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Making an impact

New Zealand Government

Research and knowledge creation

This report forms part of a series called Research and knowledge creation.

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1 Summary

Key findings:

This report examined the latest bibliometric data for evidence that the Performance-Based Research Fund (PBRF) has improved university research performance and also compared New Zealand university performance with that of the Australian universities. The report showed that the bibliometric performance of New Zealand universities has improved since the introduction of the PBRF. In particular:

- The share of world indexed publications produced by New Zealand university authors has increased since the PBRF was introduced.
- The share of world indexed citations by New Zealand university research has increased since the PBRF was introduced.
- The overall relative academic impact of research has increased since the PBRF was introduced.

The comparison of New Zealand and Australian university bibliometric performance showed that in the period 2003 to 2007:

- The relative academic impact of New Zealand university research was higher than the Group of Eight (G8) research universities in Australia in three out of 10 broad subject areas.
- The relative academic impact of New Zealand university research was higher than the Non-G8 Australian universities in eight out of 10 broad subject areas.

This report examined the latest bibliometric data from Thomson Reuters for evidence that the Performance-Based Research Fund (PBRF) may have impacted on the research performance of New Zealand universities. The PBRF was introduced in 2004 (and was signalled as early as 2001) and once the lags associated with the publication of research are taken into account, any initial effects of the PBRF should now be appearing in the bibliometric data.

Bibliometric data has previously been used to evaluate the impact of the introduction of a research funding system based on peer review. The best example is the Research Assessment Exercise (RAE) in the United Kingdom. The evaluation of the RAE (see Adams and Smith 2006) found that the share of world citations by United Kingdom researchers and the number of citations per publication (academic impact) increased following the introduction of the RAE in 1986. Although the authors were at pains to say that correlation was not causation, they nevertheless felt that the RAE was a factor in the result.

This study used a similar suite of bibliometric measures to evaluate the impact of the PBRF on the research performance of New Zealand universities. A key measure in the analysis was the relative academic impact of research. This is the average rate of citation for New Zealand university research divided by the average world rate of citation. This normalisation of the rate of citation is important as different subject areas have differing rates of citation. A relative academic impact value of 1 indicates that the New Zealand research was equal to the world average, a value greater than 1 indicates that the impact of the New Zealand research was above average and a value below 1 indicates an impact below the world average.

As a number of academic studies have found a positive correlation between a higher measured quality of research and higher rates of citation, if the impact of New Zealand university research has risen, this should be seen in an increase in the relative academic impact and an increase in the share of world indexed citations.

Although there are important caveats on the use of bibliometrics data, such as the degree of coverage of research in certain subject disciplines, the data nevertheless provide one of the few monitoring tools that is external to the PBRF itself.

1.1 Summary of results

The results of the bibliometric analysis show that:

- The share of world indexed publications authored by staff at New Zealand universities has risen from 0.41 percent in 2001 to 2005 to 0.43 percent in 2003 to 2007.
- The share of world indexed citations of publications by New Zealand university authors increased from 0.35 percent in 2001 to 2005 to 0.40 percent in 2003 to 2007.
- The relative academic impact of research by New Zealand university authors increased from 0.85 in 2001 to 2005 to 0.93 in 2003 to 2007.
- The recent increase in overall relative academic impact by New Zealand university research was not exhibited by the Australian Group of Eight (G8) or Non-Group of Eight (Non-G8) university groupings.
- At the broad subject panel level, the relative academic impact of New Zealand university research increased in eight out of the 10 panels assessed in this study. The greatest percentage improvement in relative academic impact was exhibited by the 'Humanities' and 'Engineering'.
- In 2003 to 2007, the broad panels with a relative academic impact above the world average were 'Health' (1.14), 'Medicine' (1.08) and 'Mathematics and information technology' (1.03).
- In 2003 to 2007, 52 percent of narrow subject areas had a relative impact higher than the world average. This compares with 46 percent in 1998 to 2002.
- The narrow subject areas with the greatest relative academic impact were 'Information Technology & Communication Systems' (1.64) and 'Rehabilitation' (1.58).
- At the institutional level, all eight universities exhibited an improvement in overall relative academic impact between 2001 to 2005 and 2003 to 2007. The largest increase was exhibited by Auckland University of Technology (69 percent), followed by the University of Waikato (39 percent) and the University of Canterbury (21 percent). Note that the large increase in the Auckland University of Technology's relative academic impact performance would be partly due to the increasing research capability at this relatively new university.
- In 2003 to 2007, the relative academic impact of New Zealand university research was higher than the G8 universities in three out of 10 broad subject areas. These three subject areas were 'Health', 'Business and economics' and 'Social sciences'.
- In 2007 to 2007, the relative academic impact of New Zealand university research was higher than the Non-G8 universities in eight out of 10 broad subject areas. The two subject areas where the relative academic impact of the Non-G8 universities exceeded the New Zealand universities were 'Engineering, technology and architecture' and 'Education'.

These findings indicate that the introduction of the PBRF has been associated with a significant improvement in the bibliometric performance of New Zealand universities, as measured by the Thomson Reuters database. Although explicitly linking this rise in performance to the PBRF as a possible cause is difficult, a number of factors point to it being a major influence in the change in performance.

2 Introduction

This report is one of a series by the Ministry of Education examining the bibliometric performance of New Zealand tertiary education institutions (TEIs). Whereas the previous reports[1] established baseline data and methodology, this new report examines the latest bibliometric data for evidence that the introduction of the Performance-Based Research Fund (PBRF) in 2004 has impacted on TEI research performance and in particular the universities.[2]

Among the key objectives of the PBRF was a desire to increase the average quality of research in New Zealand tertiary education organisations (TEOs) (Tertiary Education Commission, 2004), with the PBRF Quality Evaluation the main tool used to achieve this.[3] The Quality Evaluation uses a process of peer review to measure the quality of research produced by the TEOs, with the results determining the funding allocated to TEOs. Those TEOs with higher levels of measured research quality receive higher levels of funding. Importantly, the results of the Quality Evaluation are also published and so create an additional incentive for TEOs to maximise the quality of research produced by staff. Given the PBRF was introduced in 2004 (and was signalled as early as 2001) its impact should be starting to appear in the research performance of TEOs, once the lag time involved in the publication of research is taken into account.

In the United Kingdom, bibliometric data has been used to evaluate the impact of the Research Assessment Exercise (RAE) on the research performance of tertiary institutions. The RAE, like the PBRF, is a peer-review based system for funding tertiary education research introduced in 1986 and repeated at around six yearly intervals. In evaluating the impact of the RAE on research performance, Adams and Smith (2006) found that the share of world citations from research carried out by United Kingdom researchers increased following the introduction of the RAE. They also found that the crude rate of citation (citations per publication) increased. Although the authors were at pains to note the difference between correlation and causation, they nevertheless were of the opinion that the RAE is likely to have been a key factor in these observed trends.

To determine if the PBRF has impacted on the research performance of New Zealand universities, bibliometric measures similar to those used by Adams and Smith are analysed. These are the trend in the share of world indexed publications authored by New Zealand university staff, the trend in the share of world indexed citations and relative academic impact. The measure of relative academic impact is calculated by dividing the rate of citation of New Zealand publications by the world average rate of citation. This normalising of the data is important as different subject areas have different rates of citation. As a number of academic studies have found a positive correlation between higher peer-assessed research quality and higher rates of citation,[4] it would be expected that if the PBRF has worked as intended, this will be observed in the New Zealand bibliometric data via a greater share of world citations and a rise in relative academic impact.

To help isolate any PBRF effect, the bibliometric performance of the New Zealand universities is compared with two groupings of Australian universities – the Group of Eight (G8) and Non-Group of Eight (Non-G8) universities. The G8 is comprised of eight large metropolitan universities that are research intensive in nature.[5] The Non-G8 universities are comprised of a mix of older, newer and technological universities. The Australian government has been considering introducing a stronger performance link in their assessment of research, leading eventually to performance-based funding for research in higher education. This may include an element of peer-review of research quality or

[1] See Smart and Weusten (2007a, 2007b) and Ministry of Education (2007).
[2] The difficulties associated with evaluating whether there has been an increase in the measured quality of research using PBRF Quality Evaluation data alone are discussed in Tertiary Education Commission (2007).
[3] The other two performance dimensions in the PBRF are the number of research degree completions and the amount of external research income attracted by the TEOs.
[4] See Norris and Oppenheim (2003), Smith and Eysenck (2002) and Smart (2007).
[5] The members of the G8 are the University of Sydney, University of New South Wales, University of Melbourne, University of Western Australia, University of Adelaide, Monash University, University of Queensland and the Australian National University.

bibliometrics to measure research performance.[6] This may have impacted on institutional bibliometric performance. However, this was proposed some time after the introduction of the PBRF and should not coincide with any trends in the New Zealand data. Therefore, if the New Zealand bibliometric data exhibits different patterns to the Australian data this will suggest that factors within New Zealand, such as the introduction of the PBRF, are influencing the research performance of New Zealand's universities.

2.1 Interpretation of bibliometric data

It is important in any analysis of bibliometric data that its limitations and particularly those of the Thomson Reuters dataset used in this analysis, are well understood. The Thomson Reuters database examines the academic impact of research published in selected journals only and excludes research published in books and book chapters. It also excludes research in the form of performances or exhibitions. Therefore, the research output in subject disciplines such as the social sciences, humanities and performing arts is not as well represented compared with the biological and physical sciences. Also, the journals in the Thomson Reuters database are mostly based in Europe or North America, and so exclude a large proportion of research published in New Zealand and Australian journals. The smaller size of the New Zealand university sector, relative to those of other countries, also poses problems as the citation data tends to vary more widely over time when based on a smaller number of publications.

Nevertheless, despite these caveats, bibliometrics data still provides a one of the few independent ways that the impact of the PBRF on the research performance of New Zealand TEIs can be monitored.

2.2 Structure of report

This report has the following structure. Firstly, in section 3 which follows, the bibliometric dataset used in the analysis is discussed along with the important caveats that apply to the use and interpretation of bibliometric data. Then, the bibliometric performance of New Zealand universities is presented in section 4. This includes a profile of the research performance of each of the eight New Zealand universities. Finally, some conclusions are presented in section 5. In the appendices, a bibliometric profile of New Zealand non-university tertiary education institutions and the mapping of narrow subject areas to broad subject panels are presented.

[6] See Australian Research Council (2008) for more details.

3 Data and limitations[7]

The bibliometric dataset used in this report was sourced from Thomson Reuters and contains the number of research publications and their associated citations in overlapping five-year time periods between 1993 and 2007. For example, the five-year period 2003 to 2007 contains the number of publications indexed during that five-year period and the citations linked to those publications.

The publications included in the database are articles, notes, reviews, and proceedings papers. Other types of items such as editorials, letters, corrections, and abstracts have been omitted. A publication was assigned to an institution if at least one author was from that institution. Note that this dataset treats the universities as having been merged with colleges of education for the entire time period.

The measures presented in this report include the share of world indexed publications and citations and the relative academic impact of research. The relative academic impact is measured by dividing the average number of citations per New Zealand TEI publication by the average number of citations for every publication worldwide. The normalisation of the academic impact is important as the rates of citation vary between subject areas and the rates of citation are rising over time.

A relative academic impact value of 1 indicates the citations per publication in a New Zealand institution are the same as the world average. A relative academic impact value greater than 1 indicates that the citations per publication of New Zealand research is higher than the world average and a relative academic impact value less than 1 indicates the citations per publication of New Zealand research is below the world average.

To help determine whether any change in academic impact is due to real change and not due to random fluctuation, 95 percent confidence intervals are calculated for the relative academic impact measure by adapting methodology suggested by Nieuwenhuysen and Rousseau (1988) and Motulsky (1995).

First, equation 1 is used to generate the standard error (SE) of the raw academic impact values (RAI):

$$SE = (\sqrt{CIT})/PUB \quad (1)$$

Where CIT equals the sum of citations and PUB is the number of publications.

Then equation 2 is used to generate the SE for the relative academic impact measure:

$$SE_{RAI} = RAI \sqrt{(SE^2_{NZ}/PUB^2_{NZ} + SE^2_{World}/PUB^2_{World})} \quad (2)$$

Then equation 3 is used to generate 95 percent confidence intervals for the raw relative academic impact measure:

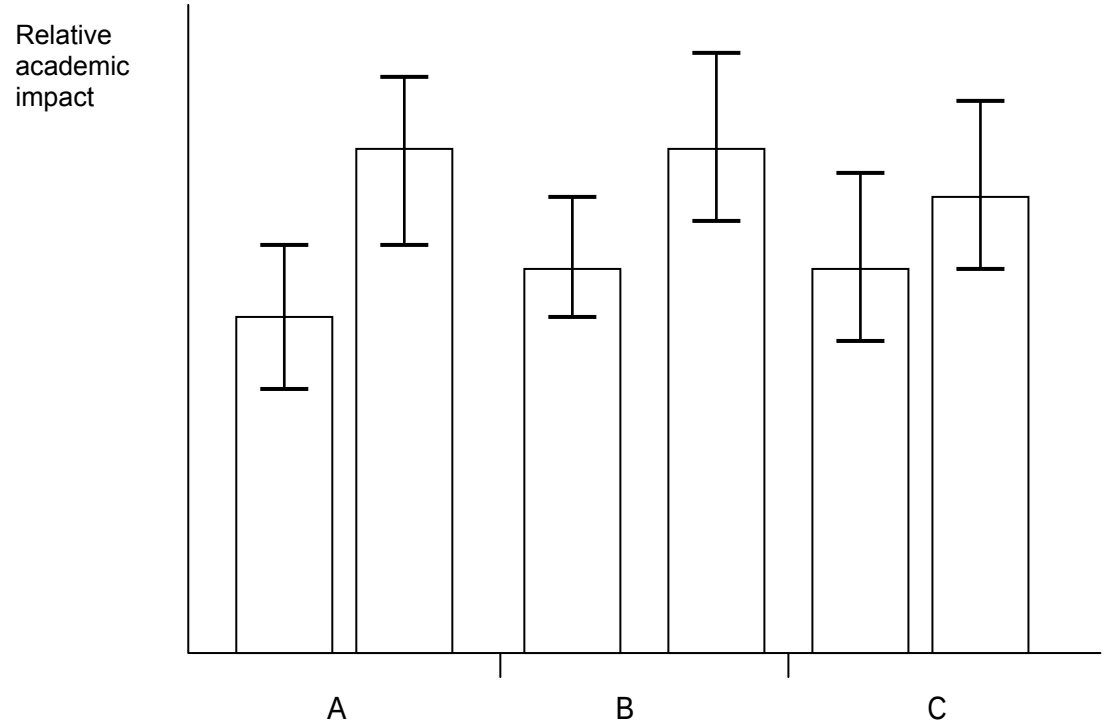
$$RAI \pm 1.96 \times SE_{RAI} \quad (3)$$

These confidence intervals can then be illustrated through the use of error bars in the graphs showing the relative impact. In terms of interpretation of the confidence intervals, if the error bars for two different time periods or universities do not overlap, there is a statistically significant difference between the two measures. However, if the error bars overlap this may not necessarily indicate a lack of a statistically significant difference between the measures. For example, a rule of thumb is that if the overlap is around one half of one of the arms of the error bars, this will equate approximately to a significant difference where $p \approx 0.05$. If the tips of the error bars are aligned then $p \approx 0.01$.

[7] Parts of this section have been reproduced from Smart and Weusten (2007a).

Figure 1 below helps to illustrate these points. For the two values in 'A', there is a statistically significant difference between the two relative impact values as the tips of the error bars are aligned. Similarly, in 'B' the difference between the two values is still statistically significant as the error bars are overlapping by less than half of the length of each arm. However, in 'C' the difference between the two relative impact values is not statistically significant.

Figure 1: Confidence intervals and statistical significance



The relative academic impact of research is presented in narrow and broad subject areas. In the case of the broad subject areas, they have been aligned with 10 of the broad PBRF subject panels.[8] Note that as a publication can be assigned to more than one narrow subject area in the Thomson Reuters database, by aggregating the data upwards to the broad subject panel level there will be an element of double counting in the dataset.

Aggregating upwards to calculate the academic impact at the broad panel level can sometimes mask strong performance at the narrow subject level. Therefore, the relative academic impact for narrow subject areas is also reported to present a more detailed profile of the performance of the New Zealand universities.

While citations have become an increasingly common measure of research performance, there are reservations about their use and the results presented in this analysis need to be considered in the light of these caveats. Some of the most important (but by no means all) caveats are:[9]

- The coverage of the social sciences and humanities in the Thomson Reuters database – the most commonly used source of citations data – is not as extensive as coverage of the natural and medical sciences. In addition, publishing conventions in disciplines such as humanities and social sciences may favour research outputs such as books and book chapters which are not captured in the Thomson database.

[8] The Māori knowledge and development panel and the Creative arts panel subject areas are excluded from this study. Research in the former panel cannot be identified from the Thomson Reuters database and there are few publications in the latter category.
[9] A fuller discussion on the issues surrounding the use of citations to measure research performance can be found in Coryn (2006) and the Research Evaluation and Policy Project (2005).

- Because citations are a better measure of science and medicine research impact, we need to take care when comparing performance. For instance, it isn't appropriate to compare raw citations scores across disciplines. Nor is it appropriate to draw conclusions from a comparison of citation rates among research organisations without allowing for the balance of the disciplines in which the organisations conduct research.

- The Thomson Reuters database is mostly made up of English language journals based in North America and Europe. As such, research in New Zealand journals that may be of a high impact may be excluded from the Thomson Reuters database. In New Zealand, this may be a greater problem for applied fields of research and for research in the social sciences, where the research may be more focused on local problems and hence more likely to appear in local journals.

- Some of the citations may in fact refer to the source article in a negative way, meaning that some cites reflect a low opinion of the quality of the research. However, it is estimated that only around 7 percent of citations are negative (Bayers, 2007).

- One of the key measures in this study, relative academic impact, is an average figure. Therefore, one or two highly cited papers can skew the relative academic impact figure upwards. This is especially a problem in cases where there are a small number of papers. Therefore, in this study the results reported are restricted to subject areas which have a minimum of 50 publications within each five-year period.[10]

- The relatively small size of the New Zealand university sector, relative to other countries, can pose a problem in terms of the smaller number of publications the citation data is based on. The smaller the number of publications, the less stable the data can be. Therefore, some of the smaller narrow subject areas can be subject to considerable shifts in relative academic impact between periods.

- Publications indexed earlier in the five-year periods used in this study will have more time to build up citations than those indexed later in the five-year period. As a result, the publications indexed earlier in the five-year period will have the greatest influence on the relative academic impact measure.

[10] In previous reports 25 papers was used as the threshold. The limit has been increased to 50 in this report to reduce distortions in the data from a low number of publications.

4 University bibliometric performance

This section examines the bibliometric performance of New Zealand universities. In section 4.1, the performance of New Zealand universities as a whole is compared to the Australian Group of Eight (G8) and Non-G8 university groupings. Then, in section 4.2 the performance of individual New Zealand universities in 10 broad subject fields is examined. Finally, in Section 4.3, the bibliometric profile of each of the New Zealand universities is examined with a focus on comparing their performance in 2003 to 2007 with their performance in 1998 to 2002.

4.1 New Zealand universities v Australian universities

The bibliometric performance of New Zealand universities across three dimensions is presented in Figure 1. These performance dimensions are the share of world indexed publications, share of world indexed citations and the relative academic impact.

Figure 2 shows that the percentage of world indexed publications authored by staff at New Zealand universities has risen over time. In 1994 to 1998, 0.37 percent of world indexed publications were authored by New Zealand university staff, rising to 0.40 percent by 1996 to 2000. Between 1996 to 2000 and 2001 to 2005, the share of world publications authored by New Zealand university staff remained relatively static at around 0.41 percent. However, since then, the share of world indexed publications has risen to 0.43 percent by 2003 to 2007. This recent increase in share of world publications is not surprising, given that academics in the United Kingdom targeted publication of research in frequently cited journals following the introduction of the Research Assessment Exercise (RAE) in the United Kingdom (McNay 1998).

The share of world citations by New Zealand universities has also increased over time. In 1994 to 1998, citations of research by New Zealand university authors were 0.30 percent of the world total. By 1997 to 2001, the share had increased to 0.35 percent. This increase reflected the increase in share of world indexed publications that occurred over this period. It then remained around that level till 2001 to 2005. Since then, the share of world citations has increased significantly to reach 0.40 percent by 2003 to 2007. Taking into account the lag that occurs in the publication of research findings in journals, this upswing in share would appear to be associated with the introduction of the PBRF as it mirrors an increase in the share of citations observed in the United Kingdom following the introduction of the RAE in 1986 (Adams and Smith 2006).

As a result of the faster growth in share of citations compared with publications in the last two five-year periods,[11] the overall relative academic impact of New Zealand university publications has increased significantly. The relative impact of New Zealand university research increased from 0.85 in 2001 to 2005 to 0.93 in 2003 to 2007. This followed several years where the relative academic impact remained fairly stable around the 0.85 to 0.86 level. The increase in relative academic impact between 2001 to 2005 and 2003 to 2007 was statistically significant[12] and the scale of increase suggests that the PBRF has stimulated the rate of citation of research by New Zealand universities.

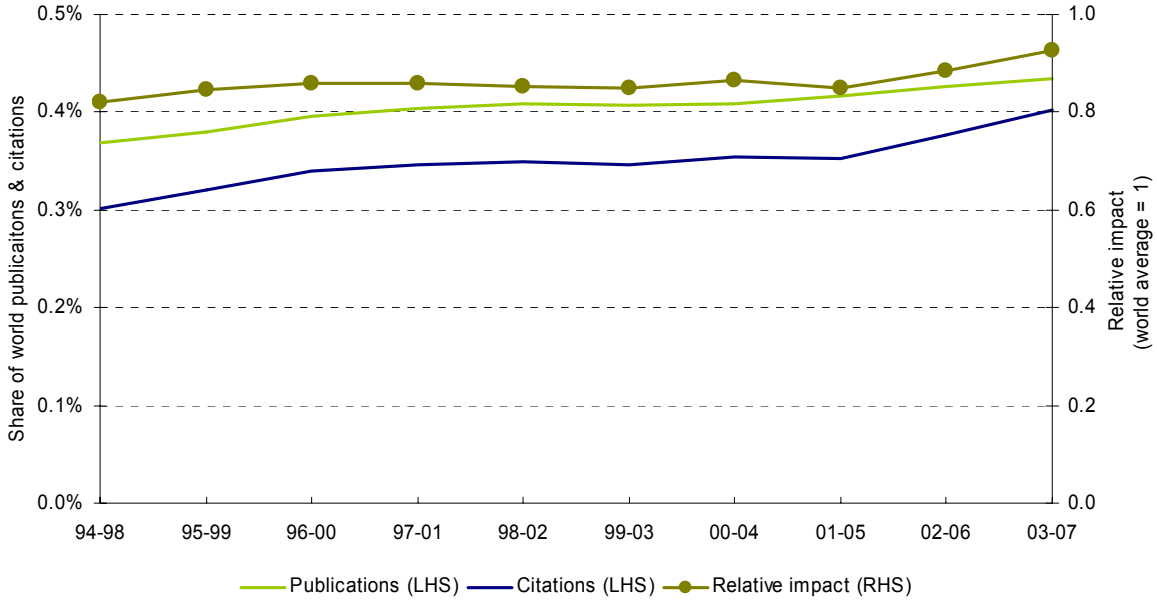
To provide some context to the New Zealand results and help determine if the PBRF is a likely factor in the change in citation behaviour, the comparative performance of the Australian G8 and Non-G8 universities is presented in Figure 3 and Figure 4, respectively. Figure 3 shows that since 1994 to 1998 the share of world publications and citations and relative impact of research at the G8 universities has been rising steadily. However, there is no sign of the dramatic upswing in overall relative academic impact exhibited by the New Zealand universities in the last two five-year periods.

[11] Overall relative impact increased by 4.1 percent and 4.7 percent in 2002 to 2006 and 2003 to 2007, respectively. This compares with an average decrease of 0.04 percent in each five-year period between 1994 to 1998 and 2001 to 2005.
[12] As indicated by the tests of statistical inference described in section 3.

Similarly, the Non-G8 universities do not exhibit the same level of increase in relative impact that was exhibited by the New Zealand universities during the last two five-year periods.

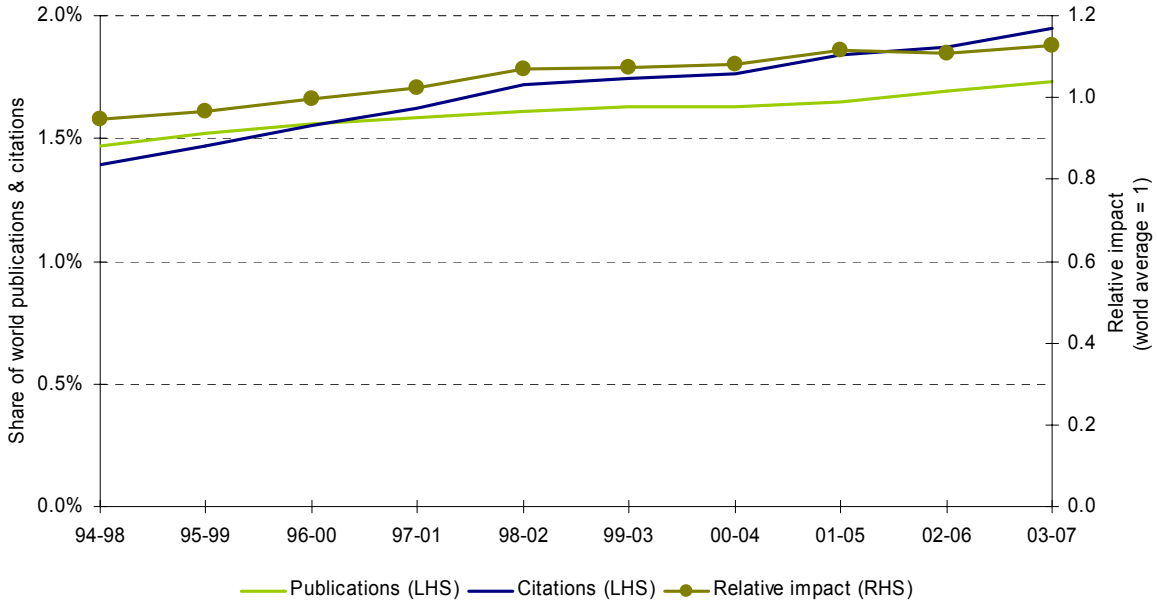
Therefore, it is unlikely that the recent sharp rise in the relative academic impact of New Zealand university research is part of a wider Australasian phenomenon. This leaves domestic factors as the likely cause of the upswing in overall relative academic impact, of which the introduction of the PBRF is one of the key events in the New Zealand tertiary research environment during this time.

Figure 2: Share of world publications and citations and relative academic impact – New Zealand universities



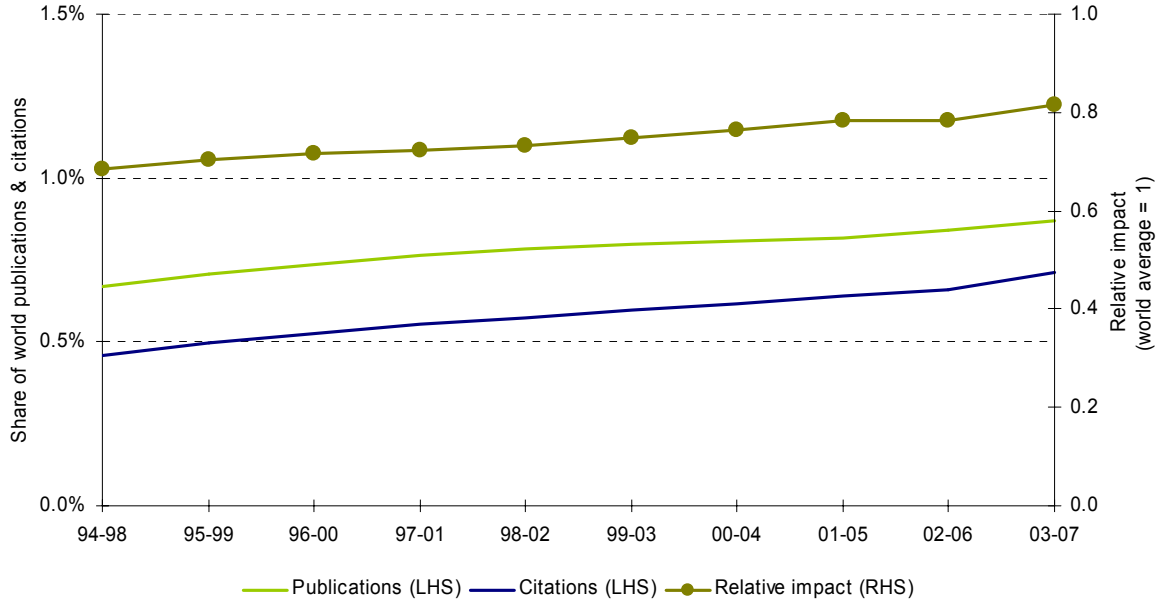
Source: Thomson Reuters

Figure 3: Share of world publications and citations and relative academic impact – G8 universities



Source: Thomson Reuters

Figure 4: Share of world publications and citations and relative academic impact – Non-G8 universities



Source: Thomson Reuters

Figure 5 presents the relative academic impact of research of the three university groupings – New Zealand, the G8 and Non-G8 – across 10 broad subject areas and in two five-year periods – 1998 to 2002 and 2003 to 2007. In 2003 to 2007, the relative academic impact of research by New Zealand universities in 'Health' (1.14), 'Medicine' (1.08) and 'Maths/IT' (1.03) were all above 1, indicating the academic impact of research was above the world average. The lowest relative academic impact was exhibited by 'Education' (0.74).

In terms of comparative performance, New Zealand universities had a relative impact that was equal to the G8 in 'Health' and slightly lower in 'Business' and 'Humanities'. The relative impact of New Zealand university research in 'Education', 'Physical sciences' and 'Biological sciences' was much lower than the G8 universities.

The comparative performance of New Zealand universities was much better against the Non-G8 universities. The relative impact of New Zealand research was higher than the Non-G8 universities in seven out of the 10 broad subject areas. The advantage was highest for New Zealand university research in Medicine, with the biggest disadvantage being in Education.

Comparing the performance in 2003 to 2007 with the earlier period of 1998 to 2002, shows the relative academic impact of New Zealand university research has become less variable across the 10 broad subject panels. The range in relative impact reduced from a low of 0.60 and a high of 1.11 in 1998 to 2002, to a low of 0.74 and a high of 1.14 in 2003 to 2007.

The broad subject areas that exhibited improvement in relative academic impact between 1998 to 2002 and 2003 to 2007 were: 'Engineering' (up 31 percent), 'Mathematics' (up 2.8 percent), 'Biological sciences' (up 21 percent), 'Medicine' (up 4.6 percent), 'Health' (up 2.5 percent), 'Business' (up 21 percent), 'Education' (up 16 percent), and 'Humanities' (up 34 percent). The broad subject areas showing a fall in relative impact were 'Physical sciences' (down 7.7 percent) and 'Social sciences' (down 18 percent).

An increase in 'Business' and 'Humanities' was also observed in G8 and Non-G8 universities during this time, as well as a slight fall in the relative impact of research in the 'Physical sciences'. There was

also an increase in the relative academic impact of research in the 'Biological sciences' by the G8 and Non-G8 universities – although the increase was slightly lower percentage wise than the other broad subject areas.[13]

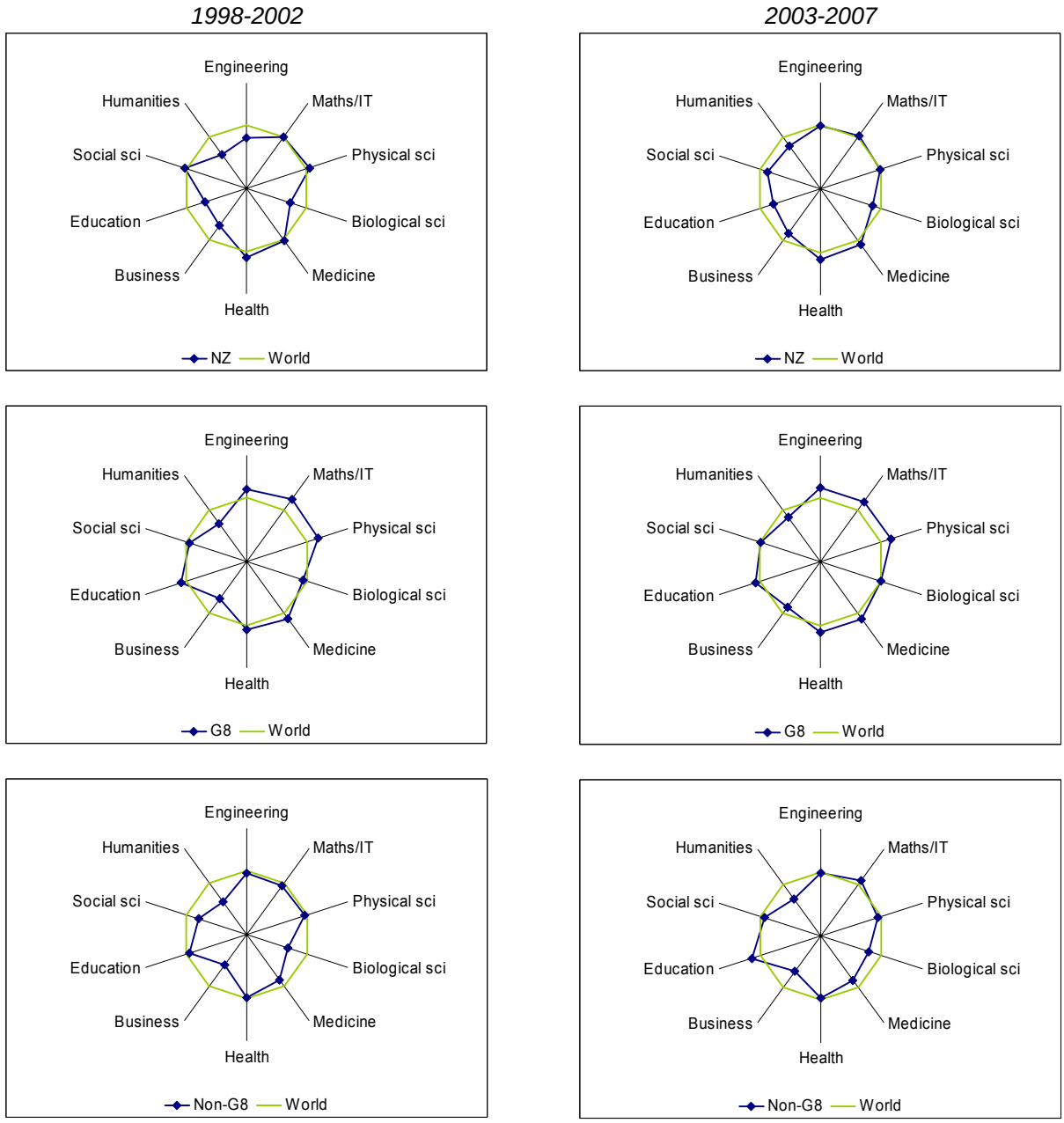
As was mentioned previously, aggregating the citation data upwards to the broad subject panel level can mask the performance of the universities in narrow subject areas. Table 1 presents the relative impact in narrow subject areas for the three groupings of universities, with the New Zealand subjects ranked from highest to lowest for the 2003 to 2007 period. Note that only those narrow subject areas where New Zealand recorded at least 50 publications have been presented. For the New Zealand universities, the narrow subjects with the highest relative academic impact in 2003 to 2007 were 'Information technology and communication systems' (1.64), 'Rehabilitation' (1.58) and 'Urology' (1.57).

Overall, for the New Zealand universities, 52 percent of the 93 narrow subjects had a relative impact of 1 or higher. This compares with 46 percent of the 85 subject areas in 1998 to 2002. The average relative academic impact across the narrow subject areas was 1.02 in 2003 to 2007 compared with 0.98 in 1998 to 2002.

In 2003 to 2007, 70 percent of the narrow subject areas had a relative academic impact of 1 or higher for the G8 universities, the same as in 1998 to 2002. For the non-G8 universities the figure was 37 percent in both time periods. The average academic impact of the G8 universities was 1.13 in 2003 to 2007 (1.14 in 1998-2002) and 0.95 for the non-G8 universities (0.93 in 1998-2002).

[13] The relative performance of the three university groupings across the 10 broad subject panels is explored in more depth in section 4.2.

Figure 5: Relative academic impact by broad subject area and university grouping



Source: Ministry of Education and Thomson Reuters

Table 1: Relative academic impact by narrow subject area and university grouping

	NZ		G8		Non-G8	
Narrow subject area	2003-2007	1998-2002	2003-2007	1998-2002	2003-2007	1998-2002
Info Technol & Commun Syst	1.64	1.41	0.90	1.67	0.80	1.23
Rehabilitation	1.58	0.52	1.03	0.93	0.74	1.00
Urology	1.57	0.91	1.40	1.27	0.78	
Language & Linguistics	1.54	0.71	0.88	0.87	1.25	
Cardiovasc & Respirat Syst	1.52	1.65	1.38	1.51	1.04	0.94
Pediatrics	1.50	1.58	1.11	1.25	1.04	1.33
Philosophy	1.49	1.18	1.29	1.42	0.76	1.09
Chemical Engineering	1.42	0.76	1.12	1.21	0.80	1.12
General & Internal Medicine	1.42	0.69	1.42	1.56	1.08	1.48
Rheumatology	1.40		1.32	1.15	1.15	1.22
Chemistry	1.39	1.01	1.00	1.08	0.73	0.65
Entomology/Pest Control	1.37	1.27	1.32	1.31	0.93	1.19
AI, Robotics & Auto Control	1.31	0.59	1.15	1.27	0.98	1.02
Optics & Acoustics	1.31	1.37	1.31	1.36	1.01	1.20
History	1.26	1.11	1.38	1.05	1.00	1.00
Psychiatry	1.25	0.98	0.93	0.85	0.76	0.60
Neurology	1.25	0.66	1.22	1.07	0.93	0.90
Clin Psychology & Psychiatry	1.24	0.95	0.94	0.82	0.68	0.60
Oncology	1.24	1.31	0.96	1.05	0.83	0.73
Literature	1.23	1.15	1.00	0.77	1.15	1.00
Animal Sciences	1.23	1.23	1.33	1.26	1.08	1.12
Gastroenterol and Hepatology	1.23		1.48	1.32	0.96	1.90
Veterinary Med/Animal Health	1.23	1.31	1.01	1.12	1.07	1.13
Environment/Ecology	1.23	1.02	1.20	1.19	1.22	1.04
Environmt Engineering/Energy	1.23	0.45	1.12	1.10	1.07	0.73
Experimental Biology	1.20	0.87	1.06	1.08	1.04	0.80
Medical Res, Organs & Syst	1.19	1.04	1.15	1.14	0.91	1.06
Agriculture/Agronomy	1.17	1.10	1.48	1.83	1.32	1.54
Ortho, Rehab & Sports Med	1.16	1.14	1.35	1.10	1.06	0.94
Inorganic & Nucl Chemistry	1.16	1.31	1.23	1.48	0.92	1.40
Reproductive Medicine	1.13	1.08	1.17	1.24	1.09	1.00
Public Hlth & Hlth Care Sci	1.13	0.93	1.20	1.04	0.90	0.72
Mechanical Engineering	1.13	0.91	1.18	1.28	1.03	0.88
Radiol, Nucl Med & Imaging	1.12		0.92	1.07	0.83	0.57
Engineering Mgmt/General	1.11	0.64	1.42	1.14	1.11	0.85
Physics	1.10	1.29	1.38	1.09	0.84	0.85
Biotechnol & Appl Microbiol	1.10	0.53	1.18	0.99	0.86	0.86
Medical Res, General Topics	1.10	1.00	1.01	1.04	0.73	0.85
Neurosciences & Behavior	1.07	0.82	0.89	0.86	0.75	0.72
Cardiovasc & Hematology Res	1.07	0.94	1.16	1.25	0.88	0.67
Earth Sciences	1.07	1.07	1.22	1.31	1.24	1.17
Food Science/Nutrition	1.06	1.31	1.19	0.87	0.91	1.13
Oncogenesis & Cancer Res	1.05	1.35	0.91	0.97	0.78	0.63
Aquatic Sciences	1.05	0.96	1.36	1.20	1.14	1.05
Space Science	1.03	1.02	1.29	1.54	0.91	1.17
Environmt Med & Public Hlth	1.02	1.04	1.04	0.90	0.94	0.82
Mathematics	1.02	0.95	1.19	1.23	1.20	0.99
Biology	1.02	1.24	1.08	1.14	1.05	1.07
Communication	0.98		0.95	0.88	0.88	1.29
Clin Immunol & Infect Dis	0.98	1.25	1.17	1.20	0.87	1.09

Table 1: Continued…

Narrow subject area	NZ 2003-2007	NZ 1998-2002	G8 2003-2007	G8 1998-2002	Non-G8 2003-2007	Non-G8 1998-2002
Physical Chem/Chemical Phys	0.97	0.98	1.07	1.04	0.95	0.82
Molecular Biology & Genetics	0.96	0.79	0.98	0.85	0.62	0.71
Civil Engineering	0.96	1.08	1.40	1.18	0.93	1.48
Biochemistry & Biophysics	0.94	0.84	0.99	0.92	0.77	0.72
Medical Res, Diag & Treatmt	0.92	1.09	1.24	1.26	0.87	0.69
Dentistry/Oral Surgery & Med	0.92	0.90	1.00	1.10	0.63	
Organic Chem/Polymer Sci	0.92	1.05	1.39	1.06	0.74	0.92
Ophthalmology	0.89		1.44	1.20	1.10	0.78
Anthropology	0.89	0.80	0.99	1.11	1.14	0.74
Animal & Plant Sciences	0.89	0.75	1.14	1.10	0.78	0.76
Pharmacology & Toxicology	0.88	0.86	1.06	1.07	0.85	0.90
Appl Phys/Cond Matt/Mat Sci	0.88	1.01	1.16	1.21	0.95	0.92
Endocrinol, Nutrit & Metab	0.87	1.04	1.14	1.15	0.97	0.69
Instrumentation/Measurement	0.87		1.22	1.29	1.08	1.39
Pharmacology/Toxicology	0.87	0.86	0.99	1.15	0.97	1.08
Surgery	0.87	1.18	1.23	1.45	0.81	0.92
Plant Sciences	0.86	0.79	1.22	1.17	0.91	0.81
Library & Information Sci	0.85		2.06	1.04	0.76	0.97
Health Care Sci & Services	0.85	0.70	0.87	0.91	0.73	0.79
Anesthesia & Intensive Care	0.85	1.17	0.98	1.24	1.19	
Economics	0.81	0.58	0.79	0.67	0.62	0.54
Microbiology	0.81	0.66	1.04	0.99	1.02	0.88
Psychology	0.80	0.97	1.02	1.02	0.86	0.75
Materials Sci and Engn	0.79	0.97	1.18	1.02	0.85	0.83
Engineering Mathematics	0.77	0.82	1.09	0.96	0.79	0.85
Environ Studies, Geog & Dev	0.76	0.95	0.78	0.88	0.76	0.81
Education	0.74	0.64	1.09	1.10	1.16	0.94
Resrch/Lab Med & Med Techn	0.72	1.26	1.32	1.10	0.71	0.74
Cell & Developmental Biol	0.72	0.39	0.78	0.69	0.60	0.46
Elect & Electronic Engn	0.72	0.94	1.11	1.13	0.89	0.77
Multidisciplinary	0.71	0.78	0.85	0.84	0.79	0.87
Endocrinol, Metab & Nutrit	0.69	0.90	0.99	0.86	0.74	0.57
Physiology	0.68	0.67	0.96	0.96	0.89	0.93
Computer Sci & Engineering	0.68	0.83	1.27	1.10	1.18	0.66
Management	0.68	0.59	1.06	0.67	0.58	0.40
Social Work & Social Policy	0.65	1.63	0.77	0.75	0.73	0.70
Spectrosc/Instrum/Analyt Sci	0.65	1.07	1.15	0.93	1.21	1.23
Sociology & Social Sciences	0.65	1.85	0.99	0.79	1.12	0.69
Immunology	0.64	0.78	0.89	0.87	0.66	0.61
Chemistry & Analysis	0.62	0.84	0.91	1.02	0.78	0.87
Agricultural Chemistry	0.62	1.01	1.00	1.21	0.85	0.87
Political Sci & Public Admin	0.59	0.52	0.82	0.62	0.60	0.51
Hematology	0.42		1.29	1.15	0.82	

Source: Thomson Reuters

4.2 Relative academic impact by broad subject panel analysis and university

In this section, the relative academic impact across the 10 broad subject panels is examined by university grouping and by individual New Zealand university for two time periods – 1998 to 2002 and 2003 to 2007. The earlier time period is prior to the introduction of the PBRF and so provides a baseline for the bibliometric performance of the universities.

Note that the absence of an institution in the subject panels does not necessarily mean they have not produced any research publications in that subject area, but rather they may not have reached the 50 publication threshold for inclusion in the analysis. Also note that 95 percent confidence intervals are presented as error bars in the graphs in this section. See section 3 for their method of calculation and how they should be interpreted.

4.2.1 Engineering, technology and architecture

In this panel area:

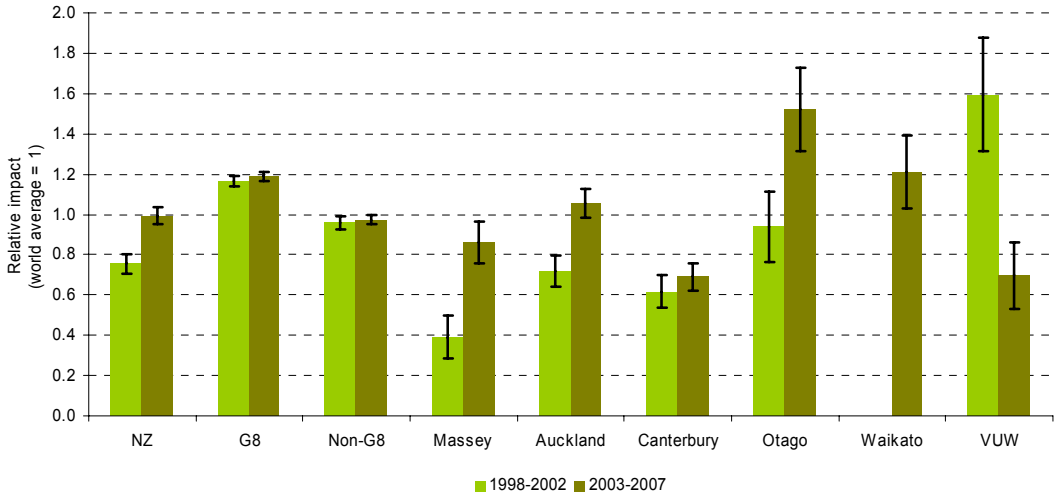
- The two universities with the longest-established engineering schools (and hence the largest number of publications), the Universities of Auckland and Canterbury, both exhibited higher relative academic impact in 2003 to 2007 than in 1998 to 2002 (although the increase by Canterbury does not appear to be statistically significant). The University of Auckland had a relative academic impact (1.06) above the world average in 2003 to 2007.

- In 2003 to 2007, the University of Otago had the highest relative academic impact (1.52) followed by the University of Waikato (1.21).[14] Three of the six universities in this panel exhibited a relative academic impact above the world average.

- Four New Zealand universities appearing in this panel exhibited a rise in relative impact between 1998 to 2002 and 2003 to 2007 (three of the increases were statistically significant).[15]

- Between 1998 to 2002 and 2003 to 2007, the scale of the increase in the relative academic impact of research by New Zealand universities in aggregate saw them achieve a similar level of academic impact to the Non-G8 universities and close the gap significantly with the relative academic impact of the G8 universities.

Figure 6: Relative academic impact in Engineering, technology and architecture



Note: The error bars represent 95 percent confidence intervals. See section 3 for more detail on their calculation and interpretation.
Source: Ministry of Education and Thomson Reuters

[14] Note that both of these universities had a much lower number of publications than the Universities of Auckland and Canterbury.
[15] Although the relative academic impact at VUW decreased between 1998 to 2002 and 2003 to 2007, this figure is based on a relatively small number of publications.

4.2.2 Mathematical and information sciences and technology

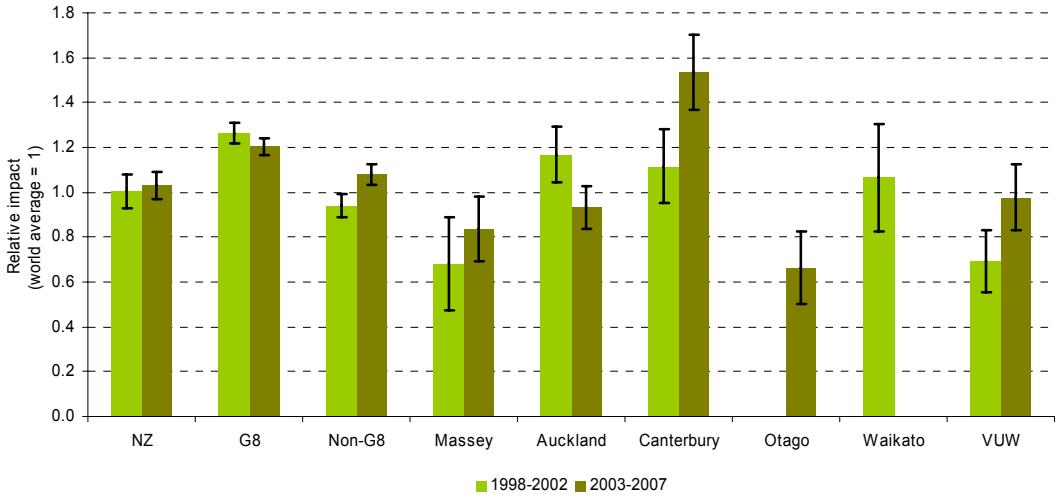
In this panel area:

- In 2003 to 2007, the University of Canterbury exhibited the highest relative academic impact (1.54) followed by Victoria University of Wellington (0.98).

- Three universities increased their relative academic impact (Massey, Canterbury and Victoria) between 1998 to 2002 and 2003 to 2007 (two of the increases were statistically significant).

- Between 1998 to 2002 and 2003 to 2007, the increase in academic impact exhibited by the New Zealand universities in aggregate was smaller than that achieved by the Non-G8 universities. As a result, the academic impact of research by the Non-G8 universities in 2003 to 2007 (1.08) exceeded that of the New Zealand universities (1.03). However, the G8 universities exhibited a fall in relative academic impact in 2003 to 2007 and so the gap in performance compared with the New Zealand universities closed.

Figure 7: Relative academic impact in Mathematical and information sciences and technology



Note: The error bars represent 95 percent confidence intervals. See section 3 for more detail on their calculation and interpretation.
Source: Ministry of Education and Thomson Reuters

4.2.3 Physical sciences

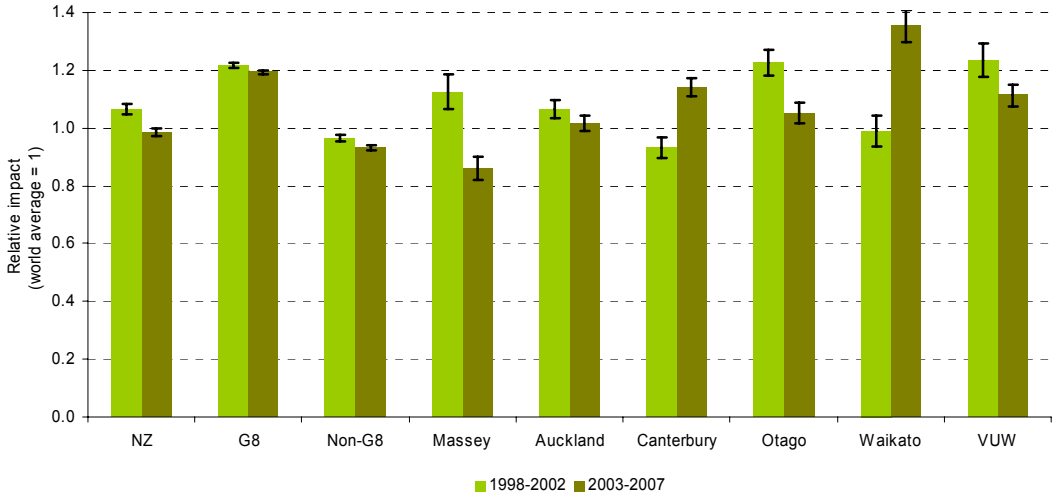
In this panel area:

- In 2003 to 2007, the University of Waikato had the largest relative academic impact (1.35) followed by the University of Canterbury (1.14). Five of the six universities in this panel exhibited a relative academic impact that was above the world average.

- Between 1998 to 2002 and 2003 to 2007, two universities (Waikato and Canterbury) increased their relative academic impact and four universities (Massey, Auckland, Otago and Victoria) exhibited a decrease in academic impact. The largest improvement was by the University of Waikato where the relative academic impact increased from 0.99 in 1998 to 2002 to 1.35 in 2003 to 2007.

- The New Zealand universities in aggregate, the G8 and Non-G8 universities all exhibited a fall in relative academic impact between 1998 to 2002 and 2003 to 2007. Although the relative academic impact of New Zealand universities decreased the most of the three university groupings, it still remained close to the world average and remained above the level of performance of the Non-G8 universities.

Figure 8: Relative academic impact in Physical sciences



Note: The error bars represent 95 percent confidence intervals. See section 3 for more detail on their calculation and interpretation.
Source: Ministry of Education and Thomson Reuters

4.2.4 Biological sciences

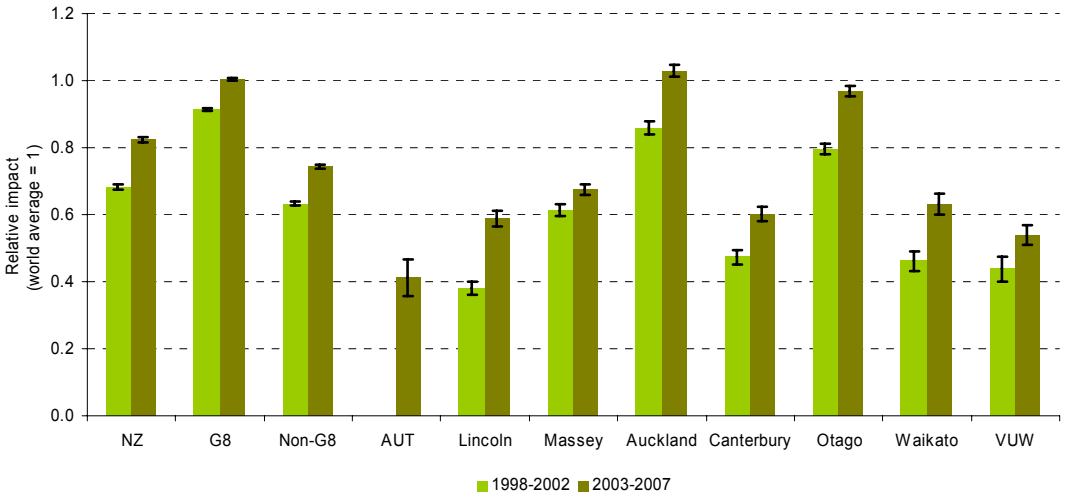
In this panel area:

- In 2003 to 2007, the University of Auckland had the highest relative academic impact (1.03) followed by the University of Otago (0.97). One of the eight universities (Auckland) had an academic impact above the world average in this broad subject panel.

- Six of the universities exhibited a rise in relative academic impact between 1998 to 2002 and 2003 to 2007.

- Between 1998 to 2002 and 2003 to 2007, the New Zealand universities in aggregate improved their relative academic impact. However, the G8 and Non-G8 universities also improved their relative academic impact so the performance of the New Zealand universities remained below the G8 and above the Non-G8 universities.

Figure 9: Relative academic impact in Biological sciences



Note: The error bars represent 95 percent confidence intervals. See section 3 for more detail on their calculation and interpretation.
Source: Ministry of Education and Thomson Reuters

4.2.5 Medicine and public health

In this panel area:

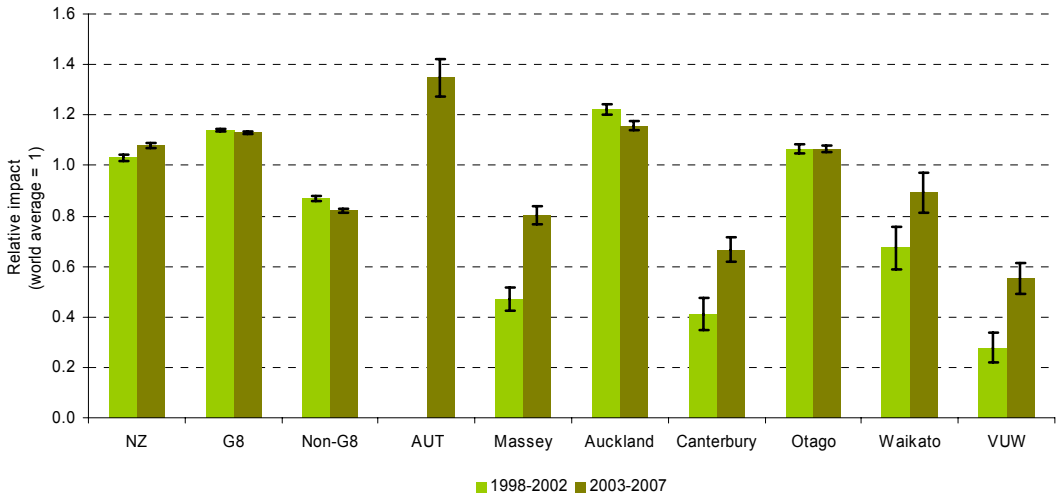
- In 2003 to 2007, the two universities with medical schools, the Universities of Auckland (1.16) and Otago (1.07) both exhibited a relative academic impact above the world average.

- Although the Auckland University of Technology achieved the highest relative academic impact in 2003 to 2007 (1.35), this was off a relatively small number of papers that occurred within one narrow discipline.

- Between 1998 to 2002 and 2003 to 2007, four New Zealand universities (Massey, Canterbury, Waikato and Victoria) increased their relative academic impact, one remained the same (Otago) and one decreased slightly (Auckland).

- Between 1998 to 2002 and 2003 to 2007, the increase in relative academic impact by the New Zealand universities in aggregate resulted in a closing of the gap in performance compared with the G8 universities and a widening of the gap compared with the Non-G8 universities.

Figure 10: Relative academic impact in Medicine and public health



Note: The error bars represent 95 percent confidence intervals. See section 3 for more detail on their calculation and interpretation.
Source: Ministry of Education and Thomson Reuters

4.2.6 Health

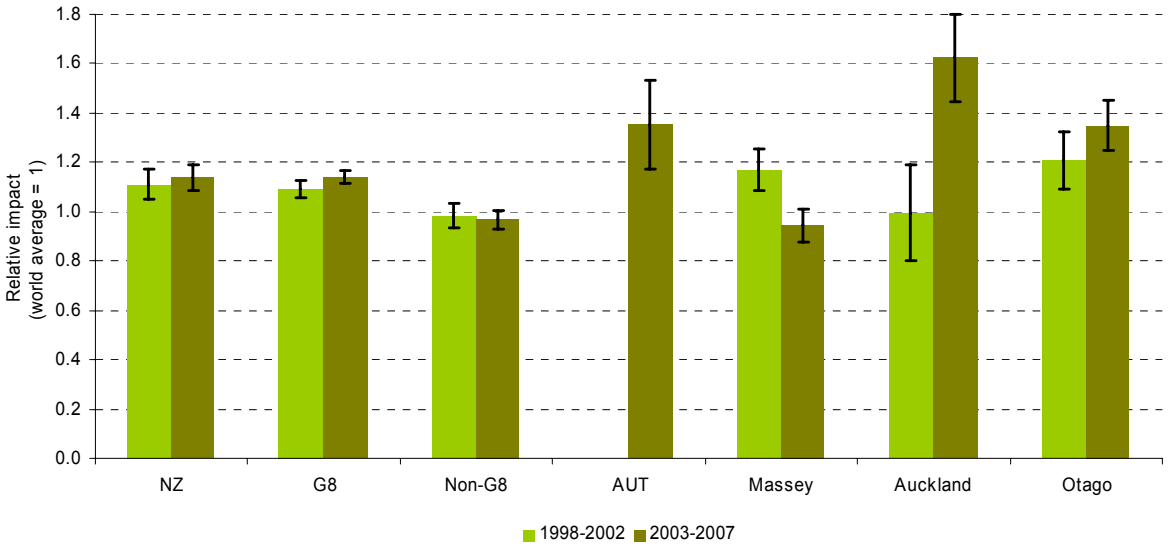
In this panel area:

- In 2003 to 2007, the University of Auckland achieved the highest relative academic impact (1.62) followed by the University of Otago (1.35) and the Auckland University of Technology (1.35). Three of the four universities in this panel exhibited a relative academic impact above the world average.

- Between 1998 to 2002 and 2003 to 2007, the Universities of Auckland and Otago increased their relative academic impact (although the increase by Otago was not statistically significant) while Massey University exhibited a fall in relative academic impact.

- In 2003 to 2007, the performance of the New Zealand universities in aggregate remained similar to the performance of the G8 universities and above the Non-G8 universities.

Figure 11: Relative academic impact in Health



Note: The error bars represent 95 percent confidence intervals. See section 3 for more detail on their calculation and interpretation.
Source: Ministry of Education and Thomson Reuters

4.2.7 Business and economics

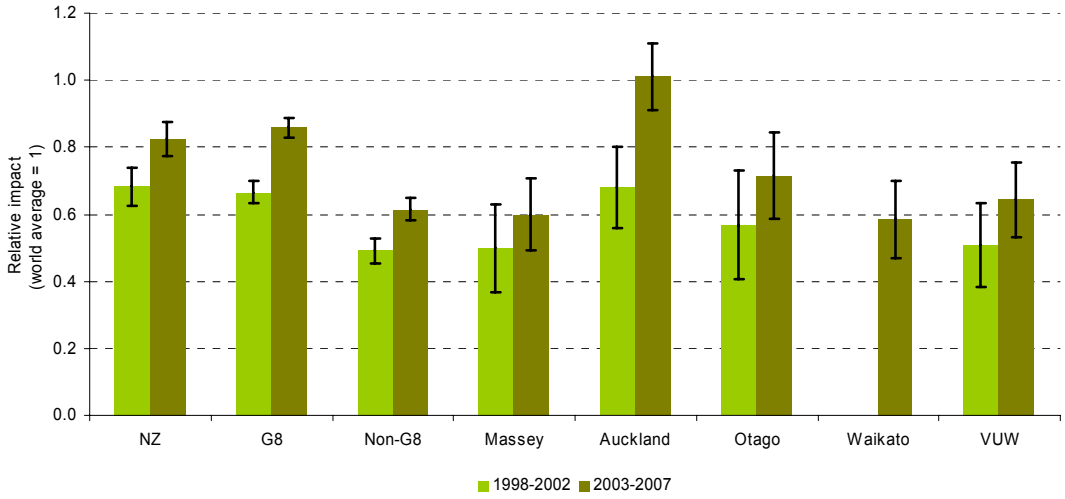
In this panel area:

- In 2003 to 2007, the University of Auckland achieved the highest relative academic impact (1.01) followed by the University of Otago (0.72).

- All five New Zealand universities appearing in this panel showed an improvement in relative impact between 1998 to 2002 and 2003 to 2007 (although just two of the increases were statistically significant).

- All three university groupings exhibited significant increases in relative academic impact between 1998 to 2002 and 2003 to 2007. In 2003 to 2007, the relative academic impact of research by the G8 universities (0.86) was slightly above that of the New Zealand universities in aggregate (0.82). Both the G8 and New Zealand university groupings were well ahead of the relative academic impact achieved by the Non-G8 universities (0.62).

Figure 12: Relative academic impact in Business and economics



Note: The error bars represent 95 percent confidence intervals. See section 3 for more detail on their calculation and interpretation.
Source: Ministry of Education and Thomson Reuters

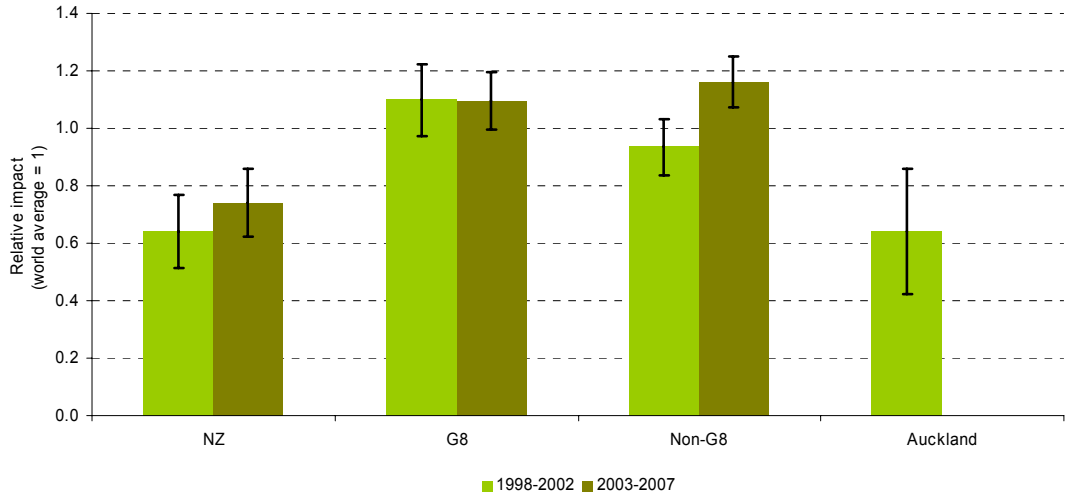
4.2.8 Education

In this panel area:

- In 2003 to 2007, no individual New Zealand university had 50 or more publications indexed in the Thomson Reuters database. In 1998 to 2002, the University of Auckland achieved a relative academic impact of 0.64.

- Between 1998 to 2002 and 2003 to 2007, the New Zealand universities improved their relative academic impact (although the increase was not statistically significant) and closed the gap compared with the G8 universities. However, the Non-G8 universities had a significant increase in relative academic impact and are now above the G8 universities.

Figure 13: Relative academic impact in Education



Note: The error bars represent 95 percent confidence intervals. See section 3 for more detail on their calculation and interpretation.
Source: Ministry of Education and Thomson Reuters

4.2.9 Social sciences

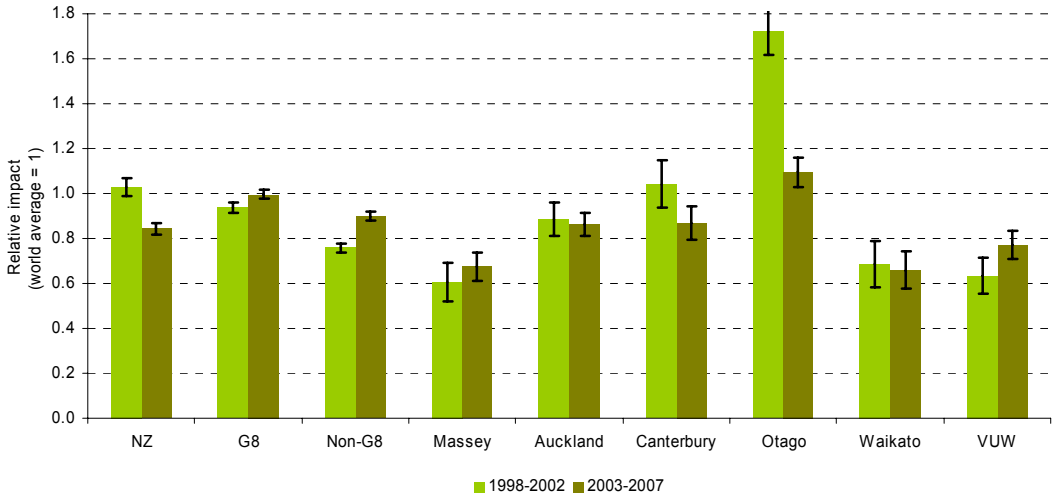
In this panel area:

- In 2003 to 2007, the University of Otago had the highest relative impact (1.10) followed by the University of Canterbury (0.87) and University of Auckland (0.86). One university of the six in this panel exhibited a relative academic impact above the world average.

- Between 1998 to 2002 and 2003 to 2007, two universities (Massey University and Victoria University of Wellington) out of six improved their relative academic impact (although the increase by Massey was not statistically significant).[16]

- Between 1998 to 2002 and 2003 to 2007, the relative impact of New Zealand university research in aggregate fell while the G8 and Non-G8 rose. As a result, the relative impact of New Zealand university research is now below that of the G8 and Non-G8 universities.

Figure 14: Relative academic impact in Social sciences



Note: The error bars represent 95 percent confidence intervals. See section 3 for more detail on their calculation and interpretation.
Source: Ministry of Education and Thomson Reuters

[16] The significant fall in relative impact for the University of Otago between 1998 to 2002 and 2003 to 2007 was mainly due to a drop in the rate of citation in 'Psychology'.

4.2.10 Humanities and law

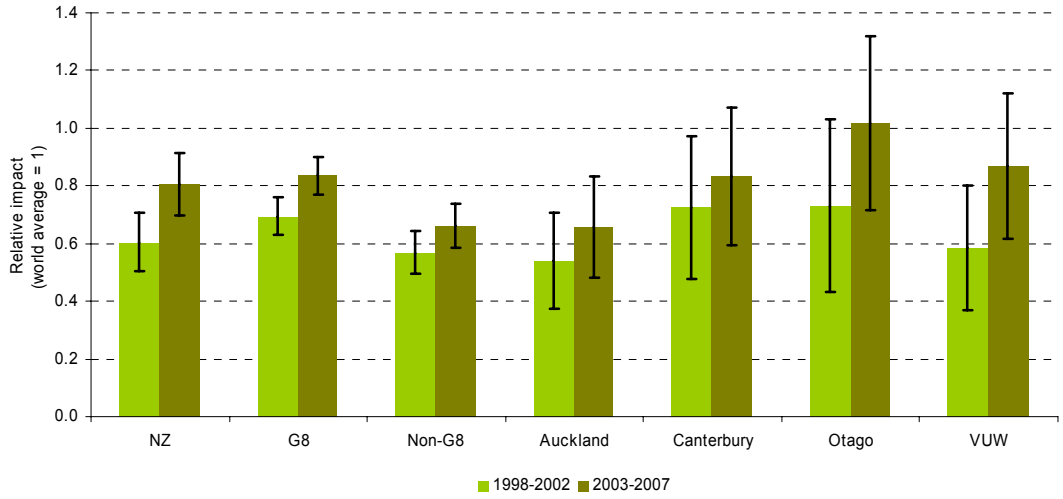
In this panel area:

- In 2003 to 2007, the University of Otago had the highest relative academic impact (1.02) followed by Victoria University of Wellington (0.87). One university out of the four in this panel exhibited a relative academic impact above the world average.

- All of the New Zealand universities appearing in this panel improved their relative academic impact between 1998 to 2002 and 2003 to 2007 (although none of the increases were statistically significant).

- Between 1998 to 2002 and 2003 to 2007, a strong increase in the relative academic impact of New Zealand universities in aggregate saw the gap compared with the G8 universities close significantly. The gap compared with the Non-G8 universities widened as a result of the stronger New Zealand university improvement.

Figure 15: Relative academic impact in Humanities and law



Note: The error bars represent 95 percent confidence intervals. See section 3 for more detail on their calculation and interpretation.
Source: Ministry of Education and Thomson Reuters

4.3 University profiles

In this section, a profile of the bibliometric performance of each of the eight New Zealand universities is presented. The performance measures examined include their share of world indexed citations and publications and the relative academic impact of their research.

4.3.1 Auckland University of Technology

Share of world indexed publications and citations

- There has been a significant increase in the share of world indexed publications authored by Auckland University of Technology staff, especially since the institution become a university in 2000. The share of world indexed publications has increased from 0.001 percent in 1995 to 1999 to 0.009 percent in 2003 to 2007.

- The share of world citations has also increased from 0.001 percent in 1995 to 1999 to 0.006 percent in 2003 to 2007.

- As a result of these trends, the overall relative academic impact of research by the Auckland University of Technology increased from 0.59 in 1995 to 1999 to 0.73 in 2003 to 2007.

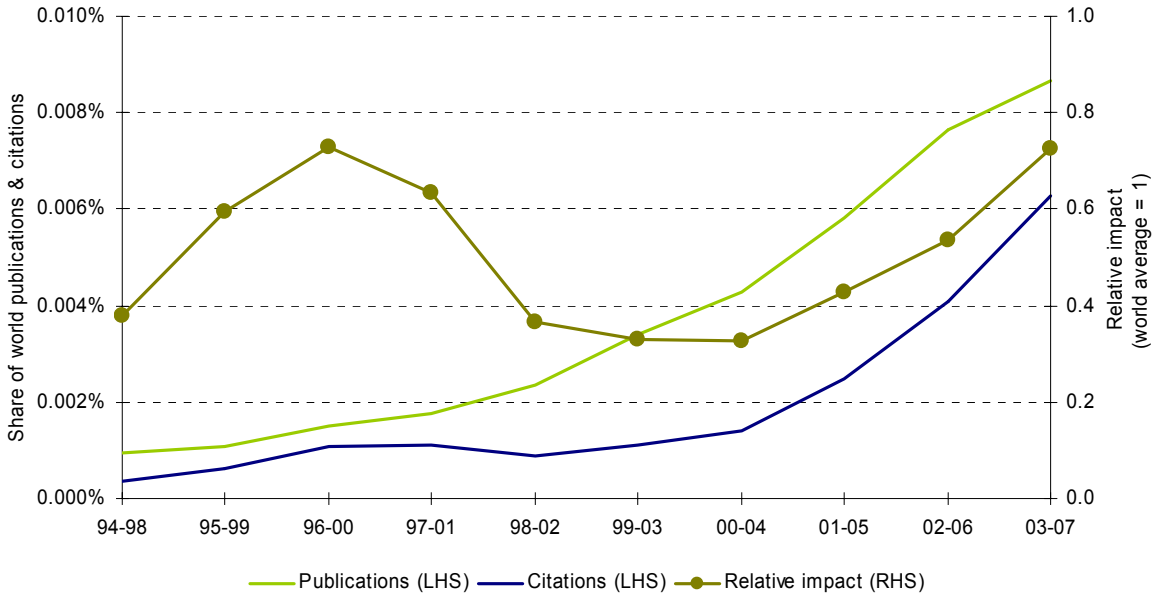
Relative academic impact – broad subject panel

- More broad subject areas met the minimum paper threshold in 2003 to 2007 (three) than in 1998-2002 (none), illustrating the increase in research activity at the Auckland University of Technology as its research capability increases. In 2003 to 2007, two of the broad subject areas, 'Medicine' (1.35) and 'Health' (1.35) exhibited a relative impact above world average.

Relative academic impact – narrow subject area

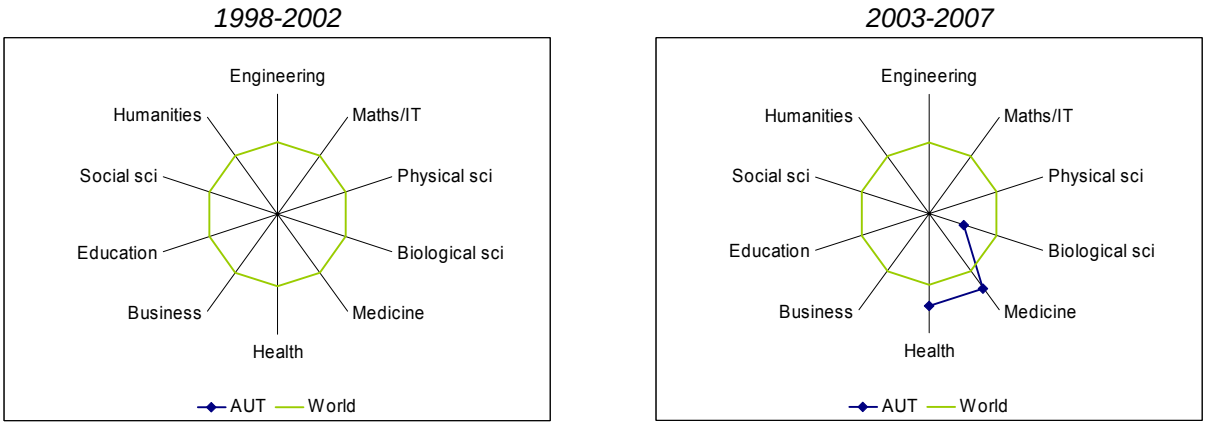
- No narrow subject areas met the met the minimum 50 paper threshold in 2003 to 2007. However, the narrow subject area of 'Orthopaedics, rehabilitations and sports medicine' had 49 publications indexed in the Thomson Reuters database and achieved a relative academic impact of 1.16.

Figure 16: Share of world publications and citations and relative academic impact – Auckland University of Technology (AUT)



Source: Thomson Reuters

Figure 17: Relative academic impact by broad subject area – Auckland University of Technology



Source: Ministry of Education and Thomson Reuters

4.3.2 Lincoln University

Share of world indexed publications and citations

- The share of world indexed publications by Lincoln University authors has decreased slightly in recent years. In 1998 to 2002, 0.016 percent of world indexed papers were by Lincoln University authors, compared with 0.014 percent in 2003 to 2007.

- However, the share of world citations has risen. In 1998 to 2002, 0.009 percent of world citations were linked to research publications by Lincoln University authors, compared with 0.011 percent in 2003 to 2007.

- As a result of these trends, the overall relative academic impact of research at Lincoln University has risen strongly from 0.55 in 1998 to 2002 to 0.77 in 2003 to 2007.

Relative academic impact – broad subject panel

- There was a significant improvement in the relative academic impact of 'Biological sciences' between 1998 to 2002 and 2003 to 2007.[17]

Relative academic impact – narrow subject area

- Two narrow subjects had a relative academic impact above the world average in 2003 to 2007, compared with just one in 1998 to 2002. These narrow subjects all have an agricultural focus, which reflects the specialisation of Lincoln University in this area.

- All three of the narrow subjects in Table 2 improved their relative academic impact compared with 1998-2002.

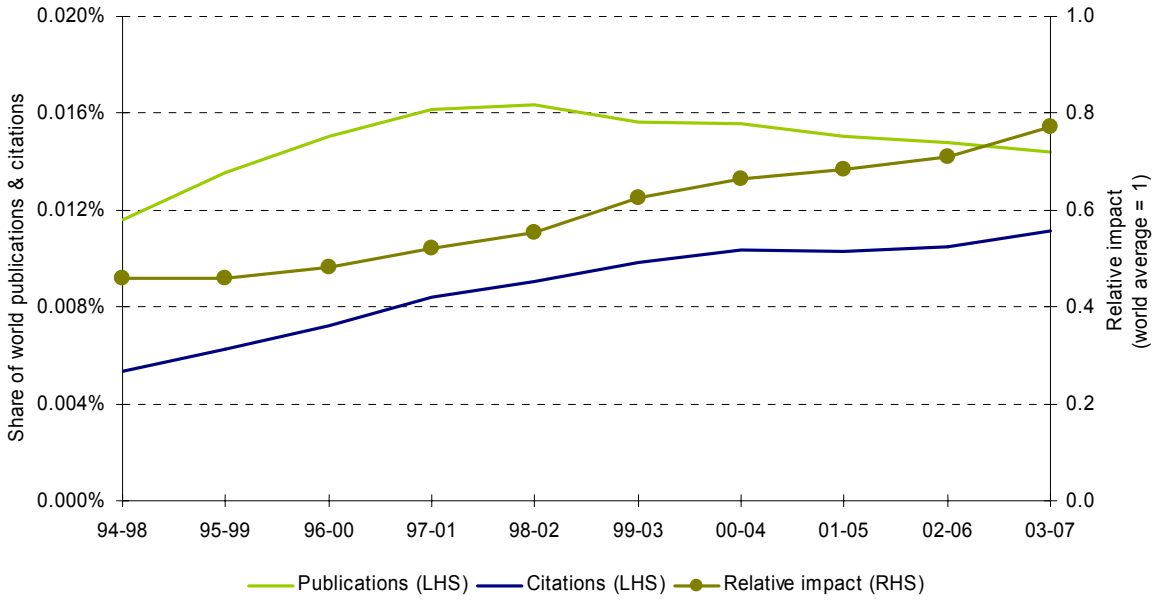
Table 2: Relative academic impact by narrow subject area – Lincoln University

Narrow subject area	2003-2007	1998-2002
Environment/Ecology	1.44	0.98
Agriculture/Agronomy	1.32	1.23
Animal Sciences	0.97	0.84

Source: Thomson Reuters

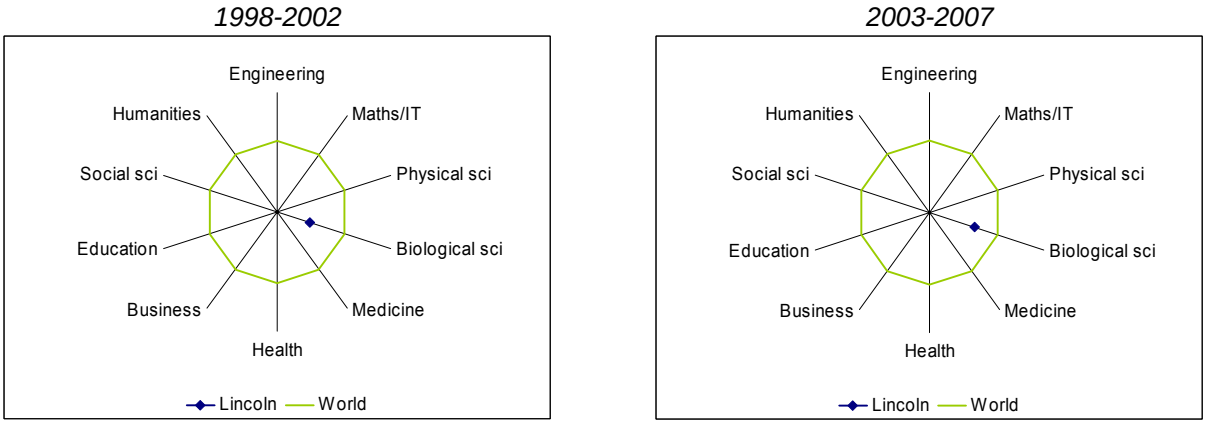
[17] Note that the aggregating of the data into the broad subject panels can mask strong performance by Lincoln University in some narrow subject areas. The narrow subject areas where Lincoln performed well in the 'Biological sciences' area are detailed in Table 3.

Figure 18: Share of world publications and citations and relative academic impact – Lincoln University



Source: Thomson Reuters

Figure 19: Relative academic impact by broad subject area – Lincoln University



Source: Ministry of Education and Thomson Reuters

4.3.3 Massey University

Share of world indexed publications and citations

- After remaining relatively stable at around 0.055 percent in the early 2000s, Massey University's share of indexed world publications increased to reach 0.065 percent in 2003 to 2007.

- There was a significant increase in Massey University's share of world citations, with the share increasing from 0.038 percent in 2001 to 2005 to 0.046 percent in 2003 to 2007.

- As a result of these trends, the overall relative impact of Massey University research increased from 0.64 in 2001 to 2005 to 0.71 in 2003 to 2007.

Relative academic impact – broad subject panel

- The highest relative academic impact in the broad subject panels areas in 2003 to 2007 was in 'Health' (0.94), 'Physical sciences' (0.86) and Engineering' (0.86).

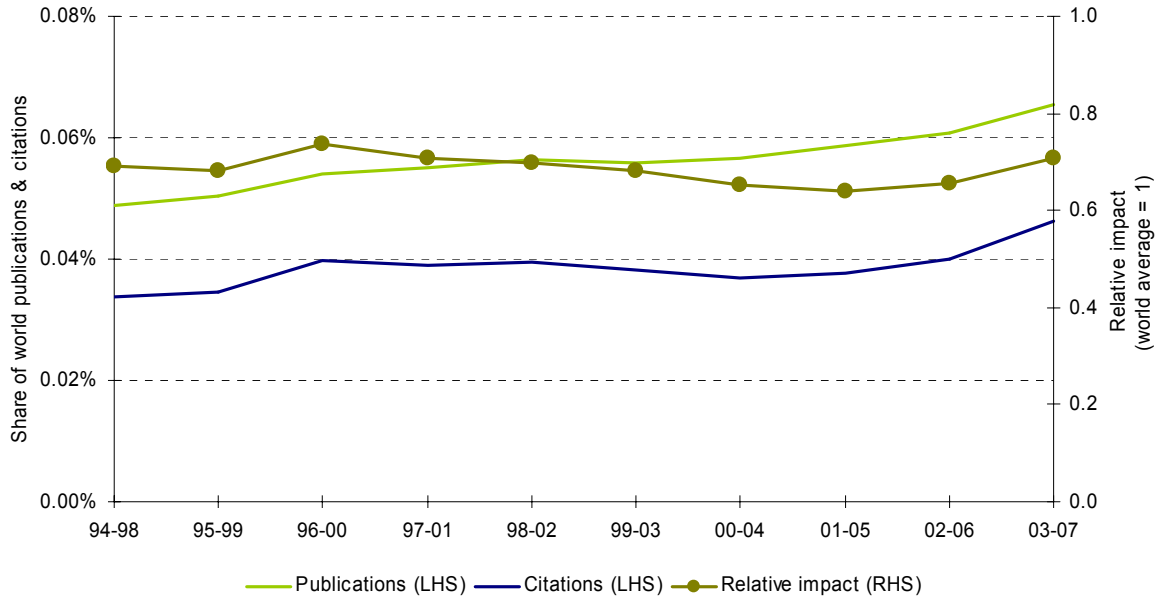
- Although the relative academic impact of research by Massey University decreased in the 'Physical sciences' and 'Health' panels, the remaining six panels exhibited an improvement in relative academic impact between 1998 to 2002 and 2003 to 2007.

Relative academic impact – narrow subject area

- In 2003 to 2007, 48 percent of narrow subjects at Massey University had a relative academic impact above the world average. This compares with 54 percent in 1998 to 2002.

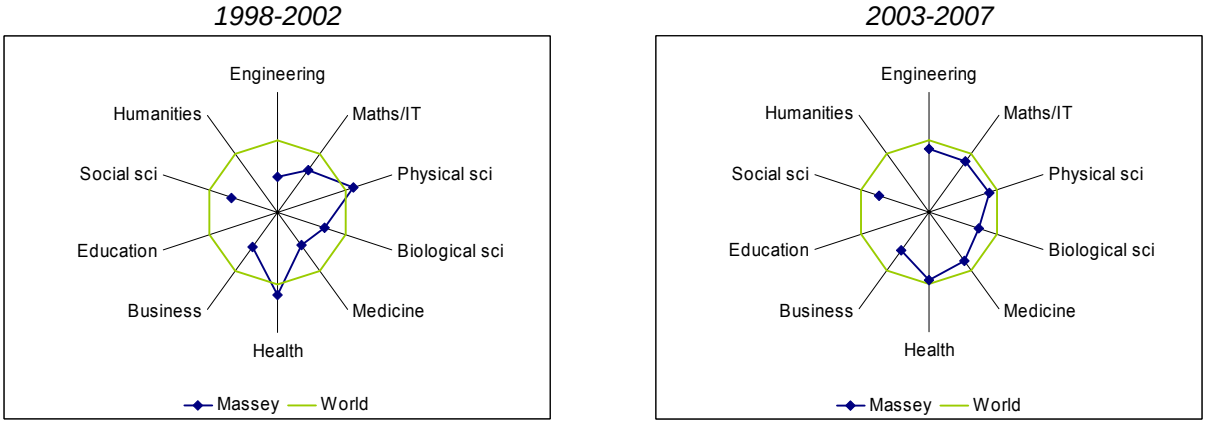
- The areas of biology and the animal sciences, areas of specialisation at Massey University, feature prominently in narrow subject areas that had a relative academic impact above the world average in 2003 to 2007.

Figure 20: Share of world publications and citations and relative academic impact – Massey University



Source: Thomson Reuters

Figure 21: Relative academic impact by broad subject area – Massey University



Source: Ministry of Education and Thomson Reuters

Table 3: Relative academic impact by narrow subject area – Massey University

Narrow subject area	2003-2007	1998-2002
Experimental Biology	1.40	
Biology	1.36	1.99
Public Hlth & Hlth Care Sci	1.36	
Animal Sciences	1.21	1.40
Veterinary Med/Animal Health	1.08	1.36
Biotechnol & Appl Microbiol	1.08	
Environment/Ecology	1.06	0.90
Mathematics	1.03	
Agriculture/Agronomy	1.03	1.05
Food Science/Nutrition	1.00	1.69
Plant Sciences	0.91	0.71
Appl Phys/Cond Matt/Mat Sci	0.90	
Physical Chem/Chemical Phys	0.90	1.06
Earth Sciences	0.72	
Microbiology	0.70	0.48
Biochemistry & Biophysics	0.61	1.12
Physics	0.58	
Economics	0.58	
Psychology	0.57	0.59
Agricultural Chemistry	0.50	
Chemistry & Analysis	0.44	0.99

Source: Thomson Reuters

4.3.4 University of Auckland

Share of world indexed publications and citations

- The share of world indexed publications by University of Auckland authors increased from 0.124 percent in 2001 to 2005 to 0.130 percent in 2003 to 2007.

- The share of world citations also increased from 0.123 percent in 2001 to 2005 to 0.139 percent in 2003 to 2007.

- As a result of these trends, the overall relative academic impact of research by the University of Auckland has increased from 0.99 in 2001 to 2005 to 1.07 in 2003 to 2007.

Relative academic impact – broad subject panel

- The broad subject panel with the highest relative academic impact in 2003 to 2007 was 'Health' (1.62) followed by 'Medicine' (1.16). Six of the nine broad panels had a relative academic impact above the world average.

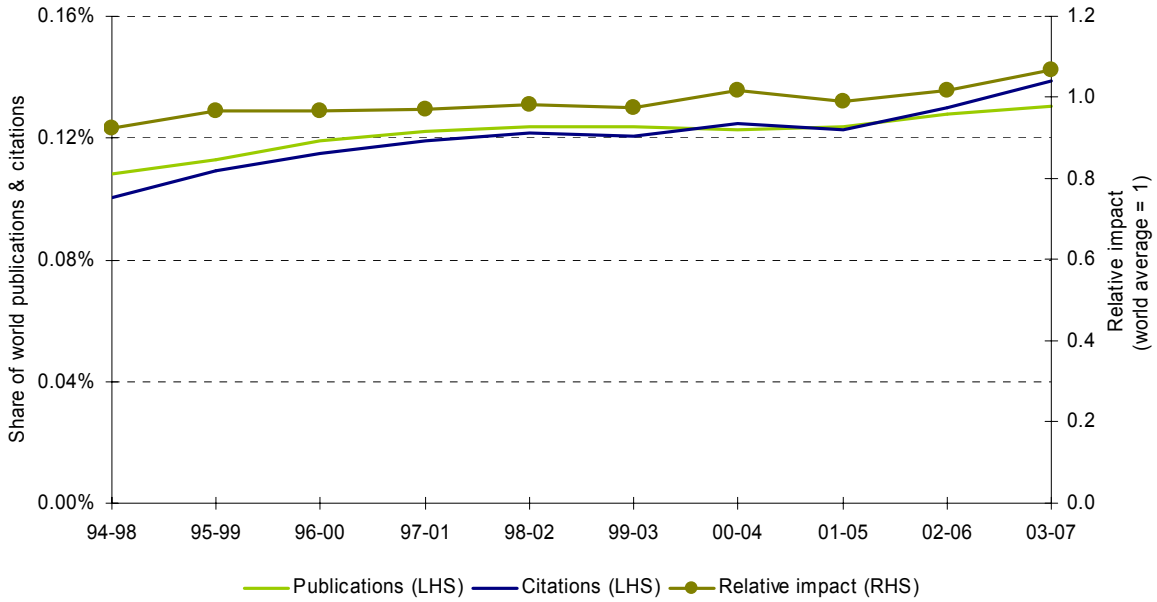
- Five out of nine broad subject panels exhibited an increase in relative academic impact between 1998 to 2002 and 2003 to 2007.

Relative academic impact – narrow subject area

- In 2003 to 2007, 55 percent of narrow subject areas had a relative academic impact above the world average. This compares with 58 percent in 1998 to 2002.

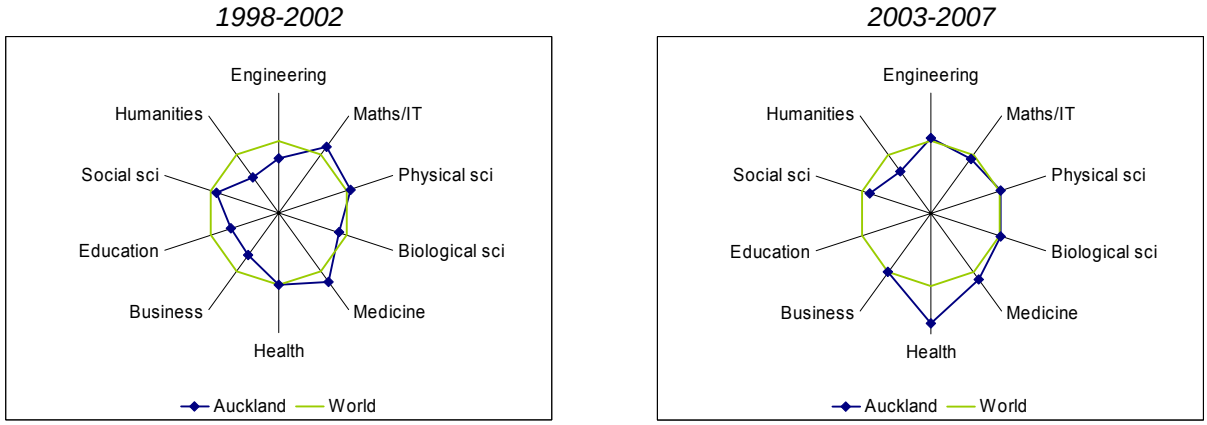
- In 2003 to 2007, 'Chemistry' had the highest relative academic impact (2.13) followed by 'Neurology' (1.75) and 'Pediatrics' (1.66).

Figure 22: Share of world publications and citations and relative academic impact – University of Auckland



Source: Thomson Reuters

Figure 23: Relative academic impact by broad subject area – University of Auckland



Source: Ministry of Education and Thomson Reuters

Table 4: Relative academic impact by narrow subject area – University of Auckland

Narrow subject area	2003-2007	1998-2002	Narrow subject area	2003-2007	1998-2002
Chemistry	2.13	1.34	Endocrinol, Metab & Nutrit	0.69	1.25
Neurology	1.75		Elect & Electronic Engn	0.69	1.01
Pediatrics	1.66	2.02	Computer Sci & Engineering	0.69	0.84
General & Internal Medicine	1.52	1.18	Resrch/Lab Med & Med Techn	0.51	
Cardiovasc & Respirat Syst	1.50	1.87			
Medical Res, General Topics	1.45	1.39			
Optics & Acoustics	1.40	1.02			
Experimental Biology	1.39				
Ortho, Rehab & Sports Med	1.37				
Cardiovasc & Hematology Res	1.37	0.91			
Biology	1.37				
Physics	1.33	1.65			
Mechanical Engineering	1.31	1.07			
Environment/Ecology	1.30	1.18			
Microbiology	1.28				
Medical Res, Organs & Syst	1.24	1.03			
Reproductive Medicine	1.24	1.30			
Animal Sciences	1.23	1.19			
Pharmacology & Toxicology	1.22	0.92			
Plant Sciences	1.17	1.22			
Chemical Engineering	1.16				
Economics	1.16	0.53			
Aquatic Sciences	1.11	0.90			
Biochemistry & Biophysics	1.06	0.76			
Food Science/Nutrition	1.06				
Mathematics	1.03	1.11			
Public Hlth & Hlth Care Sci	1.02	1.07			
Ophthalmology	1.01				
Neurosciences & Behavior	1.00	0.94			
Multidisciplinary	1.00	0.87			
Civil Engineering	0.99	0.92			
Environ Studies, Geog & Dev	0.98				
Appl Phys/Cond Matt/Mat Sci	0.96	0.91			
Engineering Mgmt/General	0.95				
Endocrinol, Nutrit & Metab	0.94	1.24			
Medical Res, Diag & Treatmt	0.94	1.46			
Oncogenesis & Cancer Res	0.93	1.10			
Molecular Biology & Genetics	0.93	0.81			
Earth Sciences	0.92	0.72			
Psychiatry	0.92	0.63			
Clin Psychology & Psychiatry	0.87	0.63			
Physiology	0.85	1.01			
Materials Sci and Engn	0.81	0.87			
Surgery	0.79				
Environmt Med & Public Hlth	0.78	1.13			
Physical Chem/Chemical Phys	0.76	0.91			
Chemistry & Analysis	0.76	1.04			
Psychology	0.74	0.84			
Organic Chem/Polymer Sci	0.71	0.80			
Management	0.71				
Cell & Developmental Biol	0.71				

Source: Thomson Reuters

4.3.5 University of Canterbury

Share of world indexed publications and citations

- In 2003 to 2007, the share of world indexed publications authored by University of Canterbury staff fell slightly to 0.056 percent from 0.057 percent in 2002 to 2006. However, it remains well above the average share of 0.048 percent of world indexed publications exhibited during the late 1990s.

- Between 1998 to 2002 and 2003 to 2007, the share of world citations by the University of Canterbury increased from 0.031 percent to 0.042 percent.

- As a result of the strong increase in share of world citations, the overall relative academic impact of research at the University of Canterbury increased from 0.60 in 1998 to 2002 to 0.76 in 2003 to 2007.

Relative academic impact – broad subject panel

- In 2003 to 2007, the highest relative academic impact was in 'Mathematics and information technology' (1.54) followed by 'Physical sciences' (1.14). Three of the seven panels had a relative academic impact greater than the world average.

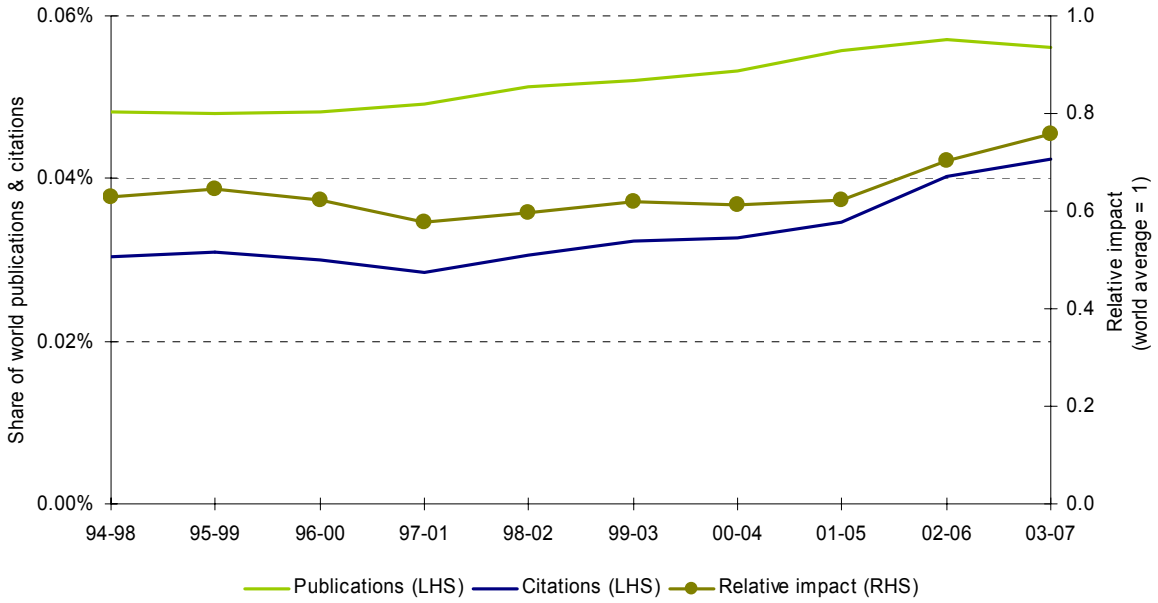
- The relative academic impact of research increased in six of the seven broad subject panels at the University of Canterbury between 1998 to 2002 and 2003 to 2007.

Relative academic impact – narrow subject area

- In 2003 to 2007, 32 percent of narrow subject areas at the University of Canterbury had a relative impact above the world average. This compares with 38 percent in 1998 to 2002.

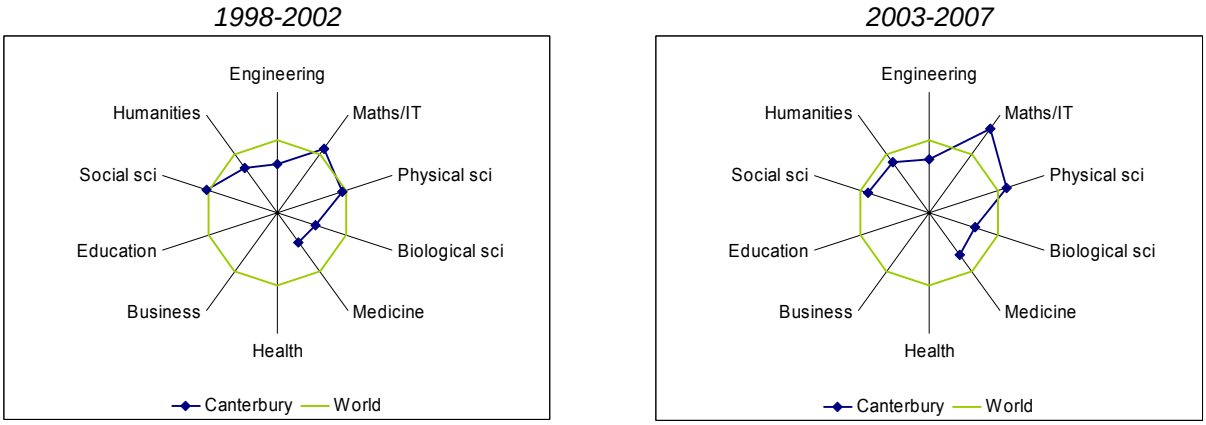
- In 2003 to 2007, the highest relative impact was in the narrow subject areas of 'Chemistry' (1.84) and 'Environment/ecology' (1.35).

Figure 24: Share of world publications and citations and relative academic impact – University of Canterbury



Source: Thomson Reuters

Figure 25: Relative academic impact by broad subject area – University of Canterbury



Source: Ministry of Education and Thomson Reuters

Table 5: Relative academic impact by narrow subject area – University of Canterbury

Narrow subject area	2003-2007	1998-2002
Chemistry	1.84	0.61
Environment/Ecology	1.35	1.13
Space Science	1.23	1.26
Organic Chem/Polymer Sci	1.19	1.64
Physical Chem/Chemical Phys	1.12	0.70
Animal Sciences	1.03	1.05
Appl Phys/Cond Matt/Mat Sci	0.92	0.64
Mathematics	0.88	1.10
Aquatic Sciences	0.83	0.75
Plant Sciences	0.80	0.49
Psychology	0.78	0.98
Earth Sciences	0.78	0.83
Physics	0.72	
Biology	0.70	
Civil Engineering	0.70	0.90
Elect & Electronic Engn	0.65	0.37
Chemistry & Analysis	0.65	0.67
Multidisciplinary	0.58	
Neurosciences & Behavior	0.46	

Source: Thomson Reuters

4.3.6 University of Otago

Share of world indexed publications and citations

- The share of world indexed publications by the University of Otago fell slightly from 0.126 percent in 1998 to 2002 to 0.122 percent in 2003 to 2007.

- However, the share of world citations increased from 0.131 percent in 2001 to 2005 to 0.139 percent in 2003 to 2007.

- As a result of these trends the overall relative academic impact at the University of Otago has increased from 1.06 in 2001 to 2005 to 1.14 in 2003 to 2007.

Relative academic impact – broad subject panel

- In 2003 to 2007, six of the nine broad subject panels had a relative academic impact above the world average.

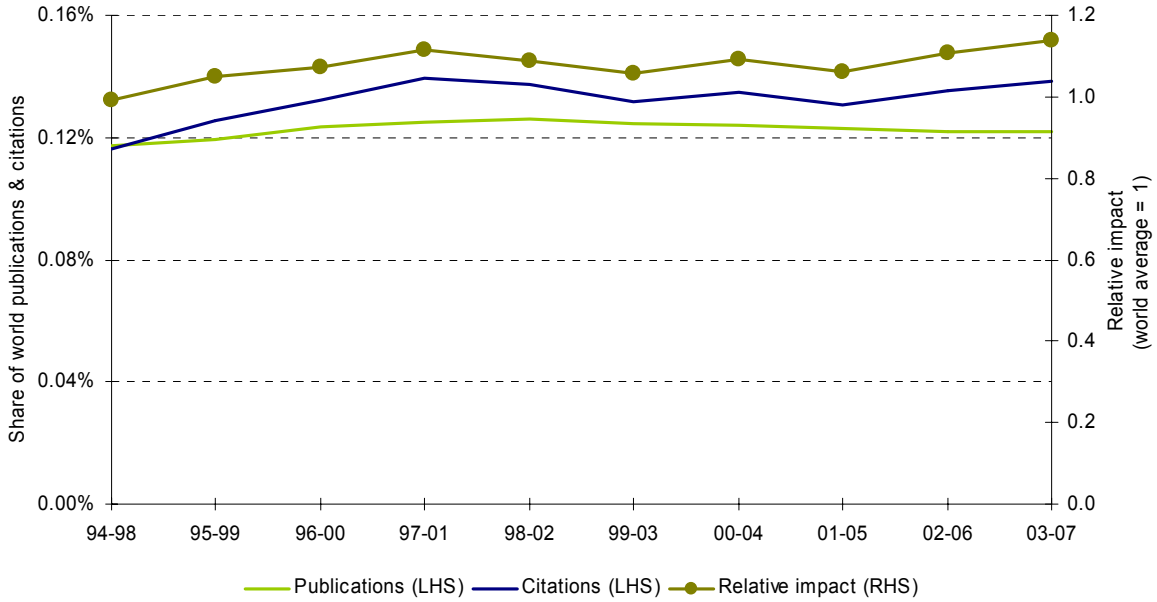
- In 2003 to 2007 the broad subject panel with the highest relative academic impact was 'Engineering' (1.52) followed by 'Health' (1.35).

Relative academic impact – narrow subject area

- In 2003 to 2007, 53 percent of narrow subject areas had a relative academic impact above the world average, compared with 51 percent in 1998 to 2002.

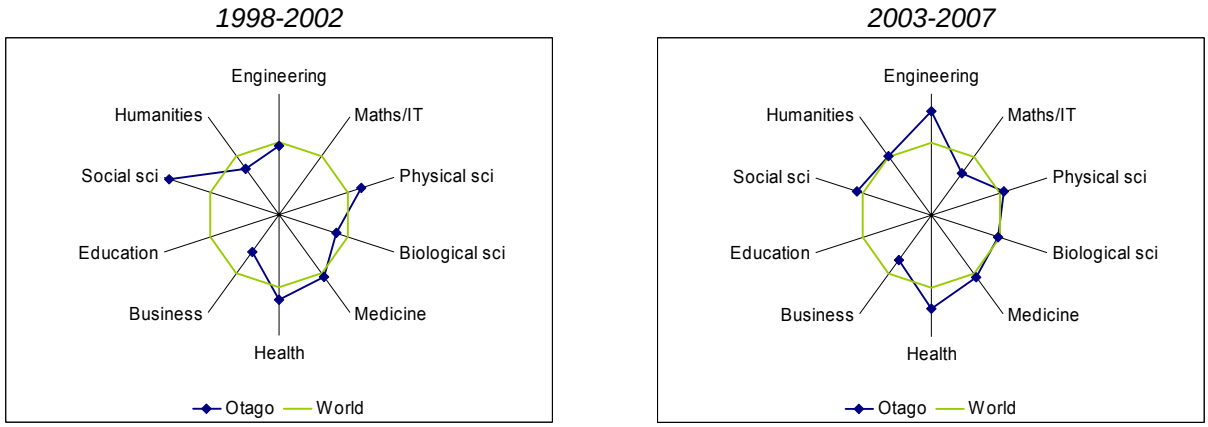
- The narrow subject area with the highest relative academic impact was 'Inorganic and nuclear chemistry' (1.78) followed by 'Cardiovascular and respiratory systems' (1.70).

Figure 26: Share of world publications and citations and relative academic impact – University of Otago



Source: Thomson Reuters

Figure 27: Relative academic impact by broad subject area – University of Otago



Source: Ministry of Education and Thomson Reuters

Table 6: Relative academic impact by narrow subject area – University of Otago

Narrow subject area	2003-2007	1998-2002
Inorganic & Nucl Chemistry	1.78	1.35
Cardiovasc & Respirat Syst	1.70	1.74
Urology	1.70	1.04
Experimental Biology	1.47	0.87
Pediatrics	1.46	1.49
Psychiatry	1.46	1.25
Clin Psychology & Psychiatry	1.45	1.20
Animal Sciences	1.33	1.35
Neurosciences & Behavior	1.32	0.78
Oncology	1.29	1.33
Food Science/Nutrition	1.24	1.17
Aquatic Sciences	1.22	1.23
Public Hlth & Hlth Care Sci	1.19	1.24
Medical Res, Organs & Syst	1.18	1.27
Oncogenesis & Cancer Res	1.18	1.72
General & Internal Medicine	1.18	0.65
Ortho, Rehab & Sports Med	1.17	
Physics	1.16	
Earth Sciences	1.14	1.55
Environment/Ecology	1.12	1.21
Psychology	1.09	1.53
Physical Chem/Chemical Phys	1.08	
Biochemistry & Biophysics	1.08	0.90
Medical Res, Diag & Treatmt	1.01	0.86
Health Care Sci & Services	1.00	
Molecular Biology & Genetics	0.97	0.90
Reproductive Medicine	0.97	1.05
Dentistry/Oral Surgery & Med	0.96	0.90
Neurology	0.96	0.45
Surgery	0.92	0.92
Pharmacology/Toxicology	0.92	0.83
Medical Res, General Topics	0.90	0.98
Cardiovasc & Hematology Res	0.90	0.94
Biology	0.88	1.09
Environmt Med & Public Hlth	0.85	1.16
Endocrinol, Nutrit & Metab	0.84	0.92
Clin Immunol & Infect Dis	0.81	
Resrch/Lab Med & Med Techn	0.81	1.29
Plant Sciences	0.79	0.69
Microbiology	0.78	0.85
Endocrinol, Metab & Nutrit	0.76	0.71
Ophthalmology	0.69	
Immunology	0.65	0.85
Chemistry & Analysis	0.63	0.48
Pharmacology & Toxicology	0.62	0.87
Environ Studies, Geog & Dev	0.56	
Multidisciplinary	0.55	0.74

Source: Thomson Reuters

4.3.7 University of Waikato

Share of world indexed publications and citations

- From 1994 to 1998, the share of world indexed publications by University of Waikato authors has ranged between 0.024 and 0.026 percent. In 2003 to 2007, the share of world indexed publications was 0.025 percent.

- The share of world citations by University of Waikato research has increased from 0.014 percent in 2000 to 2004 to 0.021 percent in 2003 to 2007.

- The effect of these trends has seen the overall academic impact of research by the University of Waikato rise from 0.58 in 2000 to 2004 to 0.84 in 2003 to 2007.

Relative academic impact - broad subject panel

- The University of Waikato exhibited an increase in three of five broad subject panels between 1998 to 2002 and 2003 to 2007.

- In 2003 to 2007, the panel with the highest relative academic impact was 'Physical sciences' (1.35) followed by 'Engineering' (1.21).

- In 2003 to 2007, two of the six panels had a relative academic impact above the world average.

Relative academic impact – narrow subject area

- In 2003 to 2007, two out of four of narrow subject areas had a relative academic impact above the world average. This compares with two of five in 1998 to 2002.

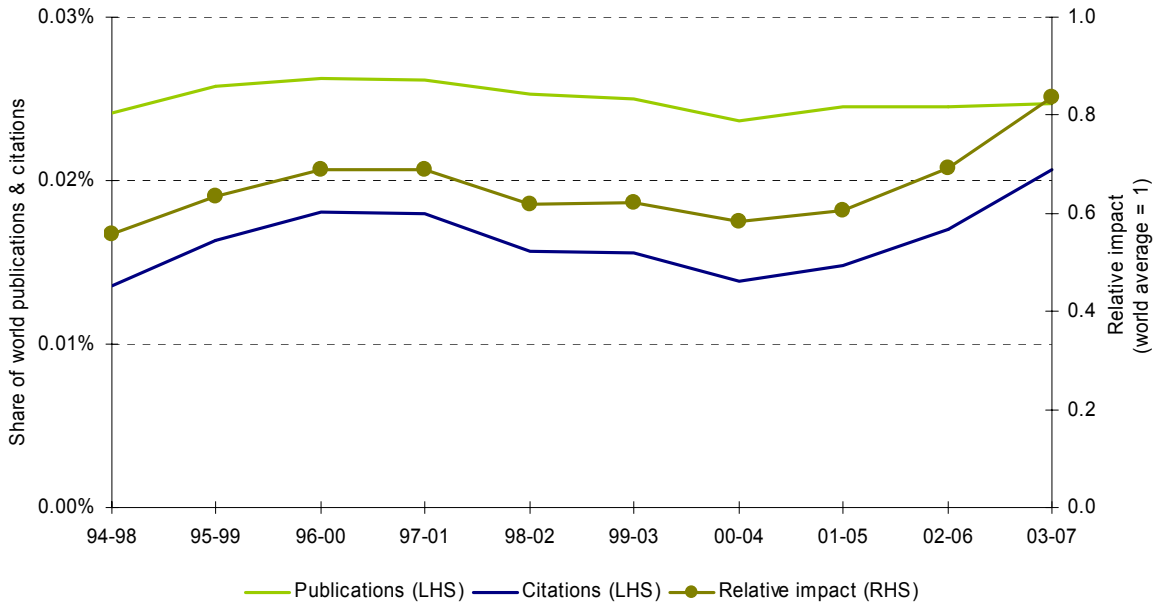
- In 2003 to 2007, the narrow subject area with the highest relative impact was 'Earth sciences' (2.07) followed by 'Aquatic sciences' (1.02).

Table 7: Relative academic impact by narrow subject area – University of Waikato

Narrow subject area	2003-2007	1998-2002
Earth Sciences	2.07	1.09
Aquatic Sciences	1.02	0.58
Environment/Ecology	0.97	0.59
Psychology	0.50	0.31

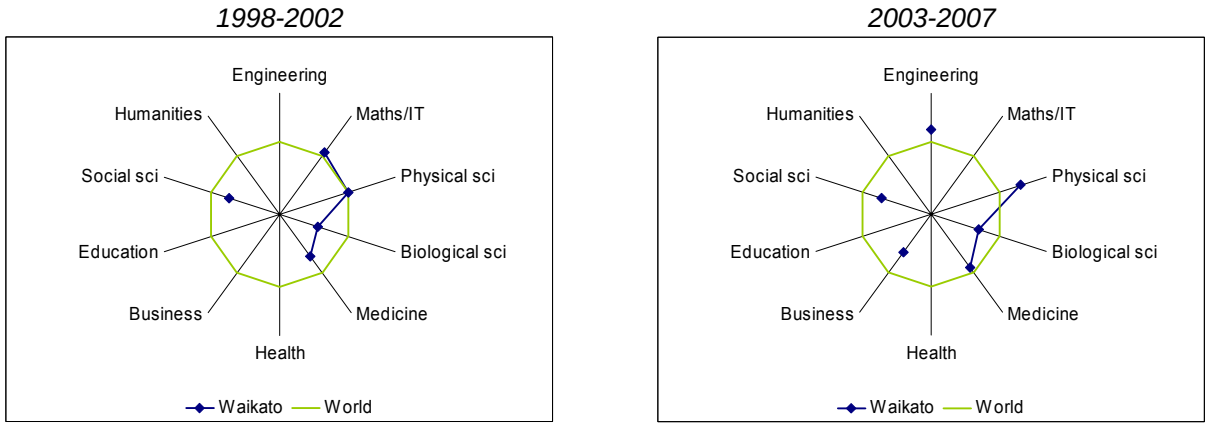
Source: Thomson Reuters

Figure 28: Share of world publications and citations and relative academic impact – University of Waikato



Source: Thomson Reuters

Figure 29: Relative academic impact by broad subject area – University of Waikato



Source: Ministry of Education and Thomson Reuters

4.3.8 Victoria University of Wellington

Share of world indexed publications and citations

- The share of world indexed publications by Victoria University of Wellington (VUW) increased significantly from 0.029 percent in 1998 to 2002 to 0.039 percent in 2003 to 2007.

- The rise in share of world citations was even greater from 0.017 percent in 1998 to 2002 to 0.028 percent in 2003 to 2007.

- As a result of these trends, the overall relative academic impact of research at VUW has increased from 0.58 in 1998 to 2002 to 0.72 in 2003 to 2007.

Relative academic impact – broad subject panel

- Six of the eight broad subject areas increased their relative academic impact between 1998 to 2002 and 2003 to 2007.

- The broad subject panel with the highest relative academic impact in 2003 to 2007 was 'Physical sciences' (1.11).

Relative academic impact – narrow subject area

- In 2003 to 2007, five out of nine narrow subject areas had a relative academic impact above the world average. This compares with two of four in 1998 to 2002.

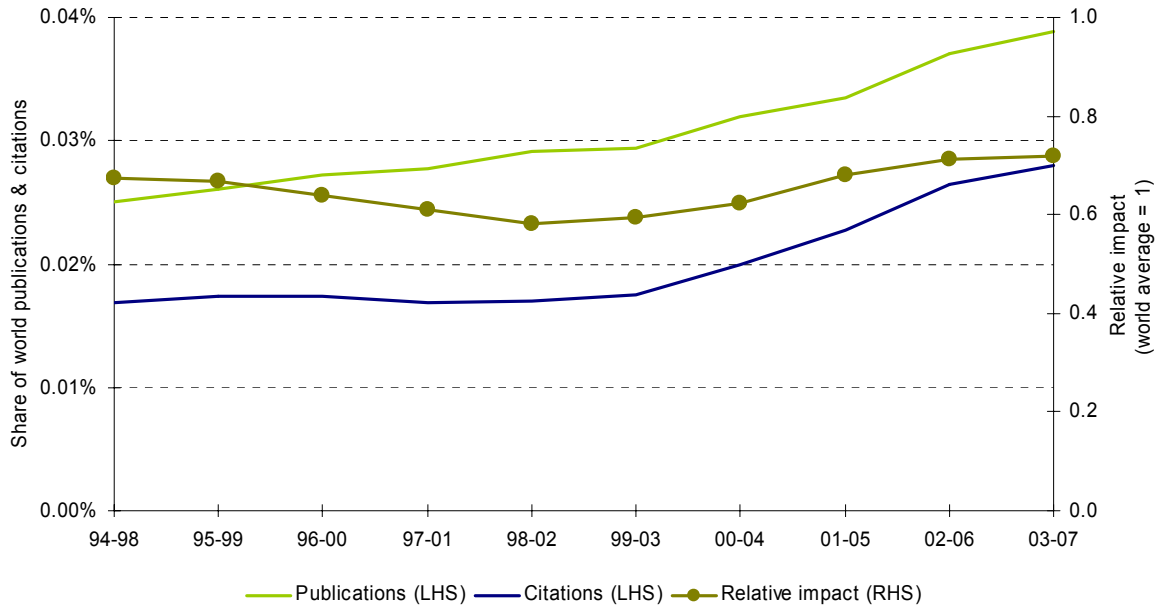
- The narrow subject area with the highest relative academic impact in 2003 to 2007 was 'Physics' (1.49) followed by 'Mathematics' (1.15).

Table 8: Relative academic impact by narrow subject area

Narrow subject area	2003-2007	1998-2002
Physics	1.49	
Mathematics	1.15	0.50
Environment/Ecology	1.14	
Earth Sciences	1.05	1.15
Physical Chem/Chemical Phys	1.00	
Psychology	0.82	0.59
Appl Phys/Cond Matt/Mat Sci	0.81	1.52
Aquatic Sciences	0.60	
Economics	0.59	

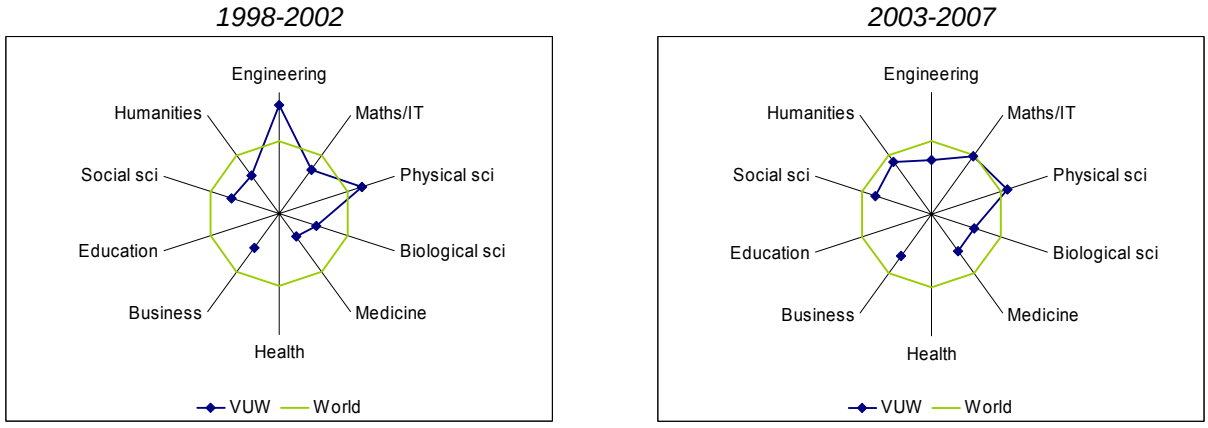
Source: Thomson Reuters

Figure 30: Share of world publications and citations and relative academic impact – Victoria University of Wellington



Source: Thomson Reuters

Figure 31: Relative academic impact by broad subject area – Victoria University of Wellington



Source: Ministry of Education and Thomson Reuters

5 Conclusion

The introduction of the Performance-Based Research Fund (PBRF) has been associated with an encouraging improvement in the bibliometric performance of New Zealand universities as measured by citation in the Thomson Reuters database. Although explicitly linking this rise in performance to the PBRF is difficult, a number of factors point to it being an influence in the change in performance. Firstly, the introduction of the PBRF was the single biggest change in the research environment for universities during the last decade. Secondly, the recent improvement in citation share and relative academic impact is consistent across all of the New Zealand universities suggesting that it is not a unique factor at one or two universities influencing performance. Thirdly, the trends in New Zealand university bibliometric performance were not matched by the G8 and non-G8 Australian universities indicating it was not part of a wider Australasian phenomenon.

Although these initial signs are encouraging, continued monitoring of the bibliometric data over time will be required to show if the positive trends exhibited in this report are sustained over the longer term.

Appendix A: Non-university bibliometric performance[18]

Share of world indexed publications and citations

- The share of world indexed publications by non-university tertiary education institutions (TEIs) has steadily risen from the mid 1990s. In 1994 to 1998, 0.0013 percent of world indexed publications were by non-university TEI authors. By 2003 to 2007 this had increased to 0.0045 percent.

- The share of world citations has also risen for non-university TEIs. In 1994 to 1998, 0.0002 percent of world citations were for non-university TEI publications. This compares with 0.0018 percent in 2003 to 2007.

- The overall relative academic impact of research by non-university TEI authors has risen over time. In 1994 to 1998, the overall relative academic impact was 0.13. Between 1998 to 2002 and 2003 to 2007, the overall relative academic impact has remained around 0.40.

Relative academic impact – broad subject panel

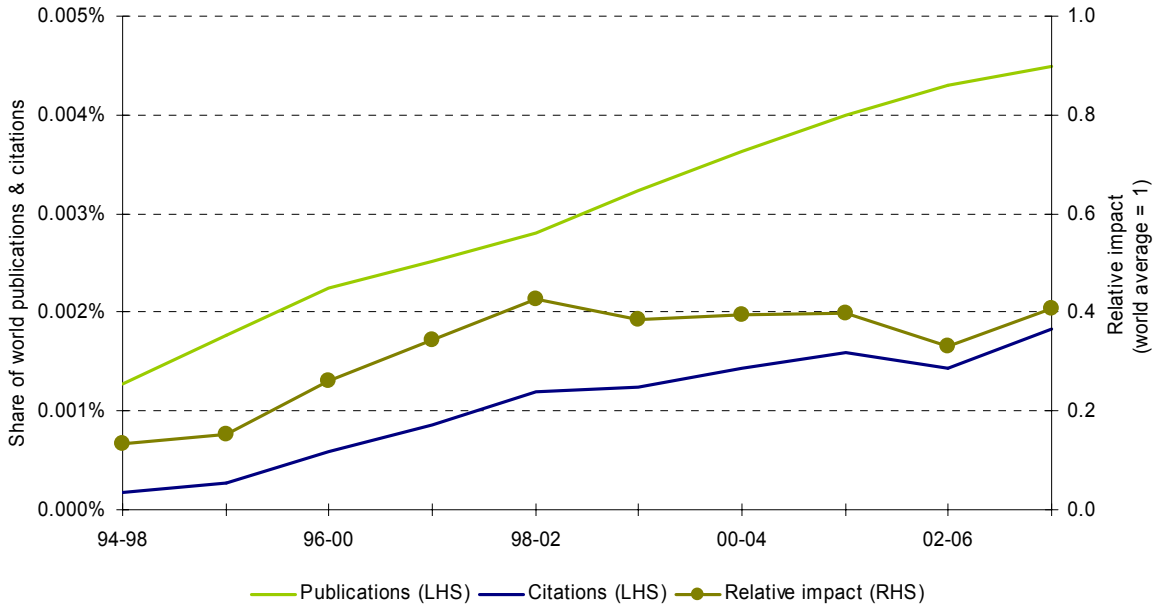
- Just one broad subject panel ('Biological sciences') met the minimum publication threshold in 2003 to 2007. It achieved a relative academic impact of 0.49.

Relative academic impact – narrow subject area

- No narrow subject areas reached the 50 publication threshold for inclusion in this analysis.

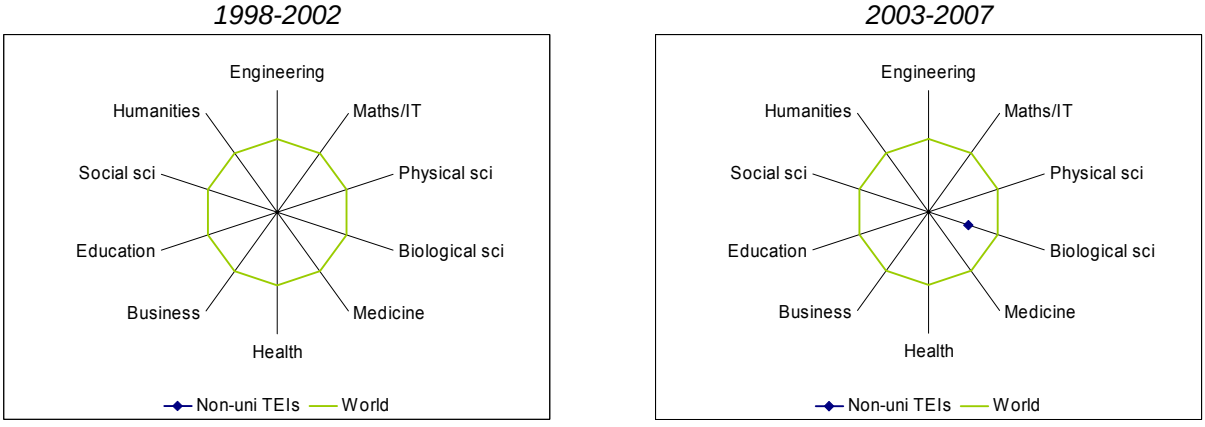
[18] The non-university tertiary education institutions with publications recorded in the Thomson Reuters database were: Unitec New Zealand, Waikato Institute of Technology, Bay of Plenty Polytechnic, Eastern Institute of Technology, Manakau Institute of Technology, Nelson Marlborough Institute of Technology, Northtec, The Open Polytechnic, Otago Polytechnic, Southern Institute of Technology, Te Wānanga o Aotearoa, Universal College of Learning, Waiariki Institute of Technology, Wellington Institute of Technology, Western Institute of Technology Taranaki, and Whitirea Community Polytechnic.

Figure 32: Share of world publications and citations and relative academic impact – non-university tertiary education institutions



Source: Thomson Reuters

Figure 33: Relative academic impact by broad subject area – Non-university tertiary education institutions



Source: Ministry of Education and Thomson Reuters

Appendix B: Mapping of PBRF panels to Thomson Reuters subject areas

PBRF subject panels	Thomson Scientific subject fields
Biological sciences	Agriculture/agronomy
	Agricultural chemistry
	Animal & plant sciences
	Animal sciences
	Aquatic sciences
	Biochemistry & biophysics
	Biology
	Biotechnology & applied microbiology
	Cell & developmental biology
	Endocrinology, nutrition & metabolism
	Entomology/pest control
	Environment/ecology
	Experimental biology
	Food science/nutrition
	Immunology
	Microbiology
	Molecular biology & genetics
	Neurosciences & behaviour
	Physiology
	Plant sciences
Business and economics	Economics
	Management
Education	Education
Engineering, technology and architecture	Aerospace engineering
	AI, robotics & automatic control
	Art & architecture
	Civil engineering
	Electrical & electronics engineering
	Engineering management/general
	Engineering mathematics
	Environmental engineering & energy
	Instrumentation & measurement
	Mechanical engineering
	Nuclear engineering
Health	Dentistry/oral surgery & medicine
	Orthopaedics, rehabilitation & sports medicine
	Rehabilitation
	Veterinary medicine/animal health
Humanities and law	Classical studies
	History
	Language & linguistics
	Law
	Literature
	Philosophy
	Religion & theology

PBRF subject panels	Thomson Scientific subject fields
Mathematical and information sciences and technology	Computer science & engineering Information technology & communications systems Library & information sciences Mathematics
Medicine and public health	Anaesthesia & intensive care Cardiovascular & haematology research Cardiovascular & respiratory systems Clinical immunology & infectious disease Clinical psychology & psychiatry Dermatology Endocrinology, metabolism & nutrition Environmental medicine & public health Gastroenterology & hepatology General & internal medicine Health care sciences & services Hematology Medical research, diagnosis & treatment Medical research, general topics Medical research, organs & systems Neurology Oncogenesis & cancer research Oncology Ophthalmology Otolaryngology Paediatrics Pharmacology & toxology Pharmacology/toxicology Psychiatry Public health & health care science Radiology, nuclear medicine & imaging Reproductive medicine Research/laboratory medicine & medical technology Rheumatology Surgery Urology
Physical sciences	Applied physics/condensed matter/materials science Chemical engineering Chemistry Chemistry & analysis Earth sciences Geological, petroleum & mining engineering Inorganic & nuclear chemistry Materials science & engineering Metallurgy Optics & acoustics Organic chemistry/polymer science Physical chemistry/chemical physics Physics Space science Spectroscopy/instrumentation/analytical sciences

PBRF subject panels	Thomson Scientific subject fields
Social sciences and other cultural/social studies	Anthropology Archaeology Communication Environmental studies, geography & development Political science & public administration Psychology Social work & social policy Sociology & social sciences

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