

MINISTRY OF  
RESEARCH  
SCIENCE +  
TECHNOLOGY



# **National Bibliometric Report**

**2001 to 2004**

**International Benchmarking of New  
Zealand Research**

## Executive Summary

This report is an analysis of the Thomson-ISI National Citation Report database, 2001-2004<sup>1</sup>.

### Papers

The number of New Zealand-authored research publications indexed from 2001-2003 was 16,678, on average 5560 per year. This rate has not significantly changed since 1997.

### Scientific Productivity

In 2003, New Zealand ranked 11<sup>th</sup> out of 22 countries in terms of scientific productivity per capita, close to Belgium and Canada. Amongst countries for which comparable data was available, New Zealand ranked highest for number of publications per million dollars spent on basic Research and Development (R&D), and second highest for publications per million dollars gross expenditure on R&D.

### Subjects

Medical Science had the highest publication output - 7,340 publications (2001-2004), about a third of total output. The Biological Sciences were next, publishing 4,007 papers. Compared to world averages, New Zealand publishes proportionately more papers in the following subjects; Plant and Animal Science; Agricultural Science; Ecology/Environment; Geosciences; Social Science; Psychology/Psychiatry; Pharmacology; Economics & Business and Education.

### Citations as a measure of impact

The average number of citations for New Zealand science and social science articles and reviews published in 2001, was 5.6 citations per paper over the four year period 2001-2004. The comparable world average is 6.8 citations per paper. New Zealand ranks 20<sup>th</sup> out of 22 countries, just behind Japan, Hungary and Spain. Major subjects with a relative citation impact above the world mean were Ecology/Environmental, Pharmacology and Physics.

### Sectors

Between 2000 and 2003, all sectors except the government sector increased their publication output. The tertiary sector produced 63 percent of all New Zealand papers. The private sector showed a marked increase in papers published from 1997 to 2003 and had high citation rates. Inter-sector collaboration increased from three to 14 percent between 1997 and 2003.

### Collaboration

On average, 79 percent of papers published from 2001-2004 had more than one author. Co-authored papers increased from 73 percent in 1997 to 82 percent in 2004. In 2001, co-authored papers received on average 5.3 citations per paper compared with 1.6 citations for single authored papers.

Internationally co-authored<sup>2</sup> papers had the highest impact, averaging 6.4 citations per 2001 paper. Between 2001 and 2003 the increase in internationally co-authored papers was from 37 percent in 2001 to 43 percent in 2003.

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<sup>1</sup> Due to indexing time lags 2004 data is incomplete and only used in some analyses.

<sup>2</sup> In this publication 'co-authored' should be taken to mean 'has two or more co-authors'.

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## 1. Introduction

In order to obtain an overview of the strengths and focus of New Zealand's research community, ongoing evaluation of the knowledge base must be performed.

Bibliometrics is the quantitative study of research publications<sup>3</sup>. It can be used (along with measures of patent and innovation activity) to:

- gain an overview of a country's research output;
- understand the subject distribution of a country's research effort;
- estimate the impact of a country's publications by counting the number of times they are cited by other authors; and
- examine collaborative activity both within a country and internationally.

A particular strength of the bibliometric approach is that it is possible to benchmark results against international findings. Recent bibliometric studies of New Zealand research include:

- **A bibliometric profile of the New Zealand science system, 2001** by Liu.  
The focus of this study was New Zealand-authored publications for the years 1986 and 1996, examining how New Zealand's research output had changed in the ten year period.
- **National Bibliometric Report 1997– 2001** commissioned jointly by the Ministry of Research Science and Technology (MoRST), the Foundation for Research Science and Technology (FRST), the Health Research Council (HRC) and the Royal Society of New Zealand (RSNZ).  
This report analysed research publications with at least one New Zealand author for the 5 year period 1997–2001.

### 1.1 Objectives of the study

This third New Zealand report analyses papers published from 2001–2004, and the citations to these papers indexed by the Thomson–ISI New Zealand National Citation Report database to April 2005 (early results only for 2004 so not used for all analyses). The Thomson–ISI New Zealand National Citation Report database indexes papers from 8,730 internationally distributed journals in the fields of science, engineering, social science, and arts and humanities.

The objective of this report is to describe the productivity, impact and intensity of collaboration of knowledge production within New Zealand. This is achieved by:

- determining the number of New Zealand papers in various research fields;
- determining the impact of New Zealand research papers through the analysis of citations to them;
- investigating the contribution of different sectors (tertiary, Crown Research Institutes, government, local government and private sector) to New Zealand's research output and impact;
- investigating patterns of inter–sector and international collaboration;
- examining changes in New Zealand's research output, impact and collaboration over time and
- benchmarking results against international findings, wherever possible.

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<sup>3</sup> In this report, 'publications' and 'papers' are used to refer to the same collection of outputs.

Chapter two presents the analysis of the number of papers in different fields of study, whilst chapter three deals with the number of citations to those papers. Chapter four shows how the different sectors performed and chapter five discusses intra and inter-sector collaborations.

This report has tried to be consistent with previous studies and overseas definitions. This is to enable valid comparisons over time and with other countries. In only a few instances, which are clearly marked, have such comparisons not been possible.

## 1.2 Methodology

The main analysis methodology for the first three objective points above is to:

- count the number of papers published in a certain 'period' of time, and to
- count the number of citations to each paper for a certain 'window' of time.

Although they may sometimes refer to the same years, the publication 'period' and the citation 'window' are NOT the same thing. For analyses pertaining to the count of papers, the publication periods vary according to what is most appropriate. Generally 2001–2003 is used as full data was obtained for these years. At other times 2001–2004 is used, as early (incomplete) data was also obtained for 2004. Occasionally a single year is used, e.g. 2003.

For the citation analyses, the publication 'period' is usually 2001 with a citation 'window' of 2001–2004, although sometimes other combinations of years are used.

The basic counting exercise to produce the results is simplistic in itself. However care must be taken when comparing results between different studies. Some useful questions to alert the user to statistical traps that can hinder meaningful comparisons are:

- Is the publication 'period' of the same length?
- Is the citation 'window' of the same length?
- Are the databases used in the analyses comparable in their coverage?

As with the previous bibliometric studies, the raw data was obtained from the Thomson–ISI New Zealand National Citation Report database. Thomson–ISI records all papers in which at least one author has a New Zealand address, and for the purposes of this study, for the period 2001 to 2004 (due to indexing time lags 2004 data was not complete). The number of citations made to each paper is shown in the database. Also shown for each paper is the mean number of citations a typical article in that journal historically received.

To conduct international comparisons two extra datasets were obtained from Thomson–ISI<sup>4</sup>. These international datasets counted articles and reviews only and excluded papers in the Arts and Humanities. For the sector and collaboration analyses, all types of publication were included in all subject areas.

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<sup>4</sup> For further details see Appendix A.9



### **1.2.1 Double-counting**

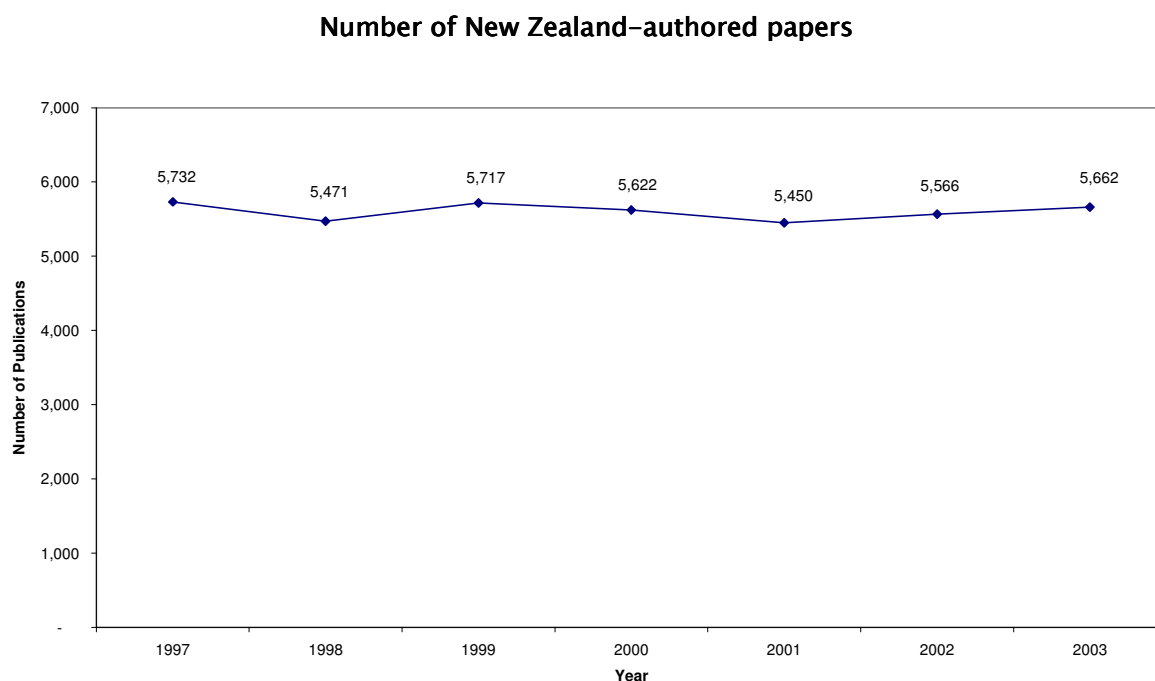
Care must be taken in comparing totals when papers are split by sector or subject.

A paper may belong to more than one sector due to collaboration between authors from different sectors, and can therefore be counted in each sector. Similarly, each paper can be indexed to multiple subject areas by Thomson-ISI (to a maximum of three subjects). Consequently, when papers are tabulated by subject or by sector, there will be double-counting of papers in the subject totals. In the presentation of results in this report the share for each subject or sector is taken of the total of subjects/sectors allocated, rather than total papers.

## 2. Papers Published

For the years 2001–2003 a total of 16,678 papers by New Zealand authors (including the fields of Science, Social Science and Humanities) were indexed in the Thomson–ISI database, compared with 16,561 papers for the period 1997–1999. This represents an increase of 0.7 percent in four years which is not a statistically significant increase. Similarly, if the total papers for 2000 (5622) are compared with the total papers for 2003 (5662) there is not a significant change.

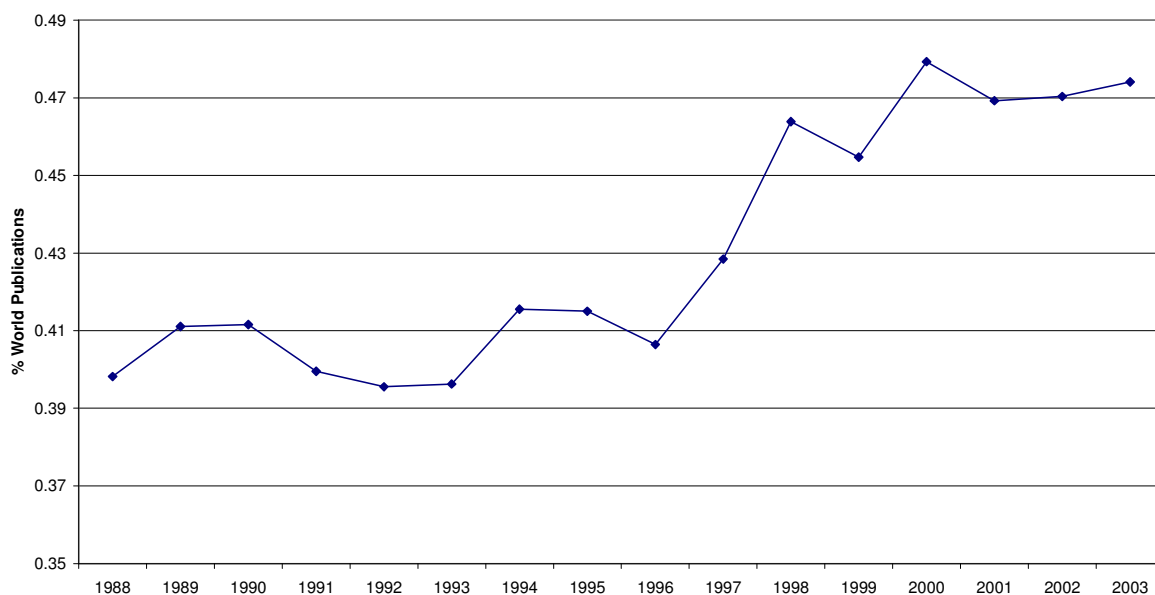
A comparison of the 1997 total (5732<sup>5</sup>) with 2003 (5662) shows no statistical difference (Figure 1). The four percent per annum growth from 1993, noted in the previous bibliometric report, has not been sustained. That growth was probably due to the inclusion of Royal Society of New Zealand journals in the Thomson–ISI database since 1994, and other increases in the database coverage.



**Figure 1.** The number of New Zealand–authored papers has remained static in the last six years. [Appendix A.9, data source 1]

<sup>5</sup> This figure differs from that given in the *National Bibliometric Report 1997 to 2001* as in that report data was sourced from Thomson–ISI Web of Science and is not directly comparable to data used here [Appendix A.9, data source 1].

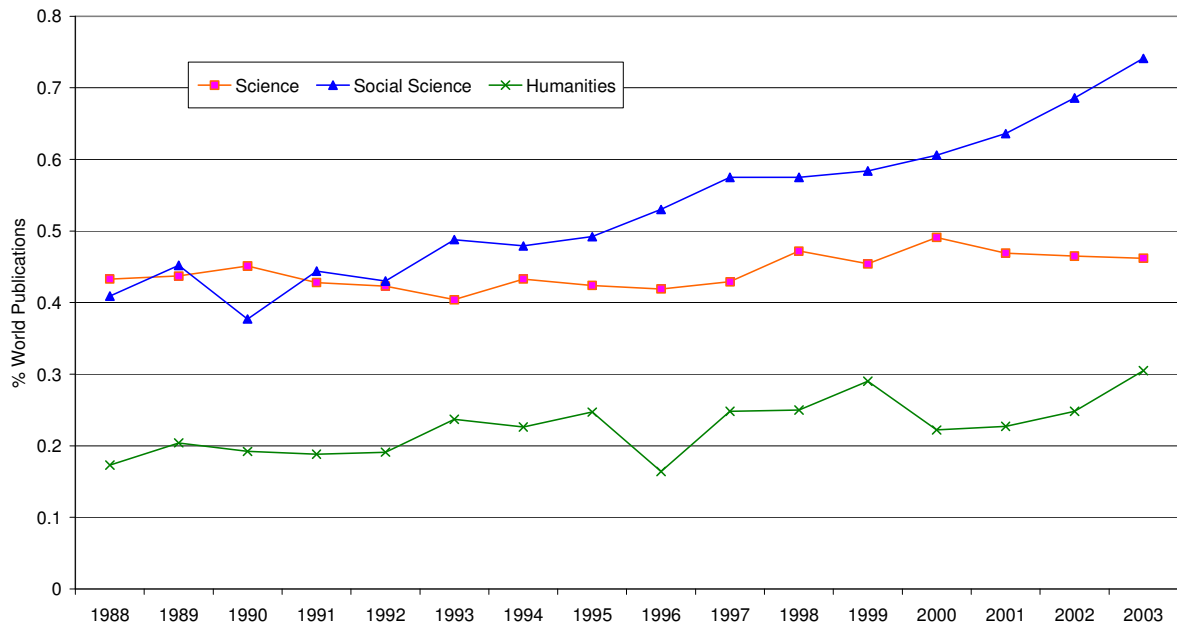
### NZ Share of World Papers (total)



**Figure 2** New Zealand papers as a percentage of world papers. Data includes papers in Science, Humanities and Social Sciences.  
[Appendix A.9, data source 4]

New Zealand has maintained an increase in its share of world papers from just below 0.41 percent before 1998 to about 0.47 percent since 2000 (Figure 2), largely due to an increase in the journal coverage affecting New Zealand.

### NZ Share of World Papers (by subject)

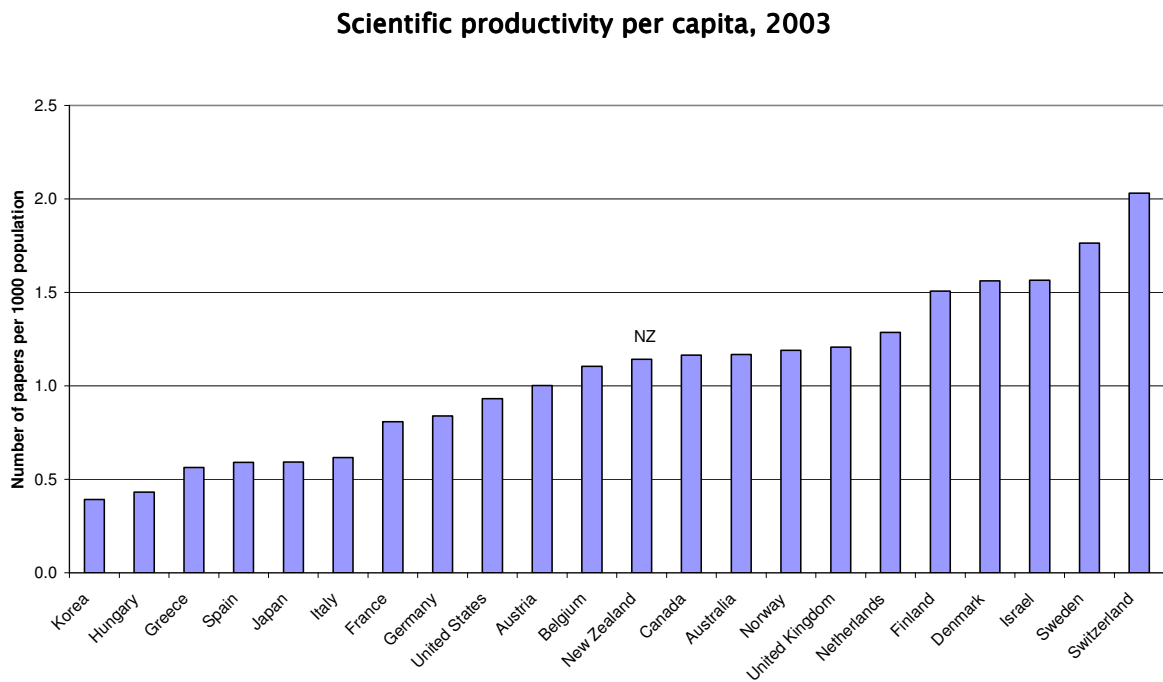


**Figure 3.** The New Zealand share of World Papers by subject.  
[Appendix A.9 , data source 4]

The ratio of New Zealand science papers to world science papers has remained stable at about 0.45 percent (Figure 3). Social science papers increased their share of world papers, reaching 0.75 percent in 2003. The Humanities also show a steady rate of increase as a share of world papers.

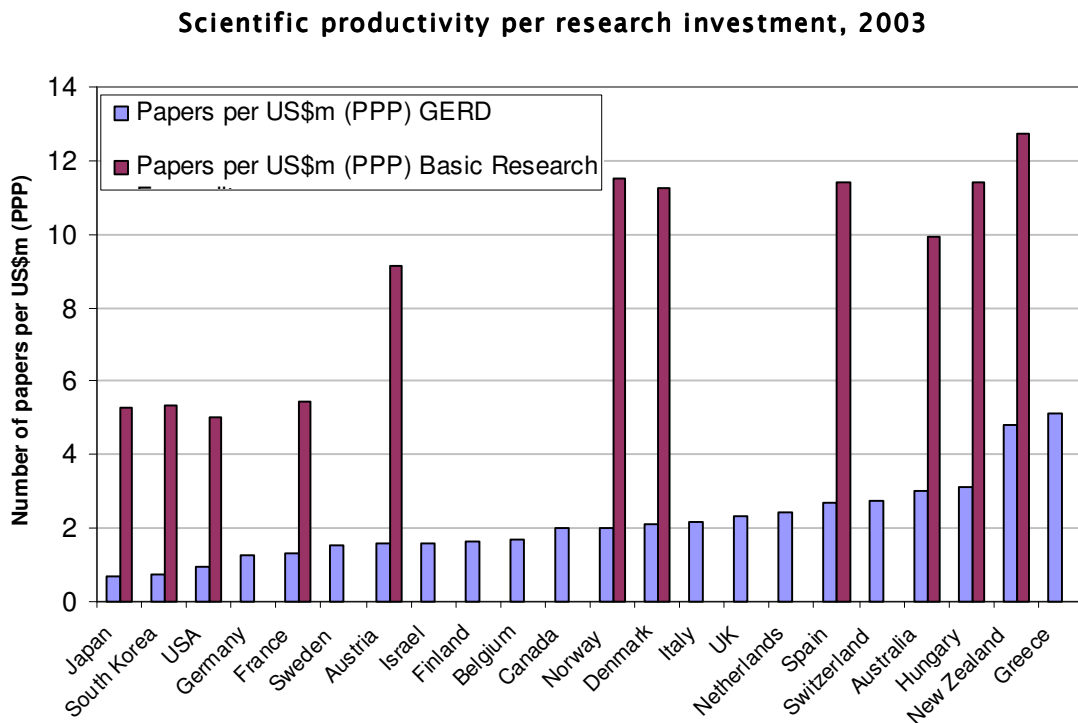
## 2.1 Scientific productivity

In 2003 New Zealand published 1.14 scientific papers per 1000 population (Figure 4), ranking 11<sup>th</sup> out of 22 countries, alongside Belgium and Canada. This figure has not changed significantly since 2001. Similarly, New Zealand's ranking relative to other countries has not changed markedly since 2001.



**Figure 4.** New Zealand papers per 1000 population compared to other countries, 2003.  
[Appendix A.9, data source 1, OECD MSTI 2005/2]

Scientific productivity can also be measured by number of papers per research dollar investment. Figure 5 compares New Zealand to 21 other OECD countries for which data is available. Two measures are shown, number of papers per million US dollar (corrected for Purchasing Power Parity or PPP) Gross Expenditure on R&D (GERD) and basic research expenditure. As papers are primarily outputs from basic research, the latter measure is more appropriate, but figures are available for fewer countries. In both analyses New Zealand rates highly, with 4.8 papers per US\$m (PPP) GERD (ranked second highest) and 12.8 papers per US\$m (PPP) basic research expenditure (ranked highest).



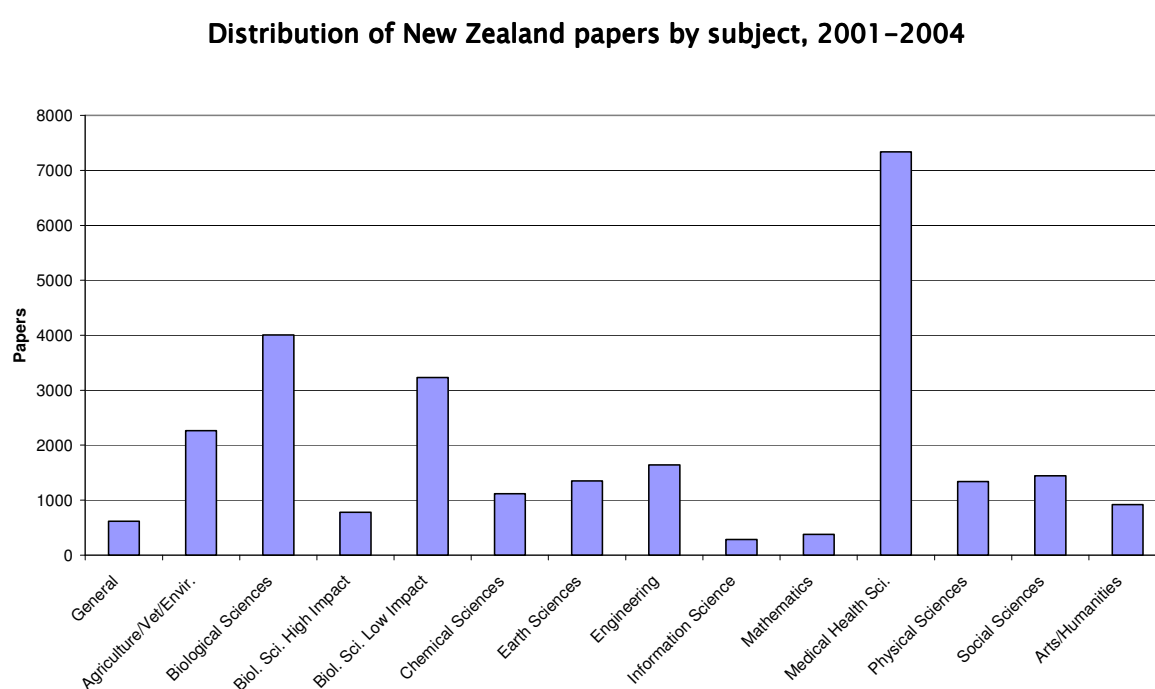
**Figure 5.** New Zealand papers per research dollar GERD and basic research expenditure compared to other countries, 2003.

[Appendix A.9, data source 1, OECD MSTI 2005/2]

## 2.2 Distribution of New Zealand papers by subject

Three analyses were carried out on the distribution of papers by subject. The first analysis (Figure 6) uses the Australian Standard Research Classification (ASRC), as was done in the previous bibliometric report. This allows for a direct comparison between the distribution of papers in 2001–2004 and 1997–2001. Note however that the current analysis uses a four year window, compared to the previous report's five year window.

The subject which produced the most papers was Medical/Health Sciences with 7,340 papers over the four years, followed by Biological Sciences with 4,007 papers. The distribution across subjects is very similar to that shown in the 1997–2001 analysis, except that the Social Sciences' share has increased to more than that of the Physical Sciences.

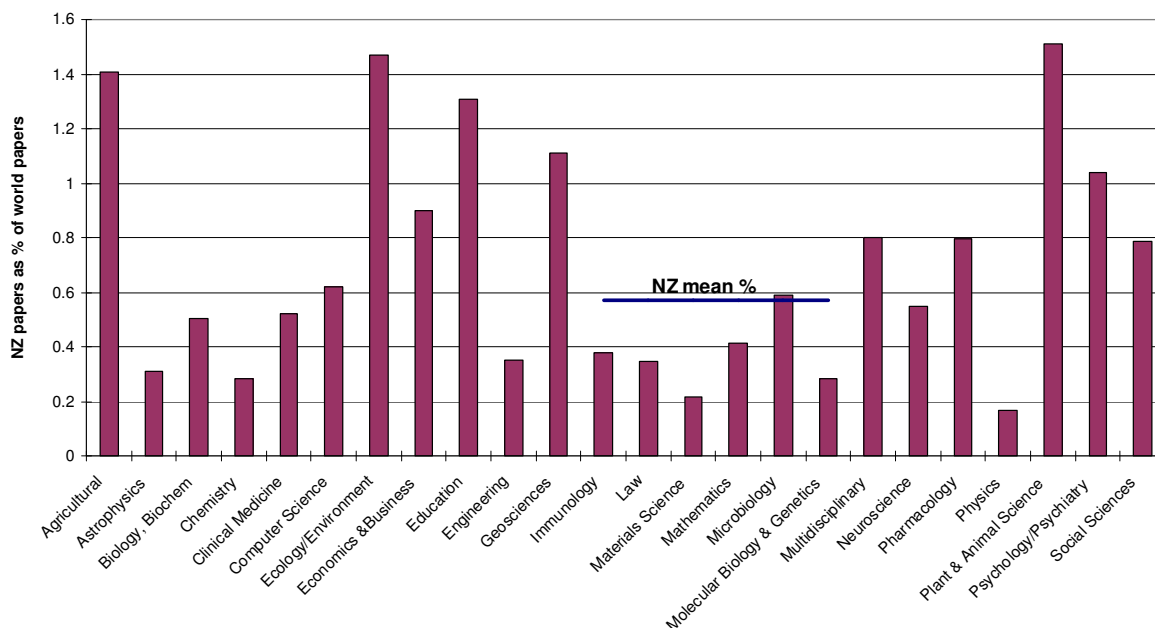


**Figure 6.** Subject distribution of New Zealand–authored research papers 2001–2004 in Australian Standard Research Classification (ASRC) categories, see Appendix A.5. All publication types included. [Appendix A.9, data source 1]

Note:

1. The General category is repeated and included in Arts/Humanities. See Appendices A.5 and A.6.
2. Economics, Education, Law and No Category are not included in Figure 6 as they are not ASRC categories.
3. Biological Sciences is comprised of 'Biological Science High Impact' and 'Biological Science Low Impact'.  
For definitions see Appendix A.5.

**New Zealand papers as a percentage of world papers by subject, 2003**



**Figure 7.** New Zealand papers (articles and reviews only, excludes editorials, notes, and proceedings) as a percentage of world papers in each subject (Thomson-ISI categories), 2003. World 2003 paper numbers by subject taken from National Science Indicators extracted for this bibliometric report by Thomson-ISI on the 20th April 2005. [Appendix A.9, data source 2. New Zealand papers from Appendix A.9, data source 1]

The second analysis (Figure 7) uses the subject categories adopted by Thomson-ISI. This type of analysis was not carried out in the previous bibliometric report. For each subject, the number of New Zealand papers is shown as a percentage of the total of world papers in that subject rather than a straight count of numbers of papers. This analysis was carried out for papers published in 2003 only.

Overall New Zealand produced 0.57 percent of world papers (articles and reviews only, excludes editorials, notes, proceedings) in 2003. The subjects New Zealand was prolific in (above one percent) were:

- Plant and Animal Science;
- Ecology/Environmental Science;
- Agricultural Science;
- Education;
- Geosciences and
- Psychology/Psychiatry.

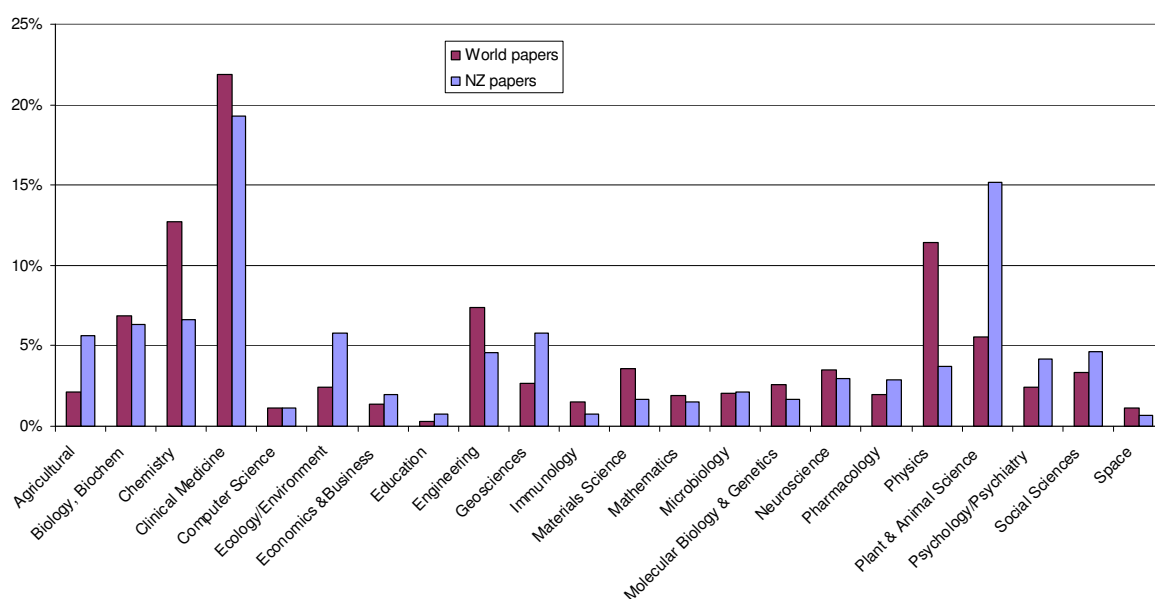
The third analysis (Figure 8) explicitly compares New Zealand’s subject distribution against the world subject distribution for published articles and reviews in 2001 to 2003. It shows that New Zealand has a proportionately larger share than the world average in the following subjects:

- Plant and Animal Science;
- Agricultural Science;



- Environment;
- Geosciences;
- Social Science;
- Psychology/Psychiatry;
- Pharmacology;
- Economics and
- Education.

**New Zealand subject distribution compared to world subject distribution, 2001-2003**



**Figure 8** Number of papers (articles and reviews only) in each subject shown as a percentage share of all New Zealand papers compared to the percentage share of world of papers in each subject, 2001–2003.

When the subjects are aggregated into fields of science, the shares of articles in each science field for New Zealand and the world can be seen below in Table 1. New Zealand publishes a proportionately greater number of agricultural and social science papers and a slightly lower proportion of medical science papers than the world in total.

**Table 1: Percentage of articles and reviews in each field of science, 2001–2003.**

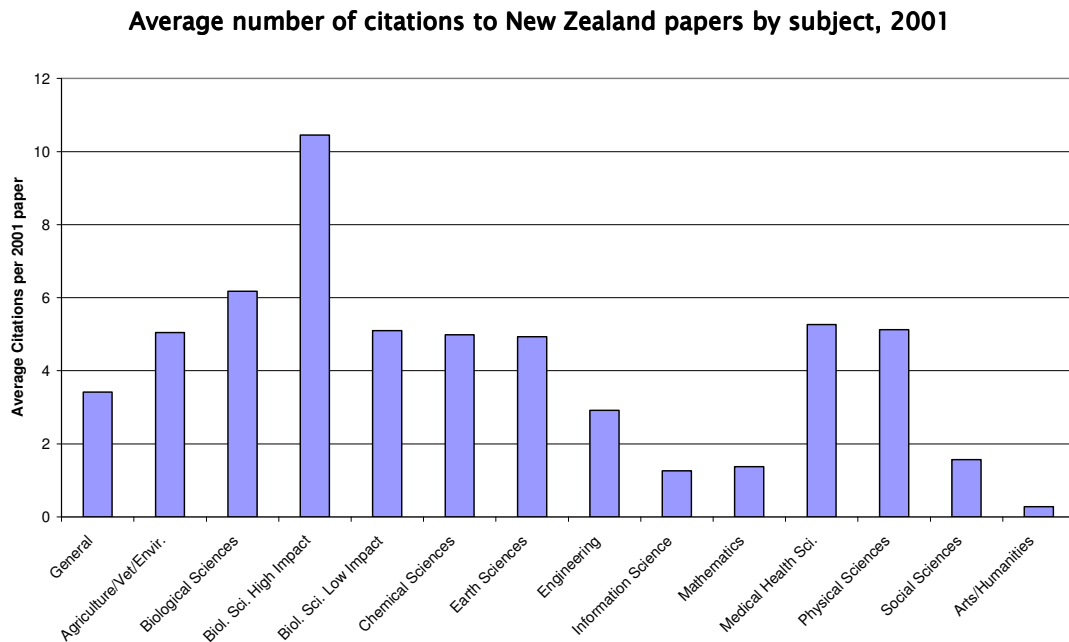
Field of science*	World	New Zealand
Natural Sciences	45.3	45.8
Medical Sciences	35.3	33.3
Engineering and Technology	10.8	6.1
Agricultural Sciences	2.1	5.5
Social Sciences	4.9	7.2

\* See Appendix A.8 for this classification.

### 3. Citation analysis

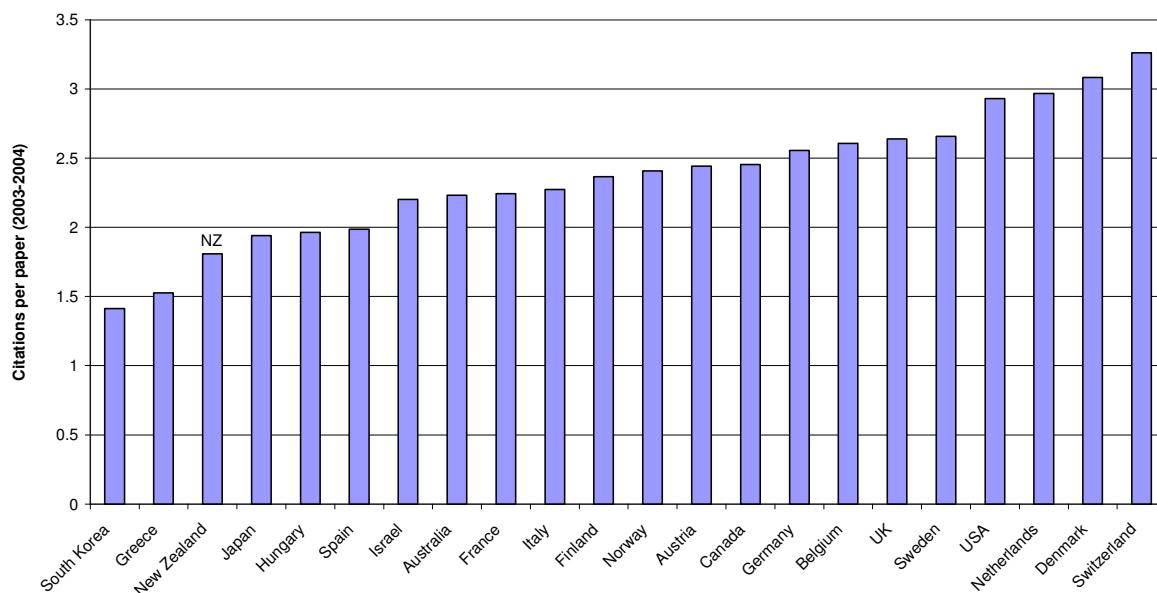
Citation analysis is the most common method of measuring the impact of a particular paper. Thomson–ISI records the number of times each publication is referenced, or cited, in another paper. The greater the number of recorded citations, the more impact that paper has made.

Figure 9 shows the average number of citations per New Zealand paper published in 2001 that were indexed over the period 2001–2004, by subject. The data includes all papers and is classified using the Australian Standard Research Classification (ASRC) method. For comparison purposes with the last bibliometric report it should be noted that the length of both the publication period and citation window vary from the previous analysis.



**Figure 9** Average number of citations to New Zealand–authored papers by subject (ASRC categories) for papers published in 2001 and cited from 2001–2004. [Appendix A.9, data source 1]

### Number of citations per paper by country, 2003



**Figure 10** Citations per paper by country for papers published in 2003 and cited from 2003–2004. [Appendix A.9, data source 3]

Figure 10 shows that for papers published in 2003, New Zealand ranked 20th in citations per paper compared with 22 other developed countries. To be comparable with other countries, only articles and reviews were included in this chart. The citation window is only two years so the citation rates will be lower than in Figure 9.

Judging New Zealand’s overall citation performance is difficult due to some incompatibility with world data across all subjects. This incompatibility stems from the fact that New Zealand produces above average numbers of papers in Agriculture and Social Sciences which traditionally generate fewer citations relative to other subjects. For this reason, relative citation (see below) is a better way of comparing New Zealand to the world. The 2001 world and New Zealand citation rates per paper were 6.8 and 5.6 respectively<sup>6</sup>.

Oksanen et al (2003)<sup>7</sup> shows that in 1998–2002, New Zealand was placed 20th out of 30 OECD countries with a five year window citation rate of 3.57. In comparison, New Zealand’s citation rate for the period 1993–1997 was 3.00, putting it in 18th position. Spain and Ireland moved ahead of New Zealand in 1998–2002. For the same comparison periods the OECD overall citation rate went from 4.03 to 4.57.

<sup>6</sup> Citation window 2001–2004, excludes arts and humanities and counts only articles and reviews. Both world and New Zealand citation rates are calculated from totals across subjects. New Zealand papers counted this way are over-counted by 10 percent. While citations per paper rather than per subject could be calculated for New Zealand data (5.4) it was not available for the world data provided.

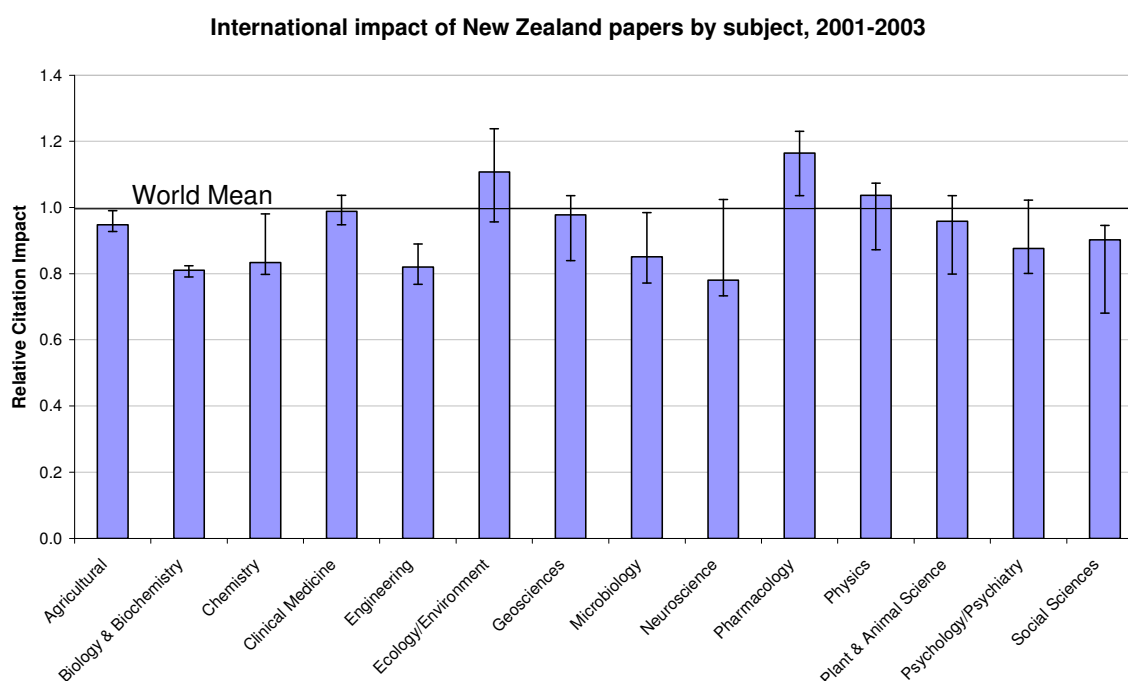
<sup>7</sup> Scientific Research in Finland: A Review of Its Quality and Impact in the Early 2000s  
Editors: Timo Oksanen, Annamajja Lehvo and Anu Nuutinen, 2003

### 3.1 Relative impact of New Zealand papers in each subject

The New Zealand citation rate for each subject can be compared with the world citation rate for the same subject. The ratio of these two rates is called the relative impact of New Zealand papers compared to world papers (articles and reviews only). Figure 11 shows the mean of New Zealand papers' relative impacts for papers that were published in 2001–2003 and cited in the same period. Error bars indicate the variation of relative impacts for each year over the three year period. Only major subjects with 100 or more papers per year are included.

New Zealand papers in Ecology/Environment, Pharmacology and Physics had a relative impact above the world mean. Most other subjects were close to or above the world mean in at least one year.

The Oksanen report shows that New Zealand ranked third in relative citation impact for Humanities, 11th in Social Sciences, 14th in Medical Sciences, 17th in Agricultural Sciences, 20th in Natural Sciences and 22nd in Engineering and Technology papers, out of 30 countries in 1998–2002.



**Figure 11** Relative international impact of New Zealand–authored papers (articles and reviews only) in major subjects (those with 100 or more papers per year) compared to world means, using Thomson–ISI subject fields. Papers published in each year 2001–2003 and cited in the same period. Mean impact shown. Error bars indicate the variation of relative impacts for each year over the three year period.

[Appendix A.8, data sources 1 and 2]

The relative international impact is calculated as:

$$\frac{\# \text{ citations to New Zealand–authored papers} / \text{total} \# \text{ New Zealand–authored papers}}{\# \text{ citations to world total of papers} / \text{total} \# \text{ world papers}}$$

The world mean of this ratio is by definition 1.0.

Figure 11 is not strictly comparable with the equivalent chart in the previous bibliometric report. For this study, world mean citation rates were obtained from Thomson-ISI for each subject (see Appendix A.9, data source 2). This allowed the relative impact to be calculated more accurately than could be done for the 1997-2001 bibliometric report, which used expected citations for each paper to create proxy world subject citation rates.

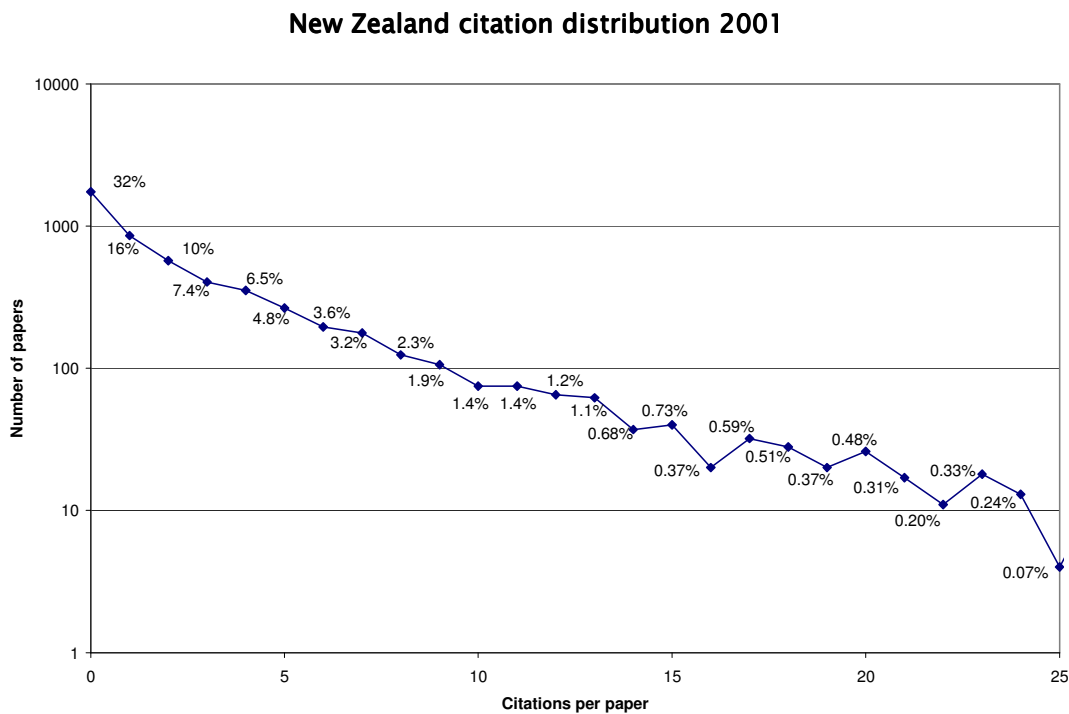
For the purposes of comparison, an equivalent chart relating to the previous bibliometric report is shown in Appendix 10, for the years 2001-2004.

### 3.2 Distribution of number of citations per paper

The distribution of citations per paper is skewed. Most papers receive few citations whilst a small proportion of papers receive a large number of citations.

Looking only at papers indexed for the publication year 2001<sup>8</sup> (Figure 12), it is clear that fewer than 100 papers had more than nine citations each. The chart below shows that 32 percent of papers had no citations, 16 percent had one citation, and 10 percent had two citations.

The distribution pattern in Figure 12 is very similar to the one shown in the previous bibliometric report. This is despite the fact that the Figure 12 data has a four year citation window, compared to the previous five year citation window. The distribution in the previous report was for 1997 papers cited between 1997–2001.



**Figure 12.** The number of New Zealand–authored papers with associated numbers of citations (for all articles and reviews published in 2001 and cited from 2001–2004).

<sup>8</sup> The earliest year in the database and so the year for which the citations collected by 2004 will be the most complete set.

## 4. Sector analysis

For the purposes of undertaking a comparative analysis of the sectors within the research, science and technology system in New Zealand, all publications have been classified under the following sectors:

- Tertiary education;
- Crown Research Institutes (CRIs);
- Government;
- Local and Regional government and
- Private sector.

The data has been allocated to these sectors manually for publications recorded in the Thomson–ISI National Citation Report database for the years 1986, 1997, 2000, 2001 and 2003. The analysis substantially uses the years 1997 and 2003 with occasional references to 1986, 2000 and 2001 depending on the particular comparison sought.

### The Tertiary Sector

The tertiary sector includes all publications where the author's address is attached to universities, polytechnics, teacher training colleges and private tertiary academic institutions. It corresponds to the University sector in Liu (2001).

### Crown Research Institutes (CRIs)

New Zealand's Crown Research Institutes (CRIs) were established in 1992 as government-owned companies with a focus on servicing the technology and innovation needs within particular sectors of the economy.

### The Government Sector

The government sector includes the Reserve Bank, Treasury and all other government departments. It also includes hospitals and the Museum of New Zealand Te Papa Tongarewa (Appendix A.2 contains a complete listing of government entities).

### The Local Government Sector

The local government sector includes publications attributable to local bodies such as City and Regional Councils, as well as museums and other entities that receive support from these bodies (Appendix A.4 lists local government entities whose publications have appeared in Thomson–ISI). Te Papa Tongarewa has been included within the government sector rather than the local government sector as 70 percent of its funding is received directly from central government.

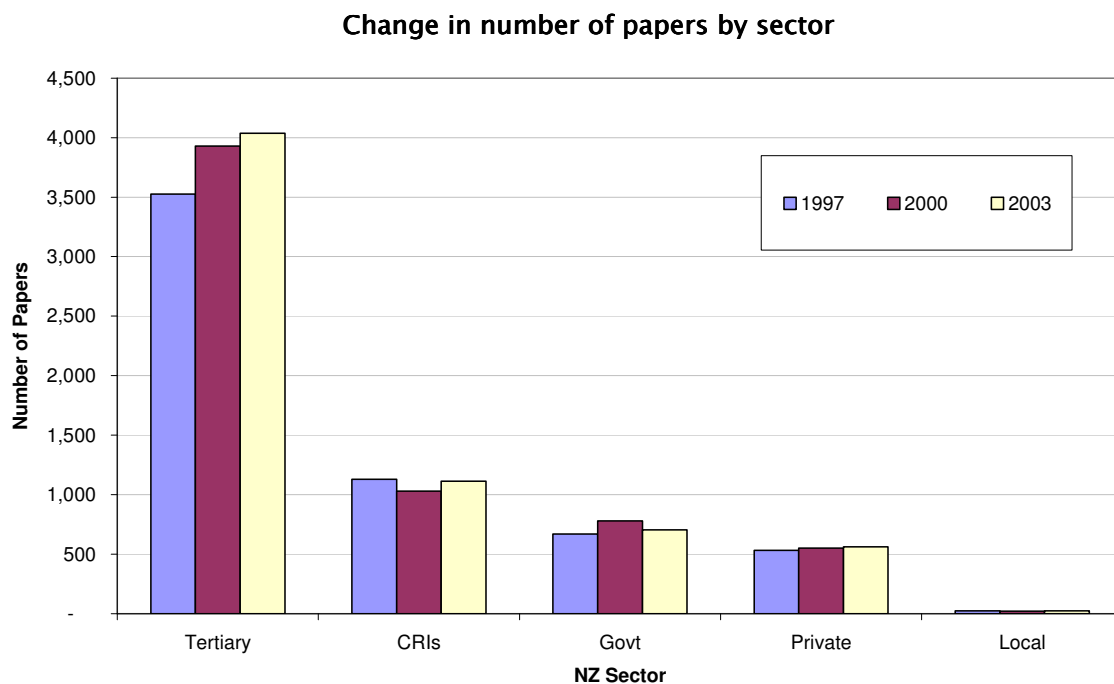
### The Private Sector

The private sector includes publications attributable to non-government organisations, New Zealand registered companies, State Owned Enterprises (SOEs), and individuals who are not affiliated with an organisation. Publications with secondary school addresses were classified either as government or as private sector depending on the status of the school i.e. state funded or privately funded.

## 4.1 Sector Performance

This section compares different sectors' publication outputs and citation rates. Citation rates are a measure of the impact of the papers, but are influenced by the mix of subjects in the sector.

Figure 13 illustrates that the tertiary sector achieved the greatest output in terms of the number of Thomson-ISI indexed papers. They are followed by the CRIs, the government sector, the private sector and the local government sector in that order.



**Figure 13.** Changes in the numbers of papers produced by each sector in 1997, 2000 and 2003.

All sectors, with the exception of the government sector, have increased their publication output between 2000 and 2003. Table 2 shows that, for 2001 papers, the private sector had the highest citation rate per paper (5.1) followed by the CRI sector (5.0) and the government sector (4.3). Variation in citation rates between sectors reflects the different mix of subjects published by each sector, as different subjects have different expected average citation rates.



**Table 2** Citation rates for 1997 and 2001 papers by sector.

	1997 citation rate (five year window)	2001 citation rate (four year window)
<b>Tertiary</b>	6.1	4.1
<b>CRIs</b>	5.9	5.0
<b>Government</b>	5.7	4.3
<b>Private</b>	6.4	5.1
<b>Local</b>	2.2	1.9

Citation rates by sector are lower for 2001 papers than for 1997 papers, as shown in the previous bibliometric report. This is attributable to the fact that the window for citations is only four years in this current study compared to the five years used in the previous bibliometric report. The rates for 2001 may yet increase as more citations are received and indexed.

The private sector rate is high due to a continuing number of highly cited reviews (see section 4.2.5 for further details). Local government sector papers and citation rates are quite small. It is likely that papers published by local government will have local interest only, therefore international citation is unlikely.

## 4.2 Sector Outputs

The following analysis shows the distribution of each sector's publications across fields of research.

Thomson-ISI may assign more than one subject to a paper (to a maximum of three subjects), so that the sum of papers from all fields will add up to more than the total number of papers from that sector. In the sector Tables 3 to 6 the share for each subject is taken of the total of subjects allocated, rather than total papers. A small number of papers have not been allocated to a subject, and do not appear in the subject total but are counted in the paper total.

Note also that papers falling under the category of 'multidisciplinary' are not in fact multidisciplinary papers, but instead they are papers published in multidisciplinary journals such as the **Journal of the Royal Society of New Zealand**. Papers in high profile journals, such as **Nature** and **Science**, are categorised by Thomson-ISI into individual subject fields, but Thomson-ISI does not do this for papers from some of the less well known multidisciplinary journals. The re-classification of papers from the multidisciplinary category was outside the scope of this study.

### 4.2.1 Tertiary Sector

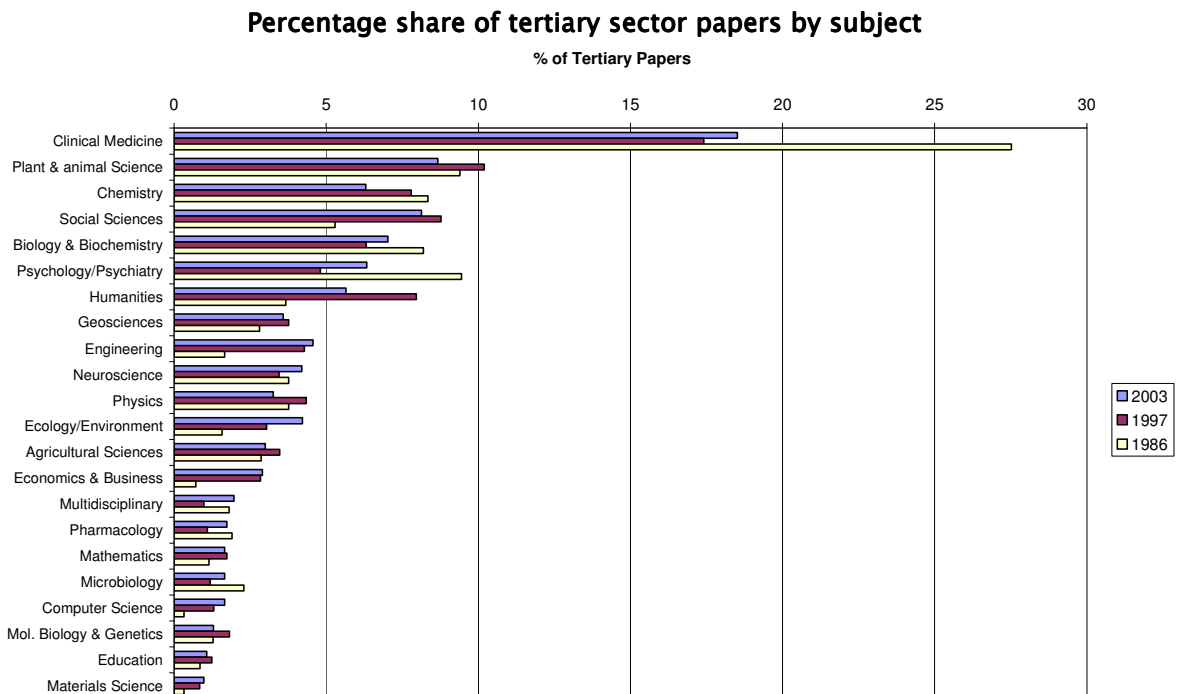
Thomson–ISI indexed 4,036 papers published in the tertiary sector in 2003. This represents 63 percent of New Zealand–authored publications for that year. Figure 14 and Table 3 show the distribution of papers across subject fields for the year 2003 using the years 1986 and 1997 for comparison. Clinical Medicine is the largest subject category, representing 19 percent of all tertiary publications in 2003.

Out of the 24 subject categories, the top five in terms of output were:

- Clinical Medicine;
- Plant and Animal Science;
- Social Science;
- Biology and Biochemistry and
- Psychology/Psychiatry.

The number of papers allocated to each subject area generally increased, as did the total number of papers over the given period. In 1997 1.05 subjects were allocated to each paper. In 2003 this increased to 1.11 subjects per paper. This illustrates that papers are increasingly multi-disciplinary in nature.

While Clinical Medicine and Psychology/Psychiatry papers decreased their share of total tertiary papers, Engineering, Ecology/Environment, Economics and Business, Computer Science and Materials Science papers increased their share.



**Figure 14** Share of tertiary sector papers for each subject area 1986, 1997 and 2003.

**Table 3** Change in the subject distribution of tertiary sector papers over time.

FIELD	1986*		1997		2003	
	Papers	% subjects allocated	Papers	% subjects allocated	Papers	% subjects allocated
Clinical Medicine >	577	27.5	601	17.4	790	18.5
Plant and Animal Science	197	9.4	352	10.2	370	8.7
Social Sciences >	111	8.3	303	7.8	347	8.1
Biology and Biochemistry	172	5.3	218	8.8	300	7.0
Psychology/Psychiatry	198	8.2	166	6.3	270	6.3
Chemistry >	175	9.4	269	4.8	269	6.3
Humanities	77	3.7	275	8.0	241	5.7
Engineering > %	35	2.8	148	3.8	195	4.6
Ecology/Env. > %	33	1.7	105	4.3	180	4.2
Neuroscience >	79	3.8	119	3.4	179	4.2
Geosciences >	59	3.8	130	4.3	153	3.6
Physics	79	1.6	150	3.0	139	3.3
Agricultural Sci. >	60	2.9	120	3.5	128	3.0
Economics and Business > %	15	0.7	98	2.8	124	2.9
Multidisciplinary	38	1.8	34	1.0	84	2.0
Pharmacology	40	1.9	38	1.1	74	1.7
Mathematics >	24	1.1	60	1.7	71	1.7
Microbiology >	48	2.3	41	1.2	71	1.7
Computer Science > %	7	0.3	45	1.3	71	1.7
Mol. Biology and Genetics	27	1.3	63	1.8	55	1.3
Education >	18	0.9	43	1.2	46	1.1
Materials Science > %	7	0.3	29	0.8	42	1.0
Immunology > %	12	0.6	25	0.7	32	0.8
Astrophysics > %	9	0.4	20	0.6	29	0.7
Law			1	0.0	6	0.1
Remainder				0		0
Total Subjects allocated	2097	100	3453	100	4266	100
Papers not allocated to a subject			250		209	
Total Tertiary Papers			3525		4036	

\*Data from Liu (2001)

> indicates a consistent increase in the number of papers.

% indicates a consistent increase in the relative percentage.

Individual cells have been rounded so totals will not be exactly 100 percent.

#### 4.2.2 Crown Research Institutes

In 2003 Thomson-ISI indexed 1,114 publications with authors from the CRI sector. Table 4 shows the distribution of these papers by subject field for the years 1986, 1997 and 2003. Approximately 30 percent of CRI publications are in the Plant and Animal Science subject field. The number of papers produced in the fields of Geosciences and Ecology/Environment appear to be increasing, while papers in Agricultural Science have decreased. Plant and Animal Science papers have shown a decreased share from 1997 to 2003. Figure 15 illustrates the 1997 and 2003 data.

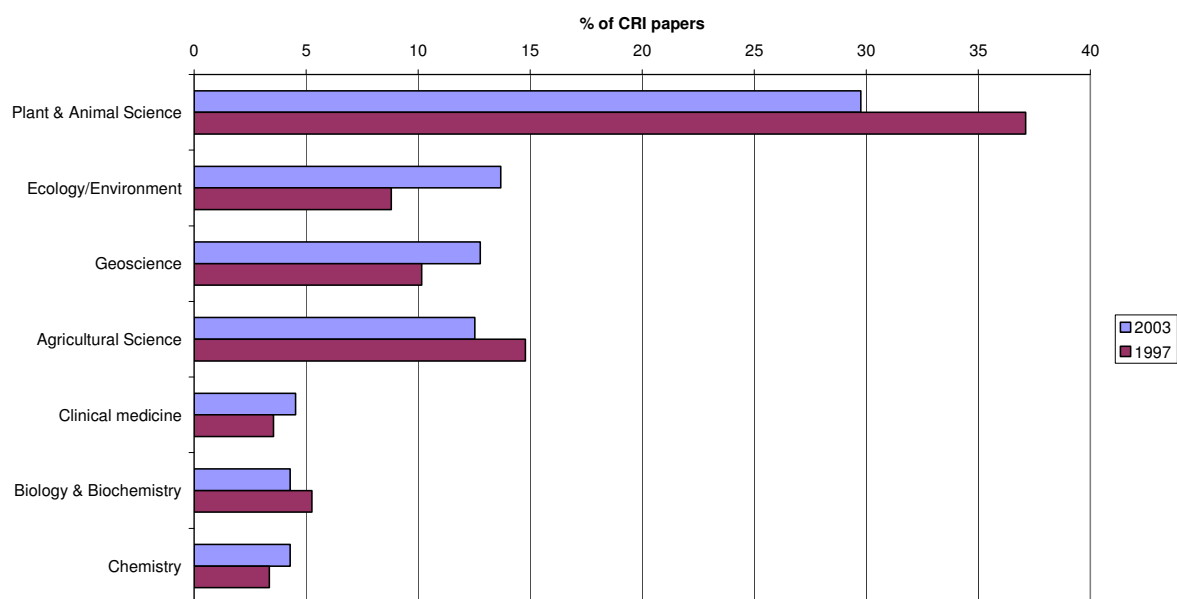
For the CRIs, the share of papers in agricultural related fields decreased from 1986-1997 and there-after stabilised. The share of papers in Geosciences and Ecology/Environment show an increase, and in Chemistry and Biology/Biochemistry the share of papers is static.

**Table 4.** Change in the distribution of CRI papers over time

FIELD	1986*	1997		2003	
	percentage of subjects allocated	Papers	percentage of subjects allocated	Papers	percentage of subjects allocated
Plant and Animal Science	32.1	409	37.1	361	29.8
Ecology/Environment	5.7	97	8.8	166	13.7
Geosciences	8.3	112	10.2	155	12.8
Agricultural Science	23.4	163	14.8	152	12.5
Clinical Medicine		39	3.5	55	4.5
Biology and Biochemistry	4.8	58	5.3	52	4.3
Chemistry		37	3.4	52	4.3
Remnant		187	17.0	220	18.1
Total Subjects allocated		1102	100.1	1213	100
Papers unallocated to subject		98		23	
Total CRI Papers		1128		1114	

\* 1986 data from Liu (2001)

### Percentage share of CRI sector papers by subject



**Figure 15** Share of CRI sector papers by subject for 1997 and 2003, using Thomson-ISI subject categories.

In 1997 1.07 subjects were allocated to each paper, and in 2003 this increased to 1.11 subjects per paper, illustrating that more papers are being allocated to more than one subject.

### 4.2.3 Government Sector

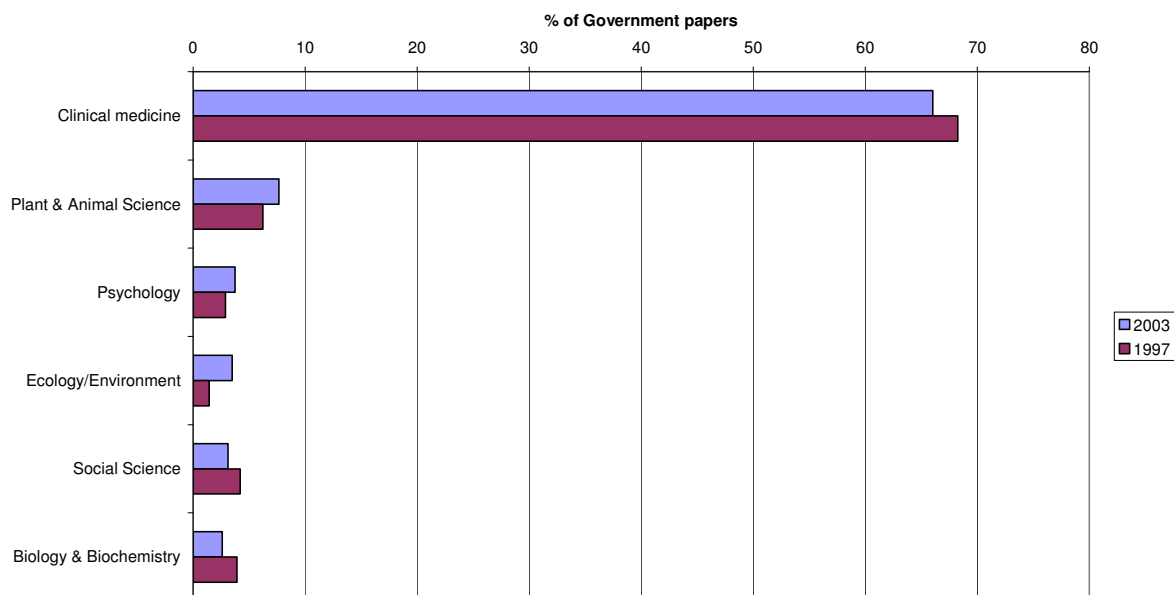
Thomson-ISI indexed 705 publications in 2003 from the government sector. Sixty-six percent of these papers are in the field of Clinical Medicine and reflect the inclusion of hospitals within this sector. Table 5 and Figure 16 show the distribution of government sector papers by subject field for papers published in 1997 and 2003.

The average citation rate per paper for the government sector was 4.3 for papers published in 2001 and cited in the period 2001-2004.

**Table 5** Changes in the subject distribution of government sector papers over time.

FIELD	1997		2003	
	Papers	percentage of subjects allocated	Papers	percentage of subjects allocated
Clinical Medicine	471	68.3	509	66.0
Plant and Animal Science	43	6.2	59	7.7
Psychology/Psychiatry	20	2.9	29	3.8
Ecology/Environment	10	1.5	27	3.5
Social Sciences	29	4.2	24	3.1
Biology and Biochemistry	27	3.9	20	2.6
Remainder	90	13.0	103	13.4
Total Subjects allocated	690	100	771	100.1
Total Govt. Papers	668		705	

### Percentage share of Government sector papers by subject



**Figure 16** Share of Government sector papers by subject, 1997 and 2003.

#### 4.2.4 Local Government Sector

Thomson-ISI indexed 24 papers published by the local government sector in 2003 compared to 23 papers published in 1997. There were six papers in the Ecology/Environment field, four in Geosciences, six in Plant and Animal Science and five in the Social Sciences. This was similar to the distribution of papers in 1997.

Local government papers received 1.9 citations per paper in the period 2001-2004, which was only 0.51 of the expected number of citations for the journals in which they were published. The low citation rate may be attributable to the local content of the papers which seldom attracts international citations.

#### 4.2.5 Private Sector

Thomson-ISI indexes approximately 550 publications each year from the New Zealand private sector. In 2003 analysis shows that 31 percent were in the field of Clinical Medicine (22 percent in 1997), 14 percent in Plant and Animal Sciences (16 percent in 1997), 11 percent in Pharmacology (12 percent in 1997), and nine percent in Agricultural Science (nine percent in 1997). Table 6 and Figure 17 shows the main subject distribution of private sector papers for 2003.

**Table 6** Subject distribution of papers from the Private sector.

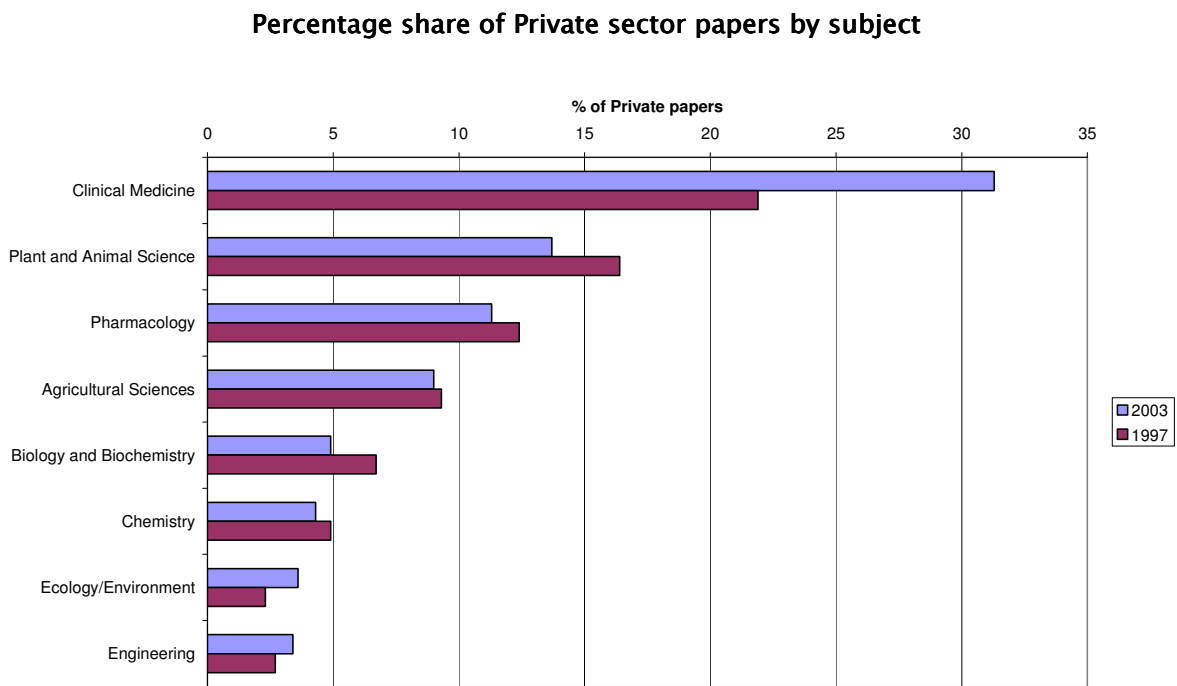
FIELD	1997		2003	
	Papers	percentage of subjects allocated	Papers	percentage of subjects allocated
Clinical Medicine	115	21.9	217	31.3
Plant and Animal Science	86	16.4	95	13.7
Pharmacology	65	12.4	78	11.3
Agricultural Sciences	49	9.3	62	9.0
Biology and Biochemistry	30	6.7	35	4.9
Chemistry	22	4.9	30	4.3
Ecology/Environment	12	2.3	25	3.6
Engineering	12	2.7	24	3.4
Remainder	135	24.5	127	18.3
Total Subjects allocated	526	101.1	693	99.8
Papers not allocated to a subject	38		10	
Total Private Papers	532		562	



Most remarkable is the growth of papers in Clinical Medicine which increased by 89 percent.

The average citation rate per paper for the private sector was 5.1 citations for papers published in 2001 and cited in the period 2001–2004. Examination shows that this high rate is due to 75 reviews published by Adis International Ltd (a New Zealand based subsidiary of the Wolters Kluwer publishing company), in addition to a large number of small hi-tech start-up biotechnology firms with high citation rates. Wakefield Hospital also features prominently, again exhibiting a high citation rate. The number of papers from each company is small but each seems to have had a fairly high impact.

The influence of review papers should be viewed in a cautionary manner by those wanting to extrapolate citation analysis results to the wider performance of the science system. Reviews are not the outcome of R&D or similar scientific work, but primarily a summary of work done by others.



**Figure 17** Share of Private sector papers by subject, 1997 and 2003.

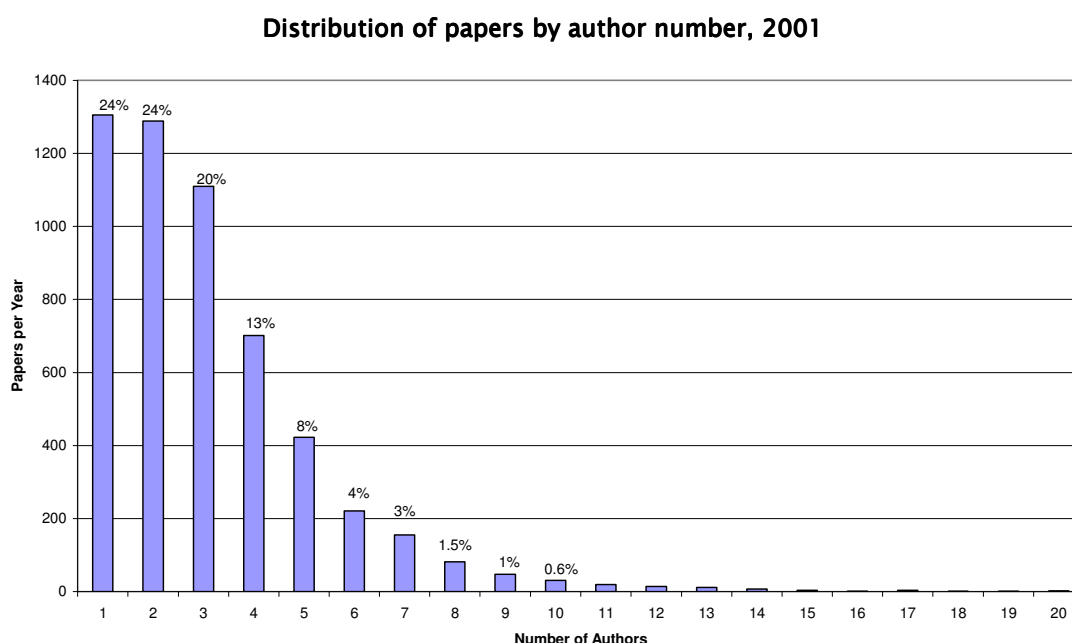
## 5. Collaboration

New Zealand papers indexed by Thomson–ISI from 2001–2004 were examined for numbers of authors and inter–institutional, inter–sector and international collaborations. Collaboration is defined as being when two or more researchers from different institutions, different sectors or different countries jointly author a paper.

### 5.1 Multiple authorships

The majority of New Zealand papers (79 percent) published in 2001–2004 had more than one author.

Figure 18 shows the distribution of papers by author number for 2001.



**Figure 18** Multiple authorships of New Zealand papers, 2001. Papers with only one author accounted for 24 percent of all papers in 2001.

### 5.2 Collaboration and citations by field of science

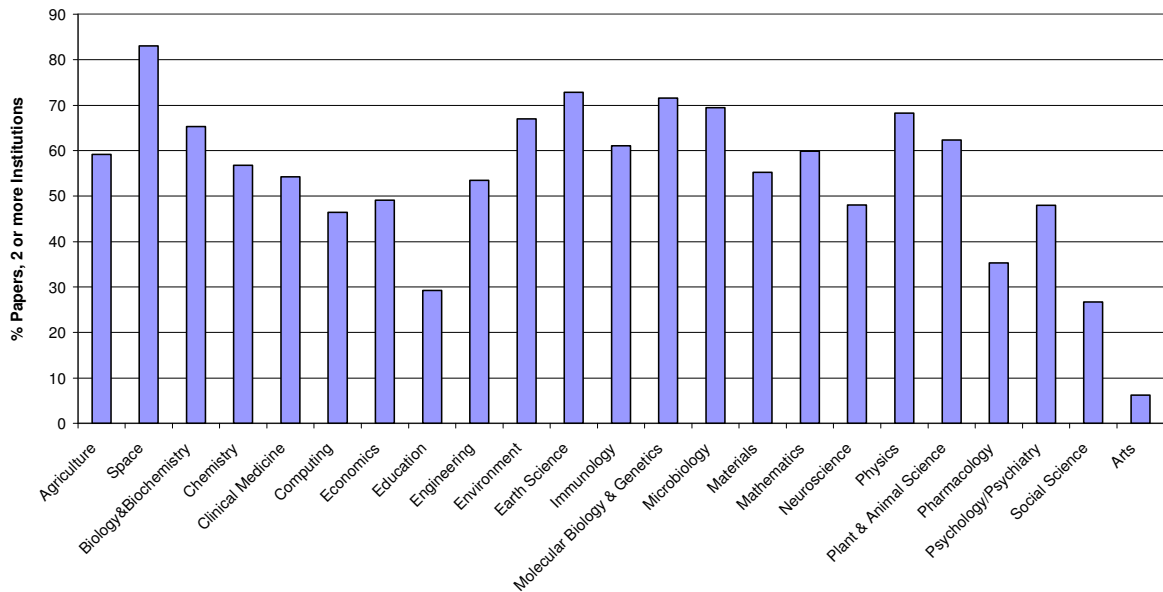
Fields such as Medicine and Biology tend to have high rates of collaboration and high citation rates. Fields where papers usually have a single author, for example in the Arts and Mathematics, have low citation rates and this is shown in the New Zealand data in Table 7. There is a general trend in most fields for a higher citation rate as the degree of collaboration increases.

**Table 7** Citation rates for 2001 papers by field and collaboration

		One author	Two or more authors	Two or more institutions	International collaboration	First named author is international
Agricultural	Agricultural Science	2.3	3.5	3.4	3.7	3.7
Natural Sciences	Space	2.3	10.6	12.6	12.6	9.3
	Biology and Biochemistry	4.0	8.3	9.5	10.6	12.2
	Chemistry	3.3	4.9	5.0	5.1	4.5
	Environment	6.8	5.7	6.8	7.6	8.3
	Computer	0.8	1.7	1.3	1.4	2.3
	Molecular Biology	11.8	10.4	11.8	13.3	15.3
	Microbiology	5.7	7.9	9.6	11.6	15.0
	Geosciences	2.8	5.8	6.1	6.4	7.0
	Mathematics	1.1	1.7	1.6	1.5	1.3
	Physics	3.6	6.2	6.2	6.6	6.4
	Plant and Animal	2.7	4.9	5.6	6.3	7.4
Engineering and Technology	Engineering	0.8	2.3	2.5	2.6	3.0
	Materials	4.6	3.2	2.2	1.9	2.2
Medical Sciences	Immunology	4.0	12.6	17.5	18.8	26.5
	Clinical Medicine	1.8	6.2	6.6	8.2	8.8
	Neuroscience	5.8	7.8	7.3	7.6	7.6
	Pharmacology	2.8	9.0	4.1	4.8	5.3
	Psychiatry	1.5	4.3	5.1	4.8	5.9
Social Sciences	Economics	0.6	1.8	2.1	2.1	2.4
	Education	0.5	1.1	1.1	1.1	1.3
	Law	1.7				1.7
	Sociology	0.7	2.9	2.8	3.3	3.7
Humanities	Arts	0.2	1.6	1.2	0.7	1.4

Collaborations between institutions are more common in fields where there is a tangible benefit in sharing expensive equipment or specialised expertise. Figure 19 shows that more than 60 percent of papers in Space Science, Earth Sciences, Molecular Biology, Microbiology, Physics, the Environment, Biology and Biochemistry, Plant and Animal Science and Immunology involved collaboration with at least one other institution. Less than 30 percent of papers in Education, Social Science and the Arts involved inter-institutional collaboration.

### Distribution of collaborative papers by subject, 2001–2004



**Figure 19** Percentage of all New Zealand papers from 2001–2004 with collaboration between two or more institutions, by field of study.

Authors tend to collaborate on important topics with a broad interest, and where specialised knowledge is required across a broader base. This in itself will generate citation. There is a general trend towards more collaborative papers internationally.

### 5.3 Trends in collaboration

Examination of the figures for 2001–2003 indicate that the single author paper continued to decline over time and the internationally co-authored paper continued to increase over time. If this trend continues, then by 2006 about half of the New Zealand papers indexed by Thomson–ISI will be international collaborations.

Figure 20 charts the distribution of types of collaboration from 1997–2003. The figure illustrates that co-authored papers, domestic and international, rose during the period 2001–2003, with a corresponding drop in the percentage of single author papers. Particularly notable is the increase of internationally co-authored papers during this time, from 37 percent in 2001 to 43 percent in 2003.

### Change in distribution of collaborative papers

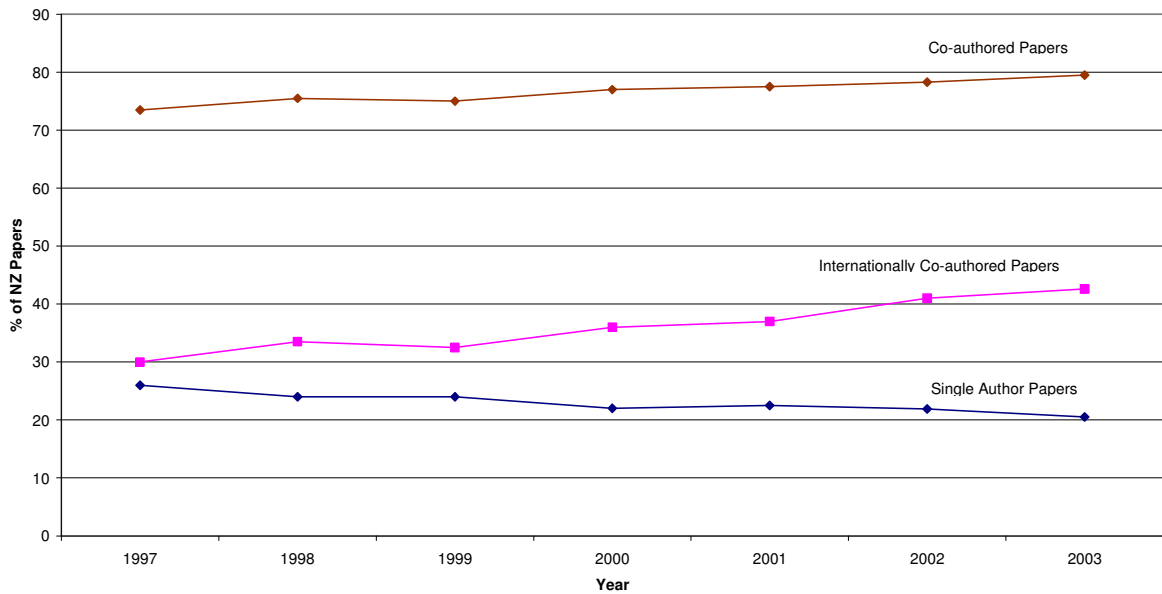


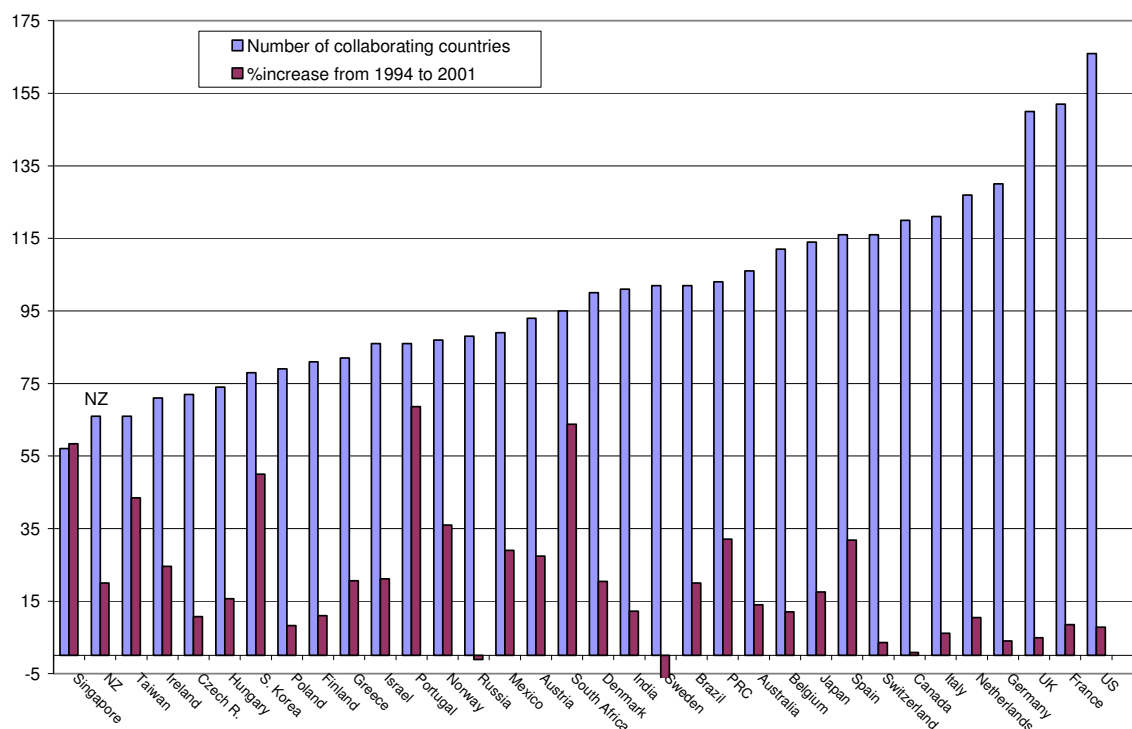
Figure 20. Change in percentage of collaborative papers 1997–2003.

## 5.4 International collaboration

It is difficult to benchmark New Zealand’s degree of international collaboration against that of other countries. One crude way is simply to record the number of other countries involved in collaborations with New Zealand authors. Figure 21 shows this type of benchmark for 34 countries in 2001. The National Science Foundation (NSF) data shows New Zealand increasing international ties at an average rate

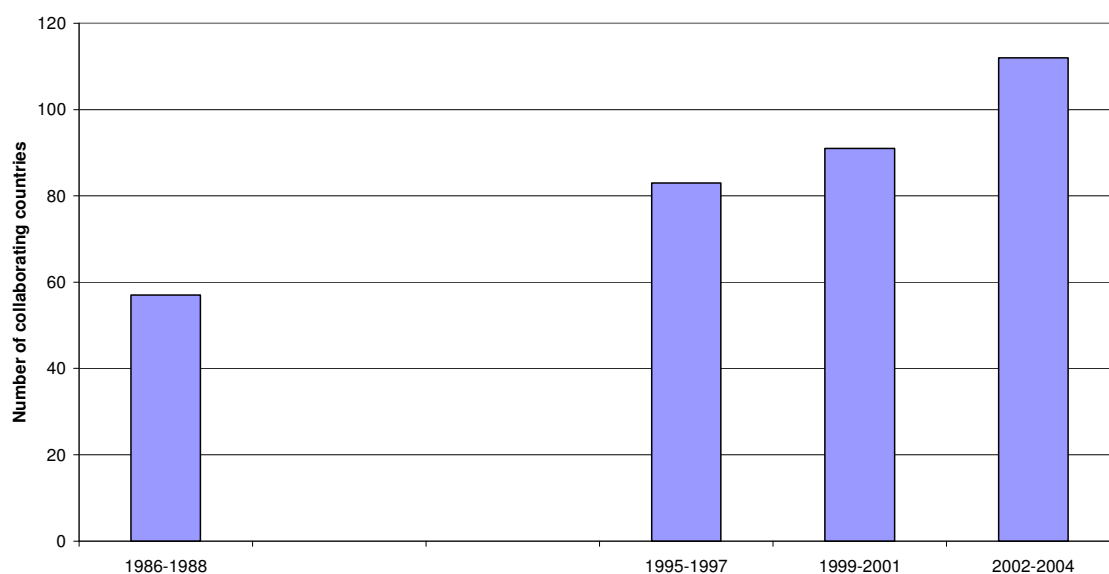
The number of countries that New Zealand collaborates with is increasing, from 83 in 1995–1997 to 112 in 2002–2004, as shown in Figure 22.

### Number and percentage change of collaborating countries, 2001



**Figure 21** The number of other countries collaborated with in 2001, for 34 countries, and percentage of change in the number of countries collaborated with from 1994–2001. [Data taken from the National Science Foundation, (2004)]

### Increase in the number of collaborating countries



**Figure 22** Increase in the number of countries collaborating with New Zealand, from the Thomson-ISI citation database, 1986–2004. Bars show the number of countries that collaborating authors were from, for papers published in the three year periods indicated.

Table 8 shows those countries most often collaborated with. The percentages may overlap. For example, 33.7 percent of internationally co-authored papers in the review period were in collaboration with the United States of America, but these papers may also have included authors from other countries. A total of 75 percent of New Zealand papers were co-authored with at least one other author from the United States of America, Australia, the United Kingdom or Canada. A total of 41 percent were co-authored with other countries but those papers may also have included authors from the top four.

**Table 8** Percentage of New Zealand's international collaboration with various countries.

Country	1986–1988	1995–1997	1997–2001	2001–2004
U.S.A	37.7 percent	36.7 percent	33.2 percent	33.7 percent
Australia	23.8 percent	22.1 percent	24.0 percent	24.0 percent
U.K.	19.5 percent	19.3 percent	21.0 percent	21.9 percent
Canada	8.4 percent	9.2 percent	8.4 percent	8.4 percent

## 5.5 Patterns of inter-sector collaboration

Inter-sector collaboration can be shown in two ways. Using the simpler method, Table 9 illustrates that collaboration has increased from 1997–2003. Sector collaboration is measured by comparing the total number of papers (Total papers in Table 9) against the total number of 'sector authors' (Summed papers all sectors in Table 9). The definition of 'sector authors' is the number of authors representing different sectors per paper.

**Table 9** Increased collaboration between sectors.

Year	Total papers	Summed papers all sectors	Sector collaboration
1997	5732	5876	3 percent
2000	5622	6311	12 percent
2003	5662	6441	14 percent

Table 10 shows collaboration in a more complex manner. Collaborations have been counted as one divided by the number of organisations represented in each paper. Thus in a paper with three organisations A, B, C, each collaborative combination is given the value one divided by three. For A, B, C, D, each of the six combinations has a value of one divided by six.

Note that this method of counting collaborations produces decimal fractions. For example the Tertiary-Overseas link represented 1,076.2 collaborations in 2003. Intra-sector collaboration exists when two or more authors from separate institutions within a sector co-author a paper, for example two universities collaborating on one paper. Note also that this method attaches more weight to collaborations between a few authors in a single paper. The greater the number of joint authors on a paper, the 'weaker' the collaboration will be.

**Table 10** Collaborations between sectors in 2003.

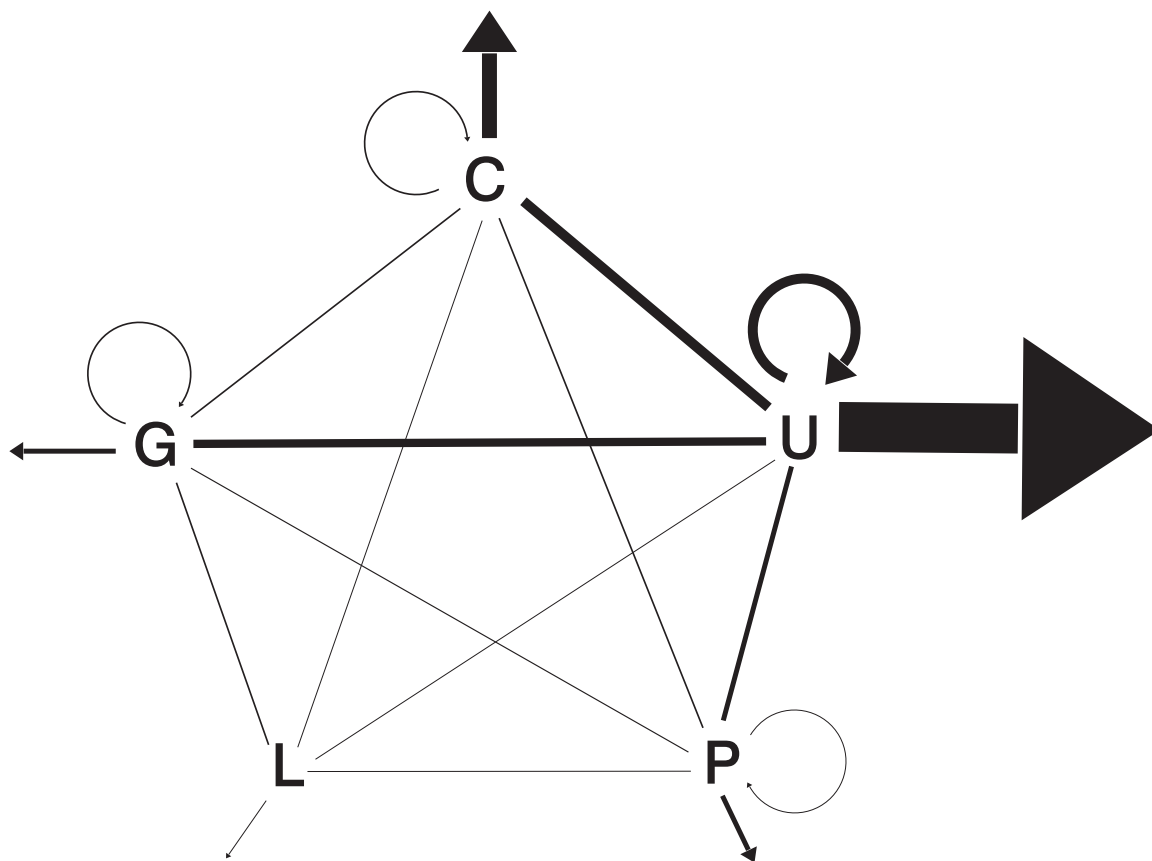
For a paper with four organisations A, B, C, D, each of the six combinations has a value of one divided by six<sup>9</sup>.

	<b>CRI</b>	<b>Govt</b>	<b>Local</b>	<b>Overseas</b>	<b>Private</b>	<b>University</b>
<b>CRI</b>	36.8	29.6	4.4	297.9	26.9	196.1
<b>Govt</b>		36.2	1	114	26.4	163.7
<b>Local</b>			0	2.9	1	6.9
<b>Overseas</b>				734.3	96.3	1,076.2
<b>Private</b>					9.4	105.6
<b>University</b>						200.3

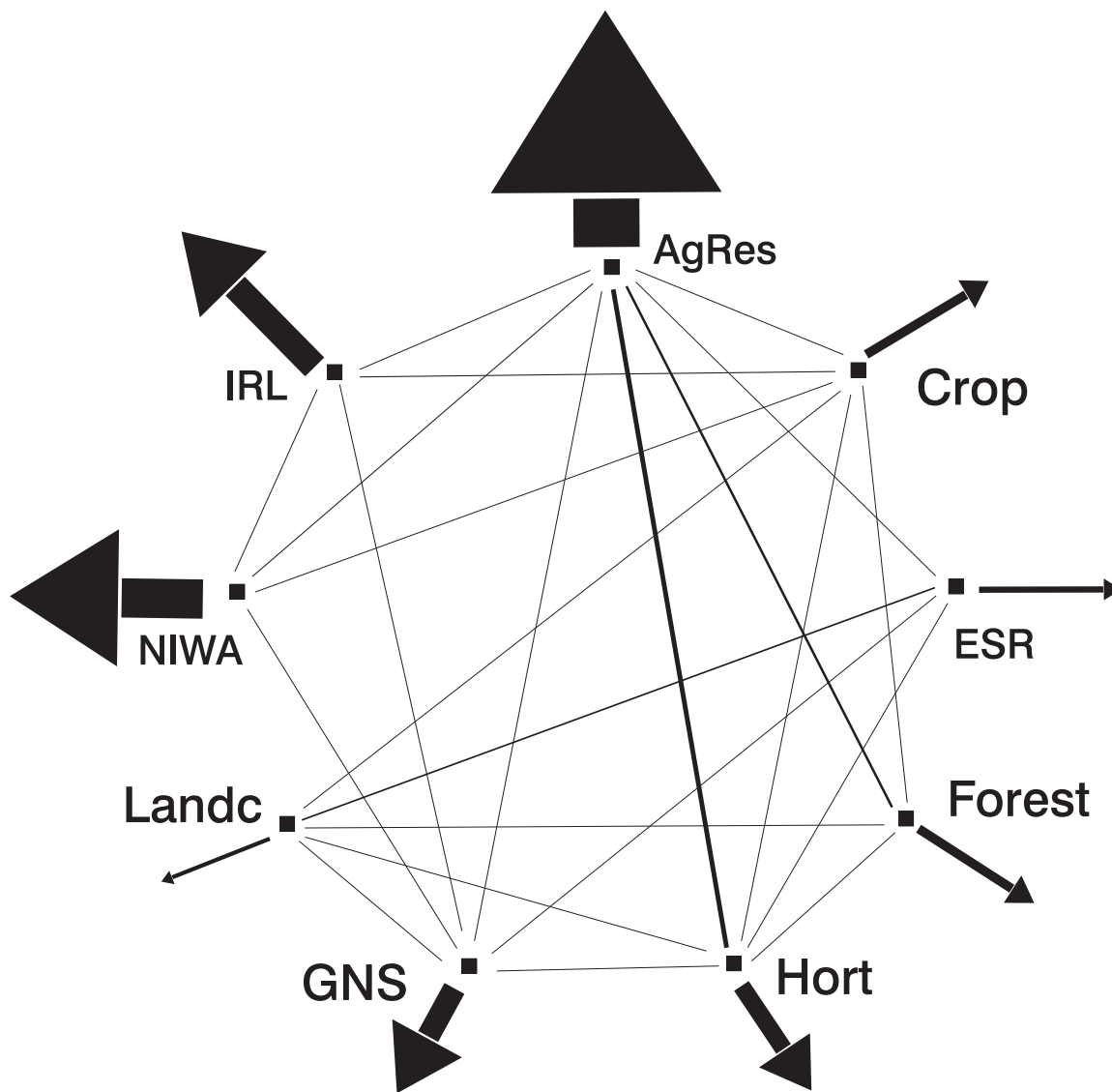
Collaborations between and within sectors for 2003 are shown visually in the diagrams that follow (Figures 23 to 26). The width of the connecting lines is an indication of the number of collaborative papers between the sectors. Patterns of collaboration are shown for all sectors, then for each sector separately. Arrows pointing outwards represent collaborations with an overseas institution. To indicate scale within each diagram, the number of 'collaborations' corresponds to the width of the arrow in the diagram. The greater the number of collaboration, the wider the arrow.

<sup>9</sup> There were 3,166 collaborative papers and 2,605 single organisation papers in 2003. This grand total of 5,771 papers compares with an actual total of 5,686 papers for 2003 i.e. corresponds to about 1.5% double-counting.





**Figure 23** Number of papers with collaboration between sectors.  
 C : Cri U : Tertiary P : Private L : Local G : Government.  
 The width of the arrow pointing outwards from the Tertiary sector corresponds to 1076 'collaborations'.



**Figure 24** Number of papers with collaboration between CRIs.

AgRes : AgResearch

ESR : Environmental Science Research

Hort : HortResearch

GNS : Institute of Geological and Nuclear Sciences

NIWA : National Institute of Water and Atmosphere

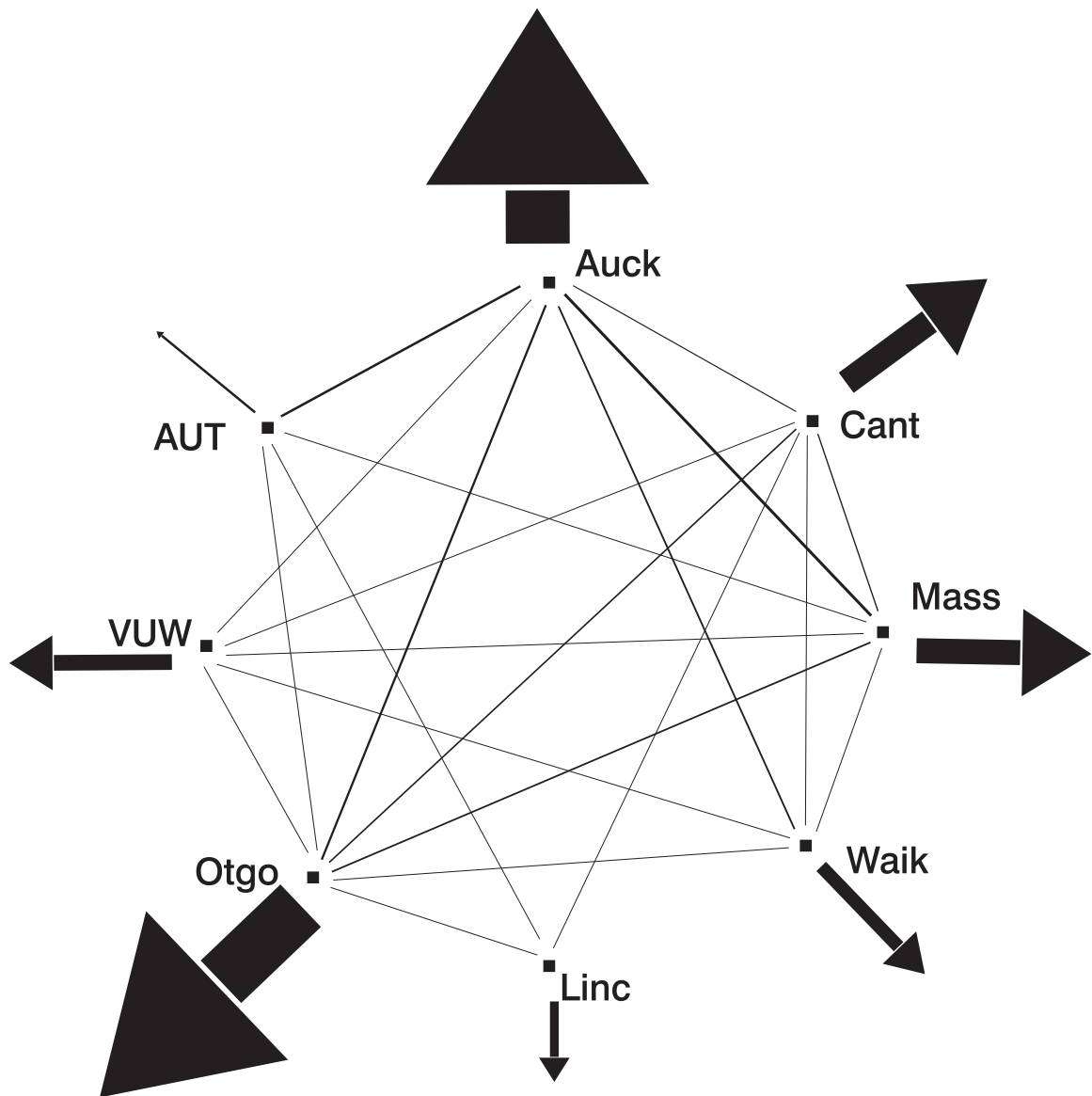
Crop : Crop & Food

Forest : Forestry Research

Landc : Landcare

IRL : Industrial Research Ltd

The width of the arrow pointing outwards from AgResearch corresponds to 96 international 'collaborations'.



**Figure 25** Number of papers with collaboration between universities.

Auck : Auckland University

Mass : Massey University (including Albany)

Linc : Lincoln University

VUW : Victoria University of Wellington

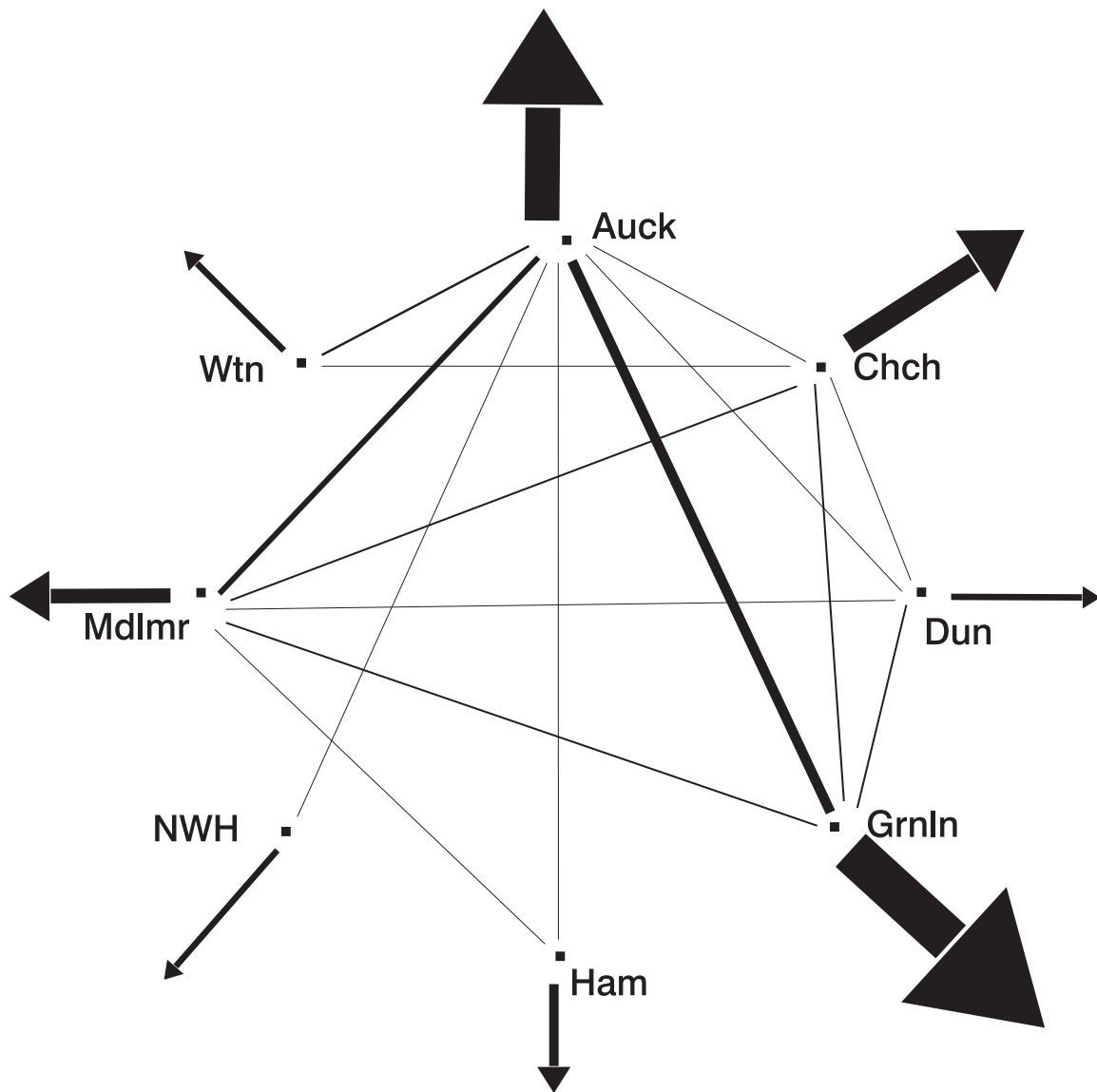
AUT : Auckland University of Technology.

Cant : Canterbury University

Waik : University of the Waikato

Otgo : University of Otago

The width of the arrow pointing outwards from Auckland University corresponds to 320 international 'collaborations'.



**Figure 26** Number of papers showing collaboration between hospitals.

Auck : Auckland Hospital  
 Dun : Dunedin Hospital  
 Ham : Hamilton Hospital  
 Mdlmr : Middlemore Hospital

Chch : Christchurch Hospital  
 Grnln : Greenland Hospital  
 NWH : National Women's Hospital  
 Wtn : Wellington Hospital

The width of the arrow pointing outwards from Greenlane Hospital corresponds to 23 international 'collaborations'.

## Appendices

### A. 1 Most frequently cited papers 2001-2004.

The papers below are selected to show the range of subjects involved in high impact New Zealand papers.

Tallon, JL; Loram, JW.

*Physica*, 349: 53–68.

***The doping dependence of  $T^*$  – what is the real high- $T$ - $c$  phase diagram?* (2001)**

152 citations (expected 2.41).

[A paper from IRL about superconductors.]

Van Cutsem, E; Twelves, C; Cassidy, J; Allman, D; Bajetta, E; Boyer, M; Bugat, R; Findlay, M; Frings, S; Jahn, M; McKendrick, J; Osterwalder, B; Perez-Manga, G; Rosso, R; Rougier, P; Schmiegel, WH; Seitz, JF; Thompson, P; Vieitez, JM; Weitzel, C; Harper, P; Xeloda.

*Journal of Clinical Oncology*, 19: 4097–4106.

**Oral capecitabine compared with intravenous fluorouracil plus leucovorin in patients with metastatic colorectal cancer: Results of a large phase III study. Colorectal Cancer Study Group (2001)**

116 citations (28.4 expected).

[Two New Zealand organisations credited are the Wellington Cancer Centre and Auckland Hospital.

This is a large international comparative drug study with more than 20 authors.]

Wesley, SV; Helliwell, CA; Smith, NA; Wang, MB; Rouse, DT; Liu, Q; Gooding, PS; Singh, SP; Abbott, D; Stoutjesdijk, PA; Robinson, SP; Gleave, AP; Green, AG; Waterhouse, PM.

*Plant Journal*, 27: 581–590.

**Construct design for efficient, effective and high-throughput gene silencing in plants. (2001)**

102 Citations (19.31 expected).

[A CSIRO–Hort Research collaboration (CSIRO–led) on gene silencing with large potential in agriculture/horticulture.]

Anderson, MJ

*Austral Ecol*, 26: 32-46.

**A new method for non-parametric multivariate analysis of variance. (2001)**

92 Citations (5.78 expected).

[This is a single author paper, with organisational credit to both Auckland University and Sydney University, on a new method of application of statistical analysis to ecology. The citations are high because the method is widely applicable in many fields.]

Reid, IR; Hague, W; Emberson, J; Baker, J; Tonkin, A; Hunt, D; MacMahon, S; Sharpe, N; LIPID Study Group

*Lancet*, 357: 509–512.

**Effect of pravastatin on frequency of fracture in the LIPID study: secondary analysis of a randomised controlled trial. (2001)**

80 Citations (34.24 expected)

[Led by two Auckland University researchers.]

Verhagen, AM; Silke, J; Ekert, PG; Pakusch, M; Pakusch, M; Kaufmann, H; Connolly, LM; Day, CL; Tikoo, A; Burke, R; Wrobel, C; Moritz, RL; Simpson, RJ; Vaux, DL.  
*Journal of Biological Chemistry*, 277: 445–454.

**HtrA2 promotes cell death through its serine protease activity and its ability to antagonize inhibitor of apoptosis proteins.** (2002)

150 citations (13.2 expected)

[Led by Australians with Otago University contribution.]

Caspi, A; McClay, J; Moffitt, TE; Mill, J; Martin, J; Craig, IW; Taylor, A; Poulton, R.  
*Science*, 297:851–854.

**Role of genotype in the cycle of violence in maltreated children.** (2002)

148 citations (48.13 expected)

[Coordinated from the UK.]

Boynton, WV; Feldman, WC; Squyres, SW; Prettyman, TH; Bruckner, J; Evans, LG; Reedy, RC; Starr, R; Arnold, JR; Drake, DM; Englert, PAJ; Metzger, AE; Mitrofanov, I; Trombka, JI; dUston, C; Wanke, H; Gasnault, O; Hamara, DK; Janes, DM; Marcialis, RL; Maurice, S; Mikheeva, I; Taylor, CJ; Tokar, R; Shinohara, C.

*Science*, 297:81–85.

**Distribution of hydrogen in the near surface of Mars: Evidence for subsurface ice deposits.** (2002)

87 Citations (48.13 expected).

[This 25 member collaboration included NASA, Caltech, Cornell University, the Russian Academy of Sciences, Los Alamos and Max Planck Institute of Chemistry. The New Zealand contribution was from Victoria University of Wellington.]

Coen, S; Chau, AHL; Leonhardt, R; Harvey, JD; Knight, JC; Wadsworth, WJ; Russell, PSJ  
*Journal of the Optical Society of America B*, 19:753–764.

**Supercontinuum generation by stimulated Raman scattering and parametric four-wave mixing in photonic crystal fibers.** (2002)

73 Citations (4.62 expected)

[Auckland University, Bath University and the Free University of Brussels.]

Blunt, JW; Copp, BR; Munro, MHG; Northcote, PT; Prinsep, MR  
*Natural Product Reports*, 20

**Marine natural products.** (2003)

60 Citations (8.2 expected)

[This Auckland University/Victoria University/Waikato University/Canterbury University collaboration is a review, hence the good citation rate in only about 18 months.]

Hucka, M; Finney, A; Sauro, HM; Bolouri, H; Doyle, JC; Kitano, H; Arkin, AP; Bornstein, BJ; Bray, D; Cornish-Bowden, A; Cuellar, AA; Dronov, S; Gilles, ED; Ginkel, M; Gor, V; Goryanin, II; Hedley, WJ; Hodgman, TC; Hofmeyr, JH; Hunter, PJ; Juty, NS; Kasberger, JL; Kremling, A; Kummer, U; Le Novere, N; Loew, LM; Lucio, D; Mendes, P; Minch, E; Mjolsness, ED; Nakayama, Y; Nelson, MR; Nielsen, PF; Sakurada, T; Schaff, JC; Shapiro, BE; Shimizu, TS; Spence, HD; Stelling, J; Takahashi, K; Tomita, M; Wagner, J; Wang, J; SBML Forum *Bioinformatics*, 19: 524–531.

**The systems biology markup language (SBML): a medium for representation and exchange of biochemical network models.** (2003)

31 citations, (4.1 expected)

[The University of Auckland was the New Zealand contributor.]

## **A.2 Organisations in the Crown Research Institute sector**

Industrial Research Limited  
Institute of Environmental Science & Research Limited (ESR)  
Institute of Geological Sciences Limited (GNS)  
Landcare Research New Zealand Limited  
National Research Institute of Water and Atmospheric Research Limited (NIWA)  
New Zealand Forest Research Institute Limited (name change to Scion, June 2004)  
New Zealand Institute for Crop and Food Research Limited (Crop & Food Research)  
New Zealand Pastoral Agriculture Research Institute Limited (AgResearch)  
The Horticulture and Food Research Institute of New Zealand Limited (HortResearch)

## **A.3 Organisations in the government sector**

These organisations published papers in 2001 or 2003. No attempt has been made to assign them to their correct Ministries. Name forms are as given in the Thomson–ISI database.

Accident Compensation Corporation  
Archives New Zealand  
Auckland and Christchurch Colleges of Education  
Crown Minerals  
Defence Technology Agency  
Department of Conservation  
Department of Corrections  
Department of Health (includes a number of Public Hospitals)  
Department of Labour  
Department of the Prime Minister and Cabinet  
Halswell Residential College  
Internal Affairs Department  
New Zealand Ministry of Foreign Affairs and Trade  
Ministry of Agriculture and Forestry  
Ministry of Culture and Heritage  
Ministry for the Environment  
Ministry of Fisheries  
Ministry of Maori Development  
Ministry of Research Science and Technology  
Museum of New Zealand, Te Papa Tongarewa  
National Library of New Zealand  
New Zealand Army  
New Zealand Food Safety Authority  
New Zealand Police Department  
Office of the Controller and Auditor General  
Royal New Zealand Air Force  
State Services Commission  
Tertiary Education Commission  
Transit New Zealand  
The Treasury  
Understanding Learning and Teaching Institute  
Wallaceville Animal Research Centre

#### A.4 Organisations in the local government sector

These organisations published papers in 2001 or 2003.

Auckland Art Gallery

Auckland City Library

Auckland Zoo

Dunedin City Council

Otago Museum

Regional Councils: Auckland Regional Council, Hawkes Bay Regional Council, Manawatu Regional Council, Marlborough District Council, Otago Regional Council, Rotorua District Council, Ruapehu District Council, Tasman District Council, Wellington Regional Council.

Waikato Museum of Art and History

Waitakere City Council

#### A.5 Composition of ASRC groupings

##### ASRC groupings

Agricultural, Veterinary and Environmental Sciences

Biological Sciences

    High Impact

    Low Impact

Chemical Sciences

Engineering

General

Geological Sciences

Information Technology

Mathematics

Medical & Health Sciences

Physical Sciences

##### ISI category

A/A; AN; ENV; VET

BIL; CEL; MBG

AS; AQU; BIO; BTC; ENT; EXP; MCB; PL;

CMA; CML; CMP; INC; ORG; PHC;

AER; ARA; CIV; CME; EEE; EL; F; GPM; MEC;

MET; MTR; NCL

GEN; MGT; MUL;

EAR; GEO

CSE; COM; IST

EMA; MTH

AIC; BEH; CAR; CGS; CVS; DEN; DER;

DGX; END; GAS; GNC; HEM; HLT; IMM;

INF; MED; MGN; NEU; NUT; OGS; ONC;

OPH; ORT; PED; PHM; PMC; PSI; PSL;

PSO; PSY; PUB; RAD; REH; REP; RHU;

SOC; SUR; URO

APP; I/M; O/A; PHC; PHS; SIA; SP

Social sciences and Humanities are not ASRC groupings so when these are used the Thomson-ISI category is given.

#### A.6 Composition of Thomson-ISI groupings

Agricultural Sciences

A/A; CMA; F

Astrophysics

SP

Biology and Biochemistry

BIL; BIO; BTC; END; EXP; PSL

Chemistry

CME; CML; CMP; INC; ORG; PHC;



Clinical Medicine	SIA AIC; CAR; CGX; CVS; DEN; DER; DGX; GAS; GNC; HEM; HLT; INF; PSY; MED; MGN; NEU; NUT; OGS; ONC; OPH; ORT; OTO; PED; PMC; RAD; REP; RHU; SOC; SUR; URO
Computer Science	CSE; IST
Economics and Business	ECO; MGT
Education	EDU
Engineering	AER; ARA; CIV; EEE; EL; EMA; GNE; I/M; MEC; NCL
Ecology/Environment	ENV
Geosciences	EAR; GPM
Immunology	IMM
Law	LAW
Molecular Biology and Genetics	CEL; MBG
Microbiology	MCB
Materials Science	MET; MTR
Mathematics	MTH
Neuroscience	BEH
Multidisciplinary	MUL
Physics	APP; O/A; PHS
Plant and Animal Science	AN; AQU; AS; ENT; PL; VET
Pharmacology	PHM
Psychology/Psychiatry	PSI; PSO
Social Sciences, General Arts and Humanities	ARC; ART; CLS; COM; GEN; GEO; HIS; LIB; LIP; LIT; PER; PHL; POL; PUB; REH; S/I; S/A;
REL	

## A.7 Thomson-ISI subject category abbreviations

Abbreviation	Subject field	Abbreviation	Subject field
	No category	INF	Infect./Clinical Immunology
A/A	Agriculture/Agronomy	IST	Inform. Technology
AER	Aerospace Engineering	LAW	Law
AIC	Anaesth./Intensive Care	LIB	Library Science
AN	Animal & Plant Science	LIP	Linguistics
APP	Applied Physics/Materials	LIT	Literature
AQU	Aquatic Sciences	MBG	Mol. Biol./Genetics
ARA	Robotics/Automatic control	MCB	Microbiology
ARC	Archaeology	MEC	Mechanical Engineering
ART	Art & Lit.	MED	Lab. Med & Med. Technol.
AS	Animal Sciences	MET	Metallurgy
BEH	Neurosciences & Behaviour	MGN	Med. Res. General
BIL	Biochemistry/Biophysics	MGT	Management
BIO	Biology	MTH	Mathematics
BTC	Biotechnology	MTR	Materials Research
CAR	Cardiovasc. & Resp. System	MUL	Multidisciplinary
CEL	Cell/Developmental Biol.	NCL	Nuclear Engineering
CGX	Oncogenesis & Cancer Res.	NEU	Neurology
CIV	Civil Engineering	NUT	Endocrin. /Metab. & Nutrit.
CLS	Classics	O/A	Optics/Acoustics
CMA	Agricultural Chemistry	OGS	Organs and Systems
CME	Chemical Engineering	ONC	Oncology
CML	Chemistry & Analysis	OPH	Ophthalmology
CMP	Chemistry	ORG	Org./Polymer Chemistry
COM	Communication	ORT	Orthopaedics
CSE	Comp. Sci./Engineering	OTO	Otolaryngology
CVS	Cardiovasc. & Haem. Res.	PED	Paediatrics
DEN	Dentistry	PER	Performance
DER	Dermatology	PHC	Physical Chemistry
DGX	Med. Res. Diagn. & Treat.	PHL	Philosophy
EAR	Earth Sciences	PHM	Pharmacology & Toxicology
ECO	Economics	PHS	Physics
EDU	Education	PL	Plant sciences
EEE	Environmental Engineering	PMC	Pharmacology / Toxicology
EL	Elec. /Electron. Engineering	POL	Political Science
EMA	Eng. Maths	PSI	Psychiatry
END	Endocrin. / Metab. & Nutr.	PSL	Physiology
ENT	Entomology	PSO	Psychology
ENV	Environment/Ecology	PSY	Clinical Psychol. Psychiat.
EXP	Experimental Biology	PUB	Public Health & systems
F	Food Science/Nutrition	RAD	Radiology & Nucl. Med.
GAS	Gastroent. & Hepatology	REH	Rehabilitation
GEN	General subjects	REL	Religion
GEO	Geography/Development	REP	Reproductive Medicine
GEO (ISI)	Geography/Env.	RHU	Rheumatology
GNC	General & Internal Med.	S/A	Sociology/Anthropology
GNE	Eng. Management	S/I	Social Work/Policy
GPM	Geol. /Petrol. Engineering	SIA	Spectroscopy/Instrumentation
HEM	Haematology	SOC	Envir. Med/Public Health
HIS	History	SP	Space Sciences
HLT	Health Care Science	SUR	Surgery
I/M	Instrumentation/Measurement	URO	Urology
IMM	Immunology	VET	Veterinary Science
INC	Inorg./Nuclear Chemistry		

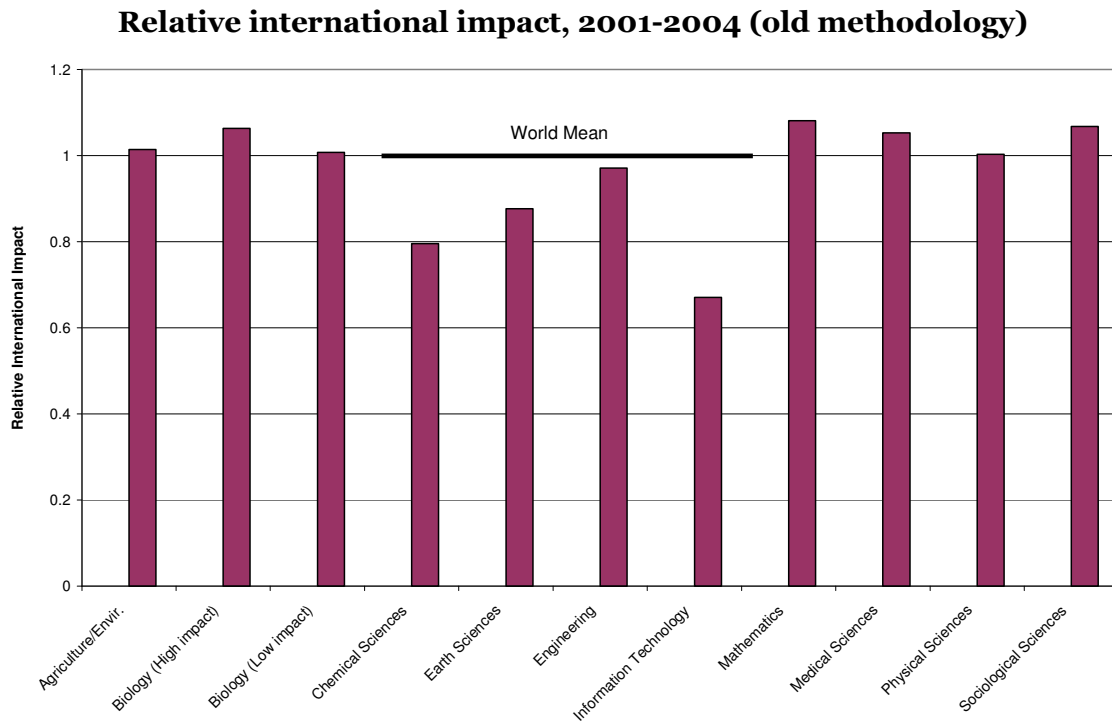
## **A.8 OECD classification of major fields of science and the corresponding Thomson-ISI classification.**

OECD classification	Thomson-ISI classification
Natural Sciences	Astrophysics Biology and Biochemistry Chemistry Computer Sciences Ecology/Environment Geosciences Mathematics Microbiology Molecular Biology Plant and Animal Sciences Physics
Engineering and Technology	Engineering Materials Science
Medical Sciences	Clinical Medicine Immunology Neuroscience Pharmacology Psychiatry (Deluxe)
Agricultural Sciences	Agricultural Sciences
Social Sciences	Economic and Business Education Law Psychology (Deluxe) Social Sciences (General)
Humanities	Arts and Humanities (General)

## A.9 Main sources of data used in this study

	Data source	Journal coverage	Articles and reviews	Editorials, notes, proceedings etc	Arts & Humanities
1	Thomson-ISI New Zealand National Citation Report database 2001-2004	NZ papers and citations by subject field 2001-2004 (A constant set which takes into account journals that cease, split or fuse).	Yes	Yes	Yes
2	National Science Indicators	World papers and citations by subject field 1981-2004	Yes	No	No
3	National Science Indicators	22 countries' papers and citations, 2003, 2004	Yes	No	No
4	Web of Science	Extended journal set, 1988-2005	Yes	Yes	Yes

## A.10 Relative international impact, 2001-2004 (old methodology)



Relative international impact of New Zealand–authored papers in different subjects compared to world means. Papers published and cited in the period 2001–2004, showing the ratio of actual citations to expected citations. Similar subject categories and methodology are used as for Figure 8 in the 1997–2001 study (see page 13, *National Bibliometric Report 1997-2001: International Benchmarking of New Zealand Research*). This chart includes all types of publications, as in the previous report.

## **A.11 Glossary**

### **ASRC**

Australian Standard Research Classification categorizations (Butler, 2001)

### **Bibliometrics**

The quantitative evaluation of scientific publications (especially papers in international refereed journals) and built on the work of others.

### **Citation**

A reference in a publication to an earlier publication, linking ideas so that statements can be verified and built on the work of others.

### **Citation impact**

Mean citations per paper over some fixed time period.

### **CRI**

Crown Research Institute. CRIs are the successors to the old DSIR. They derive a percentage of their revenue from competitive applications for government funding and the remainder from commercial sources. The CRI brief: research and application to the New Zealand situation.

### **Indexing lags**

Thomson-ISI may not receive, or may not enter publications and their citations into their database until a year or more after they have been published. A small percentage of papers do not appear in the database for more than one year. The term used in the present report for this is an "indexing lag" to be distinguished from a citation lag. The indexing lag can be estimated because Thomson-ISI supplies the year of publication and the year of indexing.

### **Relative citation impact**

The comparison of mean citations per paper between, for example, New Zealand the rest of the world calculated by dividing New Zealand's share of world citations in a particular subject by its share of world publications in the same subject.

### **SOE**

State Owned Enterprise. A dividend is expected by the Government which is not necessarily the case with a CRI.