National Bibliometric Report

1997 to 2001

International Benchmarking of New Zealand Research

A report commissioned by the:
Ministry of Research, Science and Technology, Foundation for Research Science and Technology, Health Research Council of New Zealand, and Royal Society of New Zealand.

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Executive Summary

This report is an analysis of the Thomson-ISI New Zealand National Citation Report database, 1997-2001.

Papers

The number of New Zealand-authored research publications indexed was 23,757. New Zealand-authored publications have been steadily increasing since 1993, at a rate of approximately 4 % per year.

Scientific Productivity

In 2001, New Zealand ranked 11th out of 20 countries in terms of scientific productivity per capita, approximately similar to Australia, Canada and the United States. This productivity was achieved at a relatively low cost. New Zealand produced 6.0 papers per million dollars US, ranking first among 19 countries (adjusted for Purchasing Power Parity).

Subjects

The subject with the highest publication output was medical science which published nearly 9000 papers, over a third of the total. Biological sciences was the next largest field, publishing approximately 4800 papers.

Citations as a measure of Impact

For science and engineering papers published in 1997, the average number of citations was six (including one self citation), in the five year period 1997-2001.

The health research sector had the highest citation rate per 1997 paper (7.8), followed by the private sector (6.4), the tertiary sector (6.1), then CRIs (5.9). Citation rates vary between subject areas. Variation in citation rates between sectors may merely reflect the different mix of subjects in each sector.

For all papers published and cited in the period 1997-2001 three subject areas in New Zealand had a relative international impact approximately 20% above the world mean. They were the chemical sciences, physical sciences, and agricultural/veterinary/environmental sciences. The reasons for the comparatively low impact of other subject areas are currently unknown.

In terms of overall relative impact New Zealand ranks 17th out of 27 countries, which is average.

Sectors

Between 1997 and 2000, all sectors except CRIs increased their publication output. The number of ISI-indexed publications from the CRI sector decreased by 9% from 1997 to 2000. The table below shows the approximate number of papers indexed each year from each sector and comments about their subject matter.

Sector	Number of Papers p.a.	Comments
Tertiary	3500	Form 66% of all NZ papers, all subject fields
CRI	1200	33% of CRI papers are in plant & animal sciences
Govt	650	73% are in clinical medicine
Private	550	43% are in clinical medicine

Collaboration

Some 76% of papers published in 1997-2001 were co-authored. Co-authored papers from 1997 received on average 6.7 citations each, whereas single author papers received on average 2.2 citations.

Internationally co-authored papers had the highest impact, averaging 7.6 citations per paper. Overall, 34% of papers were internationally co-authored in 1997-2001, rising from 30% in 1997 to 37% in 2001. New Zealand's increase in internationally co-authored papers is consistent with international trends.

Between 1997 and 2001, New Zealand collaborated with a total of 117 of the 191 countries represented in the United Nations.

All New Zealand research sectors had their highest degree of collaboration with overseas organisations, rather than with other New Zealand sectors. The table below shows the percentage of papers published by the tertiary and CRI sectors that had international, inter-sector and intra-sector collaborations.

Sector	2001	1996	1986
Tertiary	52%	59%	32%
CRI	66%	61%	35%

Most inter-sectoral collaboration was between the tertiary sector and other sectors. However, there was a low degree of collaboration between institutions within the tertiary sector. The health sector, when defined as hospitals and medical schools, showed a high degree of intra-sector collaboration.

The tertiary sector was the predominant overseas collaboration partner, accounting for 27% of New Zealand's overseas collaborations. CRIs accounted for 9% of overseas collaborations, health research for 7%, the government sector for 5%, and the private sector for 3%. (Note: 49% were between co -authors from outside New Zealand).

Contents

1. Introduction

Scientific and technical knowledge can be tacit (kept as personal knowledge or skills), or it can be codified in the form of publications, patents or blueprints. The measurement of a country's knowledge base is challenging, but bibliometrics is one means by which codified knowledge can be analysed.

Bibliometrics is the quantitative study of research publications. It can be used to gain an overall measure of a country's research output (number of publications)[1], to gain an overview of the subject distribution of a country's research effort, to estimate the impact of a country's publications by counting the citations to them, and to 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. An earlier bibliometric study of New Zealand research was conducted by Liu (*A bibliometric profile of the New Zealand science system*, 2001). This work focussed on New Zealand-authored publications for the years 1986 and 1996, examining how New Zealand's research output had changed in the 10 year period. The current study extends the analysis of Liu (2001), focussing on New Zealand's research publications for the years 1997-2001.

This report uses the Thomson-ISI New Zealand National Citation Report database, 1997-2001. This database contains entries for research publications published in the 5 year period 1997-2001, which have at least one New Zealand author address. Publications from 8730 internationally distributed journals in the fields of science, engineering, social science, arts, and humanities are indexed in this database. A total of 23,757 New Zealand-authored publications are contained within the database, representing many (although by no means all) of New Zealand-authored academic journal publications for 1997-2001.

The aim of this report is to show the size, impact and degree of collaboration in New Zealand's knowledge production. This is achieved by:

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

A detailed discussion of the methodology employed in this study, and the strengths and weaknesses of bibliometric analysis are described in detail in Appendices A.1 to A.11.

[1] See glossary. In this report, 'publications' and 'papers' are used to refer to the same collection of outputs.

2. Results

2.1 Papers Published

The number of New Zealand-authored research publications indexed in the ISI 1997-2001 National Citation Report database was 23,757 in total.

The output of New Zealand-authored publications has been steadily increasing since 1993, at a rate of approximately 4 % per year (Figure 1). It should be noted that this apparent increase in publications might in part result from more extensive ISI-indexing of New Zealand-authored papers in later years. In particular, the journals published by the Royal Society of New Zealand, which publishes approximately 6-7% of New Zealand-authored publications (Royal Society of New Zealand, Progress and Achievement Report 2003) were not indexed by ISI before 1994. Figure 1 shows an accordingly steep increase in New Zealand's publication output in 1994 as compared to 1993. However, New Zealand's publication output per year was already increasing steadily before 1993 (Husso *et al*, The State and Quality of Scientific Research in Finland, 2000), and it continued to increase steadily from 1995 onwards. Therefore, the increase in New Zealand's research output cannot be attributed solely to the inclusion of Royal Society journals in the Thomson-ISI database. It remains possible that the continuing increase in publication output since 1994 results from expanding ISI coverage of other journals that New Zealanders commonly publish in, however a detailed analysis of this was beyond the scope of the current study.

Figure 1 The number of New Zealand-authored publications has been steadily increasing since 1993. Data from Liu (2001), and Thomson-ISI Web of Science (1997-2001 data).

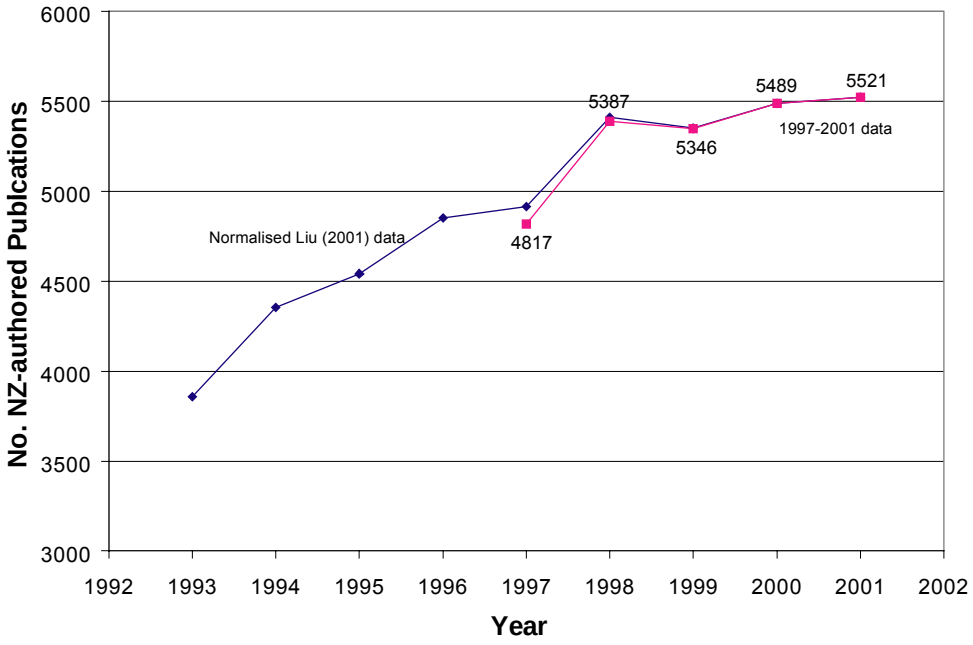


Figure 2 New Zealand has increased its share of world papers since 1993. Note that the data for 2003 is still incomplete, as the ISI database is continuously updated.

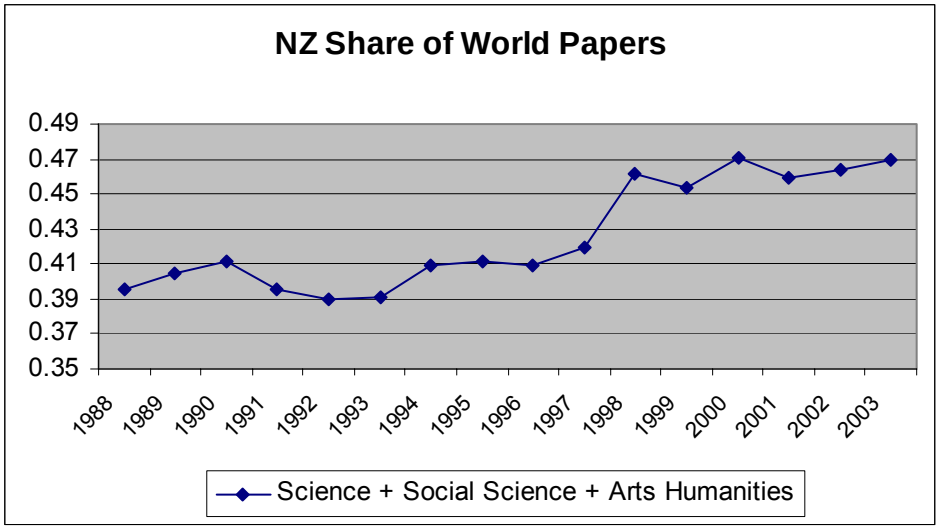
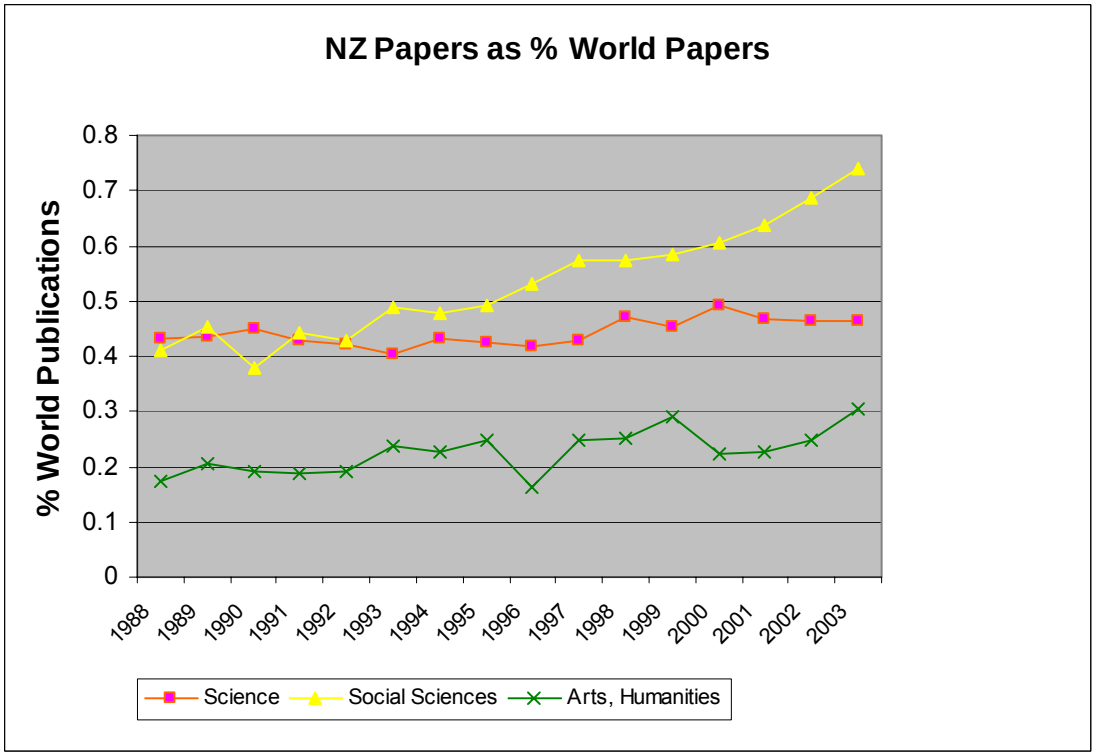


Figure 3 Total Science, Social Science and Humanities papers with a NZ author or co-author were extracted from the ISI Web of Science on 27-28 August 2003 and charted as a share of world publications in each area. The share of world publications has been increasing most steeply for NZ social science papers.

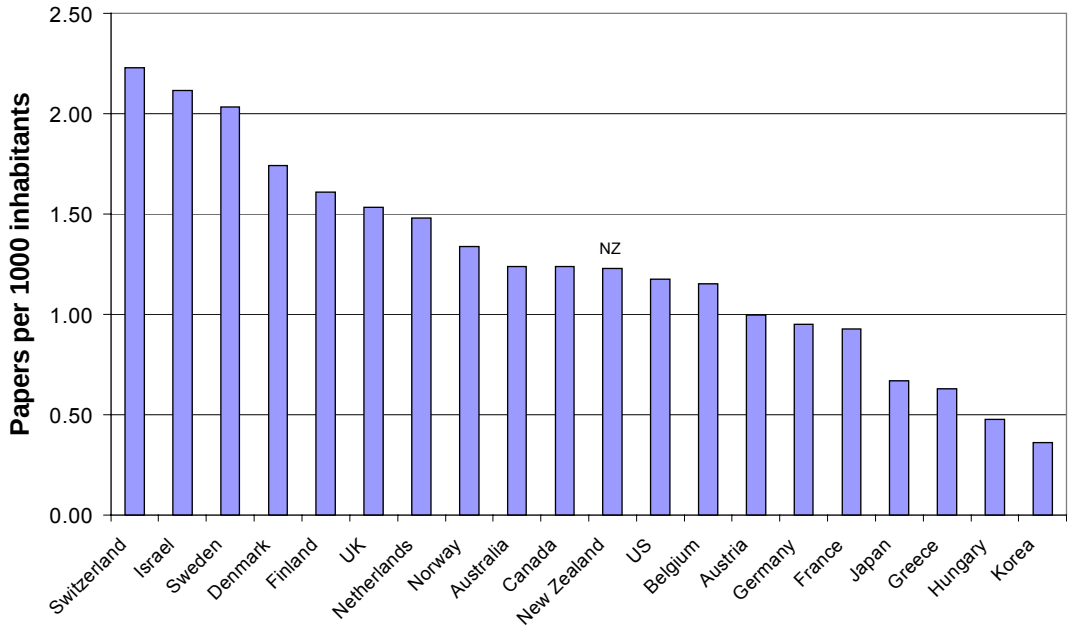


Scientific Productivity Per Capita

In terms of scientific productivity per capita New Zealand ranks 11th out of 20 countries, publishing a similar number of papers per capita to Australia, Canada and the United States (Figure 4). In 2001, New Zealand produced 1.2 journal articles per 1000 inhabitants.

Liu (2001) found that for the period covering 1995 to 1999, New Zealand ranked 7th in papers per capita produced by OECD countries. Liu (2001) did not include Israel, which is included in Figure 4.

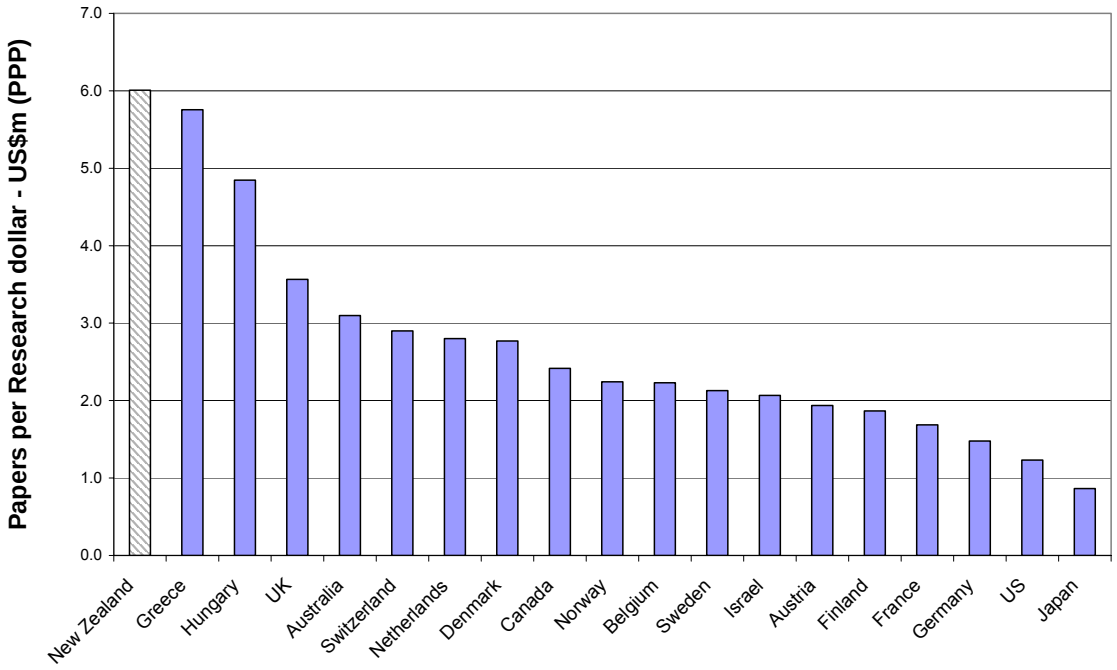
Figure 4 Scientific productivity per capita in 2001, as judged by the number of ISI-indexed publications per 1000 inhabitants. Data from OECD (www.oecd.org).



Scientific Productivity Per Research Investment

In 2001, New Zealand produced 6.0 ISI-indexed papers for every million dollars US of research investment. New Zealand's ranking adjusted for PPP places it first amongst the 19 countries shown in Figure 5; close in efficiency to Greece and Hungary. New Zealand's high ranking is an indication of its ability to produce publications from fewer resources than other countries.

Figure 5 Scientific productivity per research dollar spent, 2001. The method of calculation is outlined in Appendix A.1.

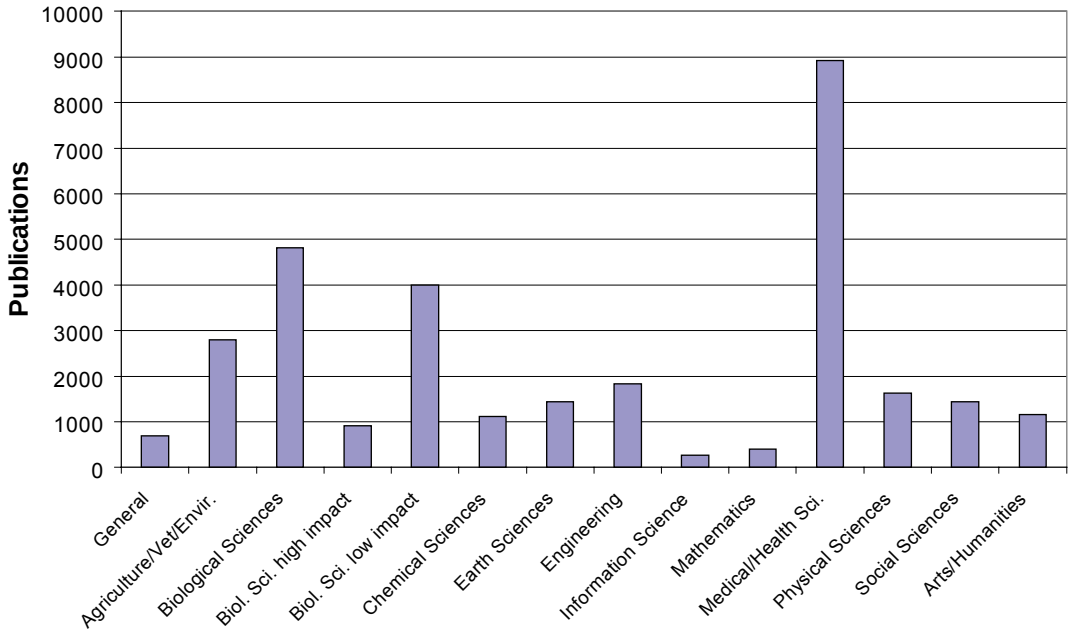


Subject Distribution

Figure 6 shows the distribution of 1997-2001 New Zealand publications by subject. Papers are categorised according to the Australian Standard Research Classification (ASRC) subject categories used by Butler (Monitoring Australia's Scientific Research, 2001) which are outlined in appendix A.2.1. The subject with the highest output is medical science, which published nearly 9000 papers in the 5 year period 1997-2001. Biological sciences is the next largest field, publishing approximately 4800 papers, most of which fall into the "low impact" category. High and low impact biological categories are differentiated on the basis of higher and lower citation rates; the high impact biological sciences primarily focus on research applicable to humans, while low impact biological sciences concentrate on plant, animal and microbial research. The subject fields in the high and low impact categories are shown in appendix A.2.1.

The distribution of New Zealand publications across ASRC subject categories is similar to that of Australian publications (Butler, 2001), with the exception of the increased proportion of agricultural science and clinical medicine publications in New Zealand. However, this difference may be due to differing journal coverage between the New Zealand and Australian analyses (L. Butler, personal communication concerning this report).

Figure 6 Subject distribution of New Zealand-authored research publications, 1997-2001. Subject categories are those defined by the Australian Standard Research Categories (ASRC) (Appendix A.2)



2.2 Citation Analysis

The following citation analysis, unless otherwise stated, is based on New Zealand-authored papers published and cited in the five-year period 1997–2001. The number of citations per paper varies according to the field of study, so in most instances papers are categorised into ASRC fields.

This study finds that for science and engineering papers published in 1997, the average number of citations was six (including one self citation), in the five year period 1997-2001.

International Impact of New Zealand Publications

Figure 7 shows that the field with the highest average citations per paper was high impact biological science, followed by physical sciences, chemical sciences, then medical sciences. This is roughly in-line with international trends where papers in some fields (e.g. arts and humanities) are less likely to be cited than papers in other fields due to differing publication behaviour and the smaller size of the field.

A comparative analysis of New Zealand's relative citation rates versus world means is presented in figure 8, and a comparison with Australia is presented in Table 1.

Figure 7 Average number of citations to New Zealand-authored papers by subject field (ARSC categories). Papers are both published and cited in the period 1997-2001. Error bars are derived following the procedure outlined in Appendix A.8.

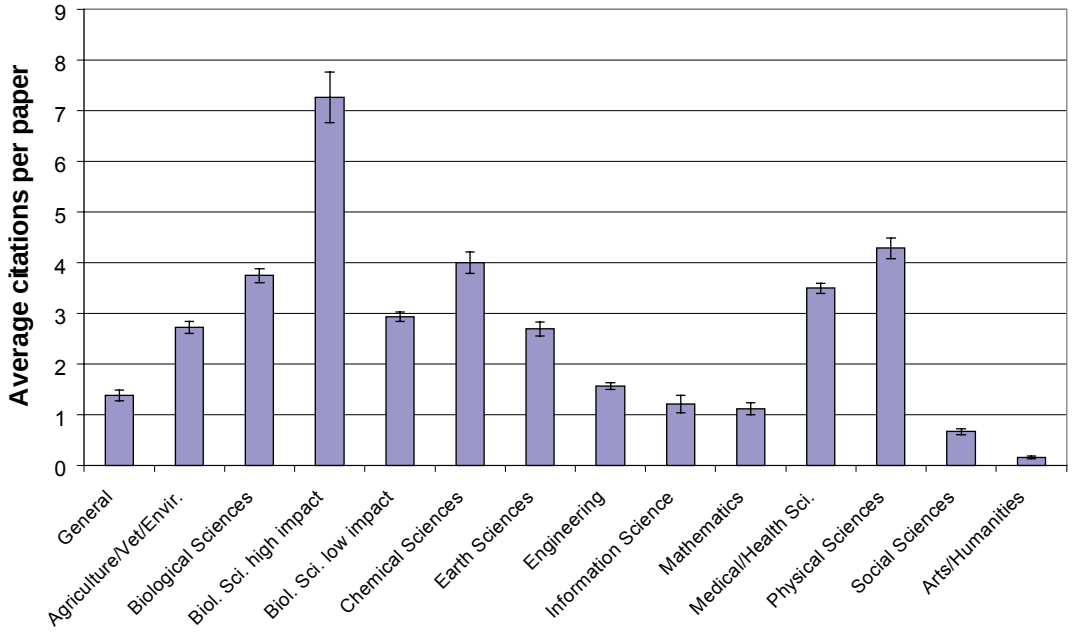


Figure 8 Relative international impact of New Zealand-authored papers in different subjects compared to world means. Papers published and cited in the period 1997-2001.
The relative international impact is calculated as:

$$\frac{\text{\# citations to NZ-authored papers}}{\text{\# NZ-authored papers}} \Big/ \frac{\text{\# citations to world total of papers}}{\text{total \# world papers}}$$

The world mean is by definition 1.0, and error bars are derived following the procedure outlined in Appendix A.8.

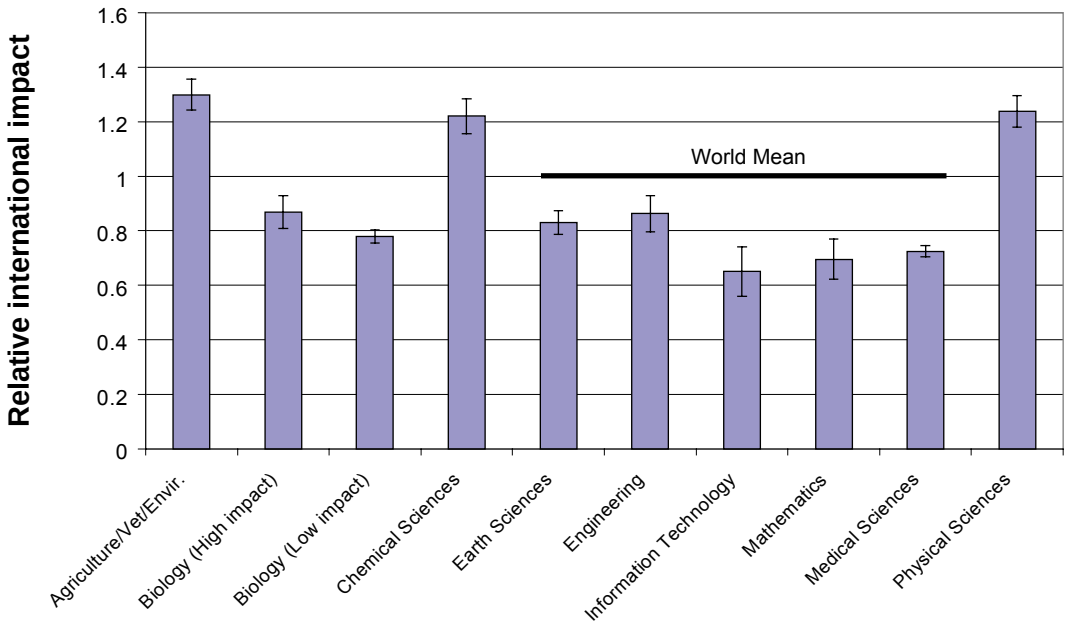


Table 1 New Zealand and Australian relative international impact by subject category.

Field	Australia*	NZ†	Error (NZ)
Agriculture/Vet/Envir	1.0	1.3	±0.057
Biological Sciences:			
high impact	0.85	0.869	±0.091
low impact	0.97	0.779	±0.032
Chemical Sciences	1.096	1.221	±0.064
Earth Sciences	1.0	0.831	±0.043
Engineering	1.1	0.864	±0.039
Information Science	0.79	0.651	±0.091
Mathematics	1.1	0.696	±0.075
Medical/Health Sci.	0.94	0.724	±0.02
Physical Sciences	1.06	1.239	±0.058

* Data from Butler, 2001.
† Relative international impact calculated as for Figure 8

Three subject areas had a relative international impact approximately 20% above the world mean. They were chemical and physical sciences and agricultural/veterinary/environmental sciences. All other areas had impacts below the world mean. The reasons for this comparatively low impact are currently unknown, and could be a topic of analysis for future bibliometric work.

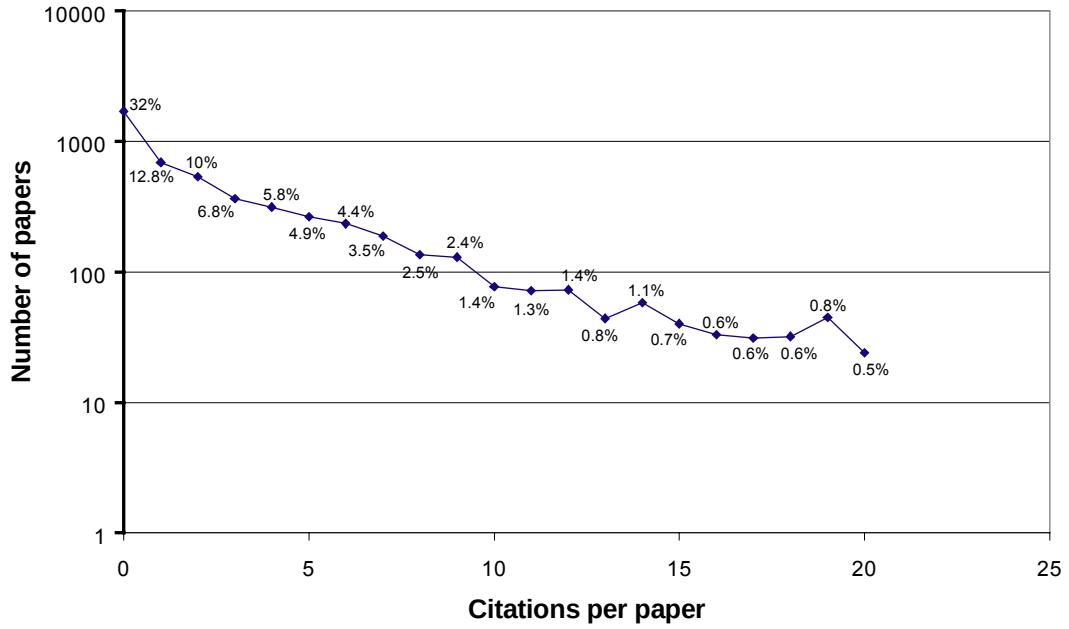
The scientific subject field with the lowest citation impact for both New Zealand and Australia is information technology. However, Butler (2001) reports that Thomson-ISI journal coverage is poor for this subject, and therefore citation results for information technology are questionable.

In terms of overall relative impact New Zealand is ranked 17th out of 27 countries (Husso et al. 2000), which is average (see A.1.1).

Citation Distribution

Citation distributions were skewed, with most papers receiving few citations, and a small proportion of papers receiving a large number of citations. Figure 9 shows the citation distribution for New Zealand-authored papers published in 1997 and cited in the five year period 1997-2001. 32% of papers received no citations, 35% of publications received between 1 and 4 citations, 15% received between 5 and 8 citations, 7% between 9 and 12 citations, 3% between 13 and 16 citations, 3% between 17 and 20 citations, and 5% received more than 20 citations.

Figure 9 Distribution of citations to New Zealand authored articles (articles published in 1997 and cited from 1997-2001).



Self Citations

Self-citations to New Zealand-authored papers appear to occur at the same frequency as self-citations from other countries. A randomised selection of New Zealand papers with 1,604 citations in total found that 310 of the citations were self-citations. From a carefully matched sample of international papers, 304 out of 1,600 citations were self-citations. Each paper in the international sample was from the same subject field as its New Zealand counterpart, had the same number of citations and the first surname letter for the author. Therefore, both internationally and in New Zealand, a 19 % self-citation rate is apparent.

2.3 Sector Analysis

For the purposes of undertaking a comparative analysis of the sectors within the research, science and technology system, all publications have been classified under the following sectors: tertiary; Crown Research Institutes (CRIs); government; local and regional bodies; private sector; and health research.

Definition of Sectors

This comparative sector analysis focuses on publications recorded in the Thomson-ISI National Citation Report database for the years 1997 and 2001.

The Tertiary Sector

The tertiary sector includes all publications with addresses 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 (see Appendix A.16 for a list of the nine CRIs).

The Government Sector

The government sector includes the Reserve Bank, Treasury and all other government departments. It also includes hospitals (see Appendix A.14 for a list 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 (see Appendix A.15 for a list of local government entities from whom publications were listed in the National Citation Report database). Te Papa Museum has been included within the government sector rather than the local government sector as 70 % 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 private.

Health Research

Liu (2001) defined the health sector as all publications with hospital addresses. The definition of the health sector in this report differs in that it encompasses additional health research institutions, as well as including papers on health topics that are published by institutions other than those classified as health research institutions.

Institutions classified under health research are:

- government and private health service providers, including hospitals
- university medical schools
- the Ministry of Health
- private medical research institutes
- health and medical advocacy associations.

Also incorporated into the health research sector were any further papers in the ASRC medical and health sciences subject category published by institutions other than those classified (as above) under health.

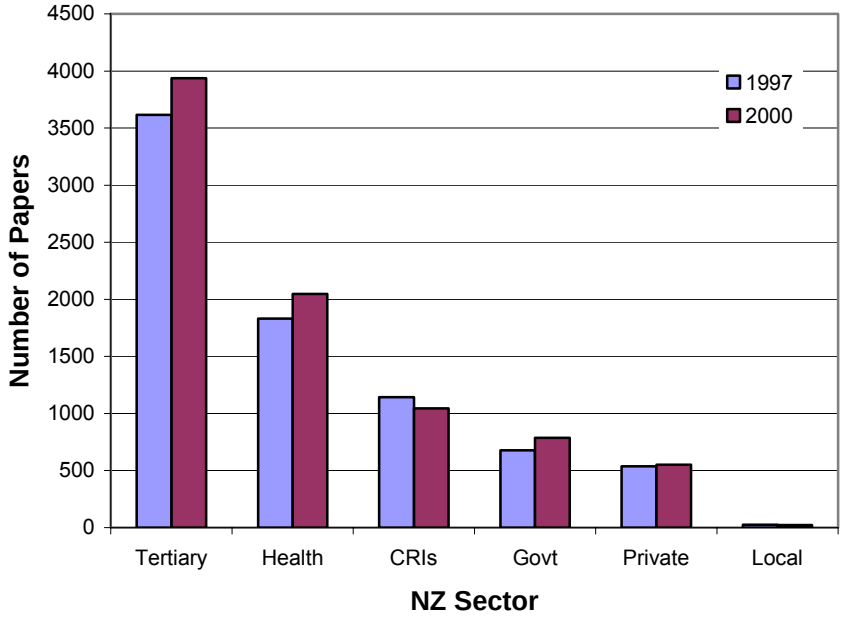
A degree of overlap exists between the sectors, and therefore publications that fall within two sectors or more are effectively counted more than once. For example, a publication that is co-authored by researchers from the tertiary and the CRI sectors has been assigned to both sectors. This should be taken into consideration when comparing sectors as the sum of publications from all sectors will add up to more than the total number of New Zealand publications.

2.4 Sector Performance

This report compares different sectors' publication outputs and citation rates. The latter are used as a measure of publication impact.

Figure 10 shows that the tertiary sector achieves the greatest output in terms of number of ISI-indexed publications, followed by health research, CRIs, the government sector, the private sector and the local government sector. A comparison of the years 1997 and 2000 shows that all sectors, with the exception of CRIs, appear to have increased their publication output. Year 2001 data was not used as it is subject to an indexing lag.

Figure 10 Change in the number of papers produced by sector, 1997-2000.



The impact of publications from the different sectors and the actual versus expected citation rates for papers published in 1997 are presented in Table 2. Health research has the highest citation rate per paper (7.5), followed by the private sector (6.4), the tertiary sector (6.1), then CRIs (5.9). Citation rates vary between research fields (see Figure 6), and thus variation in the citation rates between sectors may to a large extent reflect differing subject output. It should also be noted that the relatively high citation rate for the private sector is due to this sector's high number of review articles.

Actual versus expected citation rates are used to partially control for differences in sectors' subject output, by calculating whether the citations to a sector's publications were more or less numerous than expected for the journals in which a sector has published. For 1997 papers higher than expected citation rates were observed for the CRI sector, and for health research. It should be noted, however, that the expected citation rates for different journals vary within as well as between fields, and the fact that the tertiary, government, private and local government sectors have not received significantly more citations than expected should not be seen as problematic. These papers have simply received, on average, approximately the same number of citations as expected for the journals in which they were published. A paper published in a high impact journal such as *Nature*, may receive equal to or less than the journal's expected number of citations, but still be a high impact publication.

Table 2 Sectoral comparisons of citations per paper.

Sector	Citations/paper†	Actual / Expected‡
Tertiary	6.07	1.027
CRIs	5.92	1.13*
Health	7.54	1.12*
Government	5.66	1.08
Private	6.43	1.063
Local	2.22	0.59∫

† For papers published in 1997 and cited in the period 1997-2001

‡ This is the ratio of average citations per paper to average citations per paper expected for the journals in which the papers were published. A value of 1 indicates that the number of citations received equalled the number expected, >1 indicates that a higher than expected number of citations were received, and <1 indicates that fewer citations than expected were received.

* Significant difference between actual and expected values (significance calculated as outlined in Appendix A.8). For numbers that are not marked with an asterisk, the difference is not significant enough to conclude that a real difference between the observed and expected values exists.

∫ Error is very large due to the small sample size.

2.5 Sector Outputs

The following analysis shows the distribution of each sector's publications across fields of research (see Appendix A.2 for tables of subject fields by sector).

As a result of the Thomson-ISI assignment of more than one subject field to a publication, the sum of publications from all fields will add up to more than the total number of publications from that sector.

Note also that publications falling under the category of 'multidisciplinary' are in fact not multidisciplinary papers, but instead 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 ISI into individual subject fields, but ISI do not do this for papers from some of the less well known multidisciplinary journals. The reclassification of papers from the multidisciplinary category was outside the scope of this study.

The Tertiary Sector

ISI indexes approximately 3,500 publications each year from the tertiary sector. This represents about two thirds of New Zealand-authored publications. Figure 11 and Table 3 show the distribution of these papers across subject fields for the years 1986, 1996, and 2001. Clinical medicine is the largest single category, representing 22% of all tertiary publications in 1996 and 2001. Out of the 24 subject categories, the top five in terms of output are: clinical medicine; plant & animal science; chemistry; social sciences; and biology & biochemistry.

Between 1996 and 2001 there appears to have been little change in the subject distribution of tertiary papers. Almost all subjects are seen to have increased their percentage share in 2001 as compared to 1996. This may be due to more frequent assignation of multiple subject areas to papers by ISI. Since 1986, there has been a drop in the percentage share of clinical medicine and psychology/psychiatry papers produced by the tertiary sector.

The average number of citations to tertiary papers published in 1997 and cited in the period 1997-2001 was 6.1. This shows a gradual increase from 1996 (5.8 citations per paper) and 1986 (4.2 citations per paper).

Figure 11 Tertiary papers by subject, 1986, 1996, and 2001. 1986 and 1996 data are from Liu (2001). Papers are categorised into Thomson-ISI subject fields as outlined in Appendix A.5.

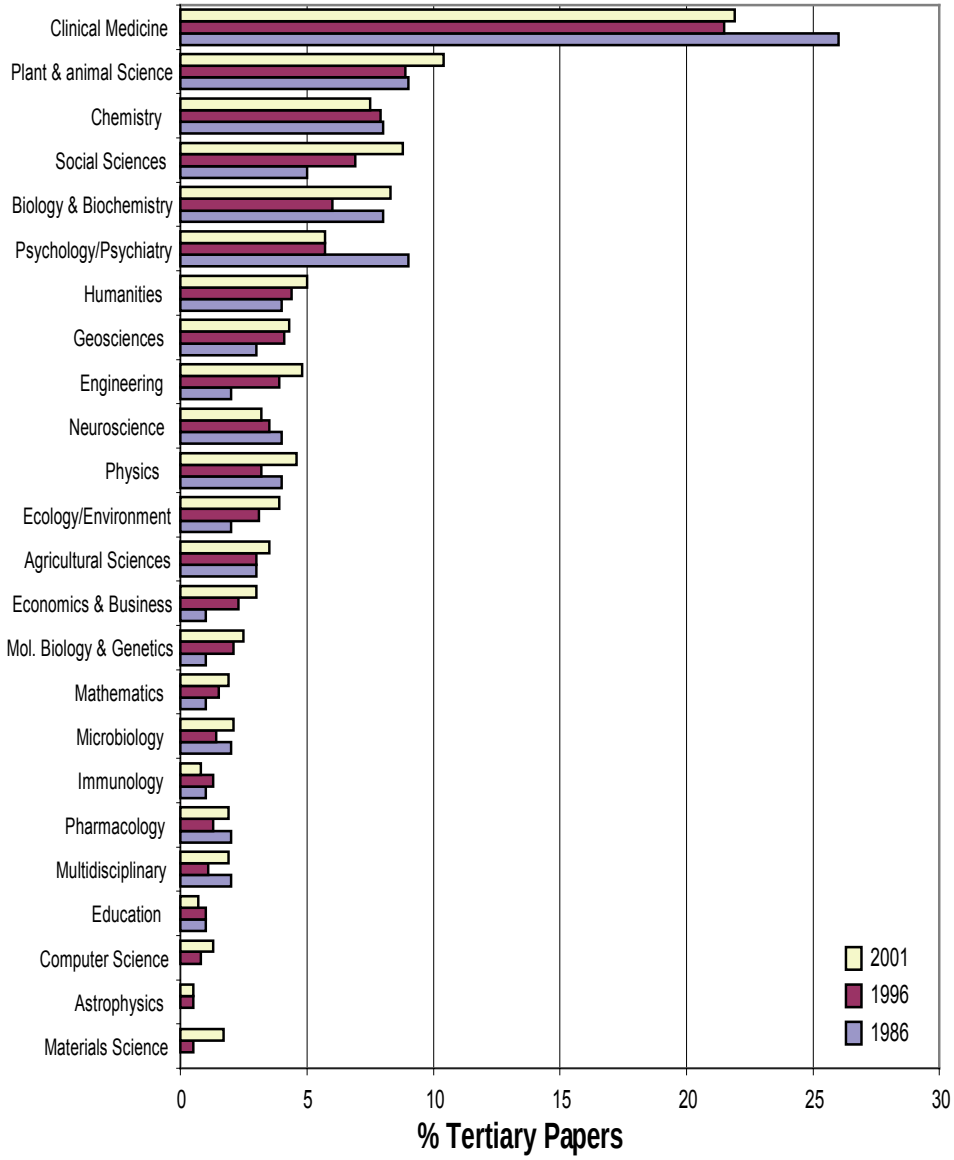


Table 3 Change in the subject distribution of tertiary sector papers over time

	2001	1996*		1986*	
FIELD	**%**	**Papers**	**%**	**Papers**	**%**
Clinical Medicine	*21.9*	720	*21.5*	577	*26*
Plant & Animal Science	*10.4*	299	*8.9*	197	*9*
Chemistry	*7.5*	264	*7.9*	175	*8*
Social Sciences	*8.8*	231	*6.9*	111	*5*
Biology & Biochemistry	*8.3*	202	*6.0*	172	*8*
Psychology/Psychiatry	*5.7*	190	*5.7*	198	*9*
Humanities	*5.0*	148	*4.4*	77	*4*
Geosciences	*4.3*	137	*4.1*	59	*3*
Engineering	*4.8*	130	*3.9*	35	*2*
Neuroscience	*3.2*	117	*3.5*	79	*4*
Physics	*4.6*	106	*3.2*	79	*4*
Ecology/Environment	*3.9*	105	*3.1*	33	*2*
Agricultural Sciences	*3.5*	102	*3.0*	60	*3*
Economics & Business	*3.0*	78	*2.3*	15	*1*
Mol. Biology & Genetics	*2.5*	71	*2.1*	27	*1*
Mathematics	*1.9*	49	*1.5*	24	*1*
Microbiology	*2.1*	47	*1.4*	48	*2*
Immunology	*0.8*	42	*1.3*	12	*1*
Pharmacology	*1.9*	42	*1.3*	40	*2*
Multidisciplinary	*1.9*	38	*1.1*	38	*2*
Education	*0.7*	33	*1.0*	18	*1*
Computer Science	*1.3*	27	*0.8*	7	*0*
Astrophysics	*0.5*	18	*0.5*	9	*0*
Materials Science	*1.7*	18	*0.5*	7	*0*

* Data from Liu (2001)
Percentages for 2001 may sum to more than 100% as some papers were allocated by ISI to more than one subject field.

Crown Research Institutes

ISI indexes approximately 1,200 publications each year from the CRI sector. Figure 13 and Table 4 show the distribution of these papers by subject field for the years 1986, 1996, and 2001. Approximately one third of CRI publications fall within the plant & animal science subject field. The number of papers produced in the fields of geosciences, plant & animal sciences and ecology/environment appear to be increasing, while papers within the agricultural science field have decreased between 1986 and 1996 by about 10 %.

The average citation rate per paper for the CRI sector was 5.9 for papers published in 1997 and cited in the period 1997-2001. This showed an increase from 1996 (5.1 citations per paper) and 1986 (4.4 citations per paper).

Figure 13 CRI papers by subject, 1986, 1996, and 2001. Only the major subject categories that were identified by Liu (2001) are given. 1986 and 1996 data are from Liu (2001). Papers are categorised into Thomson-ISI subject fields as outlined in Appendix A.5

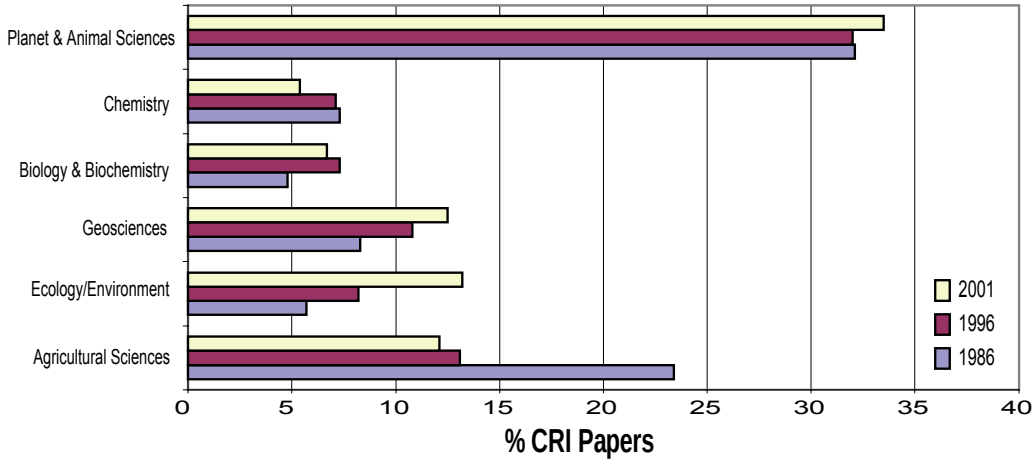


Table 4 Change in the subject distribution of CRI papers over time

	2001	1996*	1986*
FIELD	**%**	**%**	**%**
Plant & Animal Science	33.5	32.0	32.1
Chemistry	5.4	7.1	7.3
Biology & Biochemistry	6.7	7.3	4.8
Geosciences	12.5	10.8	8.3
Ecology/Environment	13.2	8.2	5.7
Agricultural Sciences	12.1	13.1	23.4

* Data from Liu (2001)

The Government Sector

ISI indexes approximately 650 publications each year from the government sector. 73 % of these papers are within the field of clinical medicine and are attributable to the inclusion of hospitals within this sector. Table 5 shows the distribution of government sector papers by subject field for papers published in 1997 and 2001.

The average citation rate per paper for the government sector was 5.7 for papers published in 1997 and cited in the period 1997-2001.

Table 5 Change in the subject distribution of Government sector papers over time

	2001	1997	
FIELD	***%***	**Papers**	***%***
Clinical Medicine	*70.0*	495	*73.0*
Plant & Animal Science	*6.3*	43	*6.4*
Chemistry	*0.5*	20	*3.0*
Social Sciences	*4.1*	29	*4.3*
Ecology/Environment	*3.5*	9	*1.3*
Biology & Biochemistry	*2.7*	27	*4.0*
Psychology/Psychiatry	*3.5*	22	*3.3*
Humanities	*0.9*	9	*1.3*
Geosciences	*0.5*	5	*0.7*
Neuroscience	*1.9*	21	*3.1*
Physics	*0.3*	1	*0.1*
Agricultural Sciences	*0.5*	9	*1.3*
Mol. Biology & Genetics	*1.4*	12	*1.8*
Microbiology	*0.9*	3	*0.4*
Immunology	*0.6*	4	*0.6*
Pharmacology	*1.1*	11	*1.6*

The Local Government Sector

The number of papers published by the local government sector was very small (approximately 25 ISI-indexed publications per year), so results are likely to vary widely across years. In 1997, the majority of local government papers were published in the fields of ecology/environment (11 papers) and plant & animal science (6 papers). The average citation rate per paper for the local government sector was 2.2 for papers published in 1997 and cited in the period 1997-2001, but this is subject to considerable statistical error due to the small sample size.

The Private Sector

ISI indexes approximately 550 publications each year from the private sector. A large number of these publications are reviews, which have increased the average citation rate of the papers within the sector. 43 % of these papers are within the field of clinical medicine, with the plant & animal science and pharmacology fields each comprising 15 % of publications. 11 % of papers fall within the agricultural sciences field. Table 6 shows the subject distribution of 2001 private sector papers.

The average citation rate per paper for the private sector was 6.43 for papers published in 1997 and cited in the period 1997-2001.

Table 6 Subject distribution of private sector papers, 2001.

	2001
FIELD	**%**
Clinical Medicine	43.0
Plant & Animal Science	15.0
Pharmacology	15.0
Agricultural Sciences	11.0
Geosciences	4.4
Engineering	4.0
Chemistry	3.2
Biology & Biochemistry	2.5
Astrophysics	0.8

Health Research

The health research analysis does not include a comparison with Liu (2001) due to the different definition that has been used to define the sector in this report. Under a subject-based definition of health research (the ASRC medical science category), 1,675 ISI-indexed health research papers were published in 2001. This represents 35% of New Zealand's 2001 publications.

The average citation rate per paper for health research was 7.5 for papers published in 1997 and cited in the period 1997-2001.

The effectiveness of the Thomson-ISI and ASRC subject classifications in identifying health research within New Zealand was evaluated by manually examining all 2001 papers (regardless of their ISI- or ASRC-assigned field of study) for health-related content. This allowed the attribution of papers within the 'multidisciplinary' and 'general' journal categories, as well as those in non-health subject fields. In total, 1,983 health-related papers were identified in this way, representing 41.5 % of the New Zealand publications for 2001.

This analysis was not undertaken for other areas of research, but it is likely that a similar analysis of other subject areas would identify an increase in the proportion of papers attributable to each subject.

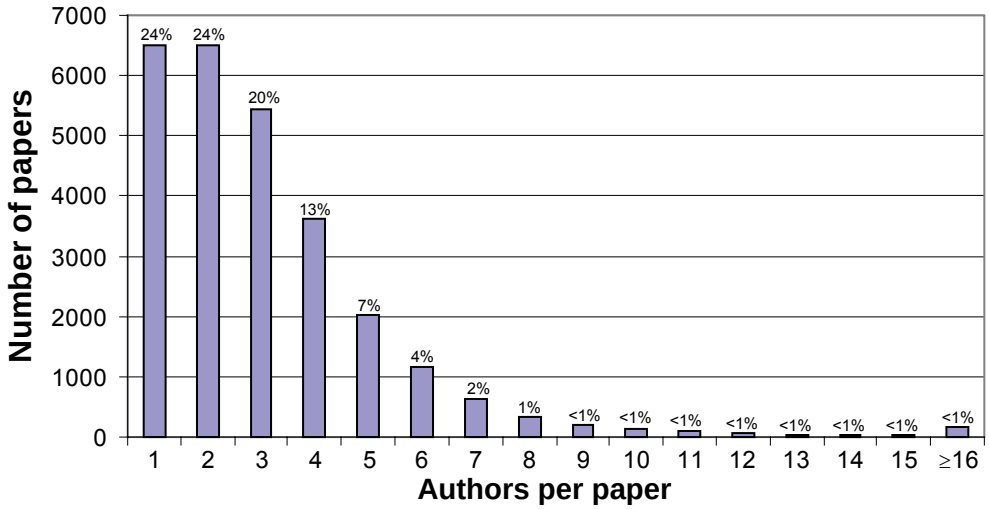
2.6 Collaboration

Papers in the 1997-2001 National Citation report were examined for co-authorship, international, and inter-sectoral collaborations.

Multiple Authorships

The majority of New Zealand papers published in 1997-2001 were co-authored, accounting for 76% of the ISI-indexed papers. Figure 14 shows the distribution of papers by author number.

Figure 14 Multiple authorships of New Zealand papers, 1997-2001. Single authorships account for 24% of the ISI-indexed papers.



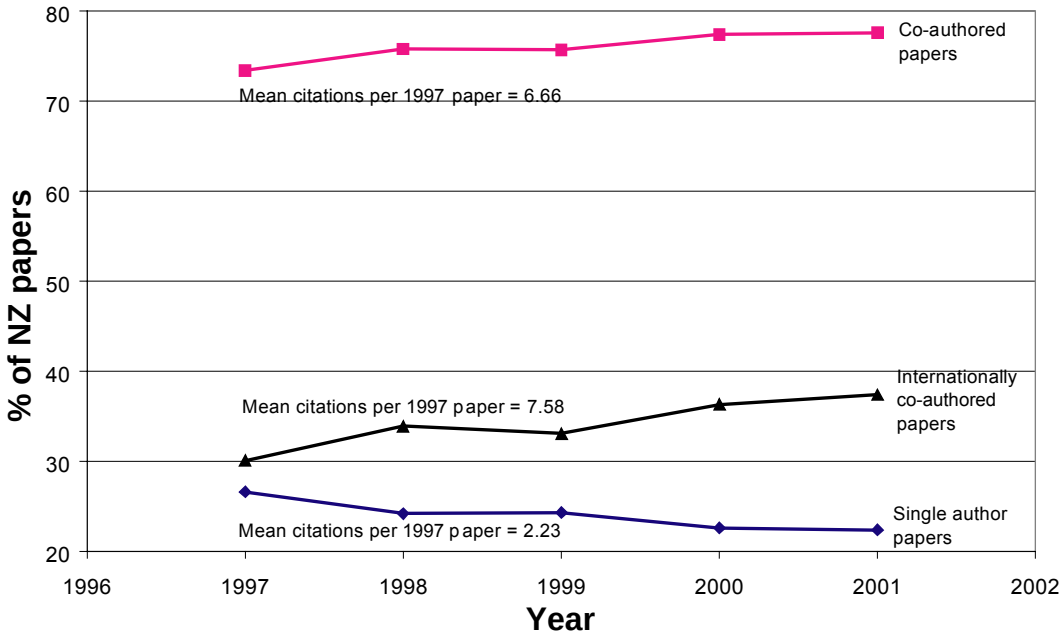
Collaborations and Citations

Co-authored papers from 1997 received on average 6.7 citations each, whereas single author papers received on average 2.2 citations. Internationally co-authored papers had the highest impact, averaging 7.6 citations per paper.

Trends in Collaboration

The percentage of New Zealand co-authored and internationally collaborative papers rose during the period 1997-2001, and a corresponding drop in the percentage of single author papers was seen. Particularly notable is the approximately 25% increase in internationally co-authored papers during this time (Figure 15), from 30.3% in 1997, to 37.6% in 2001. Overall, 34% of papers were internationally co-authored from 1997 to 2001.

Figure 15 Change in percentage of collaborative papers, 1997-2001. The mean citations per paper for single author papers, co-authored papers, and internationally co-authored papers are also given. The percentage of co-authored papers rose by approximately 7% in the period 1997-2001, and the proportion of internationally collaborative papers increased by approx. 25%.



New Zealand's increase in internationally co-authored papers is in accordance with international trends. As shown in Figure 16, the majority of countries increased their percentage of internationally co-authored papers between 1986 and 1999, and New Zealand's number of internationally collaborative papers increased by approx 95% during this period. This was the 12th highest increase among the 27 countries shown in Figure 16, and is comparable to increases for Spain, South Africa, Canada and the United Kingdom.

As illustrated by Figure 17, the number of different countries collaborating with New Zealand has also increased since 1986. In the three year period 1986-1988, New Zealand collaborated with 57 different countries, whereas in the three year period 1999-2001, New Zealand collaborated with 91 different countries. In the entire five year period covered by this study, 1997-2001, New Zealand collaborated with a total of 117 different countries, a majority of the 191 countries represented in the United Nations.

Liu (2001) found that the majority of New Zealand's international collaborations were with the English speaking countries U.S.A., Australia, U.K. and Canada (these comprised 87% of New Zealand's collaborations in 1995-1997, and 89% in 1986-1988). The present study found no change in the period 1997-2001: 87% of collaborations were with U.S.A., Australia, the U.K. or Canada (Table 7).

Figure 16 Percentage of international collaboration in 27 countries, and percentage of change in internationally collaborative papers 1986-1999. New Zealand's percentage of internationally collaborative papers in 1999 was similar to Spain, South Africa, Canada and the United Kingdom, and out of the 27 countries New Zealand had the 12th highest rise in percentage of international collaborations 1986-1999. Data from National Science Foundation (2002).

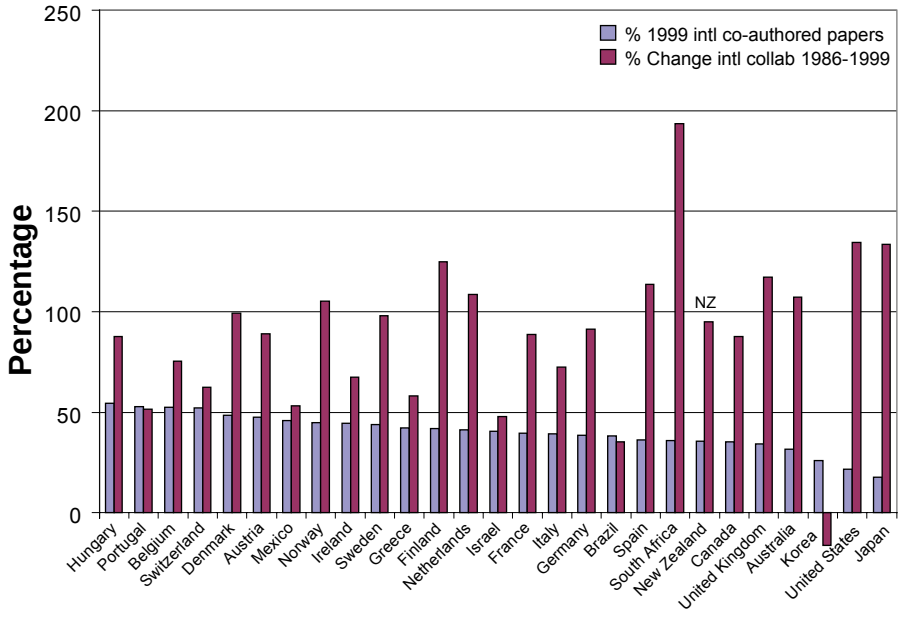


Figure 17 Increase in the number of countries collaborating with New Zealand, 1986-2001. Bars show the number of countries that collaborating authors were from, for papers published in the 3 year period indicated. 1986-1988 and 1995-1997 data from Liu (2001).

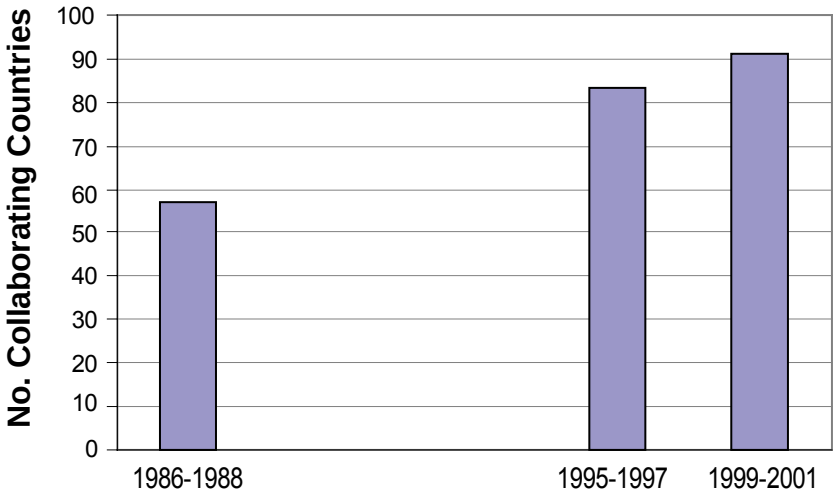


Table 7 Percentage of New Zealand's international collaborations with various countries.

Country*	1997-2001	1995-1997†	1986-1988†
U.S.	33.2%	36.7%	37.7%
Australia	24.0%	22.1%	23.8%
U.K.	21.0%	19.3%	19.5%
Canada	8.4%	9.2%	8.4%
Other	13.4%	12.7%	10.6%

* Countries with whom the percentage of collaboration was less than 9% in 1995-1997 are not shown.

† Data from National Science Foundation (2000)

Collaborations by Field

Co-authorship is more common in the scientific, engineering and medical fields than in social sciences, arts and humanities. For most fields, internationally co-authored papers made up approximately 45% to 55% of the total number of papers in 1997-2001, but international collaboration was less common in the fields of agriculture, biology (excluding biomedical research), clinical medicine, psychology, social sciences, and arts and humanities. The percentage of internationally collaborative papers has increased across all fields since 1986-1988, with the possible exception of agriculture and arts and humanities, for which earlier data is not available (Table 8).

Table 8 Co-authorships and internationally co-authored articles by field.

	% co-authored*	% Internationally co-authored†		
FIELD	1997-2001	1997-2001	1995-1997‡	1986-1988‡
Agriculture	90.6	26.0		
Physics	87.8	55.9	50.7	29.7
Chemistry	92.0	43.8	40.9	32.9
Earth Sci.	89.6	48.8	46.6	30.3
Mathematics	73.3	57.3	56.9	43.4
Biology	91.6	37.8	25.4	14.6
Biomed.Res.	96.8	50.2	39.4	28.4
Clin. Med.	91.4	30.6	27.0	15.1
Engineering	87.4	46.3	34.8	25.3
Psychology	69.0	33.1	29.3	16.0
Social Sci.	39.4	27.7	25.3	20.8
Arts/ Hum.	6.6	4.7		

* % of papers in the field that are co-authored

† % of papers in the field that have international co-authors.

‡ Data from NSF (2000). Missing data is not reported in National Science Foundation (2000).

Collaborations by Sector

In the following section, with the exception of the health sector analysis, sectors are defined as outlined in section 2.3. In addition to international and inter-sectoral collaboration, collaboration between different institutions within each sector is examined. For example, collaboration between two different Crown Research Institutes is classed as collaboration within the CRI sector.

Tertiary Collaborations

In 2001, 52% of tertiary sector papers were the result of international collaborations, collaborations with other sectors, or collaborations with other tertiary institutions. This indicates a decrease from the 59% reported for 1996 publications, but it remains a significant increase from 32% in 1986 (Liu, 2001).

More than 70% of tertiary collaborations were with co-authors from overseas (Figure 18). No other sector had such a high degree of international collaboration. The percentage of collaborations between tertiary institutes was around 5%, which is low in comparison to other sector's collaborations with the tertiary sector. This suggests that there was relatively little intra-sector collaboration, although it should be noted that this analysis did not record collaborations between different departments within a tertiary institute.

CRI Collaborations

In 2001, 66% of Crown Research Institute papers resulted from international collaborations, collaborations with other sectors, or collaborations with other CRIs. This is an increase on the 61% for 1996 publications and 35% for 1986 publications reported by Liu (2001).

The majority (62%) of CRI collaborations were with co-authors from overseas, and 22% of collaborations were with the tertiary sector (Figure 18).

Government Sector Collaborations

In 2001, 67% of government sector papers resulted from international collaborations, collaborations with other sectors, or collaborations with other government sector organisations.

Similar to the pattern of collaboration for CRIs, the majority of government collaborations were with overseas co-authors with the tertiary sector representing the next most frequent class of collaboration. The percentage of international collaborations was 50%, lower than the percentage for CRIs. At 14% there appears to have been a relatively high proportion of within-government collaboration compared to other sectors' collaboration with this sector (Figure 18).

Local Sector Collaborations

In 2001, 85% (17 of 20) papers published by the local sector resulted from international collaborations, collaborations with other sectors, or collaborations with other local sector organisations. However, this result is based on a small total number of publications, so it is likely to vary widely across publication years.

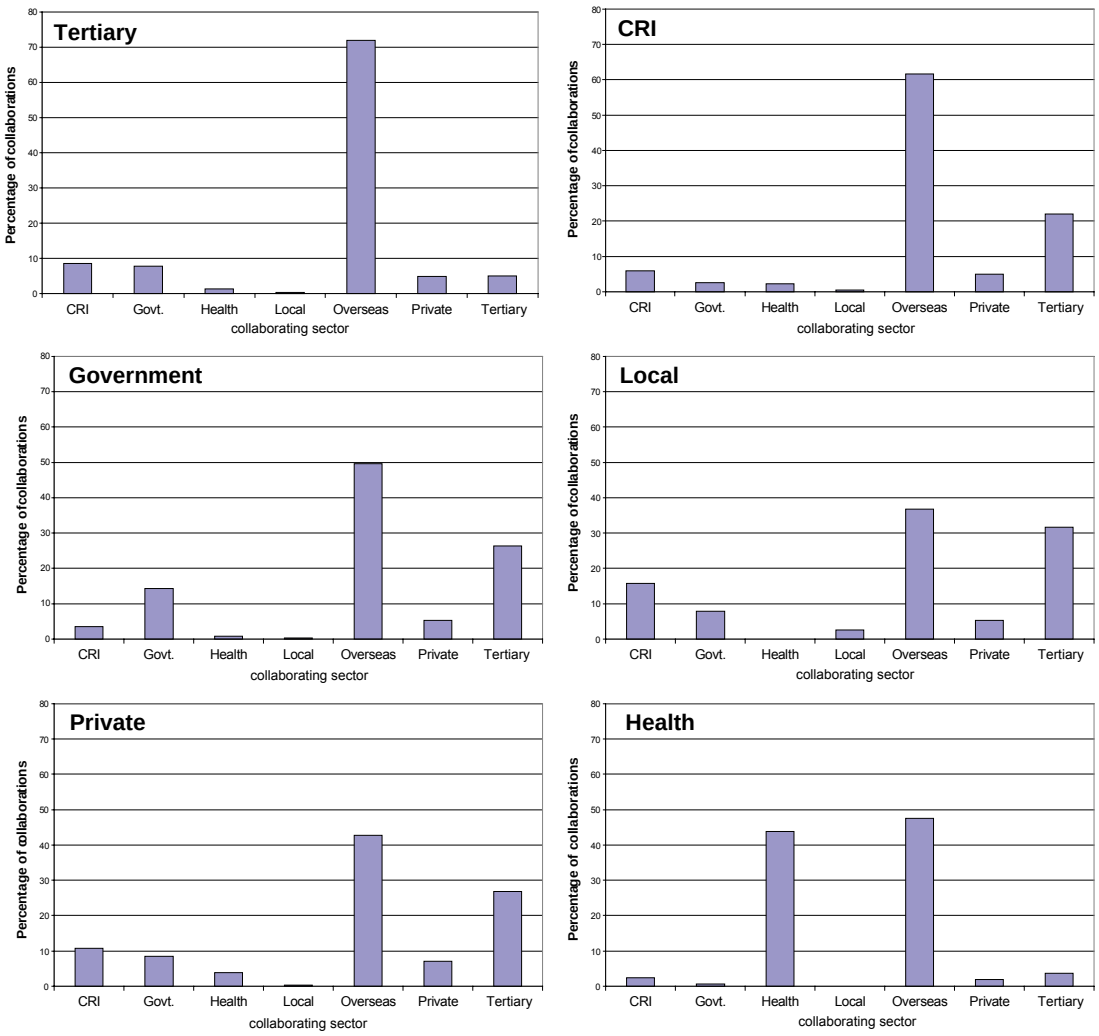
The majority of local sector collaborations were with overseas or tertiary organisations, and 16% were with CRIs (Figure 18).

Private Sector Collaborations

In 2001, 55% of private sector papers resulted from international collaborations, collaborations with other sectors, or collaborations with other private sector organisations.

The largest class of private sector collaborations (43%) was with overseas co-authors, and a further 27% and 11% of collaborations were with the tertiary and CRI sectors respectively (Figure 18).

Figure 18 Collaborations by sector, 2001. Each graph shows the percentage of a sector's collaborations with other sectors and internationally. Every collaboration has been counted individually, for example if one paper has two collaborations with a particular sector such as overseas, this is counted as two international collaborations. The composition of sectors in the Health graph differs from that in the other graphs; see health sector collaborations for details.



Health Sector Collaborations

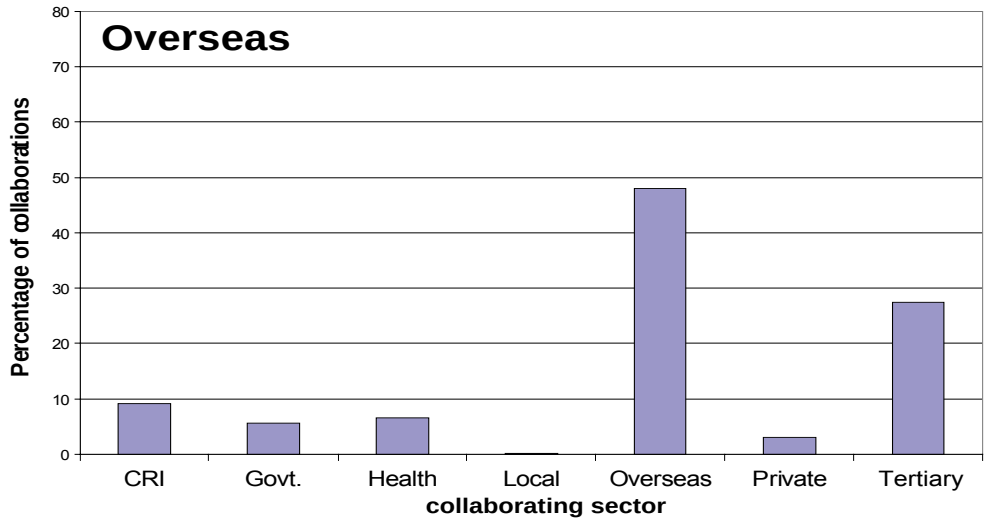
In Figure 18, the health sector is comprised of New Zealand hospitals and medical schools.

The largest proportion of collaborations for the health sector (48%) was with international co-authors. However, there was also a high degree of intra-sector collaboration, 44% of collaborations were between two institutions within the health sector. A lack of collaboration with the tertiary and government sectors can be explained by a difference in the way these sectors were defined for the health sector analysis as compared to the analysis of other sectors. For the health sector analysis only, hospitals were removed from the government sector and medical schools were removed from the tertiary sector. Overall there appears to have been comparatively little collaboration between health sector institutions and New Zealand institutions outside of the health sector, i.e. those that are not medical schools or hospitals.

Overseas Collaborations with Each Sector

Figure 19 shows the percentage of New Zealand's international collaborations that are attributable to different sectors. With the exception of the large percentage of international collaborations with other international organisations, the tertiary sector is the predominant international collaboration partner, accounting for 27% of New Zealand's international collaborations. Crown Research Institutes account for 9% of international collaborations, health research for 7%, the government sector for 5%, and the private sector for 3%.

Figure 19 The percentage of New Zealand's overseas collaborations that are with different sectors or with other overseas organisations in 2001. Papers in the ISI NZ National Citation Report database that had overseas co-authors were extracted, and the percentage of their collaborations with each New Zealand sector and between overseas entities was calculated. As in Figure 18, every collaboration is counted individually.



Appendices

A.1 How published papers per research dollar were calculated

Country	Papers	GDP in US$m PPP	R&D as % GDP	R&D Spending in US$m PPP	Papers/ US$m PPP
US	327,202	9,762,100	2.72	265,529	1.23
Japan	85,025	3,301,436	2.98	98,383	0.86
Germany	79,001	2,148,300	2.49	53,493	1.48
France	55,340	1,504,744	2.18	32,803	1.69
Italy	N/A	1,449,521	1.07	15,510	N/A
UK	91,489	1,387,353	1.85	25,666	3.56
Canada	39,119	865,544	1.87	16,186	2.42
Australia	23,969	505,552	1.53	7,735	3.10
Netherlands	23,643	434,928	1.94	8,438	2.80
Belgium	11,812	270,413	1.96	5,300	2.23
Sweden	18,045	232,072	3.65	8,471	2.13
Austria	8,116	227,659	1.84	4,189	1.94
Switzerland	16,223	212,767	2.63	5,596	2.90
Greece	6,689	173,431	0.67	1,162	5.76
Norway	6,018	162,762	1.65	2,686	2.24
Denmark	9,315	153,497	2.19	3,362	2.77
Finland	8,330	131,247	3.40	4,462	1.87
Israel	12,547	128,393	4.73	6,073	2.07
Ireland	N/A	107,462	1.15	1,236	N/A
New Zealand	4,690	78,044	1.00	780	6.01

Table A.1 Basic data for productivity calculations. Papers (scientific only) were from ISI Web of Science (2001). Shaded cells are extrapolations from prior years. Other data were taken from 'Main Science and Technology Indicators 2003/1, OECD' and is for 2000 (the latest year for which data was available for most countries). PPP is Purchasing Power Parity, tabulated in $US per person, i.e. the national per capita income on the basis of internationally comparable purchasing power. The New Zealand research and development % figure is taken from the 'Research and Development in New Zealand 2002' survey report.

Note that data on papers for Ireland and Italy was not available but the other data is included for completeness. It is likely that the inclusion of this data would not affect the rankings shown above.

The two rightmost columns were calculated from the other three.

A.1.1 Relative Impact Compared with Investment

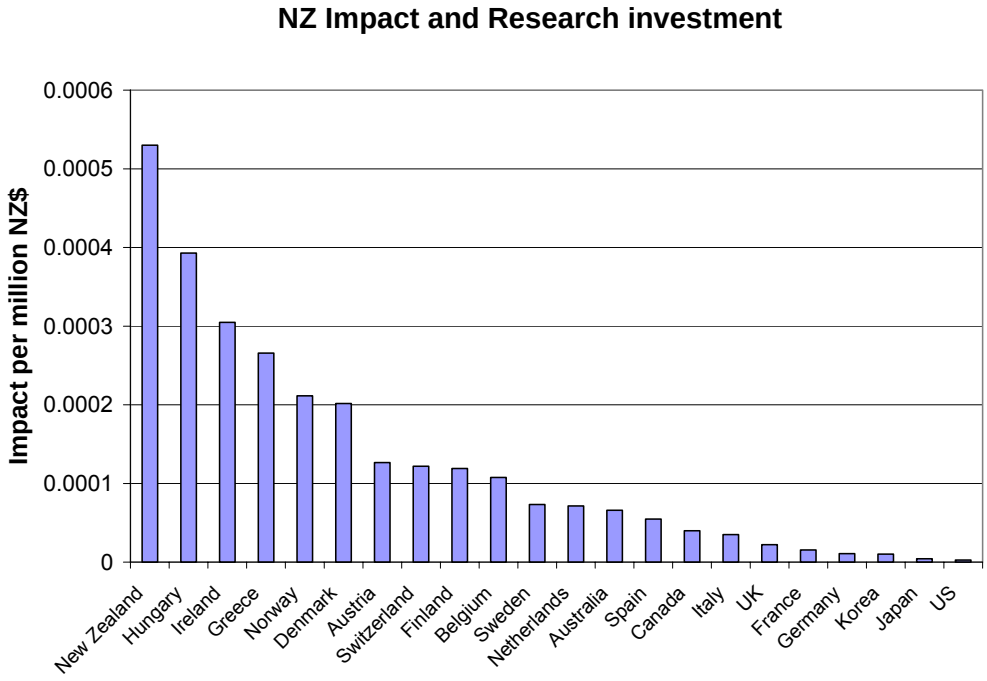


Figure A.1.1 Relative impact (citations per paper compared with world mean) per NZ$M (PPP) research investment.

New Zealand does well in these terms, as also noted by Liu (2001), but this is really an economics-based statistic rather than a scientific one. New Zealand does not produce a large number of exceptionally well-cited papers; rather it produces papers cited at or near the world mean, but produced with fewer resources than comparable countries. The countries with the most impact per dollar in Figure A.1.1 are not those normally thought of as the most outstanding countries scientifically. They are primarily those that are efficient at producing scientific papers of reasonable quality.

This relative impact/investment statistic assumes that scientific impact achieved is proportional to dollar input. Hours of research may be; impact is not. Halving the research investment of a country would not produce papers with half the impact, but fewer papers with a continuing similar impact. Similarly, a single paper takes a few hundred thousand dollars to produce but the impact immediately falls to zero if an amount of money below the threshold produces no paper and hence no impact. In neither case is the impact proportional to dollar input.

Even granting some limited validity to Figure A.1.1 it is not clear whether New Zealand scientists are unusually efficient, or New Zealand governments are unusually parsimonious in their resource allocation. Neither should be argued with finality from the present data.

Figure A.1.1 was derived from data in Husso et al. (2000). The relative impact factors were derived for each country based on the years 1995-1999, then divided by the country's budget in 2001 for research, expressed in terms of internationally comparable purchasing power per monetary unit (data derived from the World Bank). This procedure is an illustration of the type of result that inevitably emerges when

economic parameters are factored in. This report recommends the statistic not be given strong emphasis in future.

In terms of direct relative impact New Zealand is ranked 17th (Husso et al. 2000) which is average.

A.2 Detailed results

For the following papers the year of publication is 1997, and citations occurred in 1997-2001. Missing data or columns indicate zero entries or, in the case of entries under Obs/Exp (observed versus expected), errors so great that the entries are meaningless.

The Obs/Exp ratio calculates whether the citations to a group of publications were more or less numerous than expected for the journals in which they were published. If observed citations were the same as those expected by Thomson-ISI, the Obs/Exp value would be 1.00, if fewer, the Obs/Exp value would be less than 1.00.

The tertiary tables also serve as a listing of the categorisation of the 106 Thomson/ISI categories into the broader ASRC groupings.

Sector by field of Science

A.2.1 Tertiary

A.2.1.1 Tertiary: General

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
GEN	General subjects	4	25	0.16	1.15
MUL	Multidisciplinary	225	56	4.0	0.87
MGT	Management	137	50	2.74	1.12

This table and others involving the categories General Subjects and Multidisciplinary are not very informative, but are presented for completeness.

A.2.1.2 Tertiary: Mathematics

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
MTH	Mathematics	151	63	2.39	0.87
EMA	Engineering Maths	28	22	1.27	0.66

A.2.1.3 Tertiary: Physical Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
SP	Space Sciences	194	20	9.7	0.93
APP	Applied Physics/Materials	448	84	5.3	0.86
PHS	Physics	872	62	14.1	1.38
PHC	Physical Chemistry	404	62	6.5	0.88
SIA	Spectroscopy/Instrumentation	213	35	6.1	1.08
I/M	Instrumentation/Measurement	37	11	3.4	0.80
O/A	Optics/Acoustics	108	31	3.5	0.64

A.2.1.4 Tertiary: Geological Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
EAR	Earth Sciences	749	131	5.7	0.86
GEO	Geography/Develop.	117	50	2.3	1.05

A.2.1.5 Tertiary: Biological Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
High impact					
BIL	Biochemistry/Biophysics	1129	56	20.2	1.4
CEL	Cell/Developmental Biol.	204	13	15.7	0.95
MBG	Mol. Biol./Genetics	892	58	15.4	1.08
Low impact					
BIO	Biology	442	49	9.0	1.00
BTC	Biotechnology	148	20	7.4	0.91
PL	Plant sciences	448	100	4.5	1.07
ENT	Entomology	48	15	3.2	0.84
AS	Animal Sciences	400	84	4.8	1.11
MCB	Microbiology	521	56	9.3	0.93
EXP	Experimental Biology	312	36	8.7	0.96
AQU	Aquatic Sciences	732	92	8.0	1.15

A.2.1.6 Tertiary: Information Technology

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
CSE	Comp. Sci./Engineering	48	21	2.3	1.66
COM	Communication	16	13	1.2	1.12
IST	Inform. Technology	83	24	3.5	1.22

A.2.1.7 Tertiary: Engineering

Abbreviation	Subject field	Citations	Papers	Cit/pap	Obs/Exp
F	Food Science/Nutrition	177	38	4.7	0.88
AER	Aerospace Engineering				
MTR	Materials	166	34	4.9	0.91
ARA	Robotics/Automatic control	31	15	2.1	0.78
EL	Elec./Electron. Engineering	76	24	3.2	0.79
EEE	Environmental Engineering	7	3	2.3	0.98
MET	Metallurgy				
CME	Chemical Engineering	69	12	5.8	1.37
CIV	Civil Engineering	102	31	3.3	1.17
GPM	Geol./Petrol. Engineering	1	1	1	3.0
MEC	Mechanical Engineering	38	20	1.9	0.77
NCL	Nuclear Engineering				

A.2.1.8 Tertiary: Chemical Sciences

Abbreviation	Subject field	Citations	Papers	Cit/pap	Obs/Exp
PHC	Physical Chemistry	404	62	6.52	0.88
CMP	Chemistry	336	59	5.7	1.13
CML	Chemistry & Analysis	622	68	9.14	0.90
INC	Inorg./Nuclear Chemistry	209	34	6.1	0.86
ORG	Org./Polymer Chemistry	566	63	8.9	1.06
CMA	Agricultural Chemistry	111	20	5.6	0.98

A.2.1.9 Tertiary: Agricultural, Veterinary and Environmental Sciences

Abbreviation	Subject field	Citations	Papers	Cit/pap	Obs/Exp
A/A	Agriculture/Agronomy	173	64	2.7	0.99
AN	Animal & Plant Science	186	29	6.4	1.07
ENV	Environment/Ecology	516	111	4.6	0.87
VET	Veterinary Science	219	59	3.7	0.93

A.2.1.10 Tertiary: Medical and Health Sciences

Abbreviation	Subject field	Citations	Papers	Cit/pap	Obs/Exp
IMM	Immunology	395	26	15.2	0.88
INF	Infect./Clinical Immunology	106	10	10.6	1.22
PHM	Pharmacology & Toxicology	307	47	6.5	0.90
PMC	Pharmacology / Toxicology	108	14	7.7	0.72
AIC	Anaesth./Intensive Care	45	12	3.8	0.81
CVS	Cardiovasc. & Haem. Res.	343	49	7	0.89
CAR	Cardiovasc.& Resp. System	426	36	11.8	1.36
PSI	Psychiatry	306	43	7.1	0.97
PSO	Psychology	671	155	4.3	1.00
PSY	Clinical Psychol.Psychiat.	289	39	7.4	1.04
DEN	Dentistry	13	25	0.52	0.2
DER	Dermatology	0	2	0	0
END	Endocrin./Metab. & Nutrit.	519	55	9.4	0.86
SOC	Envir. Med/Public Health	130	14	9.3	0.99
GAS	Gastroent. & Hepatology	53	9	5.9	1.44
GNC	General & Internal Med.	713	159	4.5	1.24
HLT	Health Care Science	40	14	2.9	0.62
HEM	Haematology	30	7	4.3	1.0
DGX	Med. Res. Diagn. & Treat.	414	39	10.6	1.57
MGN	Med. Res. General	843	93	9.1	1.06
NUT	Endocrin./Metab. & Nutrit.	297	34	8.7	0.77
OGS	Organs and Systems	504	97	5.2	0.87
CGX	Oncogenesis & Cancer Res.	566	41	13.8	1.07
ONC	Oncology	298	21	14.1	1.04
OPH	Ophthalmology	27	9	3.0	0.85
ORT	Orthopaedics	46	7	6.6	1.66
PED	Paediatrics	256	33	7.8	1.45
PSL	Physiology	102	22	4.6	0.71
PUB	Public Health & systems	210	71	2.9	0.90
RAD	Radiology & Nucl. Med.	19	6	3.2	0.45
REH	Rehabilitation	16	10	1.6	0.68
REP	Reproductive Medicine	132	22	6	1.01
RHU	Rheumatology	11	9	1.2	0.31
SUR	Surgery	123	18	6.8	1.68
URO	Urology	46	13	3.5	1.17
NEU	Neurology	199	20	9.9	0.75
BEH	Neurosciences & Behaviour	1506	126	11.9	0.99
MED	Lab. Med &Med. Technol.	452	33	13.7	1.49

A.2.1.11 Tertiary: Social sciences (An ISI grouping)

Abbreviation	Subject field	Citations	Papers	Cit/pap
COM	Communications	16	13	1.2
GEO	Geography/Env.	117	50	2.4
LIB	Library Science	15	17	0.88
POL	Political Science	68	83	0.82
PUB	Public Hlth. & System	210	71	3.0
REH	Rehabilitation	16	10	1.6
S/I	Soc. Work/Policy	141	20	7.1
S/A	Sociology/Anthropology	40	66	0.6

A.2.1.12 Tertiary: Arts/Humanities (An ISI grouping)

Abbreviation	Subject field	Citations	Papers	Cit/pap
ARC	Archaeology	9	7	1.3
ART	Art & Architecture	0	2	0
CLS	Classics	0	5	0
GEN	General	4	25	0.16
HIS	History	13	78	0.17
LIP	Linguistics	2	34	0.06
LIT	Literature	9	78	0.12
PER	Performance	2	10	0.2
PHL	Philosophy	20	38	0.53
REL	Religion	1	10	0.1

A.2.1.13 Tertiary: Economics and Business (An ISI grouping)

Abbreviation	Subject field	Citations	Papers	Cit/pap
ECO	Economics	149	51	2.9
MGT	Management	137	50	2.7

A.2.1.14 Tertiary: Education (An ISI grouping)

Abbreviation	Subject field	Citations	Papers	Cit/pap
EDU	Education	18	44	0.41

A.2.1.15 Tertiary: Law (An ISI grouping)

Abbreviation	Subject field	Citations	Papers	Cit/pap
LAW	Law	1	1	1

A.2.2 CRIs

A.2.2.1 CRIs: General

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
GEN	General subjects	77	14	5.5	1.30
MUL	Multidisciplinary				
MGT	Management				

A.2.2.2 CRIs: Mathematics

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
MTH	Mathematics	1	1	1	1.06
EMA	Engineering Maths	1	1	1	0.83

A.2.2.3 CRIs: Physical Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
SP	Space Sciences	19	3	6.3	0.73
APP	Applied Physics/Materials	213	27	7.9	1.52
PHS	Physics	199	9	22.1	1.79
PHC	Physical Chemistry	1	3	0.33	0.091
SIA	Spectroscopy/Instrumentation	83	12	6.9	1.05
I/M	Instrumentation/Measurement	33	10	3.3	0.80
O/A	Optics/Acoustics	21	6	3.5	0.78

A.2.2.4 CRIs: Geological Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
EAR	Earth Sciences	833	114	7.31	0.96
GEO	Geography/Development				

A.2.2.5 CRIs: Biological Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
High impact					
BIL	Biochemistry/Biophysics	412	15	27.5	1.89
CEL	Cell/Develop. Biol.	6	2	3.0	0.35
MBG	Mol. Biol./Genetics	149	16	9.3	1.23
Low impact					
BIO	Biology	160	24	6.67	1.03
BTC	Biotechnology	51	10	5.1	0.61
PL	Plant sciences	837	159	5.3	0.61
ENT	Entomology	157	35	4.48	0.88
AS	Animal Sciences	268	60	4.47	0.98
MCB	Microbiology	138	27	5.11	0.65
EXP	Experimental Biology	23	5	4.6	0.74
AQU	Aquatic Sciences	958	124	7.7	1.20

A.2.2.6 CRIs: Information Technology

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
CSE	Comp. Sci./Eng.				
COM	Communication				
IST	Inform. Techn.				

A.2.2.7 CRIs: Engineering

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
F	Food Science/Nutrition	115	27	4.26	0.96
AER	Aerosp. Engin.				
MTR	Materials	90	31	2.9	0.81
ARA	Robotics/Automatic control	0	1	0	
EL	Elec./Electron. Engineering	4	3	1.3	0.38
EEE	Environmental Engineering	18	3	6.0	1.23
MET	Metallurgy				
CME	Chemical Engineering	23	9	2.6	0.65
CIV	Civil Engineering	43	18	2.4	0.49
GPM	Geol./Petrol. Engineering	0	2	0	
MEC	Mechanical Engineering	10	4	2.5	0.81

A.2.2.8 CRIs: Chemical Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
PHC	Physical Chemistry	1	3	0.33	0.091
CMP	Chemistry	48	7	6.8	1.3
CML	Chem. & Analysis	149	18	8.28	1.04
INC	Inorg./Nuclear Chemistry				
ORG	Org./Polymer Chem.	80	8	10.0	1.39
CMA	Agricultural Chem.	126	24	5.25	0.99

A.2.2.9 CRIs: Agricultural, Veterinary and Environmental Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
A/A	Agriculture/Agron.	432	116	3.72	1.18
AN	Animal & Plant Sci.	404	55	7.34	1.01
ENV	Environment/Ecology	835	104	8.02	1.15
VET	Veterinary Science	138	37	3.73	0.93

A.2.2.10 CRIs: Medical and Health Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
IMM	Immunology	61	5	12.2	1.63
INF	Infect./Clinical Immun.	20	2	10.0	0.68
PHM	Pharmacol. & Toxicology	44	7	6.3	1.48
PMC	Pharmacol. / Toxicology	24	3	8.0	1.24
AIC	Anaesth./Intensive Care	24	3	8.0	1.24
CVS	Cardiovasc.& Haem. Res.	10	1	10.0	1.71
CAR	Cardiovasc. & Resp. Syst.	40	3	13.3	1.28
PSO	Psychology	9	2	4.5	0.9
PSY	Clinical Psychol.Psychiat.	10	2	5.0	1.03
END	Endocrin./Metab. &Nutrit.				
SOC	Envir. Med/Public Health	12	1	12.0	1.93
GAS	Gastroent. & Hepatology				
GNC	General & Internal Med.	4	2	2.0	0.92
DGX	Med. Res. Diagn. & Treat.	53	3	17.7	1.95
MGN	Med. Res. General	26	4	6.5	1.26
NUT	Endocrin./Metab. &Nutrit.				
OGS	Organs and Systems	297	18	16/5	1.75
CGX	Oncogen. & Cancer Res.				
PED	Paediatrics	10	1	10.0	1.18
PSL	Physiology	22	5	4.4	1.07
PUB	Public Health & systems	2	1	2.0	0.67
BEH	Neurosci. & Behaviour	19	4	4.7	0.96
MED	Lab. Med &Med. Technol.	28	5	5.6	1.48

A.2.3 Government (includes hospitals)

A.2.3.1 Government: General

Abbreviation	Subject field	Citations	Papers	Cit/paper
GEN	General subjects			
MUL	Multidisciplinary	16	5	1.6
MGT	Management	137	50	2.7

A.2.3.2 Government: Mathematics

Abbreviation	Subject field	Citations	Papers	Cit/paper
MTH	Mathematics			
EMA	Engineering Maths	28	22	1.3

A.2.3.3 Government: Physical Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper
SP	Space Sciences			
APP	Applied Physics/Materials			
PHS	Physics			
PHC	Physical Chemistry			
SIA	Spectroscopy/Instrumentation			
I/M	Instrumentation/Measurement	37	11	3.4
O/A	Optics/Acoustics			

A.2.3.4 Government: Geological Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper
EAR	Earth Sciences			
GEO	Geography/Development	0	3	0

A.2.3.5 Government: Biological Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper
High impact:				
BIL	Biochemistry/Biophysics	63	8	7.9
CEL	Cell/Develop. Biol.	204	13	16.0
MBG	Mol. Biol/Genetics	892	58	15.4
Low impact:				
BIO	Biology	0	2	0
BTC	Biotechnology			
PL	Plant sciences			
ENT	Entomology			
AS	Animal Sciences			
MCB	Microbiology	42	3	14.0
EXP	Experimental Biology	16	2	8.0
AQU	Aquatic Sciences			

A.2.3.6 Government: Information Technology

Abbreviation	Subject field	Citations	Papers	Cit/paper
CSE	Comp. Sci./Eng.			
COM	Communication			
IST	Inform. Techn.			

A.2.3.7 Government: Engineering

Abbreviation	Subject field	Citations	Papers	Cit/paper
F	Food Science/Nutrition			
AER	Aerospace Engin.			
MTR	Materials			
ARA	Robotics/Automatic control			
EL	Elec./Electron. Engineering			
EEE	Environmental Engineering			
MET	Metallurgy			
GNE	Eng. Management			
CME	Chemical Engineering			
CIV	Civil Engineering			
GPM	Geol./Petrol. Engineering			
MEC	Mechanical Engineering			

A.2.3.8 Government: Chemical Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper
PHC	Physical Chemistry			
CMP	Chemistry			
CML	Chem. & Analysis			
INC	Inorg./Nuclear Chemistry			
ORG	Org./Polym. Chem.			
CMA	Agricult. Chemistry	3	2	1.5

A.2.3.9 Government: Agricultural, Veterinary and Environmental Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper
A/A	Agriculture/Agronomy			
AN	Animal & Plant Sci.			
ENV	Environment/Ecology	28	9	3.1
VET	Veterinary Science			

A.2.3.10 Government: Medical and Health Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper
IMM	Immunology	55	4	13.8
INF	Infect./Clinical Immun.	31	5	6.2
PHM	Pharmacol. & Toxicology	117	11	10.6
PMC	Pharmacol./Toxicology	69	7	9.9
AIC	Anaesth./ Intensive Care	112	36	2.1
CVS	Cardiovasc.&Haem. Res.	939	63	14.9
CAR	Cardiovasc.& Resp. Syst.	453	58	7.8
PSI	Psychiatry	83	17	4.9
PSO	Psychology	14	6	2.3
PSY	Clinical Psychol.Psychiat.	75	20	3.8
DEN	Dentistry	13	25	0.52
DER	Dermatology	18	5	3.6
END	Endocrin./ Metab.&Nutr.	89	15	5.9
SOC	Envir. Med/ Public Health	58	4	14.5
GAS	Gastroent. & Hepatology	0	1	0
GNC	General & Internal Med.	578	145	3.9
HLT	Health Care Science	9	4	2.3
HEM	Haematology	607	17	36.0
DGX	Med. Res. Diag. & Treat.	291	40	7.2
MGN	Med. Res. General	538	53	10.0
NUT	Endocrin./ Metab.&Nutr.	78	13	6.0
OGS	Organs and Systems	199	45	4.4
CGX	Oncogen.& Cancer Res.	73	10	7.3
ONC	Oncology	54	9	6.0
OPH	Ophthalmology	41	10	4.1
ORT	Orthopaedics	25	9	2.8
OTO	Otolaryngology	19	1	19.0
PED	Paediatrics	133	19	7.0
RAD	Radiology & Nucl. Med.	43	10	4.3
REP	Reproductive Medicine	62	11	5.6
RHU	Rheumatology	28	8	3.5
SUR	Surgery	56	19	2.9
URO	Urology	50	23	2.2
NEU	Neurology	215	15	14.0
BEH	Neurosci. & Behaviour	268	22	12.2
MED	Lab. Med &Med. Technol.	120	17	7.1

A.2.3.11 Government: Economics & Business

Abbreviation	Subject field	Citations	Papers	Cit/paper
ECO	Economics	9	5	1.8

A.2.3.12 Government: Education

Abbreviation	Subject field	Citations	Papers	Cit/paper
EDU	Education	0	1	0

A.2.3.13 Government: Law

Abbreviation	Subject field	Citations	Papers	Cit/paper
LAW	Law			

A.2.3.14 Government: Social sciences (ISI grouping)

Abbreviation	Subject field	Citations	Papers	Cit/pap
COM	Communications			
GEO	Geography/Env.			
LIB	Library Science	0	2	0
POL	Political Science	0	1	0
PUB	Public Hlth & System	25	15	1.7
REH	Rehabilitation	0	1	0
S/I	Soc. Work/Policy	15	3	5.0
S/A	Sociology/Anthropology	1	4	0.25

A.2.4 Health

A.2.4.1 Health: Medical and Health Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
IMM	Immunology	491	35	14.0	0.90
INF	Infect./Clinical Immun.	140	19	7.4	0.88
PHM	Pharmacol. & Toxicology	1866	121	15.4	1.21
PMC	Pharmacol. /Toxicology	1828	114	16.0	1.24
AIC	Anaesth./ Intensive Care	142	48	2.95	0.90
CVS	Cardiovasc.&Haem. Res.	1256	103	12.2	1.32
CAR	Cardiovasc.& Resp. Syst.	871	88	9.89	1.22
PSI	Psychiatry	335	55	6.1	0.96
PSO	Psychology	678	159	4.3	0.99
PSY	Clinical Psychol.Psychiat.	321	53	6.1	1.02
DEN	Dentistry	14	27	0.52	0.20
DER	Dermatology	18	8	2.25	0.99
END	Endocrin./ Metab.&Nutr.	574	68	8.44	0.84
SOC	Envir. Med/ Public Health	151	16	9.44	10.6
GAS	Gastroent. & Hepatology	53	10	5.3	1.21
GNC	General & Internal Med.	1189	303	3.92	1.23
HLT	Health Care Science	43	17	2.53	0.59
HEM	Haematology	620	21	29.5	2.18
DGX	Med. Res. Diag. & Treat.	687	70	9.81	1.45
MGN	Med. Res. General	1194	137	8.71	1.14
NUT	Endocrin./ Metab.&Nutr.	304	42	7.23	0.73
OGS	Organs and Systems	945	149	6.34	0.96
CGX	Oncogen. & Cancer Res.	628	47	13.3	1.00
ONC	Oncology	332	26	12.7	0.95
OPH	Ophthalmology	61	18	3.38	0.98
ORT	Orthopaedics	63	16	3.94	1.17
OTO	Otolaryngology	19	1	19.0	2.89
PED	Paediatrics	313	47	6.65	1.36
PSL	Physiology	1299	28	4.61	0.77
PUB	Public Health	241	88	2.74	0.89
RAD	Radiology & Nucl. Med.	55	14	3.93	0.75
REH	Rehabilitation	17	11	1.54	0.68
REP	Reproductive Medicine	177	36	4.92	1.04
RHU	Rheumatology	34	15	2.27	0.36
SUR	Surgery	176	36	4.89	1.28
URO	Urology	109	35	3.11	0.94
NEU	Neurology	335	26	12.8	0.90
BEH	Neurosci. & Behaviour	1790	154	11.6	1.02
MED	Lab. Med &Med. Technol.	555	46	12.1	1.45

The papers in the following table have been assigned to one category only. Papers were assigned to the first appropriate category in sequential order.

Table A.2.4.2 Health: Medical-related papers in non-health categories for 2001

Abbreviation	Field	Papers
GEN	General	1
MUL	Multidisciplinary	12
	No category	54
O/A	Optics/Acoustics	2
I/M	Instrumentation	3
BIL	Biochem/biophys	54
BIO	Biology	9
MBG	Mol. Biol./Genetics	33
BTC	Biotechnology	5
MCB	Microbiology	23
CEL	Cell biology	9
EXP	Experimental Biol.	8
AQU	Aquatic Sciences	4
F	Food Science/Nutrition	26
S/I	Social Work/Policy	3
S/A	Sociology/Anthropol	8
ENV	Environment	11
MTH	Mathematics	5
GEO	Geog. & Envir.	1
PHS	Physics	2
PL	Plant science	2
ENT	Entomology	1
MTR	Materials Research	1
ARA	Robotics	2
GNE	Eng. Management	6
MEC	Mechanical Eng.	1
CMP	Chemistry	1
CML	Chem. & Analysis	3
INC	Inorg./Nuclear Chemistry	1
CMA	Agricultural Chem	4
A/A	Agric/Agronomy	1
VET	Veterinary Science	2
	Total	298

A.2.5 Private Sector

A.2.5.1 Private: General

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
MUL	Multidisciplinary	43	10	4.3	1.001
MGT	Management	1	2	0.5	0.53

A.2.5.2 Private: Physical Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
SP	Space Sciences	66	5	13.2	1.13
APP	Applied Physics/Materials	3	2	1.5	0.58
PHC	Physical Chemistry	1	2	0.5	0.17
SIA	Spectroscopy/ Instrumentation	15	3	5.0	0.7
O/A	Optics/Acoustics	2	1	2.0	1.17

A.2.5.3 Private: Geological Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
EAR	Earth Sciences	56	14	4.0	0.94
GEO	Geography/Development	0	1	0	0

A.2.5.4 Private: Biological Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
High impact:					
BIL	Biochemistry/Biophysics	32	6	5.33	0.42
MBG	Mol. Biol/Genetics	20	5	4.0	0.5
Low impact:					
BIO	Biology	39	9	4.3	1.09
BTC	Biotechnology	33	6	5.5	0.54
PL	Plant sciences	49	9	5.4	1.2
ENT	Entomology	5	1	5.0	1.01
AS	Animal Sciences	101	19	5.3	0.98
MCB	Microbiology	130	12	10.8	1.09
EXP	Experimental Biology	11	2	5.5	1.17
AQU	Aquatic Sciences	61	20	3.05	0.77

A.2.5.5 Private: Information Technology

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
IST	Inform. Technology	15	3	5.0	1.4

A.2.5.6 Private: Engineering

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
F	Food Science/Nutrition	126	35	3.6	0.64
AER	Aerospace Engineering	4	1	4.0	1.7
MTR	Materials	50	20	2.5	1.63
ARA	Robotics/Automatic control	0	1	0	0
EL	Elec./Electron. Engineering	16	6	2.7	1.43
EEE	Environmental Engineering	3	5	0.6	0.36
MET	Metallurgy				
CME	Chemical Engineering	5	4	1.67	0.44
CIV	Civil Engineering	1	3	0.33	0.14
GPM	Geol./Petrol. Engineering	4	4	1.0	0.91

A.2.5.7 Private: Chemical Sciences

Abbreviation	Subject field	Citations	Papers	Cit/paper	Obs/Exp
PHC	Physical Chemistry				
CMP	Chemistry	17	6	2.83	0.69
CML	Chemistry & Analysis	128	13	9.84	1.03
ORG	Org./Polym. Chem.	9	2	4.5	0.75
CMA	Agricultural Chemistry	54	7	7.7	1.29

A.2.5.8 Private: Agricultural, Veterinary and Environmental Sciences

Abbreviation	Subject field	Citations	Papers	Cit/pap	Obs/Exp
A/A	Agriculture/Agronomy	23	7	3.28	1.12
AN	Animal & Plant Science	20	1	20.0	1.82
ENV	Environment/Ecology	41	12	3.4	0.85
VET	Veterinary Science	102	40	2.55	0.67

A.2.5.9 Private: Medical and Health Sciences

Abbreviation	Subject field	Citations	Papers	Cit/pap	Obs/Exp
IMM	Immunology	174	9	19.3	0.92
INF	Infect./Clinical Immun.	26	6	4.33	0.64
PHM	Pharmacology & Toxicology	1483	66	22.5	1.32
PMC	Pharmacology / Toxicology	1668	97	17.19	1.31
AIC	Anaesth./ Intensive Care	3	2	1.5	2.29
CVS	Cardiovasc.&Haem. Res.	23	3	7.67	1.19
CAR	Cardiovasc.& Resp. Syst.	4	2	2.0	0.39
PSI	Psychiatry	15	3	5.0	0.75
PSO	Psychology	3	3	1.0	0.38
PSY	Clinical Psychol.Psychiat.	12	3	4.0	0.65
DEN	Dentistry	1	2	0.5	0.17
DER	Dermatology	0	1	0	0
END	Endocrin./ Metab.&Nutr.	22	5	4.4	0.46
SOC	Envir. Med/ Public Health	6	1	6.0	0.99
GNC	General & Internal Med.	82	43	1.91	0.79
HLT	Health Care Science	3	2	1.5	0.46
HEM	Haematology	0	1	0	0
DGX	Med. Res. Diag. & Treat.	2	1	2.0	0.66
MGN	Med. Res. General	73	10	7.3	1.04
NUT	Endocrin./ Metab.&Nutr.	22	5	4.4	0.46
OGS	Organs and Systems	130	9	14.4	1.79
CGX	Oncogenesis & Cancer Res.	35	2	17.5	2.05
ONC	Oncology	16	1	16.0	2.07
ORT	Orthopaedics	17	5	3.4	1.27
PED	Paediatrics	45	3	15.0	1.93
PSL	Physiology	10	2	5.0	0.81
PUB	Public Health & systems	16	8	2.0	1.26
RAD	Radiology & Nucl. Med.	2	1	2.0	0.71
REH	Rehabilitation	1	2	0.5	0.31
REP	Reproductive Medicine	4	5	0.8	0.64
RHU	Rheumatology	3	1	3.0	0.31
SUR	Surgery	12	4	3.0	1.29
URO	Urology	17	2	8.5	1.11
NEU	Neurology	23	1	23.0	1.24
BEH	Neurosciences & Behaviour	136	16	8.5	1.27
MED	Lab. Med &Med. Technol.	2	1	2.0	0.69

A.3 How the source database records were verified.

A.3.1 Integrity of organisational addresses

Thomson-ISI aims to give an approximately (rather than an absolutely) precise database. Resources were sufficient to examine about 40% of the database for address integrity. Addresses had to be checked to avoid the possibility that papers could be indexed as of New Zealand origin when, for example, they had been researched and written in Canada.

Quite frequently a street address or PO Box was given, and in most cases it was possible to check whether that belonged to a major institution or a private individual. The fastest tool was an internet search engine which allows such searches. Some trivial cases such as “Hützel Hospital” for “Hutt Hospital” were fairly easily corrected. More troubling were several cases in which an institute was credited to New Zealand quite wrongly. “McMaster University, Hamilton, New Zealand” was not an outpost of the Canadian university but a simple Thomson-ISI error for “Hamilton, Ontario, Canada”. Similarly Royal North Shore Hospital although sometimes credited to Auckland, New Zealand in the database, is actually on the North Shore of Sydney Harbour, and had to be differentiated from the also-existing North Shore Hospital, Auckland.

This raises the awkward question of how often the reverse situation has occurred. Since papers from University of Kent, Canterbury, UK appeared in the New Zealand database, and some from Victoria University, Canada, one must ask what percentage of papers from Victoria University, Wellington and Canterbury University, Christchurch have vanished in the opposite direction. Similarly, since one paper from Ninewells Hospital, Dundee, UK, was attributed to Dunedin, have papers from some Dunedin organisations migrated to Dundee? This is not answerable without expensive full access to the Thomson-ISI database.

It seems more likely that lesser-known New Zealand addresses have been erroneously ascribed to better known addresses overseas than the reverse. As such, the counts of New Zealand papers published may be considered minimal only.

It is estimated here that the percentage of entries affected by address errors is 0.5-1% of total papers which does not change overall conclusions.

A.3.2 Sector assignment

When a researcher shifts country but publishes a paper from their previous institution, they may want to give a contact address in their new country and be forced to incorporate it in the contact details, giving rise to a kind of dual-country address. Such a dual address was considered in this report to be a New Zealand – international collaboration. This also happens in the reverse sense if immigrant researchers from, say, South Africa give their organisational affiliation as the University of the Witwatersrand but include an address in New Zealand. It was necessary to differentiate these cases from those in A.3.1 which were simply database errors.

In a few cases the correct sector could only be determined by contacting individuals personally. They were gratifyingly prompt in replying.

It was necessary to assign sectors manually to the approximately 5000 papers in each of 1997 and 2001. Sector assignments were checked using Excel database filters and the health sector was checked manually with additional input from the Health Research Council.

A.4 Subject field and journal allocations

Thomson-ISI does not routinely examine each paper to determine which subject field it should be classified under. Instead it assigns one or more subject fields to each journal in its current set of journals. In some cases a journal is classified as "multidisciplinary" or even "no category". Often a paper will be assigned two fields, and hence in section A.2 it is inevitable that some papers will be counted twice. The total for each field will be accurate, but they may overlap with others.

In subject categories such as clinical medicine, which is made up of numerous subject fields, care was taken to ensure a paper was not counted twice.

A.5 Composition of Thomson-ISI groupings

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

Composition of the ASRC subject categories can be found in the tables in the section A.2.

A.6 How NSF categories were simulated

Earlier data on international co-authorships in Table 8 was drawn from the National Science Foundation report *Science and Engineering Indicators* (2000) and the fields used were defined in the same document. The following scheme was used to simulate the subject categories present in the National Science Foundation paper:

Biology:	CMA, A/A, F, EXP, PSL, ENV, AS, AQU, ENT, BIO
Physics:	APP, O/A, PHS, PHC
Chemistry:	CME, CMP, CML, INC, ORG, PHC, SIA
Mathematics:	MTH
Clinical medicine:	AIC, CVS, CAR, INF, PSY, DEN, DER, NUT, SOC, GAS, GNC, HLT, HEM, DGX, MGN, OGS, NEU, CGX, ONC, OPH, ORT, OTO, PED, PMC, RAD, REP, MED, RHU, SUR, URO, IMM, BEH, PHM, VET
Engineering:	CME, CSE, IST, AER, ARA, CIV, EL, GNE, EMA, EEE, I/M, MEC, NCL, APP
Earth Sciences:	SP, ENV, EAR, GPM
Biomedical:	BIL, BTC, END, PSL, CEL, MGB, MCB
Social Sciences:	ECO, MGT, COM, LIB, POL, PUB, REH, S/I, S/A
Psychology:	PSI, PSO

The following two categories used in this report are not part of the system used by National Science Foundation (2000):

Agriculture:	CMA, A/A, F
Arts and Humanities:	ARC, ART, CLS, GEN, HIS, LIP, LIT, PER, PHL, 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 How errors were calculated

Errors are seldom presented for bibliometric data. This is partly because the sample sizes are large or very large, and errors are inherently small. Nevertheless Butler (2001) warns that clusters of fewer than 100 papers do not give stable results – i.e. the results have large errors. Butler is doubtful about results from samples even 100-200 in size. Glänzel and Moed (2002) give a method of deriving errors based on examination of the distribution form of the data, and quote a very few cases in which errors have been derived. Glänzel and Moed's article 'Journal impact measures in bibliometric research' (2002) did not mention the statistical method used in this report to calculate error, but the principles are well known[2].

If a good-sized sample of data is available, it may be assumed it is a good representation of the basic population from which it is derived. A second good-sized sample of data from that basic population would give similar results to the first. i.e. it's mean and other statistics would not differ very much. However, this report made use of a slightly different but well-established statistical method - the Monte Carlo method. This method holds that it is possible to create a second set of data like the first by selecting randomly from the first set rather than drawing from the basic population again. For example, if the first set contained 100 items, the second set (also to contain 100 items) would be created by randomly sampling the first set 100 times. However, the statistical values drawn would differ e.g. a single paper with citation rate of 30 might be sampled 3 times, whereas some papers might not be sampled at all. But the second set, which is derived entirely from the first set and is the same size as the first set, will be a good approximation of what one might obtain if one sampled the basic population (any target group of New Zealand papers) again.

Using this method it is possible to create a vast number of similar fresh data sets by random selection from the first data set and find, for example, how much the citation mean shifts or in other words, how great the variation is. In practice it is necessary to derive more than a thousand new data sets to do this - 3000 was the norm in this report.

In the present case, 3000 new data sets were created for any group of papers under examination and their means derived. (The entire set of New Zealand publications indexed or not by Thomson-ISI constituted the original general population.) The 3000 means were then arranged in numbered ascending order and examined for the degree of spread. Values for the means were selected as dividing points so that 2/3 of the data lay between them, and 1/6 at each end. These dividing points were, therefore, mean number 2500 and mean number 500. The difference between mean number 1500 (the mid-point) and mean 2500 or mean 500 was a measure of the spread. E.g. if mean 1500 had a value of 3.20 (citations) and means 500 and 2500 were 3.06 and 3.34 citations respectively, the spread was 0.14, and this is expressed as 3.20±0.14.

Technically, according to statistical convention, the 2/3 dividers are 66% confidence intervals. But for the data examined in this report the dividers proved to occupy nearly the same positions standard deviations would have. So errors given in this report can be understood to be essentially the same as standard deviations.

[2] See the articles by Efron & Tibshirani and Kalantar listed in the references on p62

Standard deviations allow for important statistical tests. For example, if received citations per year per paper for any sector were 3.20 and Thomson-ISI-expected citations were 2.71 the question can be asked, is this a meaningful/significant difference? If the error on 3.2 is ±0.14 the citation rate would be unlikely to be as low as 2.7, hence there is a significant difference. If the expected rate had been 3.1 that would not be significantly different from the received rate.

A.9 Limitations of Bibliometrics

While bibliometrics is an internationally recognised method for measuring performance and identifying patterns based on publications and citation analyses, it is important to recognise the inherent limitations of this evaluation tool. Bibliometrics can only hope to mirror quantitative measures of excellence, rather than subjective value to society. As such, citations in research literature are a measure of the impact of that research on further research, rather than a measure of the research's impact on commercial, social, or environmental conditions.

Thomson-ISI has long been criticised for not including important and well-cited monographs, but reports, theses, conference proceedings, bibliographies, technical and commercial documentation, and official documents that are not published commercially e.g. government reports and publications without international distribution are also omitted. It is this 'grey literature' that often has the most impact at a national and local level, and is particularly the domain of the social sciences.

Husso et al. (2000) remark that while "…bibliometric analyses have been attempted in the social sciences … [their] widespread application remains problematic and other indicators have generally been employed to measure the quality, impact, output and utility of disciplines in this area. 'In the social sciences national research interests and traditions tend to predominate, and research results are often reported in domestic journals or series… It should be stressed that in some cases monographs and readers published at home may have a greater impact on the domestic development of the field of study than articles appearing in refereed international journals".

Taking the above into consideration, bibliometric measures are generally not applied to the social sciences, nor are comparisons using bibliometrics made between different disciplines due to their heterogeneity (Husso et al, 2000). When looking at citation analyses across disciplines it is important to take into account the period of time over which a publication is expected to accrue citations. In the social sciences a paper may be cited 20 years on from its publication, whereas in areas of rapid change such as molecular biology and information technology, a paper may be outdated in a number of years.

For these reasons the customary cautions in bibliometric analyses are repeated here: bibliometrics must never be the sole criterion for judging the science of a nation, nor should it be the sole criterion for judging excellence. For example important methodological research may remain unpublished for reasons of commercial advantage, and some surveys have found only mediocre correlations between rates of citation of an article and evaluation by expert panels. West and McIlwaine's article 'What do citation counts count for in the field of addiction?' (2002) found no correlation between citations and peer review. The article 'Impact measures of interdisciplinary research in physics' Rinia et al (2002) looked specifically at

interdisciplinary research and found slight negative correlations. Hence, bibliometrics is one measure of scientific excellence, but it is only one.

A.10 Project-specific software used

To handle the data a BASIC program was written which examined the Thomson-ISI record for a paper (all the authors, all the countries, etc) and allowed selection by any chosen combination of fields and/or numerical criteria. Results could be output to another file, or summaries output to the screen. Further linked programs performed Monte Carlo tests on the results. Most tests involved a sector criterion (e.g. CRIs) and a subject category combination. Criteria for the combinations were either the ASRC (Butler, 2001) or the standard ISI groupings. The two are significantly different.

The program was run on files representing a year's output of papers at one time. The program is proprietary and no further details will be presented at this time.

A.11 How impact factors were calculated

Australian Relative Citation Impact (RCI) and citations/paper by subject were used to calculate New Zealand RCI by subject. These tables are for papers both published and cited, 1997-2001

Table A.11.1 Citations per paper, NZ and Australia

			CITATIONS/PAPER		
	Citations	**Papers**	**NZ**	**Error(±)**	**Australian**
Agriculture/Vet/Envir.	7,625	2,793	2.73	0.12	2.1
Biological Sciences:	18,075	4,820	3.75	0.14	
Biol. Sci. high impact	3,606	513	7.03	0.76	7.1
Biol. Sci. low impact	14,226	4,234	3.36	0.12	3.66
Chemical Sciences	4,491	1,120	4.01	0.21	3.6
Earth Sciences	3,888	1,440	2.7	0.14	3.25
Engineering	2,875	1,831	1.57	0.071	2.0
Information Science	327	268	1.22	0.17	1.48
Mathematics	441	394	1.12	0.12	1.77
Medical/Health Sci.	31,236	8,927	3.499	0.097	4.54
Physical Sciences	6,980	1,627	4.29	0.2	3.67
Social Sciences	964	1,436	0.671	0.059	
Arts/Humanities	194	1,168	0.166	0.024	

Table A.11.2 Citations per paper, NZ and Australia, Observed and Expected. The results of the statistical test, "Is the ratio of Observed to Expected for New Zealand greater than 1.0?" are in the last column. A low p value (less than 0.05) indicates there is a significant difference.

Citations/paper observed / expected				
	Australian	**NZ**	**Error (±)**	**O/E=1.0?**
Agriculture/Vet/Envir.	1.05	1.039	0.029	p<0.025
Biological Sciences		1.069	0.028	p<0.01
Biol. Sci. high impact	1.00	1.12	0.085	p<0.02
Biol. Sci. low impact	1.00	1.027	0.024	p>0.05
Chemical Sciences	1.10	0.972	0.049	p<0.05
Earth Sciences	1.06	0.931	0.036	p>0.05
Engineering	1.04	0.91	0.034	p>0.1
Information Science	0.89	1.024	0.11	p>0.1
Mathematics	1.11	0.864	0.078	p<0.02
Medical/Health Sci.	1.03	1.061	0.022	p<0.005
Physical Sciences	1.00	1.091	0.049	P<0.001
Social Sciences		1.0	0.095	
Arts/Humanities		0.91	0.11	

Table A.11.3 Relative citation impacts, NZ and Australia. The two statistical tests in the right-most columns are: "Is the Relative Citation Impact for New Zealand greater or less than 1.0", and "Is the NZ RCI equal to the Australian RCI?" A low p value (less than 0.05) indicates there is a significant difference.

Relative citation impact					
	Australian	**NZ**	**Error (±)**	**RCI=1.0?**	**NZ=Aus?**
Agriculture/Vet/Envir.	1.0	1.30	0.057	p<0.005	p<0.005
Biological Sciences:					
Biol. Sci. high impact	0.85	0.84	0.091	p>0.05	p>0.05
Biol. Sci. low impact	0.97	0.89	0.032	p<0.02	p>0.05
Chemical Sciences	1.096	1.22	0.064	p<0.005	p<0.005
Earth Sciences	1.0	0.83	0.043	p>0.05	p>0.05
Engineering	1.1	0.86	0.039	p>0.1	p>0.1
Information Science	0.79	0.65	0.091	p<0.01	p>0.05
Mathematics	1.1	0.70	0.075	p<0.01	p<0.005
Medical/Health Sci.	0.94	0.72	0.020	p<0.005	p<0.005
Physical Sciences	1.06	1.24	0.058	p<0.01	p<0.005
Social Sciences					
Arts/Humanities					

The relative impact factors were calculated by comparison with the Australian figures, which extended to 1999. Comparative citations per paper and RCI were given for Australian results, hence the RCI could be calculated for NZ results from citations per paper.

A.12 How sectors collaborated

Table A.12.1 CRI collaborations

	CRI	Govt.	Health	Local	Overseas	Private	University	Total
Papers	73	32	26	6	748	61	268	1,214
Percentage	6.0	2.7	2.1	0.5	61.6	5.0	22.1	100

Table A.12.2 Government collaborations

	CRI	Govt.	Health	Local	Overseas	Private	University	Total
Papers	32	131	7	3	456	48	241	918
Percentage	3.5	14.3	0.8	0.3	49.7	5.2	26.2	100

Table A.12.3 Local body sector collaborations

	CRI	Govt.	Health	Local	Overseas	Private	University	Total
Papers	6	3	0	1	14	2	12	38
Percentage	15.8	7.9	0.0	2.6	36.8	5.3	31.6	100

Table A.12.4 Overseas collaborations

	CRI	Govt.	Health	Local	Overseas	Private	University	Total
Papers	745	456	529	14	3,890	243	2,230	8,107
Percentage	9.2	5.6	6.5	0.2	48.0	3.0	27.5	100

Table A.12.5 Private Sector collaborations

	CRI	Govt.	Health	Local	Overseas	Private	University	Total
Papers	61	48	22	2	243	40	152	568
Percentage	10.7	8.4	3.9	0.4	42.8	7.0	26.8	100

Table A.12.6 University collaborations

	CRI	Govt.	Health	Local	Overseas	Private	University	Total
Papers	268	241	41	12	2,230	152	155	3,099
Percentage	8.5	7.8	1.3	0.4	72.0	4.9	5.0	100

Table A.12.7 Health sector collaborations

	CRI	Govt.	Health	Local	Overseas	Private	University	Total
Papers	26	7	487	0	529	22	41	1,112
Percentage	2.3	0.6	43.8	0.0	47.6	2.0	3.7	100

Please note that the numbers of papers in Table A.11.1 - A.11.7 cannot be expected to compare with those from other sections in this report because of difficulties defining collaboration as previously mentioned in Section 2.6.

A.13 The most frequently cited papers

Biomedical papers appeared to have the highest citation rate. The following table A.12 shows ten papers among the most highly-cited for 1997-1999 in a few scientific fields.

Of particular note are the international collaborations, the Hart single author paper which achieved the highest citation count, and the seminal AgResearch paper on cloning of calves. They are published in well-known journals such as *Nature* and *Science* and the *Lancet.* The private sector is less well represented.

Table A.13.1 Ten highly cited New Zealand papers

Reference	Institution(s)	Publication Year	Citations 1997-2001	Expected
1. Hart, DNJ, *Blood*, 90: 3245. Dendritic cells - unique leukocyte populations which control the primary immune-response. Review.	Canterbury Health Labs	**1997**	**404**	**129**
2. Udy, GB, Towers, RP, Snell, RG, Wilkins, RJ, Park, SH, Ram, PA, Waxman, DJ, Davey, HW. *Proc. Natl. Acad. Sci. USA*, 94:7239. Requirement of stat5b for sexual dimorphism of body growth-rates and liver gene-expression.	AgResearch, Boston Univ., Univ. of Waikato	**1997**	**240**	**41**
3. Carstea, ED, Morris, JA, Coleman, KG, Loftus, SK, Zhang, D, Cummings, C, Gu, J, Rosenfeld, MA, Pavan, WJ, Krizman, DB, Nagle, J, Polymeropoulos, MH, Sturley, SL, Ioannou, YA, Higgins, ME, Comly, M. *Science*, 277: 228. Niemann-pick-c1-disease gene - homology to mediators of cholesterol homeostasis.	Ben Gurion Univ. Negev, Columbia Univ. College (Phys & Surg), CUNY Mt Sinai School Medicine, Dartmouth College, Dunedin Sch. Med, Erasmus Univ. Rotterdam, Fac. Med. Hadassah Univ. Hosp. Hillel Yaffe Med Ctr. NIDDKD, NIH, NINCDS, Tufts Univ. Univ. Penn	**1997**	**214**	**89**
4. Guilford, P, Hopkins, J, Harraway, J, McLeod, M, McLeod, N, Harawira, P, Taite, H, Scoular, R, Miller, A, Reeve, A. *Nature* 392:402. Mutations in familial gastric-cancer.	Kimi Hauora Hlth Clin,, Tauranga Publ. Hosp., Univ. Otago	**1998**	**181**	**74**
5. Serruys, PW, Vanhout, B, Bonnier, H, Legrand, V, Garcia, E, Macaya, C, Sousa, E, Vandergiessen, W, Colombo, A, Seabragomes, R, Keimeneij, F, Ruyrok, P, Ormiston, J, Emaneulsson, H, Fajadet, J, Haude, M. *Lancet* 352: 672. Comparison of implantation of heparin-coated stents with balloon angioplasty in	Catharina Hosp, CHU, Clin. Pasteur, Ctr Cuore Columbus, Erasmus, Hosp, Green Lane Hosp, Gregorio Maranon, Hosp. Santa Cruz, Inst. Dante Pazzanese, Onze Lieve Vrouw Hosp. Sahlgrens Univ. Hosp, Univ. Essen Gedsamthsch., Univ. Hosp San Carlos, Univ Rotterdam Hosp	**1998**	**160**	**22**

selected patients with coronary-artery disease. Benestent-II.				
6. Wells, DN, Misica, PM, Tervit, HR. *Biol. Reprod*. 60: 996. Production of cloned calves following nuclear transfer with cultured adult mural granulosa-cells.	AgResearch	**1999**	**114**	**6.4**
7. Williams, GVM, Tallon, JL, Haines, EM, Michalak, R, Dupree, R. *Phys. Rev. L*. 78:721. NMR evidence for a D-wave normal-state pseudo gap.	IRL, Univ. Warwick	**1997**	**100**	**23**
8. Hartshorn, CM, Steel, PJ. *Chem. Commun*. 541. Self-assembly and x-ray structure of a 10-component, 3-dimensional metallosupramolecular cage.	Univ. Canterbury	**1997**	**56**	**11**
9. Beuermann, S, Buback, M, Davis, TP, Gilbert, RG, Hutchinson, RA, Olaj, OF, Russell, GT, Schweer, J, Vanherk, AM. *Macro Ch. P.* 198, 1545. Critically evaluated rate coefficients for free-radical polymerization. 2. Propagation rate coefficients for methyl-methylacrylate.	Bayer, AG, Dupont, Eindhoven, Univ. Technol., Univ. Canterbury, Univ. Gottingen, Univ. NSW, Univ. Sydney, Univ. Vienna	**1997**	**119**	**6.5**
10. Cooper, A, Penny, D. *Science* 275, 1109. Mass survival of birds across the Cretaceous-Tertiary boundary – molecular evidence.	Massey Univ., Smithsonian Inst. Oxford Univ., Victoria Univ. Wellington.	**1997**	**99**	**89**

A.14 List of government entities with publications included in the Thomson-ISI National Citation Report database for 1997 or 2001

New Zealand Commerce Commission
The Ministry of Defence
Department of Conservation
Department of Corrections
Department of Internal Affairs
Department of Labour
Department of the Prime Minister and Cabinet
Foundation for Research Science and Technology
House of Representatives
Land Transport Safety Authority
Ministry of Justice
Ministry of Agriculture and Forestry
Ministry for Culture and Heritage
Ministry of Education
Ministry of Health
Ministry of Research Science and Technology
Museum of New Zealand Te Papa Tongarewa
National Library of New Zealand
New Zealand Customs Service
New Zealand Police
New Zealand Qualifications Authority
New Zealand Post
Reserve Bank of New Zealand
Statistics New Zealand
The Treasury
Waitangi Tribunal

A.15 Entities within the local body sector publishing papers indexed by Thomson-ISI in either 1997 or 2001

Auckland Museum
Canterbury Museum
Dunedin City Council
Otago Museum
Palmerston North City Council
Regional councils:
Auckland, Bay of Plenty, Canterbury, Gisborne, Otago, Rotorua, Taranaki, Tasman, Waikato, Wellington.
Waitakere City Council
Whanganui Regional Museum

A.16 Crown Research Institutes (CRIs)

Industrial Research Limited (Industrial Research)
Institute of Environmental Science & Research Limited (ESR)
Institute of Geological & Nuclear Sciences Limited (GNS)
Landcare Research New Zealand Limited (Landcare Research)
National Institute of Water & Atmospheric Research Limited (NIWA)
New Zealand Forest Research Institute Limited (Forest Research)
New Zealand Institute for Crop & Food Research Limited (Crop& Food Research)
New Zealand Pastoral Agriculture Research Institute Limited (AgResearch)
The Horticulture & Food Research Institute of New Zealand Limited (HortResearch)

A.17 Glossary

ASRC
Australian Standard Research Classification categorisations (Butler, 2001).

Bibliometrics
The quantitative evaluation of scientific publications (especially papers in international refereed journals) particularly including the use of citations.

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 successors to the old DSIR. They derive about 65% 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 are published. A small percentage of papers do not appear in the data base 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.

Monte Carlo methods
Named after the Monte Carlo casino in Monaco, these statistical methods rely on continued random selection from the first data set drawn from the original population, instead of continued resampling of the original population. This process is approximately equivalent to resampling the original population but avoids the need for detailed knowledge of the original data.

Publications
The types of journal papers included in the ISI database and analysed in this report were research articles (75%), book reviews (5.6%), proceedings’ papers (5.2%),

letters (4.1%), meeting abstracts (3.6%), reviews (3.6%) and editorial material (2.9%).

Relative Citation Impact
The comparison of mean citations per paper between, for example, New Zealand and the rest of the world calculated by dividing (New Zealand's share of world citations in Physics by its share of world publications in Physics.

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

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N. E. Whitehead

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Efron, B, Tibshirani, R (1991). Statistical data analysis in the computer age. *Science,* 253, 390-395.

Garfield, E (1989). Delayed recognition in scientific discovery: citation frequency analysis aids the search for case histories. *Current Contents,* June 5(23), 154-159.

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Hawkins, DT (2001). *Bibliometrics of electronic journals in information science. Information Research*
http://informationr.net/ir/7-1/paper120.html.

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