not available in the dataset used in this study.
[139] These fees were derived from the websites of the tertiary institutions included in Table 4.3.

4.6 Characteristics of the datasets

The characteristics of the datasets used in the logistic regression analysis are examined in this section. Firstly, the characteristics of the School Leaver dataset is examined in section 4.6.1. This is followed by an examination of the characteristics of the All Students dataset in section 4.6.2.

4.6.1 School Leaver dataset

The characteristics of the 13,775 students in the School Leaver dataset are presented in Table 4.5. Overall, there were 12,645 students in this dataset who enrolled in a university and 1,130 that enrolled in a polytechnic.[140]

The demographic profile of the students attending universities and polytechnics exhibit a number of differences. There is a higher proportion of female degree starters at polytechnics (64 percent) compared with universities (56 percent). There is also a lower proportion of European students and a significantly higher proportion of Asian students starting bachelors degrees at universities, compared with polytechnics. Twenty percent of degree starters at universities are Asian, compared with just 8 percent at polytechnics. Sixty-four percent of domestic bachelors starters at universities are European, compared with 73 percent at polytechnics.

In terms of the decile of last secondary school attended, the lower proportion of students from lower decile schools enrolled in both universities and polytechnics reflects the reduced access that students from lower socioeconomic areas face. However, there are a greater proportion of students from higher decile schools that enrol in universities rather than polytechnics. For example, 29 percent of enrolments at university are from decile 10 schools, while just 15 percent of students enrolled in polytechnic degrees are from decile 10 schools.

There is a significant difference in the profile of university and polytechnic degree starters by highest secondary school qualification. A much higher proportion of students enrolling at a university have a highest school qualification at the year 13

[140] Due to missing values for variables this represents around 98 percent of all school leavers. A check of the mean values of variables without missing observations showed that the characteristics of the dataset without the missing values was very similar to the dataset containing the missing values.

level at the time of enrolment. Seventy-two percent of university degree starters have a year 13 qualification, compared with just 34 percent for polytechnic degree starters. Nineteen percent of university degree starters have a year 12 qualification at the time of enrolment, compared with 55 percent of polytechnic enrolments.

Only a small proportion of degree starters are part-time at either universities or polytechnics. Three percent of university degree starters are part-time and six percent of polytechnic starters are part-time.

The broad subject area of degree starters varies significantly between the two types of tertiary provider. Society and culture is the largest subject area for university degree starters (33 percent), followed by Science (23 percent) and Commerce (20 percent). In polytechnics, the largest proportion of degree starters are enrolled in Creative arts (32 percent) followed by Health (30 percent) and Society and culture (10 percent).

What also stands out in Table 4.5 is that a much higher proportion of students who travelled for degree study enrolled in universities. Around 38 percent of university students in this sample travelled for study, compared with 21 percent for polytechnic students.

Table 4.5, Characteristics of the School Leaver dataset

Factors	Categories	All (n=13,775)	Universities (n=12,645)	Polytechnics (n=1,130)	% selecting university
AGE	16	0.6%	0.5%	1.3%	80.3%
	17	19.5%	19.4%	21.4%	91.0%
	18	71.0%	71.5%	65.3%	92.5%
	19	8.9%	8.7%	12.0%	89.0%
GENDER	Male	43.6%	44.2%	36.2%	93.2%
	Female	56.4%	55.8%	63.8%	90.7%
ETHNIC GROUP	European	64.5%	63.7%	72.9%	90.7%
	Māori	8.4%	8.1%	11.8%	88.5%
	Pasifika	4.3%	4.3%	4.3%	91.8%
	Asian	19.0%	20.0%	7.8%	96.6%
	Other	3.8%	3.8%	3.2%	93.1%
SCHOOL DECILE	1	1.2%	1.2%	1.6%	89.3%
	2	2.5%	2.3%	4.9%	84.2%
	3	3.4%	3.2%	5.8%	86.2%
	4	7.4%	7.2%	9.6%	89.4%
	5	9.3%	9.1%	11.5%	89.9%
	6	8.6%	8.4%	11.2%	89.4%
	7	11.3%	11.0%	14.1%	89.8%
	8	8.9%	8.7%	11.3%	89.6%
	9	12.9%	13.0%	12.0%	92.3%
	10	27.5%	28.6%	15.0%	95.5%
	Private school – no decile	6.8%	7.2%	3.0%	96.4%
SCHOOL QUALS	Year 11 or lower	2.3%	1.4%	11.2%	59.0%
	Year 12	21.3%	18.5%	53.5%	79.4%
	Year 13	68.7%	71.7%	34.3%	95.9%
	Overseas	7.7%	8.3%	1.0%	99.0%
STUDY LOAD	Full-time	97.0%	97.3%	94.0%	92.1%
	Part-time	3.0%	2.7%	6.0%	83.5%
SUBJECT	Science	21.9%	23.0%	9.1%	96.6%
	Engineering	9.7%	9.6%	10.1%	91.5%
	Agriculture	1.1%	1.1%	0.6%	95.2%
	Health	7.2%	5.2%	29.7%	66.1%
	Commerce	19.3%	20.3%	8.6%	96.4%
	Society and culture	30.7%	32.5%	10.4%	97.2%
	Creative arts	10.2%	8.3%	31.5%	74.7%
MOBILITY	No travel	63.9%	62.5%	78.8%	89.9%
	Travel	36.1%	37.5%	21.2%	95.2%
ALL					**91.8%**

The proportion of degree starters that enrolled in a university within each of the various categories is also presented in Table 4.5. The overall percentage of students in the School Leaver dataset who enrolled in a university was 91.8 percent. In terms of demographic variables, the likelihood of enrolling in a university rises slightly with age. Ninety-one percent of students aged 17 at time of enrolment selected a university compared with 92.5 percent of students aged 18.

In terms of gender, a slightly higher percentage of men (93.2 percent) enrol to study in a university compared with women (90.7 percent).

Asian students were the most likely to study at a university. Ninety-six-point-six percent of Asian students enrolled at a university, compared with 91.8 percent for Pasifika students, 90.7 percent for European and 88.5 percent for Māori students.

The likelihood of studying at a university rises as the decile of the last secondary school attended increases. For example, the proportion of students from a decile 2 school enrolling in university was 84.2 percent, compared with 95.5 percent of students from a decile 10 school. This is also a potential sign of a parity of esteem issue, given that students from a higher socioeconomic background are potentially more influenced by the prestige of an institution.

Of the three main categories of school qualifications, 79.4 percent of students with a year 12 qualification enrolled in a university, 95.9 percent of students with a year 13 qualification enrolled in a university and 99.0 percent of students with an overseas qualification enrolled in a university. Clearly, students of greater academic ability have a higher likelihood of enrolment at a university.

Students who were enrolled on a full-time basis were more likely to enrol in a university. Ninety-two point one percent of full-time students enrolled in university study compared with 83.5 percent of students studying on a part-time basis.

Students who travelled to enrol in degree study were more likely to enrol in a university. In this school leaver sample, 95.2 percent of students who travel enrol at a university, compared with 89.9 percent of students that don't travel.

There was a significant variation in the proportion of students enrolling at a university by subject area. The highest proportion of students enrolling in a university was in Society and culture (97 percent) and the lowest in Health (66 percent). This reflects the variation in coverage of degrees by the polytechnics. The higher proportion of students enrolling in the health area is a result of the large number of students enrolled in nursing degrees at polytechnics.

4.6.2 All Students dataset

The characteristics of the 20,628 students in the All Students dataset are presented in Table 4.6. In total, 18,203 students enrolled in a university and 2,425 in a polytechnic.[141] The dataset exhibits a similar demographic profile to that of the School Leaver dataset - namely, degree students enrolled in universities tended to be younger, male, and with a higher proportion of Asian students.

The All Students dataset also shows a pattern of a higher proportion of students enrolling in universities from high decile schools and with a highest school qualification at the year 13 level. Also, a higher proportion of polytechnic students were enrolled on a part-time basis (15 percent) compared with university students (8 percent).

The subject area profile of the All Students dataset displays a similar pattern to the School Leaver dataset – the highest proportion of students in polytechnics enrol in Creative arts (28 percent), while the greatest proportion of university students enrol in Society and culture (36 percent).

In terms of prior activity, students enrolled in universities were predominantly school leavers (72 percent), while a much lower proportion of polytechnic degree students were school leavers (52 percent). Also, a slightly higher proportion of polytechnic students (7 percent) studied on an extramural basis compared with university students (3 percent).

[141] Due to missing values for variables this represents around 97 percent of relevant students. A check of the values for variables without missing observations showed that the characteristics of the dataset without the missing values was very similar to the dataset containing the missing values.

Table 4.6, Characteristics of the All Students dataset

Factors	Category	All (n=20,628)	Universities (n=18,203)	Polytechnics (n=2,425)	% selecting university
AGE	16-19	80.4%	82.9%	61.5%	91.0%
	20-27	19.6%	17.1%	38.5%	77.0%
GENDER	Male	43.1%	43.9%	37.1%	89.9%
	Female	56.9%	56.1%	62.9%	87.0%
ETHNIC GROUP	European	64.9%	64.3%	68.8%	87.5%
	Māori	10.1%	9.4%	15.4%	82.0%
	Pasifika	4.9%	4.9%	5.5%	86.8%
	Asian	16.2%	17.4%	7.2%	94.8%
	Other	4.0%	4.1%	3.1%	90.8%
SCHOOL DECILE	1	1.4%	1.3%	2.2%	82.0%
	2	3.0%	2.7%	5.1%	79.9%
	3	4.1%	3.7%	7.1%	79.7%
	4	7.9%	7.6%	10.1%	85.0%
	5	9.9%	9.6%	12.2%	85.6%
	6	9.9%	9.5%	12.5%	85.1%
	7	11.7%	11.3%	14.6%	85.3%
	8	9.0%	8.8%	10.9%	85.8%
	9	12.7%	12.9%	10.7%	90.1%
	10	24.5%	26.2%	12.3%	94.1%
	Private school – no decile	5.9%	6.4%	2.5%	95.1%
SCHOOL QUALS	Year 11 or lower	7.2%	5.2%	22.5%	63.2%
	Year 12	24.5%	21.8%	45.4%	78.3%
	Year 13	62.2%	66.3%	31.2%	94.1%
	Overseas	6.1%	6.7%	0.9%	98.2%
PRIOR ACTIVITY	School student	70.0%	72.4%	52.0%	91.3%
	University student	3.1%	3.3%	1.6%	93.8%
	Polytechnic student	2.5%	1.8%	7.5%	64.8%
	Other tertiary student	1.4%	1.3%	2.7%	78.0%
	Employed	17.3%	15.9%	28.0%	81.0%
	Unemployed	2.0%	1.7%	4.7%	72.7%
	Houseperson/beneficiary	0.3%	0.2%	0.6%	74.1%
	Overseas	3.4%	3.5%	2.9%	90.0%
STUDY LOAD	Full-time	91.4%	92.3%	84.9%	89.1%
	Part-time	8.6%	7.7%	15.1%	79.4%
STUDY TYPE	Intramural	96.2%	96.6%	92.9%	88.6%
	Extramural	3.8%	3.4%	7.1%	78.3%
SUBJECT	Science	19.7%	20.9%	10.7%	93.6%
	Engineering	7.9%	7.8%	8.5%	87.4%
	Agriculture	1.1%	1.2%	0.4%	96.0%
	Health	7.7%	5.1%	27.0%	58.5%
	Commerce	19.9%	20.9%	11.9%	92.9%
	Society and culture	33.0%	35.6%	13.8%	95.1%
	Creative arts	10.8%	8.5%	27.8%	69.7%
All					**88.2%**

The overall proportion of degree starters in the All Students dataset who enrolled in a university was 88.2 percent. Older students in this dataset were less likely to enrol in a university. The percentage of students aged between 20 and 27 enrolling in a university was 77 percent, compared with 91 percent for students aged between 16 and 19. In addition, a slightly higher proportion of men (89.9 percent) study at a university than women (87 percent).

Asians in the All Students dataset were more likely to enrol at a university compared with students from other ethnic groups. Ninety-four point eight percent of Asian students enrolled in university, compared with 86.8 percent of Pasifika students, 87.5 percent of Europeans and 82 percent of Māori.

Students from higher decile schools were more likely to enrol in university. Ninety-four point one percent of students from a decile 10 school enrolled in a university degree. This compares with 85.6 percent for students from decile 5 school and 82 percent for students from a decile 1 school.

Students with higher school qualifications had a higher likelihood of attending a university. Ninety-four point one percent of degree starters with a year 13 qualification enrolled in a university, compared with 78.3 percent of students with a year 12 qualification.

There was significant variation in the likelihood of attending a university depending on the prior activity of the student in the previous year. Students who attended a university previously were the most likely to start a degree at a university (93.8 percent) followed by students who were school leavers (91.3 percent). Those least likely to enrol in a university degree were students who had been enrolled in a polytechnic in the previous year. Just 64.8 percent of these students went on to enrol on a university degree programme. Students from other tertiary institutions were also relatively less likely to enrol in university programmes than most groups (78 percent).

The proportion of full-time students enrolling in universities was higher (89.1 percent) than students studying on a part time basis (79.4 percent). Also, the proportion of students enrolled in a university was higher for intramural students (88.6 percent) than extramural students (78.3 percent).

In terms of subject area, the All Students dataset displayed a similar pattern to the school leaver dataset. The highest proportion of students enrolled in universities did so in the subject areas of Agriculture (96.0 percent) and Society and culture (95.1 percent). The lowest proportion of students enrolled in universities did so in the subject areas of Health (58.5 percent) and Creative arts (69.7 percent).

The datasets in Table 4.5 and Table 4.6 display patterns of enrolment that suggest there is a lack of parity of esteem between polytechnic and university degrees. Student with higher school qualifications, from higher decile schools, Asian students and students who travel, were all more likely to enrol in universities.

However, confounding factors can mask the underlying relationship between the explanatory variables and the likelihood of enrolling in a university. The application of logistic regression to this dataset in section 4.7, which holds all other factors constant while examining the explanatory variable of interest, will allow a clearer picture to be obtained of the patterns in enrolment at the bachelors level.

4.7 Results

This section presents the results of the logistic regression analysis that identifies the factors associated with the choice of tertiary institution to start a bachelors degree. Firstly, the analysis of choice of provider by school leavers is presented in section 4.7.1. This is followed by the analysis of choice of provider by all domestic degree starters in section 4.7.2.

Although not explicitly stated in this section, the discussion of the results of the association between an explanatory variable of interest and the dependent variable holds all other factors constant.

4.7.1 School Leaver analysis

The results of the main effects logistic regression model and the results of a model containing interaction effects are presented in Table 4.7 and Table 4.8, respectively. The regression output in these tables includes the binary logit coefficient estimates, standard errors, odds ratios and 95 percent confidence intervals for the logit coefficients derived from 100 bootstrapped replications. Given the unbalanced nature of the dependent variable, the bootstrapped 95 percent confidence intervals provide another way of assessing the robustness of the logit estimates.[142]

The results show that although the explanatory power of the models is not overly high, the pseudo R^2 of 0.31 for the main effects model and 0.33 for the interaction model is reasonable, given the large size of the dataset.[143]

With the exception of AGE and GENDER in the main effects model, all the remaining independent variables had a statistically significant association with the type of degree provider selected.[144] Given the small range of age in the School

[142] Note that King *et al's*. (1999) Rare Event Logistic Regression (RELOGIT) algorithm was also run on the dataset, given the unbalanced nature of the dependent variable. However, little difference was found between the RELOGIT and the usual binary logistic regression estimates. Therefore the usual binary regression results are the ones reported in this study. See King and Zheng (2001) for more detail on rare events logistic regression.

[143] This compares with a pseudo R^2 of 0.57 in studies by Maani (2006) and 0.48 in Ussher (2008). However, in both of these cases multinomial regression was used and, in the case of Maani's study, the size of the dataset was much smaller than in this study.

[144] Likelihood ratio tests were used to identify the statistical significance of the explanatory variables.

Leaver dataset, its statistical insignificance is not surprising. However, GENDER has a statistically significant interaction with SUBJECT and was therefore retained in the models. Note that the results of the model containing interactions are the ones discussed in this section.

The results of the logistic regression analysis suggest that the enrolment decisions of students may be influenced by a perceived lack of parity of esteem between university and polytechnic degrees. One of the clearest indications of this is that more academically-able bachelors degree starters have a greater likelihood of enrolling in universities. The odds of a student enrolling in a university were 3.9 times higher for those with year 13 qualifications than students with year 12 qualifications. The odds of a student with a year 11 or lower qualification attending university were 78 percent lower than those of a student with a year 12 qualification. Students with an overseas qualification were even more likely to enrol in a university then students with a year 13 qualification. The odds of a student with an overseas qualification studying at a university were 9.7 times that of a student with a year 12 qualification.

It is not surprising that students with higher level school qualifications were more likely to study at a university, given the very limited options for postgraduate study at polytechnics. It is also an indicator that university qualifications are held in higher esteem, given that students of higher academic ability are likely to seek tertiary study that maximises their chances of a superior labour market outcome. Students of higher academic ability are also likely to be among the most conscious of the prestige or reputation of an institution.

Further evidence of a potential lack of parity of esteem is found in the positive association between the decile of the last secondary school attended by a student and the likelihood of enrolling in a university programme. Students from higher decile secondary schools were more likely to start a bachelors degree at a university than students from lower decile schools. The odds of a student from a decile 1 secondary school enrolling in a university were 72 percent lower than those of a student from a decile 10 secondary school and the odds of a student from a decile 9 school enrolling in university were still 52 percent lower than that of a student from a decile 10 school. There was no statistically significant difference in the likelihood of students from a private school with no decile and students from a decile 10 school enrolling in university

Although the decile of the last secondary school attended does not directly capture the socioeconomic status of the individual student, it nevertheless suggests that the education levels and wealth of the catchment of the school the student originates from are associated with the choice of type of tertiary provider in a manner that suggests a lack of parity of esteem may exist between university and polytechnic degrees.

The regression results also show that the likelihood of attending a university to study a bachelors degree varied depending on whether or not the student enrolled in a tertiary provider in a geographical area that was different from that in which they attended secondary school. Students that travelled to start a bachelors degree were more likely to attend a university than a polytechnic, compared with those who did not travel. The odds of a student who chose to travel enrolling in a university were 2.7 times higher than a student who did not travel to study.

The greater geographical coverage of polytechnics is likely to be a factor in this result. Students who may not be in a position to travel to start a bachelors degree for work or family reasons will be more likely to study at the closest institution to their location – which for many people in regional areas would be a polytechnic. Also, the fact that students who travel long distances are more likely to enrol at a university is possibly due to universities having specific specialist subjects or postgraduate programmes that students intend to continue into after completion of a bachelors degree.

Table 4.7, Logistic regression results: School Leaver main effects model

(Dependent variable: university = 1, polytechnic = 0)

Variable	Category	Logit coefficients	Standard errors	Bootstrapped 95% confidence intervals of logit coefficients		Odds Ratios
				Lower	Upper	
AGE		0.009	0.065	-0.132	0.150	1.01
GENDER	Male	-0.084	0.081	-0.268	0.099	0.92
	Female	Reference category				
ETHNIC GROUP	European	Reference category				
	Māori	0.008	0.123	-0.227	0.244	1.01
	Pasifika	0.813**	0.193	0.368	1.259	2.26
	Asian	1.370**	0.129	1.094	1.646	3.94
	Other	0.747**	0.201	0.352	1.142	2.11
SCHOOL	Year 11 or lower	-1.495**	0.152	-1.788	-1.202	0.22
QUALS	Year 12	Reference category				
	Year 13	1.366**	0.079	1.225	1.508	3.92
	Overseas	2.338**	0.316	1.683	2.993	10.36
SCHOOL	1	-1.277**	0.327	-1.976	-0.578	0.28
DECILE	2	-1.646**	0.204	-1.998	-1.293	0.19
	3	-1.424**	0.186	-1.795	-1.053	0.24
	4	-1.199**	0.153	-1.508	-0.890	0.30
	5	-1.130**	0.142	-1.413	-0.847	0.32
	6	-1.073**	0.145	-1.351	-0.795	0.34
	7	-1.113**	0.134	-1.389	-0.837	0.33
	8	-1.358**	0.143	-1.650	-1.065	0.26
	9	-0.723**	0.136	-0.997	-0.448	0.49
	10	Reference category				
	Private – no decile	0.180	0.208	-0.290	0.651	1.20
SUBJECT	Science	1.868**	0.131	1.594	2.141	6.47
	Engineering	0.565**	0.133	0.295	0.835	1.76
	Agriculture	1.392**	0.407	0.570	2.214	4.02
	Health	-0.460**	0.106	-0.690	-0.230	0.63
	Commerce	1.979**	0.130	1.693	2.265	7.23
	Society & culture	2.392**	0.122	2.110	2.673	10.93
	Creative arts	Reference category				
STUDY	Full-time	Reference category				
LOAD	Part-time	-0.663**	0.169	-1.018	-0.309	0.52
MOBILITY	No travel	Reference category				
	Travel	1.028**	0.088	0.848	1.208	2.03
CONSTANT		0.708	1.168	-1.842	3.258	
Log likelihood		-2,686				
Pseudo R^2		0.31				
Prob > Wald $\chi 2$		<0.0000				
N		13,775				

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

Table 4.8, Logistic regression results: School Leaver model with interactions

(Dependent variable: university = 1, polytechnic = 0)

Variable	Category	Logit coefficients	Standard errors	Bootstrapped 95% confidence intervals of logit coefficients		Odds Ratios
				Lower	Upper	
AGE		0.026	0.066	-0.102	0.154	1.03
GENDER	Male	0.024	0.150	-0.356	0.404	1.02
	Female	Reference category				
ETHNIC GROUP	European	Reference category				
	Māori	-0.008	0.124	-0.251	0.235	0.99
	Pasifika	0.731**	0.195	0.309	1.153	2.08
	Asian	1.290**	0.130	1.042	1.539	3.63
	Other	0.729**	0.202	0.294	1.164	2.07
SCHOOL QUALS	Year 11 or lower	-1.516**	0.156	-1.854	-1.178	0.22
	Year 12	Reference category				
	Year 13	1.363**	0.080	1.198	1.529	3.91
	Overseas	2.272**	0.316	1.569	2.974	9.70
SCHOOL DECILE	1	-1.280**	0.333	-1.927	-0.632	0.28
	2	-1.632**	0.207	-2.086	-1.178	0.20
	3	-1.430**	0.188	-1.808	-1.051	0.24
	4	-1.184**	0.155	-1.441	-0.927	0.31
	5	-1.142**	0.143	-1.458	-0.825	0.32
	6	-1.096**	0.146	-1.420	-0.773	0.33
	7	-1.138**	0.135	-1.422	-0.854	0.32
	8	-1.364**	0.144	-1.647	-1.080	0.26
	9	-0.738**	0.137	-0.999	-0.476	0.48
	10	Reference category				
	Private – no decile	0.191	0.209	-0.238	0.620	1.21
SUBJECT	Science	3.107**	0.297	2.604	3.610	22.35
	Engineering	0.343	0.216	-0.082	0.768	1.41
	Agriculture	1.666*	0.743	-11.699	15.032	5.29
	Health	-0.645**	0.119	-0.903	-0.387	0.52
	Commerce	1.811**	0.164	1.465	2.156	6.11
	Society & culture	2.810**	0.165	2.483	3.137	16.61
	Creative arts	Reference category				
STUDY LOAD	Full-time	Reference category				
	Part-time	-0.629**	0.172	-0.975	-0.284	0.53
MOBILITY	No travel	Reference category				
	Travel	1.008**	0.089	0.849	1.167	2.74
GENDER × SUBJECT	Male × Science	-1.737**	0.342	-2.423	-1.052	0.18
	Male × Engineering	0.246	0.276	-0.263	0.754	1.28
	Male × Agriculture	-0.469	0.890	-14.036	13.099	0.63
	Male × Health	1.391**	0.294	0.727	2.056	4.02
	Male × Commerce	0.342	0.267	-0.193	0.877	1.41
	Male × Society & culture	-1.033**	0.247	-1.553	-0.512	0.36
CONSTANT		0.405	1.180	-1.892	2.703	
Log likelihood		-2,631				
Pseudo R^2		0.33				
Prob > Wald $\chi 2$		<0.0000				
N		13,775				

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

There was considerable variation in the likelihood of students choosing to study at university by ethnic group. Students in the Pasifika, Asian and 'Other' ethnic groups were all more likely than Europeans to enrol in a university to study a bachelors degree. The highest likelihood of selecting a university was by Asian students (the odds of enrolling in a university were 3.6 times that of European students), followed by Pasifika students (their odds of enrolling in a university were 2.1 times that of European students) and students in the 'Other' ethnic group (their odds of enrolling in a university were also 2.1 times that of European students). There was no statistically significant difference in the likelihood of Māori students enrolling in university compared with a European student.

Given the literature suggests that Asian students are the most likely to be swayed by the prestige of a tertiary institution, the fact they are far more likely than European students to enrol in a university also presents some evidence of a lack of parity of esteem between university and polytechnic degrees. This result also suggests that a lack parity of esteem may well flow through into international students, given that the majority of these students that attend tertiary institutions in New Zealand come from Asian regions.

The higher likelihood of students from the Pasifika ethnic group enrolling in a university may be a refection of their geographical location. Pasifika students are likely to be located in urban centres, where the greater regional coverage of the polytechnics is not a factor.

Not surprisingly, the likelihood of men and women enrolling in university varied significantly by broad subject area of enrolment. Men were less likely than women to enrol in a university in Science and Society and culture and more likely than women to enrol in Health.

Also, students who enrolled on a part-time basis were less likely to enrol in a university compared with full-time students. The odds of a part-time student enrolling in a university were 47 percent lower than a full-time student. This is not unexpected, given that part-time students are more likely to be employed and thus enrolled in degree study to upskill for work purposes. Given that polytechnic degrees are vocational in nature, this would likely contribute to the greater likelihood of part time students enrolling in polytechnic programmes.

As was mentioned previously, the likelihood of a student enrolling in a university did not vary with age. However, given the majority of students in this dataset were aged 17 and 18 at time of enrolment, the small age difference means that this result is not a surprise. The association between age and the likelihood of enrolment in a university for degree study is examined in more depth in the next section, where the wider range in age of students allows for a more meaningful analysis.

4.7.2 All Students analysis

The results of the All Students regression analysis are presented in Table 4.9 and Table 4.10. Table 4.9 presents the results of the main effects model and Table 4.10 presents the results of an interaction model.

The explanatory power of these models was slightly less than the School Leaver analysis. The pseudo R^2 of 0.28 for the main effects model and 0.30 for the interactions model compares with values of 0.31 and 0.33 for the School Leaver analysis, respectively. Nevertheless, all of the explanatory variables, with the exception of STUDY TYPE, had a statistically significant association with the type of tertiary provider selected by students.[145] Given that several statistically significant interactions between explanatory variables were identified, it is the results of the model containing interactions in Table 4.10 that are discussed.

In terms of results that may indicate a lack of parity of esteem between university and polytechnic degrees, there are similar findings to those of the School Leaver analysis. Students with higher school qualifications were more likely to enrol in a university. However, the statistically significant interaction of AGE with SCHOOL QUAL indicate a more complex relationship, in that, age would appear to be a moderating factor on the parity of esteem issue.

[145] Likelihood ratio tests were used to identify the statistical significance of the explanatory variables.

The results show that the higher likelihood of enrolling in a university for those with higher school qualifications diminishes with age. The odds of a student aged between 16 and 19 enrolling in a university with a year 13 school qualification were 4.2 times higher than a student with a year 12 qualification. However, for students aged between 20 and 27 and with a year 13 school qualification, the odds of enrolling in a university decrease to 1.6 times those of a student with a year 12 school qualification.[146]

A similar pattern was evident for students with an overseas school qualification; the odds of a student aged between 16 and 19 with this level of qualification enrolling in a university were 10.7 times those of a student with a year 12 qualification. However, the odds of a student aged between 20 and 27 and with an overseas qualification enrolling in a university were just 1.3 times those of a student with a year 12 qualification.[147]

Students with a year 11 or lower school qualification exhibited an increase in likelihood of attending university, compared with students with year 12 school qualifications. The odds of a student aged between 16 and 19 with a year 11 or lower school qualification were 69 percent lower than those of a student with a year 12 school qualification. For students aged between 20 and 27, the odds were just 40 percent lower.[148]

A significant interaction effect was also found between AGE and ETHNIC GROUP. It indicates that the variation in the likelihood of attending university for the various ethnic groups also decreases with age. For students aged between 16 and 19, the odds of Asian students enrolling in a university were 2.6 times those of European students, the odds of Pasifika students enrolling in a university were 1.5 times those of a European and for students in the ‘Other’ ethnic group their odds of enrolling in a

[146] This is calculated by adding the main effect logit coefficient for Year 13 (1.437) to the logit coefficient for the interaction between AGE and SCHOOL QUALS for Year 13 (-1.001). This equals 0.436. By then calculating exp(0.436) this generates the odds ratio of 1.6.
[147] This is calculated by adding the main effect logit coefficient for Overseas (2.371) to the logit coefficient for the interaction between AGE and SCHOOL QUALS for Overseas (-2.132). This equals 0.239. By then calculating exp(0.239) this generates the odds ratio of 1.3.
[148] This is calculated by adding the main effect logit coefficient for year 11 or lower (-1.172) to the logit coefficient for the interaction between AGE and SCHOOL QUALS for Year 11 or lower (0.668). This equals an odds ratio of 0.60. This is then interpreted as the odds being 40 percent lower.

university were 1.8 times those of a European.[149] However, for students aged between 20 and 27, the odds of Asian students enrolling in a university decreased to 1.6 times those of a European.[150]

There are a number of possible reasons for the moderating influence of age on highest school qualification and ethnic group. The impact of parental and peer influence on the decisions of students are likely to diminish with age. Older students are likely to be more financially independent as well as emotionally independent. Also, older students are likely to be enrolling in degrees for different purposes than younger students. Whereas younger school leavers may have in mind postgraduate study and hence select a university, older students may be interested in only a bachelors level qualification– and more inclined to target their education towards the vocational area for employment purposes.

The likelihood of enrolling in a university varies by the prior activity of the student. Students who have previously studied at a certain type of tertiary provider are more likely to choose to study at a similar type of provider. The odds of a student who previously studied at a university enrolling in a bachelors degree at a university were 2.1 times that of school leaver. However, the odds of a student who previously studied at a polytechnic choosing to start a bachelors degree at a university were 57 percent lower than those of school leavers.

Students that previously studied at wānanga, college of education or private training establishments were more likely than students who had previously studied at a polytechnic to choose a university to begin bachelors study, but less likely than students who previously studied at a university to do so. The odds of a student from a wānanga, college of education or private training establishment enrolling in a university were 38 percent lower than those of a school leaver.

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[149] There was no statistically significant difference in Māori and European students choosing a university.

[150] This is calculated by adding the main effect logit coefficient for Asian (0.970) to the logit coefficient for the interaction between AGE and ETHNIC GROUP for Asian (-0.484). This equals 0.486. By then calculating exp(0.486) this generates the odds ratio of 1.6.

Employed people were less likely than school leavers to study at a university. The odds of a student who had a prior activity of employment choosing to study at a university was 16 percent lower than that of a school leaver. The odds of a student that was previously unemployed enrolling in a university to study a bachelors degree were 30 percent lower than those of a school leaver. The odds of a student who had been overseas in the year prior to starting a bachelors degree or were a houseperson were similar to those of a school leaver.

Table 4.9, Logistic regression results: All Students main effects model

(Dependent variable: university = 1, polytechnic = 0)

Variable	Category	Logit coefficients	Standard errors	Bootstrapped 95% confidence intervals of logit coefficients		Odds Ratios
				Lower	Upper	
AGE	16-19			Reference category		
	20-27	-0.409**	0.077	-0.585	-0.233	0.66
GENDER	Male	-0.056	0.055	-0.172	0.061	0.95
	Female			Reference category		
ETHNIC GROUP	European			Reference category		
	Māori	-0.092	0.078	-0.235	0.051	0.91
	Pasifika	0.333**	0.119	0.077	0.589	1.39
	Asian	0.840**	0.092	0.647	1.032	2.32
	Other	0.532**	0.140	0.249	0.814	1.70
	Unknown	-0.629**	0.079	-0.779	-0.479	0.53
SCHOOL QUALS	Year 11 or lower	-0.092**	0.078	-0.235	0.051	0.91
	Year 12			Reference category		
	Year 13	1.183**	0.057	1.068	1.298	3.26
	Overseas	1.859**	0.226	1.403	2.315	6.42
SCHOOL	1	-0.975**	0.201	-1.392	-0.557	0.38
DECILE	2	-1.071**	0.139	-1.362	-0.781	0.34
	3	-1.222**	0.123	-1.442	-1.002	0.29
	4	-0.829**	0.107	-1.040	-0.619	0.44
	5	-0.868**	0.099	-1.073	-0.664	0.42
	6	-0.777**	0.099	-0.995	-0.559	0.46
	7	-0.913**	0.094	-1.113	-0.713	0.40
	8	-0.980**	0.102	-1.199	-0.762	0.38
	9	-0.519**	0.099	-0.715	-0.324	0.59
	10			Reference category		
	Private – no decile	0.170	0.157	-0.141	0.482	1.19
PRIOR	School			Reference category		
ACTIVITY	University	0.679**	0.185	0.304	1.055	1.97
	Polytechnic	-0.897**	0.123	-1.153	-0.642	0.41
	Other tertiary	-0.551**	0.173	-0.895	-0.208	0.58
	Employed	-0.182*	0.078	-0.355	-0.009	0.83
	Unemployed	-0.253	0.151	-0.618	0.112	0.78
	Houseperson	0.005	0.346	-0.641	0.651	1.00
	Overseas	-0.012	0.153	-0.355	0.331	0.99
SUBJECT	Science	1.760**	0.088	1.597	1.923	5.81
	Engineering	0.650**	0.099	0.456	0.844	1.92
	Agriculture	2.485**	0.355	1.716	3.253	12.00
	Health	-0.385**	0.078	-0.552	-0.218	0.68
	Commerce	1.836**	0.086	1.655	2.017	6.27
	Society & culture	2.421**	0.081	2.241	2.602	11.26
	Creative arts			Reference category		
STUDY LOAD	Full-time			Reference category		
	Part-time	-0.343**	0.091	-0.504	-0.183	0.71
STUDY TYPE	Intramural			Reference category		
	Extramural	-0.153	0.125	-0.417	0.110	0.86
CONSTANT		1.014**	0.087	0.824	1.203	
Log likelihood		-5,409				
Pseudo R^2		0.28				
Prob > Wald $\chi 2$		<0.0000				
N		20,628				

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

Table 4.10, Logistic regression results: All Students model with interactions

(Dependent variable: university = 1, polytechnic = 0)

Variable	Category	Logit coefficients	Standard errors	Bootstrapped 95% confidence intervals of logit coefficients		Odds Ratios
				Lower	Upper	
AGE	16-19	Reference category				
	20-27	-0.087	0.109	-0.314	0.141	0.92
GENDER	Male	-0.102	0.109	-0.328	0.125	0.90
	Female	Reference category				
ETHNIC GROUP	European	Reference category				
	Māori	-0.105	0.102	-0.322	0.111	0.90
	Pasifika	0.374*	0.163	0.088	0.660	1.45
	Asian	0.970**	0.112	0.746	1.195	2.64
	Other	0.560**	0.179	0.194	0.926	1.75
SCHOOL QUALS	Year 11 or lower	-1.172**	0.122	-1.404	-0.940	0.31
	Year 12	Reference category				
	Year 13	1.437**	0.068	1.303	1.572	4.21
	Overseas	2.371**	0.300	1.706	3.036	10.71
SCHOOL DECILE	1	-0.964**	0.205	-1.384	-0.544	0.38
	2	-1.079**	0.140	-1.390	-0.767	0.34
	3	-1.236**	0.124	-1.464	-1.007	0.29
	4	-0.817**	0.108	-1.017	-0.617	0.44
	5	-0.878**	0.100	-1.083	-0.673	0.42
	6	-0.779**	0.101	-0.983	-0.576	0.46
	7	-0.923**	0.096	-1.124	-0.722	0.40
	8	-1.007**	0.103	-1.209	-0.804	0.37
	9	-0.539**	0.101	-0.755	-0.323	0.58
	10	Reference category				
	Private – no decile	0.149	0.160	-0.212	0.510	1.16
PRIOR ACTIVITY	School	Reference category				
	University	0.765**	0.187	0.389	1.142	2.15
	Polytechnic	-0.839**	0.124	-1.090	-0.588	0.43
	Other tertiary	-0.485**	0.174	-0.839	-0.131	0.62
	Employed	-0.177*	0.079	-0.335	-0.019	0.84
	Unemployed	-0.355*	0.152	-0.669	-0.041	0.70
	Houseperson	-0.178	0.350	-0.990	0.633	0.84
	Overseas	0.033	0.155	-0.307	0.373	1.03
SUBJECT	Science	2.402**	0.153	2.108	2.696	11.05
	Engineering	0.169	0.169	-0.173	0.511	1.18
	Agriculture	3.196**	0.733	-9.501	15.894	24.44
	Health	-0.622**	0.091	-0.817	-0.427	0.54
	Commerce	1.580**	0.108	1.354	1.807	4.86
	Society & culture	2.592**	0.105	2.372	2.813	13.36
	Creative arts	Reference category				
STUDY LOAD	Full-time	Reference category				
	Part-time	-0.325**	0.091	-0.515	-0.136	0.72
STUDY TYPE	Intramural	Reference category				
	Extramural	-0.241	0.124	-0.503	0.020	0.79

Table 4.10, continued…

Variable	Category	Logit coefficients	Standard errors	Bootstrapped 95% confidence intervals of logit coefficients		Odds Ratios
				Lower	Upper	
GENDER	Male × Science	-1.014**	0.193	-1.401	-0.627	0.36
× SUBJECT	Male × Engineering	0.554**	0.212	0.141	0.966	1.74
	Male × Agriculture	-1.111	0.840	-13.911	11.688	0.33
	Male × Health	1.456**	0.217	0.990	1.922	4.29
	Male × Commerce	0.594**	0.174	0.265	0.924	1.81
	Male × Society & culture	-0.540**	0.161	-0.864	-0.216	0.58
AGE × SCHOOL	20-27 × year 11 or lower	0.668**	0.161	0.340	0.995	1.95
QUALS	20-27 × year 13	-1.001**	0.126	-1.253	-0.749	0.37
	20-27 × overseas	-2.132**	0.484	-3.307	-0.957	0.12
AGE × ETHNIC	20-27 × Māori	-0.011	0.154	-0.325	0.302	0.99
GROUP	20-27 × Pasifika	-0.141	0.230	-0.599	0.317	0.87
	20-27 × Asian	-0.484*	0.198	-0.851	-0.117	0.62
	20-27 × Other	-0.092	0.288	-0.726	0.542	0.91
CONSTANT		0.962**	0.094	0.766	1.158	
Log likelihood		-5,255				
Pseudo R^2		0.30				
Prob > Wald $\chi 2$		<0.0000				
N		20,628				

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

There was a strong interaction effect between SUBJECT and GENDER. Men were less likely than women to choose to enrol in a university in the subject areas of Science, and Society and culture. Men were more likely than women to enrol in universities in the subject areas of Health, Engineering and Commerce.

There was no difference at the 5 percent level of significance in intramural and extramural students enrolling in a university to begin their bachelors degree.

There was a greater likelihood of part-time students choosing to study at a polytechnic compared with full-time students. The odds of a part-time student enrolling at a university were 28 percent lower than those of a full-time student. This result is in line with expectations, given that most part-time students are likely to also be employed. Hence they are more likely to enrol in the more vocational polytechnic degrees.

4.7.3 Nursing analysis

The analysis in the previous sections used a very broad-based approach, in that students enrolled in all subject areas were included in the analysis of student choices. A potential drawback of this approach is that polytechnics tend to specialise in specific vocational areas of degree provision compared with the comprehensive offerings available in the universities. In addition, the majority of university degrees have been in existence for a long time, and hence their worth is well known.

Examining the factors associated with the choice of type of provider in subject areas that are new to both university and polytechnic provision might provide even more compelling evidence of any lack of parity of esteem between university and polytechnic degrees. An obvious candidate in this regard is nursing, an area relatively new to degree provision for both universities and polytechnics, but one that is dominated by the latter. Therefore, the analysis in this section restricts the analysis of the factors associated with the choice of a university of polytechnic to study a bachelor of nursing degree.

The first nursing degrees were offered in the early 1990s by polytechnics (including the Auckland Institute of Technology which later became Auckland University of Technology (AUT)). Over time, a number of universities (apart from AUT) have also begun offering nursing degrees.[151]

The newness of nursing degrees in New Zealand is shown in the PBRF Quality Evaluation scores achieved by universities and polytechnics in the nursing subject area. In 2006, Nursing was placed last out of 42 subjects with an average quality score of 0.49. The average score over all subjects was 2.96. The results also showed that university staff in the nursing area were assessed as having slightly better research quality than staff at polytechnics. A total of 47 percent of university staff in the subject of nursing received an R quality category compared with 96 percent for polytechnic staff. Staff who received an R quality category did not attract any funding via the PBRF.[152]

[151] Including the University of Auckland and Massey University.

[152] These 2006 PBRF Quality Evaluation results are sourced from Tertiary Education Commission (2007).

The characteristics of the datasets used to analyse the choice of provider by nursing students are examined in the following section.

4.7.3.1 Characteristics of the Nursing datasets

The nursing School Leaver dataset contains the enrolment data of 375 students who started a bachelor of nursing degree in 2006.[153] Of this sample of bachelors degree starters, 31.2 percent chose to study at a university. The characteristics of the dataset are presented in Table 4.11.

This dataset displays a number of similarities to the full School Leaver dataset analysed in section 4.6.1. Firstly, a higher percentage of Asian students select a university to study a bachelor of nursing rather than a polytechnic, compared with Europeans. Also, students with year 13 school qualifications are more likely to choose to enrol in a university than students with a year 12 qualification. In addition, students from higher decile secondary schools were more likely than students from lower decile schools to enrol at university. Finally, those students that travelled for tertiary study were also more likely to enrol in university.

[153] Note that extramural students have been excluded from this analysis.

Table 4.11, Characteristics of the School Leaver dataset - Nursing

Factors	Category	All (n=375)	Universities (n=117)	Polytechnics (n=258)	% selecting university
AGE	16	0.3%		0.4%	0.0%
	17	19.2%	15.4%	20.9%	25.0%
	18	68.8%	74.4%	66.3%	33.7%
	19	11.7%	10.3%	12.4%	27.3%
GENDER	Male	5.6%	6.0%	5.4%	33.3%
	Female	94.4%	94.0%	94.6%	31.1%
ETHNIC GROUP	European	72.0%	63.2%	76.0%	27.4%
	Māori	10.7%	7.7%	12.0%	22.5%
	Pasifika	3.5%	4.3%	3.1%	38.5%
	Asian	9.9%	20.5%	5.0%	64.9%
	Other	4.0%	4.3%	3.9%	33.3%
SCHOOL DECILE	1	0.8%	0.9%	0.8%	33.3%
	2	3.7%	4.3%	3.5%	35.7%
	3	5.9%	5.1%	6.2%	27.3%
	4	11.7%	9.4%	12.8%	25.0%
	5	10.7%	6.0%	12.8%	17.5%
	6	14.7%	12.0%	15.9%	25.5%
	7	12.8%	10.3%	14.0%	25.0%
	8	8.0%	1.7%	10.9%	6.7%
	9	11.5%	8.5%	12.8%	23.3%
	10	17.9%	36.8%	9.3%	64.2%
	Private school – no decile	2.4%	5.1%	1.2%	66.7%
SCHOOL QUALS	Year 11 or lower	6.7%	1.7%	8.9%	8.0%
	Year 12	50.7%	44.4%	53.5%	27.4%
	Year 13	42.7%	53.8%	37.6%	39.4%
STUDY LOAD	Full-time	90.4%	94.0%	88.8%	32.4%
	Part-time	9.6%	6.0%	11.2%	19.4%
MOBILITY	No travel	83.7%	80.3%	85.3%	29.9%
	Travel	16.3%	19.7%	14.7%	37.7%
All					**31.2%**

The characteristics of the nursing All Students dataset are presented in Table 4.12. There were 721 degree starters in the All Students dataset of students enrolling in a nursing degree, of which 26.8 percent enrolled in a university.[154]

Once again, there is a pattern of students with higher school qualifications enrolling at a university, along with students from high decile schools and Asian students. Younger students were also more likely to enrol in a university, as were students who were previously enrolled in a university.

[154] Note that this dataset does not contain extramural students.

Table 4.12, Characteristics of the All Students dataset - Nursing

Factors	Category	All (n=721)	Universities (n=193)	Polytechnics (n=528)	% selecting university
AGE	16-19	66.0%	76.7%	62.1%	31.1%
	20-27	34.0%	23.3%	37.9%	18.4%
GENDER	Male	5.1%	5.7%	4.9%	29.7%
	Female	94.9%	94.3%	95.1%	26.6%
ETHNIC GROUP	European	70.5%	64.8%	72.5%	24.6%
	Māori	13.5%	7.8%	15.5%	15.5%
	Pasifika	4.6%	4.7%	4.5%	27.3%
	Asian	8.3%	18.7%	4.5%	60.0%
	Other	3.2%	4.1%	2.8%	34.8%
SCHOOL DECILE	1	2.4%	2.6%	2.3%	29.4%
	2	4.4%	3.6%	4.7%	21.9%
	3	6.5%	4.7%	7.2%	19.1%
	4	11.4%	7.8%	12.7%	18.3%
	5	11.8%	7.8%	13.3%	17.6%
	6	13.6%	9.3%	15.2%	18.4%
	7	13.6%	11.4%	14.4%	22.4%
	8	7.8%	3.1%	9.5%	10.7%
	9	11.5%	10.4%	11.9%	24.1%
	10	14.7%	33.7%	7.8%	61.3%
	Private school – no decile	2.4%	5.7%	1.1%	64.7%
SCHOOL QUALS	Year 11 or lower	19.0%	5.7%	23.9%	8.0%
	Year 12	45.6%	42.0%	47.0%	24.6%
	Year 13	34.5%	49.7%	29.0%	38.6%
	Overseas	0.8%	2.6%	0.2%	83.3%
PRIOR ACTIVITY	School student	56.3%	65.3%	53.0%	31.0%
	University student	1.5%	4.7%	0.4%	81.8%
	Polytechnic student	6.7%	2.1%	8.3%	8.3%
	Other tertiary student	1.2%	0.5%	1.5%	11.1%
	Employed	25.2%	20.2%	27.1%	21.4%
	Unemployed	4.7%	1.6%	5.9%	8.8%
	Houseperson/beneficiary	0.7%	0.5%	0.8%	20.0%
	Overseas	3.6%	5.2%	3.0%	38.5%
STUDY LOAD	Full-time	90.2%	93.3%	89.0%	27.7%
	Part-time	9.8%	6.7%	11.0%	18.3%
All					**26.8%**

4.7.3.2 Nursing logistic regression results

The results of the logistic regression analysis for the School Leaver and All Students models are presented in Tables 4.13 and Table 4.14, respectively. The pseudo R^2 of 0.21 for the school leaver model and 0.23 for the All Students model represents a slightly worse fit compared with the datasets analysed in the previous section.

The logistic regression results of the School Leaver dataset show that there is no statistically significant difference in the likelihood of students with different levels of school qualifications enrolling in a university. This is a marked difference with the analysis in section 4.7.1 and would suggest that there are no signs of more academically-able school leavers selecting universities over polytechnics.

However, in the logistic regression analysis of the All Students dataset there is a greater likelihood of students with higher school qualifications selecting a university. The odds of a student with a year 13 qualification selecting a university were 1.8 times higher than a student with a year 12 qualification. The odds of a student with an overseas qualification selecting a university were a massive 30 times higher than for a student with year 12 qualification. This result did not alter with age, which is a major divergence from the results of the All Students dataset in section 4.7.2.

The results in Tables 4.13 and 4.14 also show that the odds of a student from a decile 10 school selecting a university were much higher than students from lower decile schools. For example, the odds of a student from a decile 2 school enrolling in a university were 85 percent lower than those of a student from a decile 10 school in both the School Leaver and All Students models.

In addition, students who travelled were more likely to select a university to start a bachelor of nursing degree. The odds of a student who travelled enrolling in a university were 2.4 times that of a student who did not travel.

The results also show that Asian students are more likely than European students to select a university to study. The odds of an Asian student enrolling in a university were over six times that of a European in both the School Leaver and All Students models. As was found in the analysis in sections 4.7.1 and 4.7.2, there was no statistically significant difference in the likelihood of European and Māori students enrolling in a university.

This specific focus on bachelor of nursing degrees, an area of relatively high provision for polytechnics, would appear to confirm a lack of parity of esteem issue exists, even in an area that is new to the offering of degrees for both polytechnics and universities.

Table 4.13, Logistic regression results: School Leaver model - Nursing

(Dependent variable: university = 1, polytechnic = 0)

Variable	Category	Logit coefficients	Standard errors	Odds ratios
AGE		0.265	0.242	1.30
GENDER	Male	0.036	0.603	1.04
	Female	Reference category		
ETHNIC GROUP	European	Reference category		
	Māori	-0.058	0.470	0.94
	Pasifika	1.167	0.741	3.21
	Asian	1.875**	0.461	6.52
	Other	0.281	0.660	1.32
SCHOOL QUALS	Year 11 or lower	-1.656	0.889	0.19
	Year 12	Reference category		
	Year 13	0.511	0.270	1.67
SCHOOL DECILE	1	-2.047	1.377	0.17
	2	-1.752*	0.755	0.15
	3	-1.866**	0.616	0.12
	4	-2.129**	0.507	0.11
	5	-2.176**	0.520	0.14
	6	-1.976**	0.455	0.14
	7	-1.984**	0.465	0.03
	8	-3.449**	0.805	0.16
	9	-1.811**	0.480	1.67
	10	Reference category		
	Private – no decile	-0.052	0.773	0.95
STUDY LOAD	Full-time	Reference category		
	Part-time	-0.904	0.487	0.40
MOBILITY	No travel	Reference category		
	Travel	0.883*	0.351	2.42
CONSTANT		-4.478	4.292	
Log likelihood		-184		
Pseudo R^2		0.21		
Prob > Wald $\chi2$		<0.0000		
N		375		

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

Table 4.14, Logistic regression results: All Students model - Nursing

(Dependent variable: university = 1, polytechnic = 0)

Variable	Category	Logit coefficients	Standard errors	Odds Ratios
AGE	16-19	Reference category		
	20-27	-0.229	0.300	0.80
GENDER	Male	0.020	0.474	1.02
	Female			
ETHNIC GROUP	European	Reference category		
	Māori	-0.159	0.349	0.85
	Pasifika	0.656	0.510	1.93
	Asian	1.816**	0.361	6.15
	Other	0.565	0.549	1.76
	Unknown	-0.957	0.384	0.38
SCHOOL QUALS	Year 11 or lower	-0.159*	0.349	0.85
	Year 12	Reference category		
	Year 13	0.573**	0.212	1.77
	Overseas	3.402**	1.315	30.03
SCHOOL DECILE	1	-2.073*	0.853	0.13
	2	-1.907**	0.564	0.15
	3	-1.974**	0.485	0.14
	4	-1.931**	0.396	0.14
	5	-1.969**	0.380	0.14
	6	-2.068**	0.368	0.13
	7	-1.607**	0.338	0.20
	8	-2.960**	0.551	0.05
	9	-1.690**	0.354	0.18
	10	Reference category		
	Private – no decile	0.311	0.586	1.36
PRIOR ACTIVITY	School	Reference category		
	University	2.453**	0.911	11.62
	Polytechnic	-1.462*	0.626	0.23
	Other tertiary	-2.476	1.898	0.08
	Employed	0.102	0.297	1.11
	Unemployed	-0.584	0.724	0.56
	Houseperson	0.452	1.195	1.57
	Overseas	0.681	0.499	1.98
STUDY LOAD	Full-time	Reference category		
	Part-time	-0.662	0.379	0.52
CONSTANT		0.283	0.254	
Log likelihood		-320		
Pseudo R^2		0.23		
Prob > Wald $\chi 2$		<0.0000		
N		721		

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

4.7.4 University grouping analysis

So far, the choice of degree study has been restricted to enrolment in either a university or polytechnic. This section concentrates on those students enrolling in universities, to see if there is any evidence of a lack of parity of esteem among the universities. In other words, are certain groups of universities perceived by starting bachelors students as being 'better' than others?

An analysis of this nature which groups universities is necessarily subjective, given there are a variety of ways in which this could be done. For example, universities might be grouped by age, specialisation, location or performance in international rankings.

For the purposes of this analysis, the universities are divided into three groups. The first group contains the four older metropolitan universities. These are the Universities of Auckland, Otago, Canterbury and Victoria University of Wellington. These universities were all established in the 19th century, offer a wide range of degrees and were among the top performers in the PBRF Quality Evaluations.[155]

The second group of universities contains the University of Waikato and Massey University. Both of these universities are younger than the first group of universities, having been granted university status in 1964.[156] In addition, the main campuses for both of these universities are situated in regional centres (Hamilton and Palmerston North, respectively). Although the performance of Massey University in the PBRF Quality Evaluations was notably lower than the universities in Group 1, the University of Waikato performed well in a number of subject areas.

The final group of universities is made up of the two youngest universities. Lincoln University was granted university status in 1990[157] and is specialised in nature, focusing on agricultural subjects. The second university in this group is the Auckland

[155] It could be argued that the Universities of Auckland and Otago should be treated as a separate group, given that they are the only universities that have medical schools attached to them. However, grouping the universities in this way caused data problems with regards their subject profiles.

[156] Although as was noted in section 4.2.1, Massey University can trace its history as an affiliated college of the University of New Zealand to earlier in the 20th century.

[157] Although it has links back to Lincoln College in the 19th century and operated as a college within the University of Canterbury for many years.

University of Technology (AUT). This institution was granted university status in 2000 and previously was a polytechnic. Hence its performance in some areas, such as research, is at a much lower level than some of the other universities. Lincoln University and AUT were among the lowest performing of the universities in the 2003 and 2006 PBRF Quality Evaluations. In addition, both universities have had in their history a significant amount of sub-degree provision.[158]

The university groupings are listed in Table 4.15.

Table 4.15, Groupings of New Zealand universities

Grouping	Universities
1	Auckland, Otago, Victoria, Canterbury
2	Massey, Waikato
3	AUT, Lincoln

If there is any evidence of a lack of parity of esteem between the university groupings, it should be exhibited by students with higher school qualifications and from higher decile secondary schools being more likely to enrol in a university grouping. In addition, there should be a higher likelihood of students who travel and those from the Asian ethnic group that attend that particular grouping of university.

As there are more than two groups of universities that students could enrol in, a logistic regression model with multiple outcomes (multinomial logistic regression) is used to generate the logit coefficient estimates.[159] The logit coefficients in this case show the likelihood of enrolment in a particular university grouping compared with a reference group (in this case Group 1 universities are the reference group) following an increase in the independent variables.

The logistic regression models are presented in equations 4 and 5:

[158] Given that AUT is much larger in size in terms of enrolments, it will tend to dominate this group.
[159] Although an ordered logistic regression model could also be applied to the dataset, the use of a non-ordinal regression model allows for the different relationships between the groups of universities to be examined.

$$\ln\left[\frac{P_{Group2}}{P_{Group1}}\right] = \alpha + X_i\beta + \mu \tag{4}$$

$$\ln\left[\frac{P_{Group3}}{P_{Group1}}\right] = \alpha + X_i\beta + \mu \tag{5}$$

Where P_{Group1} is the probability that a student enrols in a Group 1 university, P_{Group2} is the probability that the student enrols in a Group 2 university, and P_{Group3} is the probability that the student enrols in Group 3 university, X is a vector of explanatory variables, β is the coefficient of the explanatory variables in logit form, μ is an error term and i = 1 to n observations.

4.7.4.1 The characteristics of the university grouping datasets[160]

The characteristics of the School Leaver dataset are presented in Table 4.16. Of the 12,645 students in this dataset, 73 percent were enrolled in Group 1 universities, 15 percent in Group 2 universities and 11 percent in Group 3 universities.

The characteristics of the students within the three university groupings show a number of differences. In terms of ethnic group, there are higher proportions of Asian students enrolled in Group 1 and Group 3 universities. This may simply be a reflection that these two groups of universities each contain an institution based in Auckland, where the greatest concentration of Asians in the New Zealand population is located.

The profiles of Group 1 and Group 2 universities exhibit a higher proportion of students with a year 13 qualification, compared with Group 3 universities. Seventy-five percent of students in Group 1 universities had this level of school qualification, compared with 89 percent for Group 2 universities and just 29 percent of Group 3 universities.

A significantly higher proportion of students enrolled in Group 1 and Group 3 universities are from decile 10 secondary schools. Thirty-two percent of students at

[160] Note that extramural students have been excluded from this analysis.

Group 1 universities were from decile 10 schools, compared with 28 percent in Group 3 universities and 15 percent in Group 2 universities.

Finally, Group 2 universities contained the highest proportion of students who travelled for tertiary study (49 percent), followed by Group 1 universities (38 percent) and Group 3 universities (20 percent).

Table 4.16, Characteristics of the School Leaver dataset – university grouping model

Factors	Categories	All (n=12,645)	Group 1 (n=9,290)	Group 2 (n=1,931)	Group 3 (n =1,424)	% selecting Group 1	% selecting Group 2	% selecting Group 3
AGE	16	0.5%	0.6%	0.3%	0.2%	86.9%	8.2%	4.9%
	17	19.4%	20.2%	17.1%	16.9%	76.7%	13.5%	9.8%
	18	71.5%	72.0%	72.8%	66.4%	74.0%	15.5%	10.5%
	19	8.7%	7.2%	9.9%	16.4%	61.2%	17.4%	21.4%
GENDER	Male	44.2%	46.4%	37.5%	39.2%	72.0%	17.0%	11.0%
	Female	55.8%	53.6%	62.5%	60.8%	70.6%	17.1%	12.3%
ETHNIC	European	63.7%	62.4%	71.1%	62.3%	72.0%	17.0%	11.0%
GROUP	Māori	8.1%	6.4%	15.6%	8.9%	58.3%	29.3%	12.4%
	Pasifika	4.3%	4.4%	2.4%	6.6%	74.5%	8.4%	17.1%
	Asian	20.0%	22.9%	8.3%	16.5%	84.3%	6.4%	9.3%
	Other	3.8%	3.8%	2.6%	5.7%	72.8%	10.5%	16.7%
SCHOOL	1	1.2%	0.9%	1.8%	2.1%	56.7%	23.3%	20.0%
DECILE	2	2.3%	1.8%	4.2%	3.1%	57.5%	27.6%	15.0%
	3	3.2%	2.7%	5.3%	3.9%	61.1%	25.4%	13.5%
	4	7.2%	6.4%	10.2%	8.9%	64.7%	21.4%	13.9%
	5	9.1%	8.5%	11.0%	10.4%	68.7%	18.5%	12.8%
	6	8.4%	7.8%	11.9%	7.8%	67.9%	21.6%	10.4%
	7	11.0%	10.8%	12.7%	10.7%	71.5%	17.6%	10.9%
	8	8.7%	8.1%	14.3%	5.3%	68.1%	25.1%	6.8%
	9	13.0%	13.8%	11.1%	10.0%	78.2%	13.1%	8.7%
	10	28.6%	31.6%	14.9%	27.8%	81.1%	7.9%	10.9%
	Private school – no decile	7.2%	7.7%	2.5%	10.0%	78.8%	5.4%	15.8%
SCHOOL	Year 11 or lower	1.4%	1.3%	1.3%	2.5%	66.7%	13.7%	19.7%
QUALS	Year 12	18.5%	13.5%	8.3%	64.7%	53.7%	6.9%	39.5%
	Year 13	71.7%	74.6%	89.3%	29.1%	76.4%	19.0%	4.6%
	Overseas	8.3%	10.6%	1.1%	3.6%	93.2%	2.0%	4.8%
STUDY	Full-time	97.3%	97.4%	96.6%	97.5%	73.5%	15.2%	11.3%
LOAD	Part-time	2.7%	2.6%	3.4%	2.5%	70.8%	19.0%	10.2%
SUBJECT	Science	23.0%	27.0%	17.2%	4.8%	86.2%	11.4%	2.4%
	Engineering	9.6%	11.7%	4.1%	3.5%	89.3%	6.6%	4.1%
	Agriculture	1.1%	0.1%	2.7%	5.3%	7.2%	38.4%	54.3%
	Health	5.2%	3.4%	6.2%	15.5%	48.0%	18.3%	33.7%
	Commerce	20.3%	18.3%	23.0%	29.5%	66.3%	17.3%	16.4%
	Society & culture	32.5%	35.9%	31.0%	12.4%	81.1%	14.6%	4.3%
	Creative arts	8.3%	3.6%	15.6%	29.0%	31.8%	28.8%	39.4%
MOBILITY	No travel	62.5%	62.2%	51.1%	80.5%	73.0%	12.5%	14.5%
	Travel	37.5%	37.8%	48.9%	19.5%	74.2%	20.0%	5.9%
ALL						**73.5%**	**15.3%**	**11.3%**

Note: Group 1 universities include: Auckland, Otago, Victoria and Canterbury. Group 2 universities include: Massey and Waikato. Group 3 universities include: AUT and Lincoln.

The student characteristics of the All Students dataset described in Table 4.17 show a very similar pattern to the characteristics of the School Leaver dataset in terms of highest school qualification, decile of last secondary school attended and ethnic group.

The characteristics in Table 4.17 also show that a much higher proportion of students who were employed prior to enrolling in degree study in Group 2 universities. Also, the proportion of younger students enrolling in degree study was much higher in Group 1 universities.

Table 4.17, Characteristics of the All Students dataset – university grouping model

Factors	Category	All (n=17,582)	Group 1 (n=12,302)	Group 2 (n=3,091)	Group 3 (n =2,189)	% selecting Group 1	% selecting Group 2	% selecting Group 3
AGE	16-19	84.9%	87.5%	82.1%	73.9%	72.1%	17.0%	10.8%
	20-27	15.1%	12.5%	17.9%	26.1%	57.8%	20.7%	21.5%
GENDER	Male	44.3%	46.5%	37.6%	41.7%	73.4%	14.9%	11.7%
	Female	55.7%	53.5%	62.4%	58.3%	67.3%	19.7%	13.0%
ETHNIC	European	63.9%	63.1%	70.4%	59.8%	69.0%	19.3%	11.6%
GROUP	Māori	9.0%	7.6%	15.1%	8.9%	58.4%	29.3%	12.3%
	Pasifika	5.0%	5.0%	2.9%	7.6%	70.7%	10.2%	19.1%
	Asian	17.9%	20.4%	8.3%	17.6%	79.6%	8.1%	12.2%
	Other	4.1%	4.0%	3.4%	6.1%	67.2%	14.4%	18.4%
SCHOOL	1	1.3%	1.0%	1.8%	2.3%	54.5%	23.8%	21.6%
DECILE	2	2.6%	2.2%	4.1%	2.7%	59.3%	27.8%	13.0%
	3	3.6%	3.1%	5.1%	4.6%	59.4%	24.9%	15.7%
	4	7.6%	6.5%	10.2%	9.8%	60.2%	23.6%	16.1%
	5	9.6%	8.8%	11.0%	12.0%	64.2%	20.2%	15.6%
	6	9.4%	8.7%	13.0%	8.3%	64.8%	24.3%	11.0%
	7	11.2%	11.1%	12.1%	10.0%	69.8%	19.1%	11.1%
	8	8.7%	8.3%	12.8%	5.3%	66.8%	25.7%	7.5%
	9	12.9%	14.0%	11.2%	9.3%	75.8%	15.2%	9.0%
	10	26.6%	29.1%	16.1%	27.3%	76.6%	10.7%	12.8%
	Private school – no decile	6.5%	7.2%	2.7%	8.5%	76.5%	7.2%	16.3%
SCHOOL	Year 11 or lower	4.6%	3.9%	5.1%	7.8%	59.6%	19.5%	20.9%
QUALS	Year 12	21.3%	16.8%	13.9%	57.2%	55.1%	11.5%	33.5%
	Year 13	67.1%	70.2%	79.8%	31.8%	73.2%	20.9%	5.9%
	Overseas	6.9%	9.1%	1.2%	3.2%	91.3%	2.9%	5.7%
PRIOR	School student	74.3%	77.1%	64.4%	72.7%	72.6%	15.2%	12.2%
ACTIVITY	University student	3.3%	3.7%	2.3%	2.5%	78.4%	12.2%	9.4%
	Polytechnic student	1.8%	1.5%	2.3%	2.9%	57.5%	22.5%	20.0%
	Other tertiary student	1.3%	1.0%	1.2%	2.6%	58.2%	16.4%	25.5%
	Employed	14.3%	11.6%	24.6%	14.7%	56.9%	30.3%	12.8%
	Unemployed	1.4%	1.3%	1.9%	1.3%	65.3%	23.1%	11.6%
	Houseperson	0.1%	0.1%	0.1%	0.2%	65.4%	15.4%	19.2%
	Overseas	3.5%	3.6%	3.2%	3.2%	72.6%	16.1%	11.3%
STUDY	Full-time	94.9%	95.4%	92.9%	94.5%	70.4%	17.2%	12.4%
LOAD	Part-time	5.1%	4.6%	7.1%	5.5%	62.4%	24.2%	13.4%
SUBJECT	Science	21.2%	25.4%	15.0%	6.4%	83.8%	12.4%	3.8%
	Engineering	8.1%	10.0%	3.5%	3.9%	86.5%	7.5%	6.0%
	Agriculture	1.1%	0.1%	2.7%	4.4%	7.6%	43.1%	49.2%
	Health	5.1%	2.9%	6.3%	15.6%	40.2%	21.7%	38.0%
	Commerce	20.5%	18.2%	21.8%	31.2%	62.2%	18.8%	19.0%
	Society and culture	35.3%	39.5%	32.4%	15.3%	78.4%	16.2%	5.4%
	Creative arts	8.7%	3.8%	18.2%	23.1%	30.6%	36.5%	32.8%
All						**70.0%**	**17.6%**	**12.5%**

Note: Group 1 universities include: Auckland, Otago, Victoria and Canterbury. Group 2 universities include: Massey and Waikato. Group 3 universities include: AUT and Lincoln.

4.7.4.2 University grouping logistic regression results

The multinomial logistic regression results for the School Leaver dataset and the All Students dataset are presented from Table 4.18 to Table 4.21. In the School Leaver models, the pseudo R^2 of the main effects and interaction models is 0.27. It is the results of the School Leaver model with interactions that are discussed below.

The results show that enrolment of students in degree study varies by the level of highest school qualification. The odds of a student with a year 13 qualification or overseas qualifications attending a Group 3 university were lower than those of students attending a Group 1 university. For example, the odds of a student with year 13 school qualification enrolling in a Group 3 university, compared with a Group 1 university, were 91 percent lower than a student with a year 12 school qualification. However, the odds of a student with a year 13 school qualification enrolling in a Group 2 university, compared with a Group 1 university, were 2.2 times those of a student with a year 12 qualification.

Students from low decile schools were more likely to enrol in Group 3 universities compared with Group 1 universities. The odds of a student from a decile 1 school enrolling in a Group 3 university, compared with a Group 1 university, were 3.9 times those of a student from a decile 10 school. Similarly, the odds of a student from a decile 1 school enrolling in a Group 2 university, compared with a Group 1 university, were 4.8 times those of a student from a decile 10 school.

There was no difference in the likelihood of students who do travel and those who don't travel selecting a Group 1 and Group 2 university. However, the odds of a student who travelled for degree study enrolling in a Group 3 university, compared with a Group 1 university, were 69 percent lower than students who did not travel.

Finally, there was a greater likelihood of Asian students enrolling in Group 1 universities. The odds of Asian students enrolling in a Group 3 university, compared with a Group 1 university, were 54 percent lower than Europeans. Similarly, the odds of an Asian student enrolling in a Group 2 university, compared with a Group 1 university, were 66 percent lower than Europeans.

The associations outlined above would suggest that there is relatively clear evidence of a lack of parity of esteem between Group 1 and Group 3 universities. Given that Group 1 universities are generally much older and better performing than Group 3 universities this is perhaps not surprising.

However, the evidence of a lack of parity of esteem between Group 1 and Group 2 universities was less conclusive. Clearly, students from higher decile schools are more likely to enrol in Group 1 universities. However, as was described above, there was no difference in the likelihood of students who travel choosing a Group 1 or Group 2 university, and there was mixed results with regards student enrolment and highest school qualifications.

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Table 4.18: Multinomial logistic regression results: School Leavers – university grouping main effects model

(Group 1= University of Auckland, University of Canterbury, University of Otago and Victoria University of Wellington; Group 2 = University of Waikato and Massey University; Group 3 = Auckland University of Technology and Lincoln University)

Variable	Category	Group 3 vs Group 1			Group 2 vs Group 1		
		Logit coefficients	Standard errors	Odds Ratios	Logit coefficients	Standard errors	Odds Ratios
AGE		0.548**	0.067	1.73	0.272**	0.054	1.31
GENDER	Male	-0.014	0.077	0.99	-0.237**	0.058	0.79
	Female	Reference category					
ETHNIC GROUP	European	Reference category					
	Māori	0.207	0.134	1.23	0.464**	0.086	1.59
	Pasifika	-0.392*	0.170	0.68	-1.106**	0.173	0.33
	Asian	-0.768**	0.101	0.46	-1.084**	0.095	0.34
	Other	0.111	0.171	1.12	-0.467**	0.161	0.63
SCHOOL	Year 11 or lower	-0.651**	0.224	0.52	0.705**	0.249	2.02
QUALS	Year 12	Reference category					
	Year 13	-2.434**	0.080	0.09	0.801**	0.093	2.23
	Overseas	-2.548**	0.168	0.08	-1.003**	0.243	0.37
SCHOOL	1	1.314**	0.300	3.72	1.554**	0.240	4.73
DECILE	2	0.920**	0.234	2.51	1.411**	0.163	4.10
	3	0.705**	0.203	2.02	1.387**	0.144	4.00
	4	0.796**	0.146	2.22	1.285**	0.112	3.62
	5	0.741**	0.138	2.10	0.967**	0.106	2.63
	6	0.586**	0.148	1.80	0.951**	0.105	2.59
	7	0.321*	0.131	1.38	0.731**	0.101	2.08
	8	0.312	0.162	1.37	1.106**	0.102	3.02
	9	-0.054	0.130	0.95	0.415**	0.102	1.51
	10	Reference category					
	Private – no decile	0.427**	0.143	1.53	-0.596**	0.167	0.55
SUBJECT	Science	-3.408**	0.158	0.03	-2.100**	0.107	0.12
	Engineering	-2.573*	0.181	0.08	-2.512**	0.150	0.08
	Agriculture	3.255**	0.362	25.92	1.411**	0.362	4.10
	Health	-0.492**	0.140	0.61	-0.707**	0.145	0.49
	Commerce	-1.297**	0.110	0.27	-1.290**	0.104	0.28
	Society & culture	-3.096**	0.123	0.05	-1.924**	0.099	0.15
	Creative arts	Reference category					
STUDY	Full-time	Reference category					
LOAD	Part-time	-0.564*	0.227	0.57	0.460**	0.156	1.58
MOBILITY	No travel	Reference category					
	Travel	-1.179**	0.094	0.31	0.013	0.058	1.01
CONSTANT		-8.189**	1.199		-5.873**	0.968	
Log likelihood		-7,031					
Pseudo R^2		0.27					
Prob > Wald $\chi2$		<0.0000					
N		12,645					

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

Table 4.19, Multinomial logistic regression results: School Leavers – university grouping model with interactions

(Group 1= University of Auckland, University of Canterbury, University of Otago and Victoria University of Wellington; Group 2 = University of Waikato and Massey University; Group 3 = Auckland University of Technology and Lincoln University)

Variable	Category	Group 3 vs Group 1			Group 2 vs Group 1		
		Logit coefficients	Standard errors	Odds Ratios	Logit coefficients	Standard errors	Odds Ratios
AGE		0.536**	0.067	1.71	0.267**	0.054	1.31
GENDER	Male	-0.763**	0.192	0.47	-0.726**	0.186	0.48
	Female	Reference category					
ETHNIC GROUP	European	Reference category					
	Māori	0.216	0.134	1.24	0.470**	0.086	1.60
	Pasifika	-0.371*	0.170	0.69	-1.096**	0.173	0.33
	Asian	-0.769**	0.101	0.46	-1.076**	0.095	0.34
	Other	0.101	0.172	1.11	-0.464**	0.161	0.63
SCHOOL QUALS	Year 11 or lower	-0.635**	0.225	0.53	0.705**	0.249	2.02
	Year 12	Reference category					
	Year 13	-2.440**	0.080	0.09	0.797**	0.094	2.22
	Overseas	-2.543**	0.169	0.08	-0.992**	0.243	0.37
SCHOOL DECILE	1	1.355**	0.300	3.88	1.566**	0.240	4.79
	2	0.951**	0.234	2.59	1.421**	0.164	4.14
	3	0.730**	0.203	2.08	1.403**	0.144	4.07
	4	0.812**	0.146	2.25	1.293**	0.113	3.64
	5	0.769**	0.138	2.16	0.978**	0.107	2.66
	6	0.607**	0.149	1.84	0.961**	0.105	2.61
	7	0.328*	0.131	1.39	0.735**	0.101	2.09
	8	0.330*	0.162	1.39	1.112**	0.102	3.04
	9	-0.051	0.130	0.95	0.415**	0.102	1.51
	10	Reference category					
	Private – no decile	0.410**	0.144	1.51	-0.605**	0.168	0.55
SUBJECT	Science	-3.495**	0.206	0.03	-2.308**	0.136	0.10
	Engineering	-3.432**	0.407	0.03	-3.364**	0.330	0.03
	Agriculture	3.049**	0.563	21.10	1.288*	0.563	3.63
	Health	-0.697**	0.167	0.50	-0.782**	0.167	0.46
	Commerce	-1.592**	0.141	0.20	-1.481**	0.131	0.23
	Society & culture	-3.452**	0.152	0.03	-2.067**	0.119	0.13
	Creative arts	Reference category					
STUDY LOAD	Full-time	Reference category					
	Part-time	-0.550*	0.228	0.58	0.456**	0.156	1.58
MOBILITY	No travel	Reference category					
	Travel	-1.182**	0.094	0.31	0.009	0.058	1.01
GENDER × SUBJECT	Male × Science	0.437	0.321	1.55	0.587**	0.222	1.80
	Male × Engineering	1.526**	0.467	4.60	1.348**	0.386	3.85
	Male × Agriculture	0.707	0.732	2.03	0.436	0.739	1.55
	Male × Health	0.641*	0.307	1.90	0.093	0.345	1.10
	Male × Commerce	0.865**	0.230	2.37	0.551*	0.217	1.74
	Male × Society & culture	1.091**	0.257	2.98	0.421*	0.214	1.52
CONSTANT		-7.752**	1.207		-5.622**	0.972	1.01
Log likelihood		-7,012					
Pseudo R^2		0.27					
Prob > Wald $\chi 2$		<0.0000					
N		12,645					

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

The results of the multinomial regression of the All Students dataset are presented in Table 4.20 and Table 4.21. The pseudo R^2s of the main effects and interactions model are 0.22 and 0.23, respectively. Table 4.21 shows there were significant interactions between AGE and DECILE, AGE and SCHOOL QUALS and AGE and ETHNIC GROUP. It is the results of the model containing interactions in Table 4.21 that are discussed below.

The greater likelihood of students from lower decile schools attending Group 2 and Group 3 universities, compared with Group 1 universities, generally decreased.[161] For example the odds of a student aged between 16 and 19 from a decile 1 school attending a Group 2 university, compared with a Group 1 university, were 4.9 times those of a student from a decile 10 school. However, for a student aged between 20 and 27, the odds of a student from a decile 1 school attending a Group 2 university, compared with a Group 1 university, was 2.1 times that of a student from a decile 10 school.

This reduction in disparity was also observed for students with higher school qualifications. The odds of a student aged between 16 and 19 with a year 13 qualification selecting a Group 2 university, compared with a Group 1 university, were 1.9 times those of a student with a year 12 school qualification. However, the odds of a student aged between 20 and 27 with a year 13 qualification enrolling in a Group 2 university, compared with a Group 1 university, was just 1.05 times higher than those of a student with a year 12 qualification. Similar patterns were observed in terms of ETHNIC GROUP, with older Asian students being less likely to enrol in Group 1 universities compared with their younger counterparts.

These results suggest that any potential lack of parity of esteem between the university groupings declines with the age of a student. This may be a result of older students being more independent, both financially and emotionally, and therefore more likely to resist the influence of parents or peers.

[161] Interestingly, the analysis comparing the enrolment choice between a polytechnic and a university in section 4.7.2 showed no sign of a decrease in the likelihood of older students from high decile schools enrolling in universities.

Table 4.20, Multinomial logistic regression results: All Students – university grouping main effects model

(Group 1= University of Auckland, University of Canterbury, University of Otago and Victoria University of Wellington; Group 2 = University of Waikato and Massey University; Group 3 = Auckland University of Technology and Lincoln University)

Variable	Category	Group 3 vs Group 1			Group 2 vs Group 1		
		Logit coefficients	Standard errors	Odds Ratios	Logit coefficients	Standard errors	Odds Ratios
AGE	16-19	Reference category					
	20-27	1.028**	0.092	2.80	0.044	0.077	1.05
GENDER	Male	-0.027	0.058	0.97	-0.247**	0.047	0.78
	Female	Reference category					
ETHNIC GROUP	European	Reference category					
	Māori	0.031	0.101	1.03	0.339**	0.069	1.40
	Pasifika	0.070	0.119	1.07	-0.938**	0.127	0.39
	Asian	-0.301**	0.077	0.74	-0.879**	0.076	0.42
	Other	0.371**	0.125	1.45	-0.180	0.117	0.84
SCHOOL	Year 11 or lower	-0.513**	0.114	0.60	0.166	0.116	1.18
QUALS	Year 12	Reference category					
	Year 13	-1.899**	0.061	0.15	0.476**	0.063	1.61
	Overseas	-2.197**	0.141	0.11	-1.121**	0.184	0.33
SCHOOL	1	0.895**	0.166	2.45	1.390**	0.189	4.02
DECILE	2	0.157	0.183	1.17	1.121**	0.130	3.07
	3	0.511**	0.194	1.67	1.096**	0.115	2.99
	4	0.510**	0.100	1.67	1.139**	0.089	3.12
	5	0.503**	0.247	1.65	0.834**	0.085	2.30
	6	0.050	0.588	1.05	0.810**	0.082	2.25
	7	-0.038	0.165	0.96	0.559**	0.081	1.75
	8	-0.177	0.217	0.84	0.883**	0.083	2.42
	9	-0.325**	0.180	0.72	0.269**	0.081	1.31
	10	Reference category					
	Private – no decile	0.278*	0.113	1.32	-0.567**	0.132	0.57
PRIOR	School	Reference category					
ACTIVITY	University	-1.227**	0.166	0.29	-0.436**	0.139	0.65
	Polytechnic	-0.229	0.183	0.80	0.446**	0.156	1.56
	Other tertiary	0.407*	0.194	1.50	0.335	0.205	1.40
	Employed	-0.574**	0.100	0.56	0.688**	0.067	1.99
	Unemployed	-1.077**	0.247	0.34	0.239	0.173	1.27
	Houseperson	-0.329	0.588	0.72	-0.046	0.576	0.96
	Overseas	-0.452**	0.165	0.64	-0.027	0.125	0.97
SUBJECT	Science	-3.015**	0.116	0.05	-2.153**	0.086	0.12
	Engineering	-2.397**	0.141	0.09	-2.471**	0.125	0.08
	Agriculture	2.431**	0.294	11.37	1.345**	0.292	3.84
	Health	-0.126	0.112	0.88	-0.645**	0.116	0.52
	Commerce	-1.130**	0.087	0.32	-1.328**	0.082	0.27
	Society & culture	-2.894**	0.095	0.06	-1.986**	0.077	0.14
	Creative arts	Reference category					
STUDY	Full-time	Reference category					
LOAD	Part-time	-0.249*	0.123	0.78	0.369**	0.093	1.45
CONSTANT		1.070**	0.095		-0.534**	0.097	
Log likelihood		-11,199					
Pseudo R^2		0.22					
Prob > Wald $\chi 2$		<0.0000					
N		17,582					

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

Table 4.21, Multinomial logistic regression results: All Students – university grouping model with interactions

(Group 1= University of Auckland, University of Canterbury, University of Otago and Victoria University of Wellington; Group 2 = University of Waikato and Massey University; Group 3 = Auckland University of Technology and Lincoln University)

Variable	Category	Group 3 vs Group 1			Group 2 vs Group 1		
		Logit coefficients	Standard errors	Odds Ratios	Logit coefficients	Standard errors	Odds Ratios
AGE	16-19	Reference category					
	20-27	0.773**	0.175	2.17	0.622**	0.191	1.86
GENDER	Male	-0.932**	0.156	0.39	-0.899**	0.142	0.41
	Female	Reference category					
ETHNIC GROUP	European	Reference category					
	Māori	0.143	0.121	1.15	0.389**	0.078	1.48
	Pasifika	0.055	0.150	1.06	-1.041**	0.155	0.35
	Asian	-0.493**	0.090	0.61	-1.034**	0.086	0.36
	Other	0.433**	0.148	1.54	-0.389**	0.143	0.68
SCHOOL	Year 11 or lower	-0.333	0.175	0.72	0.119	0.212	1.13
QUALS	Year 12	Reference category					
	Year 13	-2.248**	0.070	0.11	0.631**	0.077	1.88
	Overseas	-2.372**	0.156	0.09	-1.035**	0.207	0.36
SCHOOL	1	1.137**	0.271	3.12	1.594**	0.220	4.92
DECILE	2	0.394	0.215	1.48	1.304**	0.146	3.68
	3	0.511**	0.185	1.67	1.297**	0.130	3.66
	4	0.602**	0.129	1.83	1.173**	0.100	3.23
	5	0.550**	0.119	1.73	0.860**	0.094	2.36
	6	0.381**	0.128	1.46	0.874**	0.091	2.40
	7	0.112	0.116	1.12	0.609**	0.089	1.84
	8	-0.046	0.144	0.95	0.968**	0.089	2.63
	9	-0.137	0.116	0.87	0.272**	0.089	1.31
	10	Reference category					
	Private – no decile	0.392**	0.126	1.48	-0.621**	0.142	0.54
PRIOR	School	Reference category					
ACTIVITY	University	-1.305**	0.166	0.27	-0.432**	0.140	0.65
	Polytechnic	-0.147	0.181	0.86	0.518**	0.156	1.68
	Other tertiary	0.388*	0.194	1.47	0.433*	0.204	1.54
	Employed	-0.460**	0.100	0.63	0.733**	0.067	2.08
	Unemployed	-0.838**	0.244	0.43	0.282	0.173	1.33
	Houseperson	0.088	0.585	1.09	0.033	0.577	1.03
	Overseas	-0.438**	0.165	0.65	-0.012	0.125	0.99
SUBJECT	Science	-3.098**	0.152	0.05	-2.419**	0.112	0.09
	Engineering	-3.375**	0.345	0.03	-3.188**	0.257	0.04
	Agriculture	2.332**	0.459	10.30	1.020*	0.453	2.77
	Health	-0.314*	0.138	0.73	-0.794**	0.138	0.45
	Commerce	-1.479**	0.116	0.23	-1.676**	0.108	0.19
	Society & culture	-3.326**	0.121	0.04	-2.229**	0.096	0.11
	Creative arts	Reference category					
STUDY	Full-time	Reference category					
LOAD	Part-time	-0.197	0.122	0.82	0.367**	0.093	1.44

Table 4.21, continued…

Variable	Category	Group 3 vs Group 1			Group 2 vs Group 1		
		Logit coefficients	Standard errors	Odds Ratios	Logit coefficients	Standard errors	Odds Ratios
GENDER	Male × Science	0.538*	0.238	1.71	0.652**	0.176	1.92
× SUBJECT	Male × Engineering	1.843**	0.389	6.32	1.250**	0.303	3.49
	Male × Agriculture	0.789	0.600	2.20	0.774	0.596	2.17
	Male × Health	0.642**	0.250	1.90	0.319	0.273	1.38
	Male × Commerce	1.046**	0.184	2.85	0.825**	0.170	2.28
	Male × Society & culture	1.342**	0.197	3.83	0.602**	0.163	1.83
AGE × SCHOOL	20-27 × dec 1	-0.849	0.457	0.43	-0.868*	0.434	0.42
DECILE	20-27 × dec 2	-1.054**	0.405	0.35	-0.937**	0.324	0.39
	20-27 × dec 3	-0.419	0.310	0.66	-0.969**	0.292	0.38
	20-27 × dec 4	-0.358	0.250	0.70	-0.248	0.236	0.78
	20-27 × dec 5	-0.319	0.224	0.73	-0.301	0.226	0.74
	20-27 × dec 6	-1.260**	0.250	0.28	-0.474*	0.214	0.62
	20-27 × dec 7	-0.775**	0.246	0.46	-0.443	0.228	0.64
	20-27 × dec 8	-0.741**	0.290	0.48	-0.729*	0.244	0.48
	20-27 × dec 9	-0.815**	0.248	0.44	-0.190	0.225	0.83
	20-27 × Private – no decile	-0.607	0.333	0.55	0.350	0.399	1.42
AGE × SCHOOL	20-27 × year 11 or lower	0.179	0.233	1.20	-0.058	0.256	0.94
QUALS	20-27 × year 13	1.564**	0.146	4.78	-0.583*	0.144	0.56
	20-27 × overseas	1.105**	0.408	3.02	0.185	0.477	1.20
AGE × ETHNIC	20-27 × Māori	-0.292	0.226	0.75	-0.173	0.171	0.84
GROUP	20-27 × Pasifika	0.121	0.250	1.13	0.417	0.271	1.52
	20-27 × Asian	0.801**	0.179	2.23	0.997**	0.188	2.71
	20-27 × Other	-0.075	0.278	0.93	0.844**	0.261	2.33
CONSTANT		1.408**	0.113		-0.448**	0.117	
Log likelihood		-11,009					
Pseudo R^2		0.23					
Prob > Wald $\chi 2$		<0.0000					
N		17,582					

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

4.7.4.3 Teacher education analysis

The area of teacher degrees is an interesting area to examine the factors associated with enrolment at particular types of university, given the changes that have occurred in this area over the last five years. The two regionally-based universities, Massey University and the University of Waikato, merged with colleges of education over a decade ago (in 1997 and 1990, respectively) and have been offering teaching degrees for a longer period than the University of Auckland and Victoria University of Wellington. These universities merged with their respective colleges of education in 2004 and 2005, respectively.

How do students enrolling in teaching degrees at these four universities in 2006 view these respective institutions? Does the newness of the teaching degrees to the two older universities impact on the factors associated with enrolment at those institutions?

As this analysis examines the enrolment decisions of students who enrolled at two groups of universities, binary logistic regression is used to generate the logit coefficient estimates. For the purposes of this analysis, the dependent variable takes a value of 1 if the student enrolled in the University of Auckland or Victoria University of Wellington (Group 1 universities) and takes a value of 0 if the student enrolled in the University of Waikato or Massey University (Group 2 universities).

4.7.4.3.1 Characteristics of the teacher education datasets

The characteristics of the 401 students in the School Leaver dataset are presented in Table 4.22. The data shows that students from higher decile secondary schools were more likely to enrol in Group 1 universities. Also, Asian students were more likely to enrol in Group 1 universities than European students.

However, students with a year 13 school qualification were less likely to attend a Group 1 university, compared to students with a year 12 qualification. In addition, students who travelled for study were more likely to enrol in a Group 2 university.

Table 4.22, Characteristics of the School Leaver dataset – Teacher education

Factors	Category	All (n=401)	University of Auckland and Victoria University of Wellington (Group 1) (n=168)	University of Waikato and Massey University (Group 2) (n=233)	% selecting university of Auckland or Victoria University of Wellington (Group 1)
AGE	16	0.3%	n/a	0.4%	n/a
	17	18.7%	15.5%	21.0%	35.5%
	18	70.8%	74.7%	67.8%	45.1%
	19	10.3%	9.8%	10.7%	40.5%
GENDER	Male	12.8%	11.5%	13.7%	38.5%
	Female	87.2%	88.5%	86.3%	43.4%
ETHNIC GROUP	European	77.4%	75.9%	78.5%	41.9%
	Māori	12.3%	9.2%	14.6%	32.0%
	Pasifika	4.7%	6.3%	3.4%	57.9%
	Asian	3.7%	6.3%	1.7%	73.3%
	Other	2.0%	2.3%	1.7%	50.0%
SCHOOL DECILE	1	2.0%	3.4%	0.9%	75.0%
	2	3.9%	3.4%	4.3%	37.5%
	3	5.4%	5.2%	5.6%	40.9%
	4	10.3%	8.6%	11.6%	35.7%
	5	11.8%	6.9%	15.5%	25.0%
	6	9.8%	9.2%	10.3%	40.0%
	7	13.5%	13.2%	13.7%	41.8%
	8	9.6%	3.4%	14.2%	15.4%
	9	14.3%	13.8%	14.6%	41.4%
	10	16.7%	28.7%	7.7%	73.5%
	Private school – no decile	2.7%	4.0%	1.7%	63.6%
SCHOOL QUALS	Year 11 or lower	2.0%	1.1%	2.6%	25.0%
	Year 12	16.7%	23.6%	11.6%	60.3%
	Year 13	79.9%	71.8%	85.8%	38.5%
STUDY LOAD	Full-time	98.5%	98.9%	98.3%	42.9%
	Part-time	1.5%	1.1%	1.7%	33.3%
MOBILITY	No travel	70.8%	86.8%	58.8%	52.4%
	Travel	29.2%	13.2%	41.2%	19.3%
All					**42.8%**

The analysis of the All Student dataset examines the enrolment decisions of 626 students aged between 16 and 27 who enrolled in a teaching degree in 2006. The characteristics of the dataset are presented in Table 4.23. They share similar characteristics to the School Leaver dataset described in Table 4.22. The higher was the decile of the last secondary school attended, the more likely the student was to attend a Group 1 university.

The higher was the level of highest secondary school qualification, the more likely the student was to select a Group 1 university. Also, Asian students were much more likely than European students to attend a Group 1 university.

Table 4.23, Characteristics of the All Students dataset – Teacher education

Factors	**Category**	**All** (n=626)	**University of Auckland and Victoria University of Wellington (Group 1)** (n=353)	**University of Waikato and Massey University (Group 2)** (n=273)	**% selecting university of Auckland or Victoria University of Wellington (Group 1)**
AGE	16-19	66.0%	76.7%	62.1%	31.1%
	20-27	34.0%	23.3%	37.9%	18.4%
GENDER	Male	5.1%	5.7%	4.9%	29.7%
	Female	94.9%	94.3%	95.1%	26.6%
ETHNIC GROUP	European	70.5%	64.8%	72.5%	24.6%
	Māori	13.5%	7.8%	15.5%	15.5%
	Pasifika	4.6%	4.7%	4.5%	27.3%
	Asian	8.3%	18.7%	4.5%	60.0%
	Other	3.2%	4.1%	2.8%	34.8%
SCHOOL DECILE	1	2.4%	2.6%	2.3%	29.4%
	2	4.4%	3.6%	4.7%	21.9%
	3	6.5%	4.7%	7.2%	19.1%
	4	11.4%	7.8%	12.7%	18.3%
	5	11.8%	7.8%	13.3%	17.6%
	6	13.6%	9.3%	15.2%	18.4%
	7	13.6%	11.4%	14.4%	22.4%
	8	7.8%	3.1%	9.5%	10.7%
	9	11.5%	10.4%	11.9%	24.1%
	10	14.7%	33.7%	7.8%	61.3%
	Private school – no decile	2.4%	2.6%	2.3%	29.4%
SCHOOL QUALS	Year 11 or lower	19.0%	5.7%	23.9%	8.0%
	Year 12	45.6%	42.0%	47.0%	24.6%
	Year 13	34.5%	49.7%	29.0%	38.6%
	Overseas qualification	0.8%	2.6%	0.2%	83.3%
PRIOR ACTIVITY	School student	56.3%	65.3%	53.0%	31.0%
	University student	1.5%	4.7%	0.4%	81.8%
	Polytechnic student	6.7%	2.1%	8.3%	8.3%
	Other tertiary student	1.2%	0.5%	1.5%	11.1%
	Employed	25.2%	20.2%	27.1%	21.4%
	Unemployed	4.7%	1.6%	5.9%	8.8%
	Houseperson/beneficiary	0.7%	0.5%	0.8%	20.0%
	Overseas	3.6%	5.2%	3.0%	38.5%
STUDY LOAD	Full-time	90.2%	93.3%	89.0%	27.7%
	Part-time	9.8%	6.7%	11.0%	18.3%
All					**26.8%**

4.7.4.3.2 Teaching education logistic regression results

The results of the logistic regression analysis of the School Leaver dataset is presented in Table 4.24. The pseudo R^2 of the model is 0.17.

The results show that students with higher school qualifications were less likely to enrol in a Group 1 university. The odds of a student with a year 13 qualification enrolling in a Group 1 university were 56 percent lower than those of a student with a year 12 qualification.

In addition, there was evidence that students from lower decile schools were more likely to enrol in Group 2 universities. The odds of a student from a decile 4 school enrolling in a Group 1 university were 77 percent less than students from a decile 10 school.

Students who travelled were less likely to attend a Group 1 university than those who did not travel.[162] The odds of a student enrolling in a Group 1 university were 75 percent lower than for students who did not travel. Also, the odds of an Asian student enrolling in a Group 1 university were 4.4 times that of a European student.

So this logistic regression analysis of the School Leaver dataset presents a mixed picture in terms of parity of esteem issues. Some variables (highest school qualification, and travel) suggest that Group 2 universities may be held in higher esteem, while others (decile and ethnic group) suggest that Group 1 universities may be held in higher esteem.

[162] This finding is different to that found in the model including all degree starters, where there was no statistically significant difference in the likelihood of attending a Group 1 and Group 2 university for those that did and did not travel.

Table 4.24, Logistic regression results: School Leaver model – Teacher education

(Dependent variable: University of Auckland or Victoria University of Wellington = 1; Massey University or University of Waikato = 0)

Variable	Category	Logit coefficients	Standard errors	Odds ratios
AGE		0.007	0.217	1.01
GENDER	Male	0.258	0.363	1.29
	Female	Reference category		
ETHNIC GROUP	European	Reference category		
	Māori	-0.750	0.407	0.47
	Pasifika	0.063	0.572	1.06
	Asian	1.480*	0.690	4.39
	Other	-0.008	0.814	0.99
SCHOOL QUALS	Year 11 or lower	-1.807	0.979	0.16
	Year 12	Reference category		
	Year 13	-0.826**	0.312	0.44
SCHOOL DECILE	1	0.801	0.966	2.23
	2	-0.725	0.666	0.48
	3	-1.017	0.546	0.36
	4	-1.489**	0.475	0.23
	5	-1.597**	0.471	0.20
	6	-1.201**	0.459	0.30
	7	-0.921*	0.431	0.40
	8	-2.407**	0.544	0.09
	9	-1.307**	0.410	0.27
	10	Reference category		
	Private – no decile	-0.593	0.749	0.55
STUDY LOAD	Full-time	Reference category		
	Part-time	-0.796	0.927	0.45
MOBILITY	No travel	Reference category		
	Travel	-1.380**	0.296	0.25
CONSTANT		1.686	3.907	
Log likelihood		-225		
Pseudo R^2		0.17		
Prob > Wald $\chi 2$		<0.0000		
N		401		

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

The results of the logistic regression analysis on the All Students dataset are presented in Table 4.25. The results include estimates of the logit coefficients, standard errors and odds ratios. The pseudo R^2 of 0.22 is of a similar fit to the Nursing analysis in section 4.7.3.2.

As in the analysis of the School Leaver dataset, this analysis of teaching degree starters presents results which are at first glance somewhat contradictory in terms of identifying any potential parity of esteem issues. The likelihood of students with higher school qualifications enrolling in higher-ranked universities is not exhibited by this sample of students. The likelihood of students with a year 13 qualification attending the higher-ranked universities was 74 percent lower than that of a year 12 student.

However, students from higher decile schools were still more likely to enrol in the higher ranked universities. For example, the odds of a student from a decile 2 school enrolling in a higher ranked university were 81 percent lower than that of a student from a decile 10 school.

Also, Asian students were far more likely than European students to enrol in a higher ranked university. The odds of an Asian student enrolling in a higher ranked university were 3.8 times that of a European student. Unlike the analysis of all university degree students in section 4.7.4.2 there was no change in these likelihoods for older students.

So overall, the evidence was even more mixed than in the previous section that a parity of esteem exists between these two groups of universities. Given the history of teacher training provision, this is not surprising and suggests that the longevity of offering degrees is one of the factors that influence the esteem with which degree providers are held.

Table 4.25, Logistic regression results: All Students – university ranking model – Teacher education

(Dependent variable: University of Auckland and Victoria University of Wellington =1, University of Waikato and Massey University =0)

Variable	Category	Logit coefficients	Standard errors	Odds Ratios
AGE	16-19	Reference category		
	20-27	0.455	0.291	1.58
GENDER	Male	0.387	0.270	1.47
	Female	Reference category		
ETHNIC GROUP	European	Reference category		
	Māori	-0.307	0.285	0.74
	Pasifika	1.584**	0.543	4.87
	Asian	1.329*	0.581	3.8
	Other	0.578	0.619	1.78
	Unknown	-0.090	0.420	0.91
SCHOOL QUALS	Year 11 or lower	-0.307	0.285	0.74
	Year 12	Reference category		
	Year 13	-1.360**	0.253	0.26
SCHOOL	1	-0.937	0.706	0.39
DECILE	2	-1.667**	0.545	0.19
	3	-1.662**	0.490	0.19
	4	-2.227**	0.429	0.11
	5	-2.490**	0.421	0.08
	6	-2.332**	0.438	0.10
	7	-1.781**	0.414	0.17
	8	-3.090**	0.478	0.05
	9	-1.283**	0.434	0.28
	10	Reference category		
	Private – no decile	-1.062	0.721	0.35
PRIOR	School	Reference category		
ACTIVITY	University	3.081**	1.085	21.79
	Polytechnic	-0.547	0.579	0.58
	Other tertiary	-0.839	0.649	0.43
	Employed	0.184	0.288	1.20
	Unemployed	-1.808**	0.673	0.16
	Houseperson	0.228	1.326	1.26
	Overseas	-0.003	0.488	1.00
STUDY LOAD	Full-time	Reference category		
	Part-time	0.509	0.582	1.66
CONSTANT		2.707**	0.414	
Log likelihood		-335		
Pseudo R^2		0.22		
Prob > Wald $\chi 2$		<0.0000		
N		626		

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

4.8 Conclusion

In New Zealand, there has been no previous analysis of the choice of particular types of tertiary education provider at the same level of qualification. Given there is a perception that polytechnic degrees do not have the same level of esteem as university degrees, this is a significant gap in the literature. This study used statistical modelling to examine if the enrolment decisions of domestic degree students are influenced by the esteem with which the different types of institutions are viewed. As was the case with previous New Zealand studies, it confirmed that the academic achievement of students at school is a key factor that influences their decisions at the tertiary level with the most academically-able students more likely to enrol in universities, although the strength of this association declines with age.

In addition, the study found that students who are more likely to take into account the reputation or prestige of an institution, those students who are younger, Asian, from high socioeconomic catchments and who chose to travel, were more likely to enrol in degree study at universities. In the case of Asian students, this association also moderates with age.

These findings suggest that there is a lack of parity of esteem between university and polytechnic degrees. Notably, when the analysis was restricted to nursing, a subject area new to degree provision for both university and polytechnics, evidence of a lack of parity of esteem persisted.

Although the problem appears to decline with age, this may provide little comfort to the polytechnics. The tertiary environment is experiencing a declining number of international students at the degree level,[163] along with a forecast bulge in the school leaver population which will peak around 2012 (McClelland 2006). As younger school leavers have a higher likelihood of enrolling in degree study, this suggests that polytechnics may not be in a position to gain from the demographic trends as much as the universities.

[163] International degree-level EFTS were 1,738 in 2007, down from 3,443 in 2004. In universities (including colleges of education) they were 17,600 in 2004 and 13,307 in 2007.

It remains to be seen whether any of the proposed solutions to the parity of esteem issue, such as the creation of a university of technology classification, will be introduced and provide an effective long term answer to this important issue.

The OECD review of New Zealand's tertiary education system in 1997 suggested that the maturation of polytechnic degrees would help to solve any parity of esteem issue. A limitation of this study is that it is a snapshot of enrolment patterns in 2006, so it is impossible to tell if the problem is reducing over time. However, the scale of some of the associations found in this study would suggest that even if the parity of esteem problem may be reducing with time, it still appears to be a considerable issue almost 15 years after polytechnic degrees were first offered.

The analysis of student choices of students that enrol in universities presented less clear cut evidence of a potential parity of esteem problem between university groupings. There did appear to be a lack of parity of esteem between the four older metropolitan universities and the two newest universities, with signs the former were held in higher esteem. However, the evidence was mixed when comparing the four older metropolitan universities and the two regionally-based universities, with less indication that a lack of parity of esteem exists between these two groups of universities.

5 Conclusion

The New Zealand tertiary education sector is facing challenging times. The New Zealand government has signalled an intention to increase the use of performance indicators in the tertiary education sector (Tolley 2009). There is also a push for increased efficiency in the use of resources in the tertiary education system (Ministry of Education 2009), along with planned moves to simplify the tertiary funding system so that student choices play a greater role in the allocation of resources. The analysis in this thesis touched on all three of these areas (performance measurement, efficient use of resources, and student choice). Hence, the conclusions discussed below have a high degree of relevancy to the current tertiary education environment.

A focus on one dimension of university research performance, quality, resulting from the introduction of the Performance-Based Research Fund (PBRF) Quality Evaluation, has led to the development of a benchmark, albeit partial, of the respective performance of the universities. The multi-dimensional analysis of university research performance in chapter 2 showed that no individual university dominated all the various performance dimensions. This reinforces that a suite of indicators covering a number of dimensions is required to present a comprehensive and unbiased picture of university research performance.

The analysis of university productive efficiency in chapter 3 showed that, on average, New Zealand universities have not improved their total factor productivity at the same rate as Australian universities. Encouragingly, there were signs of improved performance in a number of New Zealand universities in the last two years of the analysis, mainly as a result of increased research output which is potentially associated with the introduction of the PBRF. This may suggest that increased performance funding, such as for qualification completions, may present incentives for New Zealand universities to further improve their performance.

Structural change in the tertiary education sector, such as mergers and changes of status, have been a constant feature of the last decade and have produced mixed results. The experience of Auckland University of Technology has shown how challenging it can be for an institution to become a university. Similarly, the absorption of Wanganui Polytechnic into UCOL has proved to be a long-term drain on the performance of UCOL. However, Massey University appears to be recovering from the absorption of Wellington Polytechnic and the mergers of the colleges of education with universities should produce economies of scale. The mixed nature of the outcomes indicates that each case where structural change is mooted as a solution needs to be carefully examined, lest the expected efficiency gains do not eventuate.

In the polytechnic sector, greater productive efficiency has come at the expense of other objectives of the tertiary education system, such as greater quality and relevance of provision. This reinforces that the tertiary funding system must have the right incentives in place to ensure that government objectives are met.

Despite the apparent high relative efficiency of some polytechnics, their financial performance remained relatively poor. This suggests that the overall level of efficiency in the polytechnic sector is low, or the funding model they operate under needs to be reviewed. As polytechnics appeared to operate best under a stable enrolment environment, some form of capping of enrolments by the government would potentially lead to greater levels of certainty and hence efficiency.

One of the factors associated with lower productive efficiency in the polytechnic sector was a higher level of degree provision. The problematic nature of polytechnic degree provision was also highlighted by the analysis of peer esteem and the demand for bachelors degrees in chapter 4. This identified that polytechnics face a challenging task in overcoming perceptions that their degrees are inferior to university degree qualifications. Almost 20 years after first offering degrees, a lack of parity of esteem is still evident between polytechnic and university degrees. Although labour market evidence now available refutes anecdotal evidence that the labour market does not recognise polytechnic degrees, the perception still holds. Given the negative impact on efficiency and the parity of esteem issues, it may well be a prudent time to review the provision of degrees, in smaller polytechnics at least.

There are a number of avenues for further research in the areas of the measurement of performance of tertiary education institutions (TEIs) and the demand for their services. In the study of productive efficiency, the extension of the study to more recent time periods as more data becomes available would show if the government's reforms of tertiary education funding have had beneficial impacts on TEI performance. It would also show the longer term impact of the structural changes that have occurred in the university sector.

The analysis of the demand for tertiary education could be extended into other areas or levels of provision. For example, at the sub-degree level, the factors associated with the choice of a polytechnic or a private training establishment could be investigated.

In addition, the analysis of the enrolment decisions of students in this study applied quantitative analysis to administrative data. A qualitative investigation of the decision making process of students and also of employers attitudes towards graduates from polytechnics and universities at the bachelors degree level would compliment this analysis and provide more insight into the parity of esteem issue.

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