

THE IMPACT OF MARSDEN-
FUNDED RESEARCH:
a bibliometric assessment of Marsden-
funded publications, 1997-2001

The ROYAL
SOCIETY of
NEW ZEALAND

JUNE, 2004

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June, 2004

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Acknowledgements:

Thanks to K.M.J Quickenden, J.S.L Quickenden and M. Smith for entry of publications data into the Marsden database, the Marsden Evaluation Steering Group members: Professor S. Casswell, Dr M.V. Berridge, Dr D.K.W. Smith, and P.A. Mazoyer for guidance and critical review of this report, J.F.W. Quickenden for software development and database advice, and Drs L. Butler, S.C. Thompson and P.W. Gilberd for advice and critical review of the report. Last but certainly not least, many thanks to the approximately 200 researchers who responded to our request for a publication update.

Executive Summary

The Marsden Fund

- The Marsden Fund supports excellence in research and researchers, and funds investigator-initiated research in all areas of natural science, mathematics, engineering, social science and humanities. The Fund's objectives are to:
 - enhance the underpinning research knowledge base in New Zealand and contribute to the global advancement of knowledge;
 - broaden and deepen the research skill base in New Zealand, and;
 - enhance the quality of the research environment in New Zealand by creating increased opportunities for excellent investigator-initiated research.
- It has grown in size from \$5.5 million in 1995 to just under \$33 million in 2003.

Methodology

- A bibliometric analysis of publications funded partially or fully by the Marsden Fund was undertaken, to assess the quantity and impact of Marsden research, and to characterise the collaborations associated with Marsden funding. This is the first study of its kind for the Marsden Fund.
- A database containing New Zealand-authored articles published in the years 1997-2001 was purchased from the Institute of Scientific Information (ISI), and the subset of Marsden-funded publications within the collection was identified. This enabled findings for Marsden publications to be benchmarked against findings for the total pool of New Zealand publications.

Main Findings

- The number of publications attributed to the Fund rose 20-fold between 1994 and 2001, and the Marsden-funded share of New Zealand-authored publications rose from 2.6% in 1997 to 7.7% in 2001. Between 1997 and 2000, there was a 2.5-fold increase in Marsden articles published per million dollars of funding, rising from just over 5 articles per million in 1997, to 13 in 2000.
- Marsden-funded research articles are published in the entire spectrum of subject fields, but as compared to all New Zealand-authored articles, proportionately more are published in fundamental areas such as chemistry, mathematics and physics, and less are published in applied fields such as agriculture/vet/environment, engineering & technology, and medical & health sciences.
- Across all fields, Marsden-funded publications accounted for 5.6% of 1997-2001 publications. In some fields, however, Marsden-funded articles accounted for a much higher percentage, e.g. 25-30% of publications in mathematics and physics.
- As judged by citation counts, Marsden-funded publications have a significantly greater impact than other New Zealand-authored publications. Marsden-funded articles are cited, on average, 1.7-fold more often than the total pool of New Zealand-authored articles. This elevated citation rate holds true for almost all subject fields.
- Marsden-funded articles are more likely to receive high numbers of citations than New Zealand-authored articles; 1.6% of New Zealand-authored papers received greater than 20 citations in their first three years after publication, while 6.9% of Marsden-funded publications received the same. Marsden-funded articles are less likely than New Zealand-authored articles to receive no citations in their first three years after publication: 32% of New Zealand-authored articles were uncited, as compared to only 16% of

Marsden-funded articles.

- The great majority of Marsden-funded articles arise from tertiary institutions, reflecting the high proportion of Marsden Fund contracts that are awarded to this sector. Authors from CRIs, government and private sector institutions, are however, under-represented on Marsden-funded articles as compared to the number of contracts awarded to them. This may result from differing productivity between sectors, differing pressure to publish, or it may be a natural consequence of the sectors' different research foci.
- Marsden-funded articles have a higher rate of international collaboration than New Zealand-authored articles, but a comparatively lower rate of inter-sectoral collaboration within New Zealand. Both phenomena are consistent with the high proportion of tertiary sector publications funded by Marsden. Tertiary sector publications also have increased international, and decreased inter-sectoral collaborations as compared to New Zealand-authored publications as a whole (MoRST *et al.*, 2003).
- 48% of Marsden-funded articles (compared to 38% of New Zealand-authored articles) have co-authors from overseas.

Coverage of Marsden publications by the database

- Analysis of the extent of coverage of Marsden-funded publications by the ISI database purchased for this study confirmed reports that the database's coverage is uneven across subject areas, and showed that for humanities research in particular, bibliometric analyses are likely to be of limited use. In addition, the database had fairly limited coverage of Marsden publications in the fields of social sciences, IT, engineering and technology and earth sciences, while its coverage of physics, biology, agriculture/vet/environment, chemistry, and medical & health sciences was fairly good.

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1. Introduction

In 1994 the New Zealand Government announced a major new initiative to support research which was not subject to the socio-economic criteria set for the Public Good Science Fund (the major source of government research funding at the time). Known at first as the "Basic Science Fund", it was renamed the "Marsden Fund" in 1995¹ and the total size of the Fund has grown from \$5.5 million in 1995 to just under \$33 million in 2003 (not accounting for inflation).

The Marsden Fund was set up to support excellence in research and researchers. Its objectives are:

- to enhance the underpinning research knowledge base in New Zealand, and contribute to the global advancement of knowledge;
- to broaden and deepen the research skill base in New Zealand, and;
- to enhance the quality of the research environment in New Zealand by creating increased opportunity to undertake excellent investigator-initiated research.

Marsden projects are selected by peer review panels on the basis of

- the merit of the proposal, including originality, insight and rigour;
- the potential of the researchers to contribute to the advancement of knowledge;
- the project's contribution to development or broadening of research skills in New Zealand, particularly those of emerging researchers (Marsden Fund, 2003).

There are no restrictions with respect to subject area and projects are supported in all areas of natural science, mathematics, engineering, social science and humanities. The full cost of each project is funded, and in most cases Marsden grants are given for a period of three years, with no further extension of funding.

The Marsden Fund has now been in existence for almost a decade, and outcomes from grants made in the early years of the scheme are becoming apparent. Follow-up interviews of grant recipients showed that in the majority of cases, Marsden-funded projects greatly influenced researchers' further work, and that, despite the Fund's untargeted nature, approximately a third led to development of applications such as new technologies, methods for increasing industry productivity, and social outcomes (Royal Society of New Zealand, 2003). The Fund has also been found to contribute to the development of international collaborations (Royal Society of New Zealand, 2003), the training of young researchers (Victoria University of Wellington, 2001), and the career development of investigators on the project (Knox, 2001). Evaluation of outcomes from the Fund is made challenging, however, by the difficulty in benchmarking Marsden Fund outcomes against New Zealand or international research outcomes.

Bibliometrics is the quantitative study of research publications. It can be used to measure research output (by counting publications), to gain an overview of the subject distribution of a group of publications, to estimate publication impact (by counting citations to the publications), and to examine collaborative activity. Bibliometric analyses are often employed by national research agencies to compare their country's research output to that of other countries and to assess national research trends over time (e.g. Butler, 2001; Liu, 2001; MoRST *et al.*, 2003; National Science Board, 2002; Oksanen *et al.*, 2003). In addition, bibliometric methods have been used to assess trends in certain research fields (e.g. Lewison *et al.*, 2001) and to examine factors that have been postulated to influence research output,

¹ The first selection round for the Marsden Fund was held in 1995. However, in 1994 the Foundation for Research, Science and Technology transferred some of their contracts granted in 1993 and 1994 to the Marsden Fund (then known as the Basic Science Fund). Thus, although the first selection round for the Fund was held in 1995, a small number of Marsden contracts were awarded in 1993 and 1994. This study covers publications from contracts awarded in the years 1993-2000.

such as collaborations (e.g. Katz and Hicks, 1997), and gender (e.g. Lewison, 2001). There is a growing interest in the use of bibliometric methods to assess the performance of funding bodies, as shown by the work of a number of agencies, including the New Zealand Health Research Council (Gunn *et al.*, 1999), the Australian National Health and Medical Research Council (Butler, 2003), The Australian Research Council (Butler, 2004), and the Natural Sciences and Engineering Research Council of Canada (Observatoire des sciences et des technologies, 2002). Bibliometric measures are attractive for this purpose because they provide objective, quantitative data, and allow the benchmarking of a funding body's output against national and international data.

Bibliometric measures are most appropriately used to assess basic research (as opposed to applied research or experimental development) because publications are a major output from this type of research. The Marsden Fund is therefore well suited to assessment by bibliometric means; although there is no requirement that Marsden-funded research be basic in nature (Marsden Fund, 2003), an estimated 95% of the research funded by the scheme is basic (Royal Society of New Zealand, 2003).

This report presents the results of the first ever bibliometric study of publications arising from the Marsden Fund. By using a database containing records of New Zealand-authored publications from 1997 to 2001, and identifying the subset of Marsden-funded publications within this database, we have been able to compare the research output, impact, and collaborative activity of Marsden-funded research to that of New Zealand as a whole.

This is only the second New Zealand bibliometric study to use a funding scheme as the unit of analysis, and it is also, to our knowledge, internationally only the second bibliometric assessment of a scheme that funds research in all fields of science, engineering, social sciences and humanities. As a result, in addition to assessing Marsden Fund performance, this report provides insights into the relative usefulness of bibliometric measures for assessing research in different subject fields.

2. Methods

2.1. Databases

The two databases used for this study were:

- the Marsden Bibliographic Database: a purpose-built database containing records of publications, patents, conference presentations, and other outputs that have been reported by grant recipients as having arisen from Marsden funded work;
- the New Zealand National Citation Report 1997-2001 (NZNCR): a database purchased from the Institute of Scientific Information (ISI). Lists journal articles and refereed conference proceedings published in the five year period, 1997-2001, that have at least one New Zealand author.

2.2. Identification of Marsden-funded publications

Publications, patents, conference proceedings and other outputs listed in the annual and final reports of the 451 projects funded from 1993 to 2000 were entered into the Marsden Bibliographic Database. Those publications that were also present in the NZNCR database were identified, and the NZNCR entries were annotated with their Marsden contract numbers.

A follow-up exercise for the 301 grants that were completed before 1 January, 2003 was conducted. Principal investigators were sent a spreadsheet listing the publications from their grants and asked to change any details that were incorrect or out of date, and to enter any new publications that had arisen since submission of the final report. 215 update responses were received, totalling 71% of those requested. Alterations to database entries were made as necessary, and new publications were entered into the Marsden Bibliographic Database, and if present in the NZNCR, were annotated, as above.

2.3. Attribution of publications to the Marsden Fund

The following instructions for attribution accompanied the follow-up exercise:

“We record outputs that are published, in press or submitted², and directly attributable to Marsden funding (although other funding sources may also have contributed). A publication or other output is attributable to Marsden funding if all or a part of the work was funded by the Marsden grant. As a guide, if you acknowledge Marsden funding of a publication, it should be included; if not, it shouldn't. Please don't attribute publications arising from research that followed on from, but was not paid for by the Marsden grant.”

In the great majority of cases, publications were only attributed to one Marsden contract. It was necessary to attribute a small number of publications to more than one contract because they had arisen from a collaboration funded by two or more Marsden grants. However, this does not affect the results of this report because such publications were only counted once in analyses of publication numbers, citations, and collaborations.

2.4. Types of publication covered

The NZNCR lists journal publications of all types, ranging from research articles, proceedings and reviews, to editorials, letters and book reviews. In this study, only three types of publication were included: articles, proceedings and reviews. Notes would also have been included, except none existed in the NZNCR. This is in line with standard international practice (e.g. Butler, 2001), and it is also consistent with the types of publications that arise from Marsden funding; the writing of editorials, letters or book reviews, for example, is not normally funded by a Marsden grant.

² However, for the purposes of this study; the pool of Marsden-funded publications was restricted to published outputs only.

This differs from the analysis of MoRST *et al.* (2003), in which all types of publications present in the NZNCR were included.

2.5. Categorisation of publications into fields of study

With a few modifications, publications were categorised either into one of the scientific Australian Standard Research Classification (ASRC) fields of study, or into the Humanities or the Social Sciences fields, following the method used by MoRST *et al.* (2003). This classification was used because it allows comparison with the New Zealand bibliometric study (MoRST *et al.*, 2003), facilitates comparison with several Australian bibliometric studies (Butler, 2001; Butler, 2003; Butler, 2004) and is concordant with the research classification codes used by the Marsden Fund (available online at http://www.rsnz.org/funding/marsden_fund/research_codes.php).

Modifications made to the MoRST *et al.* (2003) scheme, were:

- The biology “high impact” and “low impact” fields were amalgamated into the single field of biology, as it was found that for Marsden-attributed publications the two fields were not particularly distinct in terms of citation rate or research topic³;
- ‘Food Science/Nutrition’ publications were moved from the ‘Engineering’ field to the ‘Medical and Health Sciences’ field as examination of the article titles showed that this was a more appropriate categorisation;
- ‘Environmental Studies, Geography and Development’ publications were moved from the ‘Earth Sciences’ field into the ‘Social Sciences’ field as examination of the article titles showed that this was a more appropriate categorisation;
- ‘General’ publications, which were categorised into both the ‘Humanities’ and the ‘General’ Fields in MoRST *et al.* (2003), were in this report categorised only into the ‘Humanities’ field;
- ‘Communication’ publications, which were categorised into both the ‘IT, Computing, Communications’ and the ‘Social Sciences’ fields in MoRST *et al.* (2003), were in this report categorised only into the ‘Social Sciences’ field;
- ‘Physical Chemistry/Chemical Physics’ publications, which were categorised into both the ‘Chemistry’ and the ‘Physics’ fields in MoRST *et al.* (2003), were in this report categorised only into the ‘Chemistry’ field;
- ‘Management’ publications, which were categorised into both the ‘General’ and the ‘Economics and Business’ fields by MoRST *et al.* (2003), were in this report categorised into the “Social Sciences’ field;
- ‘Education’ and ‘Economics’ publications, which were categorised into the ‘Education’ and the ‘Economics and Business’ fields respectively, by MoRST *et al.* (2003), were in this report categorised into the ‘Social Sciences’ field.
- ‘Psychology’ publications, which were categorised into the ‘Medical and Health Sciences’ field by MoRST *et al.* (2003), were retained in this category for this study and were, in addition, listed in the ‘Social Sciences’ category.

In this report, the benchmark data consisting of all New Zealand-authored publications was re-analysed to incorporate the above modifications and some results will therefore differ from those of MoRST *et al.* (2003).

³ Three factors contributed to the Marsden-funded “low impact” biology articles having a higher average citation rate than the “high impact” biology articles: (1) both were small samples with citation rates very susceptible to skewing by the presence or absence of few very high impact articles; (2) several very highly cited articles in the field of molecular evolution were present in the “low impact” group of Marsden-funded articles; (3) Marsden-funded “high impact” biology articles had a lower than expected citation rate because, unlike the total pool of New Zealand-authored “high impact” biology articles, the citation rate was not boosted by a small number of very high impact human-oriented biomedical articles (funding for such articles is more likely to come from the health research sector).

Note that while the vast majority of publications have been assigned to only one subject field, there is a small amount of overlap between the Medical and the Social Sciences fields. As in MoRST *et al.* (2003), publications in the 'Public Health and Healthcare Science' and the 'Rehabilitation' fields were categorised into both the 'Medical and Health Sciences' and the 'Social Sciences' fields. In addition, 'Psychology' publications are in both the 'Medical and Health Sciences' and the 'Social Sciences' fields. This was considered to be justified because, while these subject clearly fall within the field of 'Medical and Health Sciences', Marsden Fund grants in these subjects are assessed by the Social Sciences selection panel.

A full listing, mapping the 106 ISI subject categories to the ASRC and the Social Sciences and Humanities fields is given in Appendix VII. Hereafter, for the sake of simplicity, the ASRC, social sciences and humanities fields are all referred to as ASRC fields.

2.6. Categorisation of Marsden contracts into fields of study

For Section 3.2 and Appendix A1.5, in which NZNCR coverage of publications in different subject fields is assessed, Marsden contracts were classified into ASRC fields of study. The 395 contracts that had 1997-2001 publications listed in the Marsden Bibliographic Database were examined by Marsden Fund research assessment staff, and each was assigned to an ASRC subject field on the basis of:

- its field of research;
- the ASRC subject assignments of the publications arising from the contract (if present in the NZNCR database).

In most cases, contracts were assigned to only one ASRC category, but 49 of the 395 contracts were assigned to two categories, and one was assigned to three, as they were genuinely multidisciplinary according to the ASRC scheme.

For calculating the percentage of funding allocated to each subject area in the years 1993-2000 (Figure 3.6), an additional 56 contracts funded within this time (which did not have any publications listed in the Marsden Bibliographic Database) were assigned to an ASRC subject field on the basis of their fields of research. The amount of funding that had been granted to all projects funded in the years 1993-2000 was then aggregated into ASRC fields.

2.7. Small numbers

Breaking down Marsden-funded articles by field of study has, in a number of cases, created groups of very small numbers of publications. This is particularly a problem for citation analyses because the average citation rate of small samples is greatly influenced by the presence or absence of just one or a few very highly cited articles. In this report, attention is drawn to instances in which average citation rates are calculated for particularly small groups of articles. In addition, Appendix IV shows the number of articles upon which citation analyses are based. Butler (2001) suggests that caution should be used for average citation figures based on fewer than 200 articles.

2.8. Software

All database work in this study used Microsoft Access. Microsoft Access and Excel were used for data analysis and collation, and graphs were drawn using MS Excel. SPSS was used for some statistical analyses.

3. Results

In this section, the results of bibliometric analyses of Marsden-funded research articles are reported. The analysis used the New Zealand National Citation Report database, 1997-2001 (henceforward referred to as the “NZNCR”), and the Marsden Publications database 1993-2003. Both databases are described in Section 2, as are the methods used to identify Marsden publications, and to assign publications and contracts to fields of study.

3.1. Total Marsden-funded outputs, 1993-2003

The total number of outputs published or in press, arising from Marsden projects funded in the 1993-2000 funding rounds, as of August 2003, was 5337, comprised of 2721 publications (including journal articles, conference proceedings, books, book chapters, edited volumes, and reports), 137 student theses, 2365 conference presentations, 13 patents, 2 items of software, and 99 “other” types of output (Table 3.1).

Table 3.1. Marsden-attributed publications and other outputs, 1993-2003^I

output type	number published/completed ^{II}	number in-press (where applicable) ^{III}
Journal Article	1920	109
Refereed Conf Proc	297	N/A
Book Chapter	178	73
Book	27	8
Edited Volume	19	1
Thesis	137 ^{IV}	N/A
Report	89	N/A
Patent	5 full	3 provisional, 5 pending
Software	2	N/A
Other ^V	99	N/A
Invited conference talk	375	N/A
Contributed conference talk	1259	N/A
Conference poster	731	N/A
<i>Total</i>	<i>5138</i>	<i>199</i>

^I This includes outputs from all projects funded in the 1993 to 2000 funding rounds. Outputs from projects funded after 2000 were only included if a final report was received before August 2003. Data was extracted from the Marsden Publications Database in August 2003.

^{II} For projects that have not yet finished or that finished on or after 1 January, 2003, publication status is as of the most recent project report. For projects that finished before 1 January, 2003, a follow-up exercise was conducted (described in Section 2) in order to gather updates on publication status and data on new publications that had arisen since the final report.

^{III} Not including outputs that are in preparation or submitted, but not yet accepted.

^{IV} Believed by Marsden Fund staff to be an underestimate.

^V Types of “other” output include: articles in non-specialist journals, gene sequences deposited in public databases, reagents developed, documentaries, radio interviews, websites, online databases, CDs distributed, and editorials and letters to specialist journals

The amount of Marsden-funding granted during the period 1993-2000 was \$110.2 million, but it should be noted that there is a significant lag (often of several years) between funding of a grant, and publication of results from that grant. Therefore the number of outputs arising from this funding is currently underestimated. The average time between grant award and publication (excluding conference presentations) was found to be 3 years, times taken ranging from less than one year to 9 years. In addition, some of the projects funded in 1994 still had publications, directly attributable to the grant, in preparation or in press in 2003; six years after completion of the three-year grant. This time lag must be borne in mind when looking at

the rise in Marsden publications over time (section 3.3), and comparisons of Marsden publications to Marsden funding awarded (sections 3.3 and 3.4), because considerable time-lags can be expected between increases in the amount of Marsden-funding awarded, and subsequent increases in publication output.

3.2. Coverage of Marsden-funded publications by the NZNCR bibliometric database

In order to assess the validity of a bibliometric evaluation of Marsden-funded research, it is necessary to determine the extent of NZNCR bibliographic database coverage of Marsden-funded publications. Coverage of only a small fraction of publications by the database would suggest that bibliometric analyses are of limited use, while on the other hand, more extensive coverage would give support to the use of bibliometrics for evaluation of the Fund. Furthermore, coverage may vary between fields of study, and thus bibliometric methods may be more appropriate for some fields than others. A full analysis of NZNCR coverage of Marsden-funded publications is presented in Appendix I and the main findings are summarised below.

The NZNCR lists only journal articles and refereed conference proceedings. Thus, it does not provide coverage of several important publication types such as books, book chapters, edited volumes and reports. In addition, it does not cover theses or conference presentations, but this is of less concern as these outputs are frequently the precursors of articles, proceedings, books, and book chapters. The coverage of journal articles and conference proceedings is uneven; 82% of Marsden-funded journal articles are covered by the NZNCR, while only 34% of refereed conference proceedings are covered (Appendix I).

When publications are defined as journal articles, refereed conference proceedings, books, book chapters, edited volumes and reports, the NZNCR database covers, in total, two thirds of the Marsden-funded publications published from 1997 to 2001 (Table 3.2 & Figure 3.1). Broken down by field of study, however, it is apparent that the coverage of some subjects is better than others. Particularly well covered are the fields of chemistry and medical & health sciences, and also fairly well covered are agriculture/vet/environment, biology and physics. The coverage of mathematics is reasonable at 65%, while only around 55% of earth sciences and engineering & technology publications are covered. Bibliometric analyses may be of limited use for the IT/computing/communications, social sciences and humanities fields, which have 46%, 39% and 15% NZNCR coverage respectively. At 15%, the coverage of humanities publications is particularly poor, and results from a low percentage of journal articles and conference proceedings in the total pool of publications, as well as a very low (28%) coverage of the articles and proceedings (Table 3.2). The reasons for the low coverage of social sciences publications are the same, although there is slightly better overall coverage of this field. It should be noted that within social sciences, publications in the sub-field of psychology appear to be more extensively covered than publications in other sub-fields. In the IT/computing/communications field, a large percentage (86%) of the publications are journal articles or proceedings, but the NZNCR covers only 51% of them.

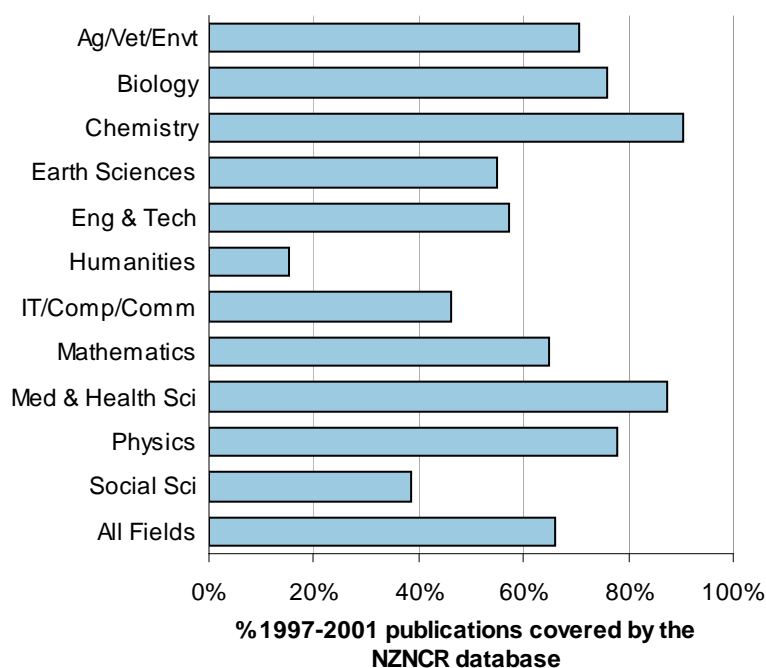
Table 3.2. NZNCR coverage of 1997-2001 Marsden-funded publications, by field of study

Subject ⁱ	% publications that are articles & proceedings	% NZNCR coverage of articles & proceedings	% NZNCR coverage of all publications ⁱⁱ
Agric/Vet/Envt	90	79	71
Biology	90	82	76
Chemistry	96	94	91
Earth Sci	87	63	55
Eng & Tech	94	62	57
Humanities	55	28	15
IT/Comp/Comm	86	51	46
Mathematics	87	70	65
Med & Health Sci	91	93	88
Physics	97	80	78
Social Sciences	70	56	39
<i>All Fields</i>	75	75	66

ⁱ publications' subject fields were assigned according to the contract from which each originated. See Section 2.6 for a description of the assignment method.

ⁱⁱ publications are defined as articles, proceedings, books, book chapters, edited volumes, and reports.

Figure 3.1. Percent coverage of different subject fields' publications by the NZNCR database. Publications are defined as articles, proceedings, books, book chapters, edited volumes, and reports.

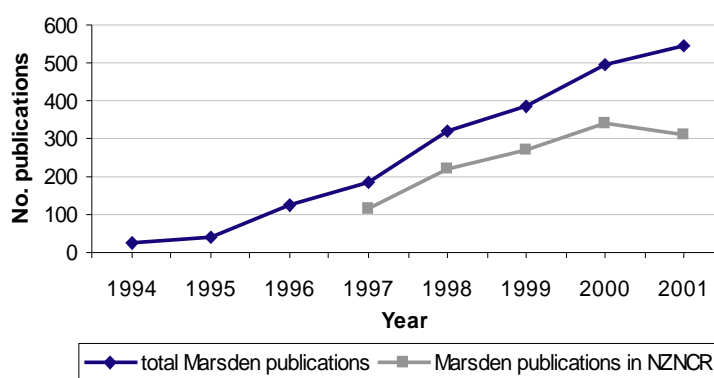


In the remainder of this report, the results of bibliometric analyses of publications from all of the subject fields listed in Table 3.2 are reported. However, results for the IT/computing/communications, social sciences, and particularly the humanities fields should be viewed with caution as the majority of these fields' publications are not listed in the NZNCR database.

3.3. Rise in Marsden-funded publications over time

Over time, the Marsden Fund has grown 6-fold, from \$5.5 million in 1995 to \$32.8 million in 2003 (not accounting for inflation). Publication rates have also grown over time, from just 27 articles, proceedings, books, book chapters, edited volumes and reports published in 1994, to 544 in 2001 (an increase of just over 20-fold). Publication rates have been rising in a linear fashion, and so far the rate of increase shows no sign of decline (Figure 3.2).

Figure 3.2. The number of Marsden-funded publications by publication year. Total publications (defined as articles, proceedings, books, book chapters, edited volumes, and reports) are in dark blue, and publications that are indexed in the NZNCR database are in grey. The apparent drop in the number of NZNCR-listed publications in 2001 is due to an indexing lag (MoRST *et al.*, 2003). Detailed results in Appendix II.



The quantity of Marsden-funded articles as a percentage of New Zealand-authored articles grew nearly 3-fold between 1997 and 2001, and in 2001 Marsden-funded articles comprised 7.7% of New Zealand-authored publications listed in the NZNCR (Figure 3.3). The Marsden Fund thus contributes a high percentage of publications to the New Zealand total as compared to its funding level, which increased from 1.7% of New Zealand's government and higher education expenditure on R&D (GovERD + HERD) in 1996, to 3.5% in 2002^{4,5}.

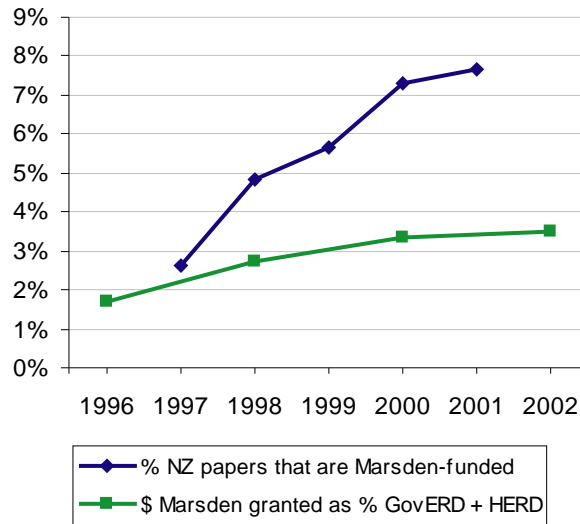
The number of Marsden-funded papers per Marsden research dollar granted rose 2.5 fold from 1997 to 2000 (Figure 3.4). This may be largely attributable to the time lag between grant funding and publication (see section 3.1). This is offset, however, by the steady rise in the level of Marsden funding since 1995, decreasing publications per \$ by raising the denominator. It is nevertheless apparent from Figure 3.4 that the number of Marsden articles per \$ million Marsden funding is rising and reached just over 13 in 2000. This can be compared to the New Zealand figure of around 6 articles per \$ million GovERD + HERD, and the Foundation for Research Science and Technology (FRST) figure of 5 peer reviewed papers per \$M FRST investment in 2001/02 (Foundation for Research Science and

⁴ GovERD + HERD is used rather than New Zealand's gross expenditure on R&D (GERD) because roughly one third of GERD is business expenditure on R&D, which is targeted to commercial outcomes rather than publications. Marsden funding as a % of GERD is given in Table AII.3.

⁵ Note that, strictly speaking, the percentage of New Zealand publications that are Marsden-funded is not comparable to the percentage of GovERD + HERD that is spent through the Marsden Fund. This is because Marsden-funded publications are not necessarily paid-for exclusively by the Fund; other funding sources can also contribute. Because multiple funding sources often contribute to publications, it is possible that almost any research fund's publication percentages would exceed its percentage of GovERD + HERD, although to what extent a fund could be expected to do so is currently unknown.

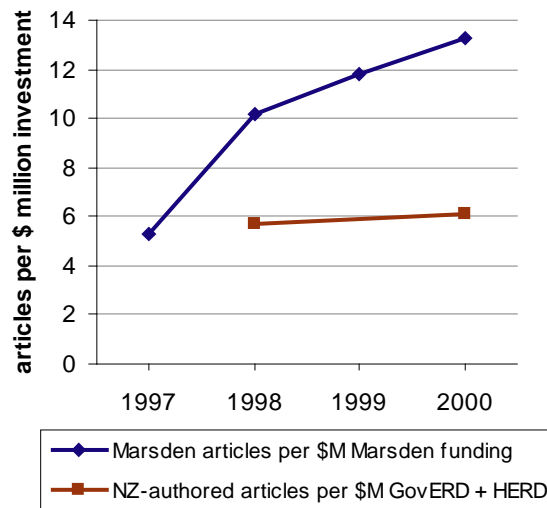
Technology, 2002)⁶.

Figure 3.3. Percentage of New Zealand-authored articles that are Marsden-funded, compared to the percentage of New Zealand's government and higher education research expenditure (GovERD + HERD) spent through the Marsden Fund.



SOURCES: NZNCR database; R&D Statistics (Ministry of Research Science and Technology and Statistics New Zealand, 2003).

Figure 3.4. Marsden-funded articles (1997-2000) per \$ million Marsden funding (1997-2000), compared to New Zealand-authored articles per \$ million GovERD + HERD (1998 and 2000). Articles are restricted to those covered by the NZNCR database.



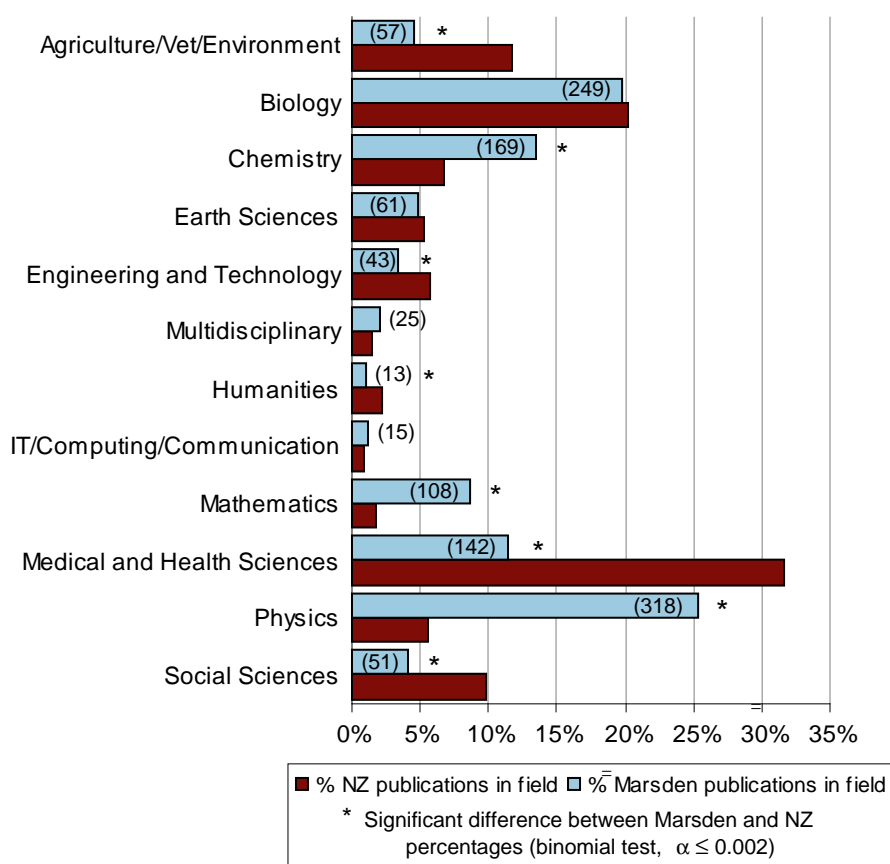
SOURCES: NZNCR database; R&D Statistics (Ministry of Research Science and Technology and Statistics New Zealand, 2003).

⁶ The FRST 2001/02 figure is the closest available comparison. Unlike the Marsden Fund data, however, the FRST data was not restricted to articles covered by the NZNCR database. Note also that FRST-funding is focussed more at outcomes for the benefit of New Zealand than at publications.

3.4. Subject distribution of Marsden-funded publications

Marsden-funded articles are published in the entire spectrum of subject fields (Figure 3.5). As compared to the subject distribution of New Zealand-authored publications, Marsden publications are weighted towards fundamental areas of research such as chemistry, mathematics and physics, and a correspondingly lower percentage of articles are published in more applied fields such as agriculture/vet/environment, engineering & technology, and medical & health sciences (Figure 3.5).

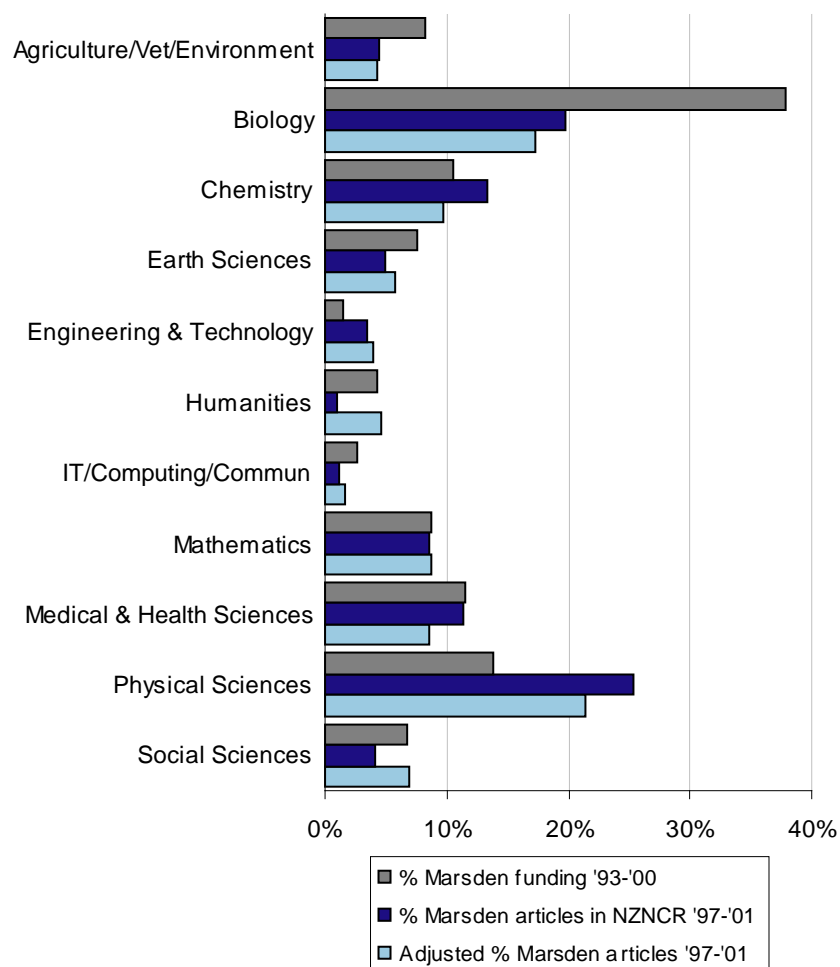
Figure 3.5. Subject distribution of New Zealand-authored and Marsden-funded articles, 1997-2001. The number of Marsden-funded articles in each subject is shown in parentheses.



SOURCE: NZNCR database

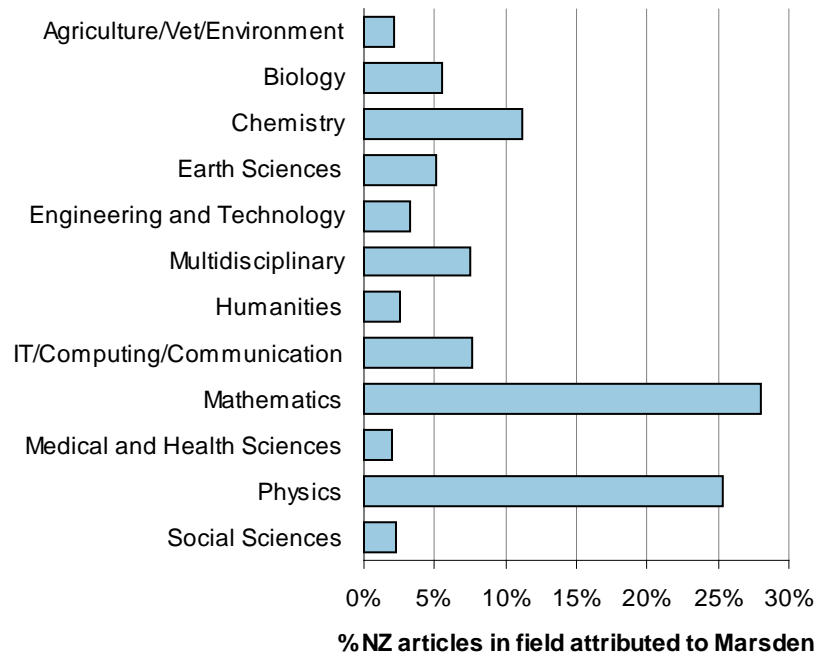
In general, subject fields' percentages of total Marsden-funded articles corresponded approximately to the amount of Marsden funding received (Figure 3.6). Exceptions are the biology and agriculture/vet/environment fields, which published a lower percentage of articles than their funding share, and physics and engineering & technology which published a higher percentage of articles than their funding share (however there are low numbers in the agriculture/vet/environment and the engineering & technology fields). This might to some extent reflect differing productivity in different fields, but it is more likely to be related to differences in publication behaviour between fields. Individual publications can require more resources in some fields than others, however, to what extent subjects differ in this respect is currently unknown.

Figure 3.6. Comparison of the number of publications arising from each subject with the funding received by each. Grey bars indicate the percentage of Marsden funding received by each subject from 1993 to 2000 (calculated as outlined in section 2.6), and dark blue bars show the percentage of NZNCR-listed Marsden-funded articles in each subject. Represented by light blue bars, the percentage of NZNCR-listed Marsden-funded articles in each field has been adjusted according to the percentage coverage of the field's publications (Table 3.2, far right column). Thus, fields that are not well covered by the NZNCR (e.g. humanities) have an adjusted percentage share higher than their actual percentage share, and fields that are more extensively covered (e.g. chemistry) have an adjusted percentage share lower than their actual share. Detailed results in Appendix III.



Across all fields, Marsden-funded articles accounted for 5.6% of the 1997-2001 NZNCR-indexed publications. In some fields, however, Marsden-funded articles accounted for a much higher percentage of New Zealand-authored articles. In particular, in the fields of mathematics and physics, Marsden-funded articles totalled 25-30% of the NZNCR-listed publications (Figure 3.7)

Figure 3.7. The percentage of 1997-2001 New Zealand-authored NZNCR-listed articles in each subject field that have been funded by the Marsden Fund.



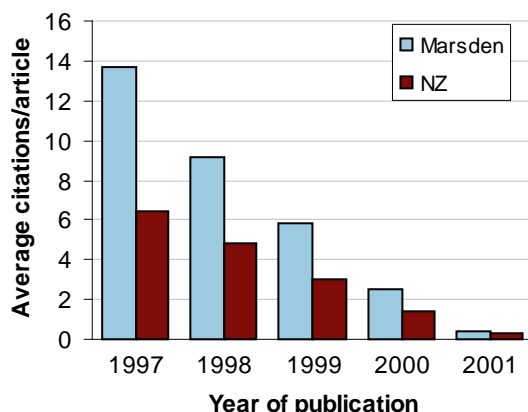
SOURCE: NZNCR database

3.5. Citations to Marsden-funded publications

Citation counts are commonly used as a proxy measure for the impact of a publication on its research field. The supporting rationale maintains that publications that influence a greater amount of further research will be cited more frequently by other research publications. Although there are some caveats with this assumption, it holds generally true (Narin, 1976) and measures based on citation counts have become well established as a means of assessing the impact of academic journals.

Given that the Marsden Fund is intended to support excellent research projects that can lead to profound developments in their fields (Marsden Fund, 2003), it is relevant to ask whether Marsden-funded publications have an elevated citation rate in comparison to other New Zealand-authored publications. As shown in Figure 3.8, analysis shows that Marsden-funded articles are cited, on average, nearly twice as often as the total pool of New Zealand-authored articles. Marsden-funded articles published in 1997 received, on average, 13.7 citations each, in contrast to the average of 6.5 citations received by New Zealand-authored articles published in 1997. A similar disparity in citation rates exists for the years 1998-2001, during which time Marsden articles were cited at an average rate of 1.7-1.9-fold that of New Zealand-authored articles (Appendix IV).

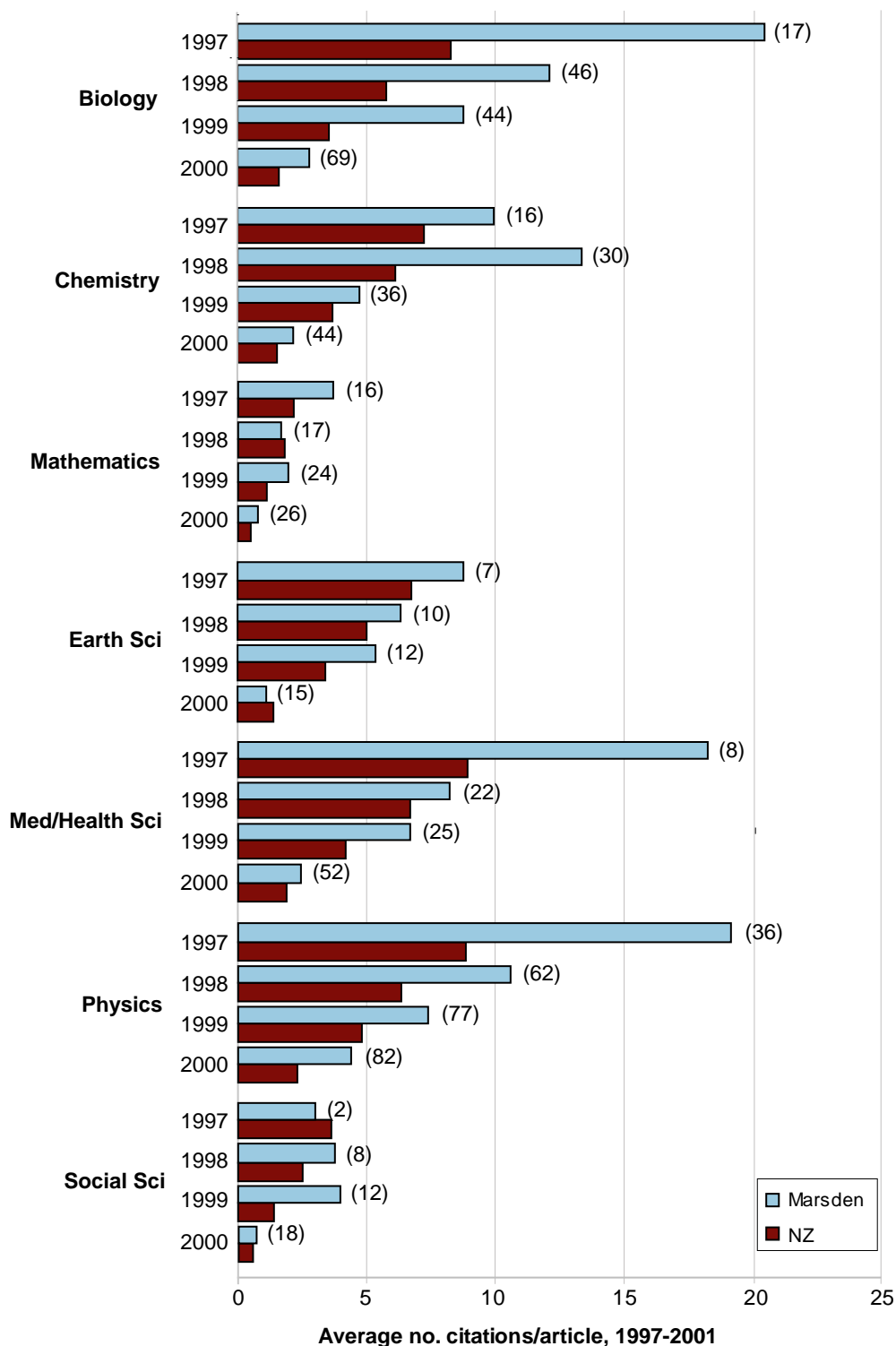
Figure 3.8. The average number of citations received by Marsden-funded (light blue) and New Zealand-authored (dark red) articles. Articles are published in the year shown, and citations are received in the years following publication, up to the end of 2001. The average number of citations decreases for articles published in more recent years because citations have had less time to accumulate since article publication.



SOURCE: NZNCR database

Given that Marsden-funded articles are cited more often than other New Zealand-authored articles, it is important to know whether this increase is consistent across subjects, or whether it results from greatly elevated citation rates in just a few fields. Figure 3.9. shows that Marsden articles are cited more often than other New Zealand-authored articles in most of the 11 ASRC subject categories. Particularly strong in this regard appear to be Marsden articles in the fields of biology, chemistry and physics. However, some caution must be taken. With only 949 1997-2000 Marsden publications split into 11 subjects and four publication years, the number of articles in some categories is very low (see Appendix IV).

Figure 3.9. The elevated citation rate of Marsden-funded articles as compared to NZ-authored articles is consistent across subjects. The number of Marsden-funded articles is given in parentheses, and caution should be taken where the average is based on just a few articles. Results for the fields of agriculture/vet/environment, engineering and technology, humanities, and IT/computing/communications are not shown because of very low numbers of Marsden-funded articles (see Appendix IV). In addition, 2001 data is not given because these publications had less than a year to accumulate citations.



SOURCE: NZNCR database

The ratio of Marsden citations per article to NZ citations per article is given for each field in Table 3.3. Marsden articles are cited 1.5-1.8 times as often as New Zealand authored articles, with the exception of the fields of agriculture/vet/environment, earth sciences, humanities and IT/computing/communications; however there were relatively few Marsden articles in these fields and also in the field of engineering & technology.

Table 3.3. Ratio of Marsden average citations per article to NZ average citations per paper by field, 1997-2001 (Source: NZNCR database).

Subject	Ratio Marsden:NZ citations per article ¹
Agric/Vet/Envt	2.6
Biology	1.8
Chemistry	1.5
Earth Sci	0.9
Eng & Tech	1.8
Humanities	2.2
IT/Comp/Comm	1.2
Mathematics	1.7
Med & Health Sci	1.5
Physics	1.8
Social Sciences	1.5
<i>All Fields</i>	<i>1.7</i>

¹ The ratio of Marsden citations/article to NZ citations/article was calculated for each subject and for each year, from data in Tables AIV.1 and AIV.2. The yearly ratios were then combined into a subject total, weighting each year's ratio according to the proportion of the subject's Marsden-funded articles published in that year.

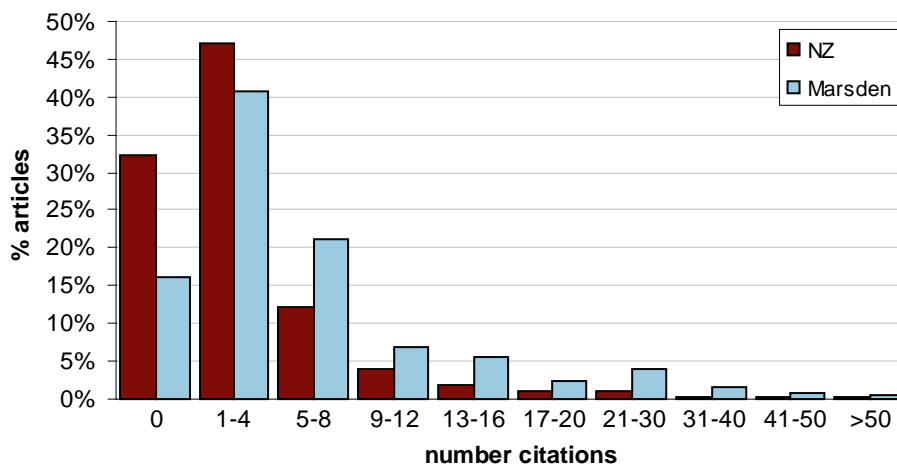
3.5.1. Citation Distributions

The results presented above show that, on average, Marsden-funded articles are cited 1.7 fold as often as the total pool of NZ-authored articles. This could come about in two ways:

- The majority of Marsden-funded articles could be more highly cited than the pool of NZ-authored articles, and/or;
- The Marsden citation average could be pushed up by just a few very highly cited articles.

In order to determine the cause of the elevated Marsden citation rate, the number of Marsden and NZ-authored articles with 0 citations, 1-4 citations, 5-8 citations, etc, were counted, and the percentage of articles in each citation category was calculated. These citation distributions are presented in Figure 3.10.

Figure 3.10. Comparison of the citation distributions of Marsden-funded and NZ-authored articles published in 1997-1999 and cited in the 3 years following publication. The apparent small peak in articles with 21-30 citations is a measurement artefact, due the use of wider citation bands for articles receiving more than 20 citations. Detailed results in Appendix IV.



SOURCE: NZNCR database

As compared to the total pool of NZ-authored articles, a lower proportion of Marsden articles received 0 or 1-4 citations, and a higher proportion received 5 or more citations (Figure 3.10). Therefore, the higher average citation rate for Marsden-funded articles is due to an elevated citation rate in general, not to a few extremely highly cited articles. This pattern is consistent across different subject areas, with the possible exception of the field of agriculture/vet/environment, which contains only relatively few Marsden-funded articles, a small number of which are exceptionally highly cited (Appendix IV).

Using a chi square test, the distribution of citations to Marsden-funded articles was found to be significantly different to the distribution of citations to NZ-authored articles, to a probability value of $p < 0.0001$ ($X^2 = 240.3$, *degrees of freedom* = 9). That is, there is less than a 0.01% chance that such a citation distribution would occur in a random sample of publications taken from the collection of NZ-authored articles. Therefore the elevated citation rate of Marsden-funded articles is extremely unlikely to be due to random fluctuation.

In comparison to NZ-authored articles, proportionately half as many Marsden-funded articles are uncited in their first three years after publication (Figure 3.10). With respect to highly cited articles, 1.6% of NZ-authored articles received greater than 20 citations in their first three years after publication, whereas 6.9% of Marsden-funded publications received the same (Appendix IV).

3.5.2. Highly cited Marsden-funded articles

Table 3.4 lists the two most highly cited Marsden-funded articles each subject field. Articles are restricted to those published in 1997-1999, and citations are restricted to those received in the three years following publication. This three year citation window is not optimal, as many articles continue to receive citations beyond the 3rd year following publication. However, this is the only way in which the NZNCR database can be used to compare citation counts per article in multiple years. Articles in the fields of humanities and IT/computing/communications are not listed because the citation rates and the number of papers published in 1997-1999 and listed in the NZNCR database in these fields are very low. Note that while each of the articles listed has been attributed to a Marsden grant, other funding sources have also contributed to some or all of them.

Table 3.4. The two most highly cited Marsden-funded articles in each subject field, published between 1997-1999, and cited in the three years following publication (Source: NZNCR database).

Reference	publication type	citations in 1 st 3yrs	Ranking ^I
Agriculture/Vet/Environment			
Wardle, D. A., Zackrisson, O., Hörnberg, G., Gallet, C. (1997) The influence of island area on ecosystem properties. <i>Science</i> 277 :1296-1299	research paper	45	1 st out of 1586 NZ papers
Wardle, D. A., Bonner, K. I., Barker, G. M., Yeates, G. W., Nicholson, K. S., Bardgett, R. D., Watson, R. N., Ghani, A. (1999) Plant removals in perennial grassland - vegetation dynamics, decomposers, soil biodiversity, and ecosystem properties. <i>Ecological Monographs</i> 69 : 535-568	research paper	25	4 th out of 1586 NZ papers
Biology			
Jorgensen, R.A., Atkinson, R. G., Forster, R. L. S., Lucas, W. J. (1998) An RNA-based information superhighway in plants. <i>Science</i> 279 : 1486-1487	review paper	77	5 th equal out of 2648 NZ papers
Cooper, A., Penny, D. (1997) Mass survival of birds across the Cretaceous/Tertiary boundary - molecular evidence. <i>Science</i> 275 : 1109-1113	research paper	54	8 th out of 2648 NZ papers
Chemistry			
Irvine, G. L., Lesley, M. J. G., Marder, T. B., Norman, N. C., Rice, C. R., Robins, E. G., Roper, W. R., Whittell, G. R., Wright, L. J. (1998) Transition metal-boryl compounds: synthesis, reactivity, and structure. <i>Chemical Reviews</i> 98 : 2685-2722	review paper	63	1 st out of 939 NZ papers
Henderson, W., Nicholson, B. K., McCaffrey, L. J. (1998) Applications of electrospray mass spectrometry in organometallic chemistry. <i>Polyhedron</i> 17 :4291-4213	review paper	46	4 th out of 939 NZ papers
Earth Sciences			
Savage, M. K. (1999) Seismic anisotropy and mantle deformation - what have we learned from shear-wave splitting. <i>Review of Geophysics</i> 37 : 65-106	review paper	29	2 nd equal out of 682 NZ papers
Marson-Pidgeon, K., Savage, M. K. (1997) Frequency-dependent anisotropy in Wellington, New Zealand, <i>Geophysical Research Letters</i> 24 : 3297-3300	research paper	19	10 th equal out of 682 NZ papers
Engineering & Technology			
Blaikie, R. J., Alkaisi, M. M., McNab, S. J., Cumming, D. R. S., Cheung, R., Hasko, D. G. (1999) Nanolithography using optical contact exposure in the evanescent near field. <i>Microelectronic Engineering</i> 46 : 85-88	research paper	11	6 th equal out of 779 NZ papers

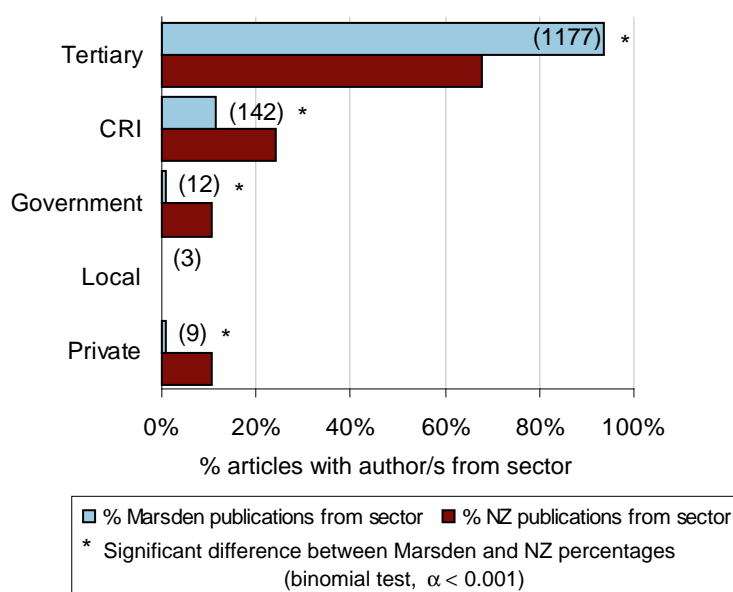
Rodger, C. J., Wait, J. R., Dowden, R. L. (1997) Electromagnetic scattering from a group of thin conducting cylinders. <i>Radio Science</i> 32 : 907-912	research paper	8	11 th equal out of 779 NZ papers
Mathematics			
Lawless, J. F., Kalbfleisch, J. D., Wild, C. J. (1999) Semiparametric methods for response-selective and missing data problems in regression. <i>Journal of the Royal Statistical Society: Series B</i> 61 : 413-438	research paper	9	2 nd out of 229 NZ papers
Erdős, P. L., Steel, M. A., Székely, L. A., Warnow, T. J. (1999) A few logs suffice to build (almost) all trees (Part I). <i>Random Structures & Algorithms</i> 14 : 153-184	research paper	6	3 rd equal out of 229 NZ papers
Medical & Health Sciences			
Kanjhan, R., Housley, G. D., Burton, L. D., Christie, D. L., Kippenberger, A., Thorne, P. R., Luo, L., Ryan, A. F. (1999) Distribution of the P2X ₂ receptor subunit of the ATP-gated ion channels in the rat central nervous system. <i>Journal of Comparative Neurology</i> 407 : 11-32	research paper	32	38 th equal out of 4021 NZ papers
Housley, G.D., Kanjhan, R., Raybould, N. P., Greenwood, D., Salih, S. G., Jarlebark, L., Burton, L. D., Setz, V. C. M., Cannell, M. B., Soeller, C., Christie, D. L., Usami, S., Matsubara, A., Yoshie, H., Ryan, A. F., Thorne, P. R. (1999) Expression of the P2X ₂ receptor subunit of the ATP-gated ion-channel in the cochlea - implications for sound transduction and auditory neurotransmission. <i>Journal of Neuroscience</i> 19 : 8377-8388.	research paper	19	141 st equal out of 4021 NZ papers
Physics			
Jaksch, D., Briegel, H. J., Cirac, J. I., Gardiner, C. W., Zoller, P. (1999) Entanglement of atoms via cold controlled collisions. <i>Physical Review Letters</i> 82 : 1975-1978	research paper	72	2 nd out of 739 NZ papers
Alcock, C., Allen, W. H., Allsman, R. A., Alves, D., Axelrod, T. S., Banks, T. S., Beaulieu, S. F., Becker, A. C., Bennett, D. P., Bond, I. A., Carter, B. S., Cook, K. H., Dodd, R. J., Freeman, K. C., Gregg, M. D., Griest, K., Hearnshaw, J. B., Heller, A., Honda, M., Jugaku, J., Kabe, S., Kaspi, S., Kilmartin, P. M., Kitamura, A., Kovo, O., Lehner, M. J., Love, T. E., Maoz, D., Marshall, S. L., Matsubara, Y., Minniti, D., Miyamoto, M., Morse, J. A., Muraki, Y., Nakamura, T., Peterson, B. A., Phillips, M. M., Pratt, M. R., Quinn, P. J., Reid, I. N., Reid, M., Reiss, D., Retter, A., Rodgers, A. W., Sargent, W. L. W., Sato, H., Sekiguchi, M., Stetson, P. B., Stubbs, C. W., Sullivan, D. J., Sutherland, W., Tomaney, A., Vandehei, T., Watase, Y., Welch, D. L., Yanagisawa, T., Yoshizawa, M., Yock, P. C. M. (1997) Macho alert-95-30 - first real-time observation of extended source effects in gravitational microlensing. <i>Astrophysical Journal</i> 491 : 436-450	research paper	48	4 th out of 739 NZ papers
Social Sciences			
Fletcher, G. J. O., Simpson, J. A., Thomas, G., Giles, L. (1999) Ideals in intimate relationships. <i>Journal of Personality & Social Psychology</i> 76 :72-89	research paper	14	10 th equal out of 1280 NZ papers
Rhodes, G., Sumich, A., Byatt, G. (1999) Are average facial configurations attractive only because of their symmetry. <i>Psychological Science</i> 10 : 52-58	research paper	13	13 th equal out of 1280 NZ papers

¹ ranking out of New Zealand-authored articles in the NZNCR database, published in 1997-1999, and cited in the 3 years following publication.

3.6. Papers by sector

The vast majority (94%) of Marsden-funded articles have authors from the tertiary sector (Figure 3.11). Crown Research Institutes (CRIs) are the next most strongly represented sector, listed on 11% of Marsden-funded articles. The government, local body and private sectors are represented at a low level, together contributing to 2% of Marsden-funded articles. This distribution differs significantly from that of NZ-authored articles, which have a comparatively lower contribution from the tertiary sector, and higher contributions from the CRI, government and private sectors.

Figure 3.11. Sector distribution of Marsden-funded articles, compared to total NZ-authored articles. Marsden-funded articles are published in the five year period 1997-2001, while NZ-authored articles are restricted to those published in 1997 and 2001. Sectors are defined according to the scheme of MoRST *et al.* (2003). The number of Marsden-funded articles from each sector is given in parentheses. Detailed results in Appendix V.



SOURCE: NZNCR database

The relatively high contribution of the tertiary sector to Marsden-funded articles reflects the high proportion of contracts that are awarded to university-based researchers. Of the Marsden contracts awarded from 1997-1999, 87% listed tertiary sector principal or associate investigators. In contrast, the CRI contribution to Marsden publications appears to be less than expected from contract statistics. While 23% of 1997-1999 contracts listed investigators from the CRI sector, only 11% of Marsden-funded articles had authors from this sector. Likewise, 11% of 1997-1999 contracts listed investigators from the government, local body, or private sector, while only 2% of Marsden-funded articles had authors from these sectors. There are several possible reasons for these discrepancies: universities may publish more than other sectors, or they may publish more in subjects that are extensively covered by the NZNCR database. It is also possible that researchers based in universities are under greater pressure to publish than CRI-based researchers. Postgraduate students based outside of universities may raise tertiary publication counts relative to contract statistics because they are always associated with a tertiary institute (in addition to the non-tertiary institute where they work), but are never listed as associate or principal investigators on Marsden grants. However, this cannot account for the low CRI publication count relative to the number of CRI contracts, because students based at CRIs generally co-author with CRI-based researchers.

3.7. Collaborative publications

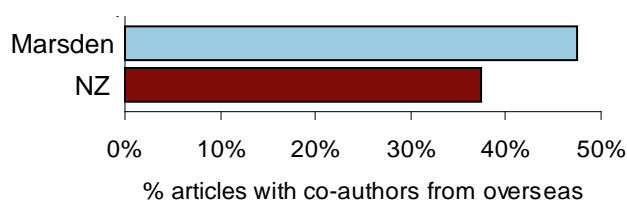
3.7.1. Inter-sectoral Collaborations within New Zealand

Inter-sectoral collaboration within New Zealand appears to be less frequent on Marsden-funded than New Zealand-authored articles. Specifically, 7% of Marsden-funded articles, and 13% of New Zealand-authored articles resulted from inter-sectoral collaboration within New Zealand (Appendix V). This may relate to the high percentage of Marsden articles that arise from the tertiary sector; MoRST *et al.* (2003) found that tertiary sector articles have a lower percentage of inter-sectoral collaborations within New Zealand than articles from other sectors.

3.7.2. International Collaborations

Although the Marsden Fund does not specifically target projects with international collaboration, it aims to ensure that New Zealand is both contributing to, and benefiting from the global advancement of knowledge (Marsden Fund, 2003). It is therefore reasonable to expect the Fund to support international collaboration, and as shown in Figure 3.12, 48% of Marsden-funded articles have co-authors from overseas.

Figure 3.12. As compared to New Zealand-authored articles, a larger percentage of Marsden-funded articles result from overseas collaborations. Articles published 1997-2001.



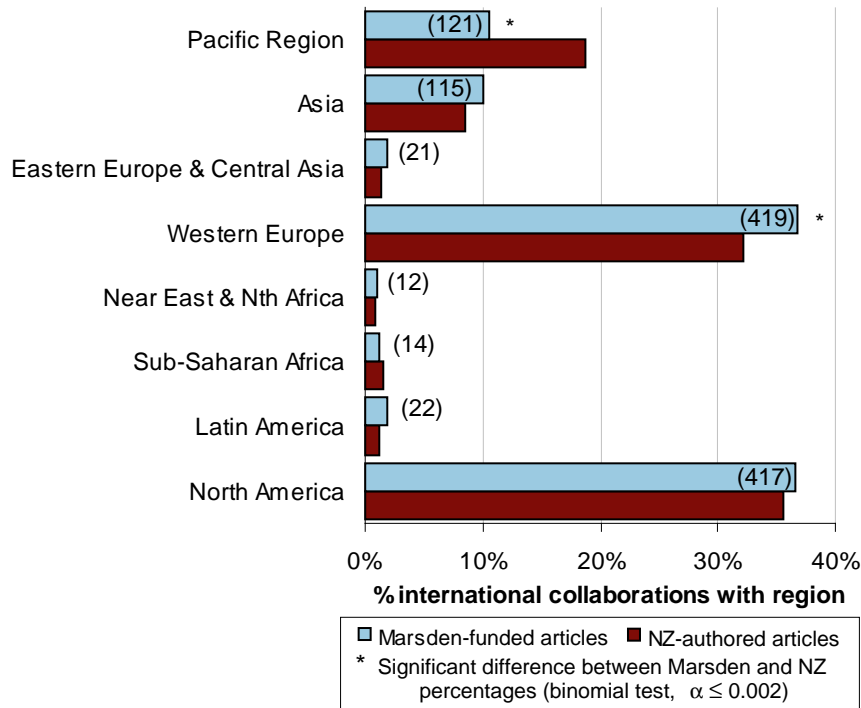
SOURCE: NZNCR database

Compared to NZ-authored articles, a higher proportion of Marsden-funded articles have co-authors from overseas (Figure 3.12). This difference is significant to a probability level of $\alpha < 0.001$ (binomial test, two tail). While this elevated collaboration rate appears to reflect the global nature of the Fund, two other factors may also contribute to raising the Marsden Fund's international collaboration rate:

- The high proportion of tertiary sector articles in the Marsden subset. MoRST *et al.* (2003) found that 52% of tertiary sector articles had international collaborations, as compared to 34% of all New Zealand-authored articles.
- The 20-fold increase in Marsden-funded articles between 1997 and 2001 (section 3.3). MoRST *et al.* (2003) found that international collaborations on New Zealand-authored articles increased by around 25% in the 5 year period; rising from 30% in 1997 to 38% in 2001.

A comparison of international collaborations by region (Figure 3.13) shows that collaborations on Marsden-funded articles are distributed in a roughly similar geographic pattern to those on New Zealand-authored articles. Marsden-funded articles, however, have significantly more collaborations with Western Europe, and significantly fewer collaborations with Pacific Region countries. Pacific Region collaborations are overwhelmingly with Australia, and the disparity between the Marsden and New Zealand proportion of Pacific Region collaborations results from the fact that 10.6% of Marsden-funded international collaborations and 18.4% New Zealand international collaborations are with Australia.

Figure 3.13. International collaborations by region on Marsden-funded versus New Zealand-authored articles. Articles were published in 1997-2001 and each international collaboration is counted individually (i.e. one article can contribute more than one collaboration). The number of Marsden-funded articles co-authored with each region is given in parentheses.



SOURCE: NZNCR database

Regarding the breadth of international collaboration, the 1997-2001 New Zealand-authored articles, of which there were 22503, had collaborations with 115 different countries. In the same period, the 1256 Marsden-funded articles has collaborations with 46 different countries (Appendix VI).

4. Conclusions

4.1 Bibliometric Evaluation of the Marsden Fund

By bibliometric measures, Marsden-funded research appears to be performing well in comparison to the total pool of New Zealand research. The number of publications attributed to the Fund rose 20-fold between 1994 and 2001, and the Marsden-funded share of New Zealand-authored publications rose from 2.6% in 1997 to 7.7% in 2001⁷. Based on these trends, it appears likely that the Marsden publication count and percentage of New Zealand publications will continue to rise in years to come. Between 1997 and 2000, there was a 2.5-fold increase in Marsden articles published per million dollars of funding, rising from just over 5 articles per million in 1997, to 13 in 2000. This compares to the FRST figure of 5 peer reviewed articles per million dollars of FRST funding in 2001/02 (Foundation for Research Science and Technology, 2002). Of note is the finding that Marsden-funded articles are cited, on average, 1.7-fold more often than the total pool of New Zealand-authored articles. This suggests that compared to New Zealand-authored articles, Marsden-funded publications have a greater impact on their research fields.

These are positive indicators for a Fund that aims to support excellence in research and researchers and to enhance the underpinning research knowledge base in New Zealand. The elevated citation rate for Marsden-funded publications is of particular note, but how does it compare to other research funds? The Australian Research Council's Discovery Fund (formerly named the Large Grants Scheme) is similar to the Marsden Fund, and it was recently reported that articles funded by the Discovery Fund and published in the period 1996-2000, were cited an average of 4.62 times each, in the years 1996-2000 (Butler, 2004). Marsden-funded citation rates are slightly higher, at an average of 4.92 citations per article, for articles both published and cited in the period 1997-2001 (this study, data not shown). However, this comparison reflects unfairly on Marsden-funded publications because, unlike Discovery Fund articles, which are evenly distributed across the years 1996-2000 (Butler, 2004), a higher proportion of the Marsden-funded articles were published in the latter years of the 1997-2001 period. This means that most Marsden-funded articles have had less time to accumulate citations than Discovery Fund articles and therefore that, if this were accounted for, Marsden Fund citation rates would be further elevated over and above the Discovery Fund citation rate⁸.

Although it is not targeted at basic research, the majority of Marsden-funded research does appear to be basic in nature (Royal Society of New Zealand, 2003), and as compared to New Zealand-authored publications, Marsden-funded publications are more heavily weighted towards the more fundamental fields of research such as chemistry, mathematics and physics. This may contribute to the elevated Marsden Fund citation rate. Of particular note, 28% of New Zealand-authored articles in mathematics, and 25% of New Zealand-authored articles in physics were funded in part or in full by the Marsden Fund. Marsden-funded research does, in addition, produce articles in the more applied fields of agriculture/vet/environment, engineering & technology, IT/computing/communications, and medical & health sciences. While publications in these fields are under-represented compared to the New Zealand subject distribution, citation rates for Marsden-funded articles within these subjects are elevated in comparison to New Zealand figures, with the possible exception of IT/computing/communications (however note that the number of Marsden-funded articles in these fields are low).

⁷ Note that the Marsden Fund may only be one of several funding sources that contribute to each publication

⁸ A comparison of Marsden and Discovery Fund citation rates broken down by year is not possible because the bibliometric study of the Discovery Fund did not analyse citation rates for individual years within the 1996-2000 period.

The great majority of Marsden-funded articles (94%) have one or more authors affiliated to tertiary institutions, reflecting the high proportion of Marsden Fund contracts that are awarded to researchers from this sector. Authors from CRIs, government and private sector institutions, on the other hand, are under-represented on Marsden-funded articles as compared to the number of contracts awarded to them. The reason for this is unclear. It may result from differing productivity between sectors, extra pressure on university researchers to publish, or it may be related to the predominant research fields of the different sectors: articles can take more resources to produce and therefore be produced less frequently in some fields than others. In addition, the NZNCR database coverage may be less extensive for fields that are predominantly worked in by the CRI, government and private sectors.

Marsden-funded articles have a higher rate of international collaboration than New Zealand-authored articles, but a comparatively lower rate of inter-sectoral collaboration within New Zealand. Both these findings may be related to the high proportion of tertiary sector articles in the Marsden-funded group of publications. MoRST *et al.* (2003) found that tertiary sector articles have a lower rate of intersectoral collaboration and a higher rate of international collaboration than articles from other New Zealand sectors. The fact that 48% of Marsden-funded articles (as compared to 38% of New Zealand-authored articles) have co-authors from overseas suggests that the Fund is assisting the development of international collaborations, and is in this sense fulfilling, at least in part, its goal of ensuring that New Zealand is contributing to and benefiting from the global advancement of knowledge.

4.2. Uneven coverage of subject fields

The fact that the Marsden Fund is not targeted to specific fields of research presents a valuable opportunity to assess the validity of applying bibliometric methods to different fields. It has been noted by many authors that Institute of Scientific Information databases such as the NZNCR do not provide even coverage across subject fields (e.g. National Board of Employment Education and Training, 1994). This is due firstly to non-inclusion of publication types other than journal papers and conference proceedings (such as books, book chapters, reports, etc), and secondly to selective coverage of journals and proceedings (Testa, 2002). Our analysis of the coverage of Marsden-funded publications by the NZNCR confirms that some fields are better covered than others, and we have been able to quantify the coverage of Marsden-funded publications in different fields. Defining research fields according to ASRC categories (section 2.5), we find that the NZNCR database provides excellent coverage of publications in the fields of chemistry and medical & health sciences (91% and 88% respectively), fairly good coverage of publications in physics, biology and agriculture/vet/environment (78%, 76%, and 71% respectively), and reasonable coverage of mathematics (65%). The NZNCR covers only just over half of the Marsden-funded publications in the engineering & technology and earth sciences fields (57% and 55% respectively), and covers less than half of the publications in the IT/computing/communications, and social sciences fields (46% and 39% respectively). Coverage of humanities publications is particularly poor at 15%. These figures pertain specifically to Marsden-funded research. The extent to which they can be extrapolated to non-Marsden research is not known, but results are consistent with others' findings (e.g. National Board of Employment Education and Training, 1994). We therefore emphasise that bibliometric evaluation of humanities, social science, IT/computing/communications, and to some extent engineering & technology and earth sciences research should be approached with caution.

Appendix I Coverage of publications by the NZNCR database

It is important to assess the extent of NZNCR database coverage of Marsden-funded publications as this affects the validity of bibliometric analysis of the Fund. If only a small percentage of Marsden-funded publications were covered by the NZNCR, it would suggest that bibliometric analyses are of limited use in evaluation of outputs from the Fund. Conversely, more complete coverage would support the use of bibliometric analysis as an tool for evaluation of the Marsden Fund.

AI.1 Marsden Fund outputs 1993-2003

The NZNCR database used for this study lists only journal articles and refereed conference proceedings published in the five year period, 1997-2001. Such publications, however, only represent a fraction of the outputs to date from Marsden grants. Many more papers and proceedings have been published outside of this time period; some publications are in press but not yet published, and a large number are output types other than journal articles and refereed conference proceedings. The total number of Marsden-funded outputs from projects funded in the 1993-2000 funding rounds listed in the Marsden bibliographic database is shown in Table 3.1 (Section 3.1).

AI.2 Marsden Fund outputs published or completed in 1997-2001

Of the Marsden-funded outputs that were published or completed in the period 1997-2001, only journal articles and refereed conference proceedings can be expected to be covered by the NZNCR database. As shown in Table AI.1, these two publication types together account for 41% of Marsden-funded outputs from 1997-2001, or when publications are defined more narrowly as articles, proceedings, book chapters, books, edited volumes, and reports (excluding conference presentations, theses, patents, software and “other” outputs), they account for 88% of Marsden publications.

Table AI.1. Marsden-attributed publications and other outputs, published or completed in 1997-2001¹

output type	# published/completed ^{II}	% of Marsden outputs
Journal Article	1438	35%
Refereed Conf Proc	239	6%
Book Chapter	131	3%
Book	15	<1%
Edited Volume	14	<1%
Thesis	96	2%
Report	72	2%
Patent	3	<1%
Software	1	<1%
Other	68	2%
Invited conference talk	309	8%
Contributed conference talk	1092	27%
Conference poster	612	15%
<i>Total</i>	<i>4095</i>	

¹ This includes outputs from all projects funded in the 1993 to 2000 funding rounds. Outputs from projects funded after 2000 were only included if a final report was received before August 2003. Data extracted from the Marsden Bibliographic Database, August 2003.

^{II} For projects that have not yet finished or that finished on or after 1 January, 2003, publication status is as of the most recent project report. For projects that finished before 1 January, 2003, a follow-up exercise (described in section 2.2) was conducted, in order to gather any updates on publication status and data on any new publications that had arisen since the final report.

AI.3 Coverage of 1997-2001 Marsden Fund journal articles and refereed conference proceedings by the NZNCR database

The NZNCR database only lists journal articles and refereed conference proceedings. However it does not exhaustively cover every journal and proceeding series. The ISI selects journals for inclusion on the basis of journal standards, editorial content, international diversity, and journal citation characteristics (Testa, 2002). While publications in the approximately 8730 journals and proceedings covered by the ISI National Citation Reports databases account for more than 95% of the world's citations, they still represent only a fraction of the actual journals published worldwide. As shown in Table AI.2, the coverage of 1997-2001 Marsden-funded journal articles by the NZNCR is quite good, at 82%, however the coverage of refereed conference proceedings is less extensive, at 34%. Overall, the NZNCR covers 75% of the Marsden-funded journal articles and refereed conference proceedings published between 1997 and 2001.

Table AI.2. Coverage of Marsden-funded journal articles and refereed conference proceedings by the NZNCR database

output type ¹	# in Marsden Bibliographic Database	# also present in NZNCR database	% NZNCR Coverage
Journal Article	1438	1176	82%
Refereed Conf Proc	239	81	34%

¹ Outputs published between 1997 and 2001, from projects funded in the 1993 to 2000 funding rounds, and from projects funded after 2000 for which a final report was been received by August 2003.

AI.4 Characteristics of journal articles that were not included in the NZNCR database

Marsden journal articles published in 1997-2001 that were not covered by the NZNCR were identified, and the probable reason for non-coverage of each article was determined by checking journal and article characteristics via a search of journal websites. Results are given in Table AI.3.

As shown in Table AI.3, the most common reason for the non-coverage of articles by the NZNCR was that the journal of publication was not indexed by ISI. A smaller number of the non-covered articles were published in journals indexed by the ISI. Of these articles, the majority were not present in the NZNCR because all author addresses were non-New Zealand (in these cases, the Marsden-funded researcher had been overseas for part of the project, and had given the overseas address at which the work had taken place). A slightly lesser proportion were not indexed due either to indexing lags (MoRST *et al.*, 2003), or to possible accidental omission by ISI.

Table AI.3. Characteristics of the 1997-2001 Marsden-funded journal articles that were not present in the NZNCR

Reason for non-coverage	Number of articles	% of non-covered articles
<i>Journal of publication is covered by ISI but article is missing from NZNCR database</i>	83	31.3%
<i>ARTICLE CHARACTERISTICS:</i>		
No NZ author address	44	16.6%
Indexing lag/possible ISI error	36	13.6%
Journal not covered prior to 2002/possible ISI error	2	0.8%
NZ author >15 th on list ^I	1	0.4%
<i>Journal of publication is not covered by ISI</i>	146	55.1%
<i>JOURNAL CHARACTERISTICS:</i>		
NZ regional journal	39	14.7%
overseas regional journal	11	4.2%
non-english language journal	5	1.9%
e-journal	1	0.4%
internationally distributed journal	44	16.6%
journal of uncertain characteristics	46	17.4%
<i>Cannot verify existence of journal/article</i> ^{II}	36	13.6%

^I ISI index a maximum of 15 authors for each article.

^{II} In these cases the journal or article does in all likelihood exist, but information about it could not be found via a web search.

The reasons for non-coverage of refereed conference proceedings were not assessed and in most cases it is likely that the proceeding series is not covered by ISI.

AI.5 NZNCR coverage of Marsden-funded publications by subject

In order to obtain an estimate of the extent of NZNCR coverage of Marsden publications in different subjects, all Marsden contracts with 1997-2001 publications listed in the Marsden Bibliographic Database were assigned to an ASRC subject field as outlined in Section 2.6. 1997-2001 publications from contracts in the same field were then aggregated and the percentage of publications present in the NZNCR was determined. It should be noted that one contract can produce publications in more than one ASRC field, so coverage could more accurately be assessed by assigning each individual Marsden-funded publication to an ASRC field. However, as this would be very time-consuming it was outside of the scope of this study.

In Table AI.4, the number and percentage of different publication types in each field are shown. Publishing behaviour differs between fields. Journal articles constitute more than 80% of the publications in the fields of agriculture/vet/environment, biology, chemistry, and medical & health sciences, 75% of the publications in the mathematics and physics fields, around 65% of the publications in the earth sciences and social sciences fields, and only around 50% of the publications in the humanities, engineering & technology, and IT/computing/communications fields. Proceedings more frequently result from contracts in earth sciences, engineering & technology, IT/computing/communications and physics. Books, book chapters and edited volumes make up a greater percentage of publications from humanities and social sciences, as compared to other fields.

Table AI.4. Marsden-funded publication types by originating contract's ASRC subject field ¹. Columns labelled “%” show the percentage of a subject field's publications that are of the specified publication type.

ASRC Field	articles		proceedings		books		book chapters		edited volumes		reports		<i>all</i>
	#	%	#	%	#	%	#	%	#	%	#	%	#
Agric/Vet/Envt	97	84	7	6	0	0	4	3	0	0	8	7	116
Biology	350	83	28	7	0	0	30	7	1	0	12	3	421
Chemistry	199	94	5	2	1	0	5	2	0	0	2	1	212
Earth Sci	105	65	36	22	1	1	4	2	1	1	15	9	162
Eng & Tech	25	46	26	48	0	0	2	4	1	2	0	0	54
Humanities	47	45	11	10	5	5	36	34	6	6	0	0	105
IT/Comp/Comm	53	53	33	33	3	3	5	5	1	1	5	5	100
Mathematics	298	75	49	12	4	1	26	7	3	1	20	5	400
Med & Health Sci	125	87	6	4	1	1	11	8	1	1	0	0	144
Physics	282	75	82	22	0	0	8	2	1	0	4	1	377
Social Sciences	94	66	5	4	4	4	20	14	3	2	14	10	142

¹ The number of publications by ASRC subject field differs from data in Section 3.4 and Appendix III because for this table, publication subject is assigned according to the originating contract's field, rather than individual articles' subject assignment in the NZNCR database.

Given that the NZNCR lists only journal articles and refereed conference proceedings, it is important to know what proportion of each field's publications are articles and proceedings, as opposed to books, book chapters, edited volumes and reports⁹. Publications in fields with a lower percentage of articles and proceedings will be less well covered by the NZNCR, and bibliometric analysis will therefore be less useful for these fields. Table AI.5 shows that for all fields except humanities and social sciences, the percentage of publications that are articles or proceedings exceeds 85%. Articles and proceedings constitute 70% of Marsden-funded social science publications, and 55% of humanities publications.

Table AI.5. Percentage of 1997-2001 Marsden-funded publications that are journal articles or refereed conference proceedings, by field (Source: Marsden bibliographic database).

ASRC Field	# articles & proceedings	% field's publications that are articles or proceedings
Agric/Vet/Envt	104	90
Biology	378	90
Chemistry	204	96
Earth Sci	141	87
Eng & Tech	51	94
Humanities	58	55
IT/Comp/Comm	86	86
Mathematics	347	87
Med & Health Sci	131	91
Physics	364	97
Social Sciences	99	70

Lastly, it is important to determine the coverage of each field's articles and conference proceedings by the NZNCR. Table AI.6 shows that the coverage is not uniform across the ASRC fields. Chemistry and medical & health sciences have particularly good coverage, at 94% and 93% respectively, and agriculture/vet/environment, biology and physics have around 80% coverage. Less well covered are: mathematics at 70%, and earth sciences and

⁹ Theses and conference presentations are not counted as publications because they are frequently the precursors of articles, proceedings, books, book chapters, or reports.

engineering & technology at just over 60%. There appears to be fairly poor coverage of social sciences (56%) and IT/computing/communications (51%), but the most striking deficit is for humanities, in which only 28% of Marsden articles and proceedings are covered by the NZNCR.

The most common reasons for lack of coverage of a field's publications are that it has a high proportion of proceedings (which are less well covered than journal articles; see Table AI.2), or articles in journals that are not covered by the NZNCR (Table AI.6). It should also be noted that within the Social Sciences field, psychology publications appear to be more extensively covered than publications in other sub-fields. The coverage by subject shown in Table AI.6 accords roughly to that found for Australian publications (National Board of Employment Education and Training, 1994). This study used very different subject categories to the ASRC categories used here, but their analysis also showed poor coverage of humanities and social science topics.

Table AI.6. Coverage of Marsden-funded 1997-2001 articles and proceedings by the NZNCR database

ASRC Field	% field's articles and proceedings in NZNCR	comments
Agric/Vet/Envt	79	
Biology	82	
Chemistry	94	
Earth Sci	63	Variety of reasons for non-coverage
Eng & Tech	62	Majority of those not covered are proceedings
Humanities	28	Most non-covered publications are articles in journals not covered by the NZNCR
IT/Comp/Comm	51	Most non-covered publications are proceedings, or articles in journals not covered by the NZNCR
Mathematics	70	Most non-covered publications are proceedings, or articles in journals not covered by the NZNCR
Med & Health Sci	93	
Physics	80	Most non-covered publications are proceedings, or articles in journals not covered by the NZNCR
Social Sciences	56	Psychology publications are more extensively covered than those in other sub-fields. Most non-covered publications are articles in journals not covered by the NZNCR

When NZNCR coverage by field is expressed as a percent of all publications in each field, coverage differs markedly across fields (Table AI.7). Particularly poor is the coverage of humanities publications (15%), and also low is the coverage of social sciences (39%), IT/computing/communications (46%), earth sciences (55%), and engineering & technology (57%). Mathematics has 65% coverage, and all other fields have coverage rates of >70%. There is particularly good coverage of chemistry and medical & health sciences, at 91% and 88% respectively.

Table AI.7. Coverage of Marsden-funded 1997-2001 total publications by the NZNCR database, by field

ASRC Field	% field's total publications in NZNCR¹
Agric/Vet/Envt	71
Biology	76
Chemistry	91
Earth Sci	55
Eng & Tech	57
Humanities	15
IT/Comp/Comm	46
Mathematics	65
Med & Health Sci	88
Physics	78
Social Sciences	39

¹ Total publications include journal articles, refereed conference proceedings, books, book chapters, edited volumes and reports.

Appendix II Publications by Year

Table AII.1. Marsden-funded publications by year, 1994-2001 (Source: Marsden bibliographic database)

Publication Type	1994	1995	1996	1997	1998	1999	2000	2001	<i>all</i>
Journal Articles	24	37	96	132	247	294	365	404	1599
Refereed Conference Proceedings	0	2	15	27	33	41	73	66	257
Book Chapters	3	2	6	11	25	25	40	46	158
Books	0	0	1	1	2	2	3	8	17
Edited Volumes	0	0	0	0	2	3	2	8	15
Reports	0	1	5	14	13	22	11	12	78
<i>total</i>	27	42	123	185	322	387	494	544	2124

Table AII.2. Marsden-funded and New Zealand-authored publications in the NZNCR database, 1997-2001.

	1997	1998	1999	2000	2001	<i>all years</i>
Number Marsden-funded articles	116	221	269	342	308	1256
Number NZ-authored articles	4444	4559	4791	4689	4020	22503
% NZ articles attributed to Marsden	2.6	4.8	5.6	7.3	7.7	5.6

Table AII.3. Marsden funding compared to New Zealand's government expenditure on R&D (GovERD), higher education expenditure on R&D (HERD), and gross expenditure on R&D (GERD)

	1995	1996	1997	1998	1999	2000	2001	2002
\$ million Marsden funding	5.5	11	21.8	21.8	22.8	25.8	27.8	30.8
\$ million GovERD ¹	-	375.6	-	391.3	-	393	-	449.6
\$ million HERD ¹	-	273.4	-	403.6	-	374.1	-	435.8
\$ million GERD ¹	-	889.1	-	1108.3	-	1091.2	-	1308.3
Marsden funding as a % GovERD + HERD	-	1.7	-	2.7	-	3.4	-	3.5
Marsden funding as % GERD	-	1.2	-	2.1	-	2.5	-	2.4

¹ From New Zealand Research and Development statistics (Ministry of Research Science and Technology and Statistics New Zealand, 2003). Statistics are published biennially.

Table AII.4. Articles¹ per \$ million research funding

	1997	1998	1999	2000
Marsden articles per \$ million Marsden funding	5.3	10.1	11.8	13.2
NZ-authored articles per \$ million GovERD + HERD	-	5.7	-	6.1
NZ-authored articles per \$ million GERD	-	4.1	-	4.3

¹ restricted to journal papers and proceedings covered by the NZNCR database.

Appendix III Publications by Subject

Table AIII.1. Subject distribution of Marsden funded and New Zealand-authored articles in the NZNCR database, 1997-2001 (Source: NZNCR database).

Subject	# Marsden articles	# NZ articles	% Marsden articles	% NZ articles	α ⁱ
Agric/Vet/Envt	57	2635	4.5	11.7	<0.001
Biology	249	4549	19.8	20.2	0.762
Chemistry	169	1506	13.4	6.7	<0.001
Earth Sciences	61	1182	4.9	5.3	0.526
Eng & Tech	43	1294	3.4	5.8	<0.001
Humanities	13	505	1.0	2.2	0.002
IT/Comp/Comm	15	197	1.2	0.9	0.338
Mathematics	108	385	8.6	1.7	<0.001
Med & Health	142	7109	11.3	31.6	<0.001
Physics	318	1258	25.3	5.6	<0.001
Social Sci	51	2219	4.1	9.9	<0.001
Multidisciplinary ⁱⁱ	25	336	2.0	1.5	0.198
No Category ⁱⁱⁱ	89	1645	7.1	7.3	0.818
<i>All subjects</i>	<i>1256</i>	<i>22503</i>			

ⁱ The probability that a random sample of 1256 New Zealand-authored articles would contain the same percentage of articles in a given subject as in the Marsden sub-set of articles is given by α (binomial test, two tail). Normally a score of $\alpha \leq 0.05$ is considered significant.

ⁱⁱ The multidisciplinary category consists of articles in multidisciplinary journals (such as the journal of the Royal Society of New Zealand), not articles that are multidisciplinary in themselves.

ⁱⁱⁱ Articles in the “no category” field were not categorised into a subject field in the NZNCR database. Re-categorisation of these articles was beyond the scope of this study.

Table AIII.2. Proportion of 1997-2001 Marsden funding by subject, compared to the proportion of 1997-2001 Marsden-funded articles by subject.

Subject	% Marsden funding, 1993-2000 ⁱ	% Marsden articles in subject ⁱⁱ	Adjusted % Marsden articles ⁱⁱⁱ
Agric/Vet/Envt	8.2	4.5	4.2
Biology	37.9	19.8	17.2
Chemistry	10.6	13.4	9.8
Earth Sciences	7.6	4.9	5.8
Eng & Tech	1.5	3.4	4.0
Humanities	4.4	1.0	4.6
IT/Comp/Comm	2.6	1.2	1.7
Mathematics	8.7	8.6	8.7
Med & Health	11.5	11.3	8.5
Physics	13.8	25.3	21.4
Social Sci	6.8	4.1	6.9

ⁱ Marsden funding by subject calculated as outlined in section 2.6.

ⁱⁱ Articles are restricted to those covered by the NZNCR database

ⁱⁱⁱ Adjusted to account for the percentage coverage of each field’s publications by the NZNCR database. The number of NZNCR-listed, Marsden-funded articles in each field (Table AIII.1, column 2) was divided by the percentage coverage of each field’s publications (Table AI.7, column 2) to give the number of Marsden-articles by subject that would be expected if the NZNCR covered every subject completely.

Table AIII.3. Percent of New Zealand-authored articles in each subject that have been funded

by Marsden (Source: NZNCR database).

Subject	% NZ articles funded by Marsden
Agric/Vet/Envt	2.2
Biology	5.5
Chemistry	11.2
Earth Sciences	5.2
Eng & Tech	3.3
Humanities	2.6
IT/Comp/Comm	7.6
Mathematics	28.1
Med & Health	2.0
Physics	25.3
Social Sci	2.3
Multidisciplinary	7.4
No Category	5.4
<i>All subjects</i>	5.6

Appendix IV Citations

Table AIV.1. Citations to Marsden-funded articles (Source: NZNCR database).

Subject	1997		1998		1999		2000		2001	
	# artls	avg cites	# artls	avg cites	# artls	avg cites	# artls	avg cites	# artls	avg cites
Agric/Vet/Envt	2	52.5	9	12.8	10	9.3	22	2.4	14	0.3
Biology	17	20.4	46	12.0	44	8.7	69	2.7	73	0.8
Chemistry	16	9.9	30	13.3	36	4.7	44	2.1	43	0.2
Earth Sciences	7	8.7	10	6.3	12	5.3	15	1.1	17	0.1
Eng & Tech	4	5.0	9	3.3	8	3.1	11	0.4	11	0.2
Humanities	0	-	2	0.0	5	0.2	4	1.3	2	0.0
IT/Comp/Comm	0	-	4	0.8	3	1.0	4	1.0	4	0.0
Mathematics	16	3.7	17	1.6	24	2.0	26	0.8	25	0.2
Med & Health	8	18.1	22	8.2	25	7.0	52	2.4	35	0.5
Physics	36	19.1	62	10.5	77	7.4	82	4.4	61	0.7
Social Sci	2	3.0	8	3.8	12	3.9	18	0.7	11	0.1
Multidisciplinary	3	10.3	4	7.0	3	4.3	7	2.1	8	0.4
No Category	10	1.9	12	2.5	23	0.9	20	0.1	24	0.1
<i>All subjects</i>	<i>116</i>	<i>13.7</i>	<i>221</i>	<i>9.2</i>	<i>270</i>	<i>5.9</i>	<i>342</i>	<i>2.5</i>	<i>308</i>	<i>0.5</i>

Table AIV.2. Citations to New Zealand-authored articles (Source: NZNCR database).

Subject	1997		1998		1999		2000		2001	
	# artls	avg cites	# artls	avg cites	# artls	avg cites	# artls	avg cites	# artls	avg cites
Agric/Vet/Envt	518	5.2	541	4.2	593	2.4	539	1.1	444	0.2
Biology	877	8.2	938	5.8	942	3.5	954	1.6	838	0.4
Chemistry	306	7.2	344	6.1	309	3.7	295	1.5	252	0.2
Earth Sciences	221	6.7	254	5.0	237	3.4	246	1.4	224	0.6
Eng & Tech	249	3.1	257	2.2	283	1.1	244	0.5	261	0.8
Humanities	112	0.5	107	0.7	116	0.2	97	0.2	73	0.0
IT/Comp/Comm	40	2.9	40	2.6	42	1.0	33	0.3	42	0.1
Mathematics	85	2.1	78	1.8	73	1.1	78	0.5	71	0.1
Med & Health	1359	8.9	1406	6.6	1481	4.1	1539	1.9	1324	0.3
Physics	252	8.8	258	6.3	251	4.8	269	2.3	228	0.4
Social Sci	452	3.6	413	2.5	486	1.4	454	0.6	414	0.1
Multidisciplinary	54	5.4	64	3.1	65	2.3	65	1.1	88	0.2
No Category	384	1.1	316	0.9	369	0.6	362	0.3	214	0.1
<i>All subjects</i>	<i>4444</i>	<i>6.5</i>	<i>4559</i>	<i>4.9</i>	<i>4791</i>	<i>3.0</i>	<i>4689</i>	<i>1.4</i>	<i>4020</i>	<i>0.3</i>

Table AIV.3. Difference between Marsden and New Zealand citation rates for articles published 1997-2001 (Source: NZNCR database).

	1997	1998	1999	2000	2001
Marsden avg citations/paper	13.7	9.2	5.8	2.5	0.5
NZ avg citations/paper	6.5	4.9	3.0	1.4	0.3
Marsden/NZ citations per paper	2.1	1.9	1.9	1.8	1.7

Table AIV.4. Citation distributions for NZ-authored and Marsden-funded articles published in 1997-1999 and cited in the 3 years following publication. (Source: NZNCR database).

# citations	# Marsden articles	% Marsden articles	# NZ articles	% NZ articles
0	98	16.2	4638	32.2
1-4	247	40.8	6780	47.1
5-8	129	21.3	1748	12.1
9-12	41	6.8	572	4.0
13-16	34	5.6	270	1.9
17-20	15	2.5	146	1.0
21-30	24	4.0	146	1.0
31-40	9	1.5	49	0.3
41-50	4	0.7	20	0.1
>50	4	0.7	29	0.2

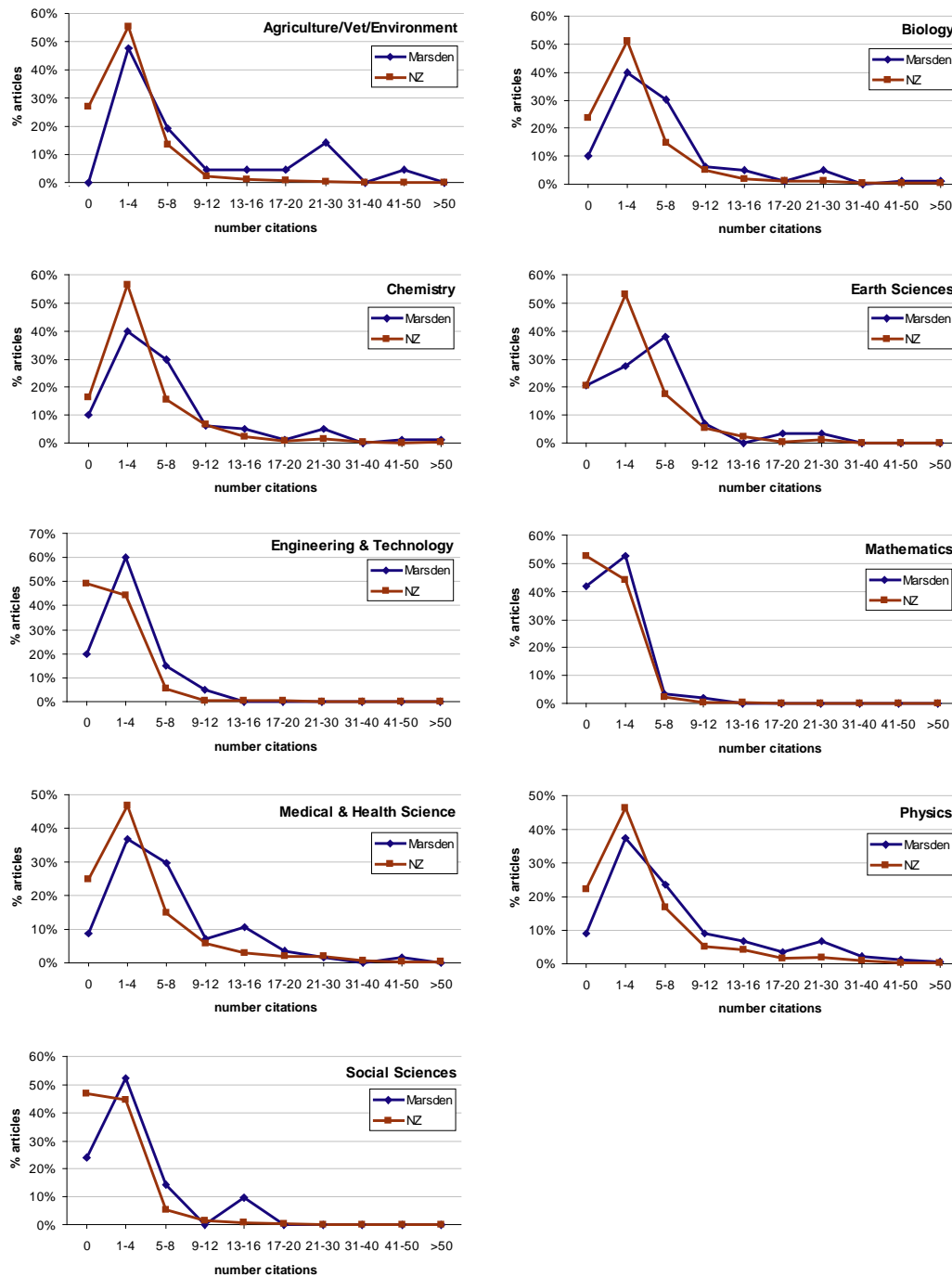
Table AIV.5. Citation distributions for Marsden-funded articles published in 1997-1999 and cited in the 3 years following publication, broken down by subject field (Source: NZNCR database).

	0 cites	1-4	5-8	9-12	13-16	17-20	21-30	31-40	41-50	>50
NUMBER OF ARTICLES										
Agric/Vet/Env	0	10	4	1	1	1	3	0	1	0
Biology	6	38	21	12	9	4	4	4	0	2
Chemistry	8	32	24	5	4	1	4	0	1	1
Earth Sci	6	8	11	2	0	1	1	0	0	0
Eng & Tech	4	12	3	1	0	0	0	0	0	0
Humanities	6	0	0	0	0	0	0	0	0	0
IT/Comp/Comm	4	2	0	0	0	0	0	0	0	0
Maths	23	29	2	1	0	0	0	0	0	0
Med & Health	5	21	17	4	6	2	1	1	0	0
Physics	15	62	39	15	11	6	11	4	2	1
Soc Sci	5	11	3	0	2	0	0	0	0	0
Multidisciplinary	0	5	5	0	0	0	0	0	0	0
No Category	16	17	0	0	1	0	0	0	0	0
PERCENT OF ARTICLES										
Agric/Vet/Env	0	47.6	19	4.8	4.8	4.8	1403	0	4.8	0
Biology	6	38	21	12	9	4	4	4	0	2
Chemistry	10	40	30	6.3	5	1.3	5	0	1.3	1.3
Earth Sci	20.7	27.6	37.9	6.9	0	3.4	3.4	0	0	0
Eng & Tech	20	60	15	5	0	0	0	0	0	0
Humanities	100	0	0	0	0	0	0	0	0	0
IT/Comp/Comm	66.7	33.3	0	0	0	0	0	0	0	0
Maths	41.8	52.7	3.6	1.8	0	0	0	0	0	0
Med & Health	8.8	36.8	29.8	7	10.5	3.5	1.8	1.8	0	0
Physics	9	37.3	23.5	9	6.6	3.6	6.6	2.4	1.2	0.6
Soc Sci	23.8	52.4	14.3	0	9.5	0	0	0	0	0
Multidisciplinary	0	50	50	0	0	0	0	0	0	0
No Category	47.1	50	0	0	2.9	0	0	0	0	0

Table AIV.6. Citation distributions for NZ-authored papers published in 1997-1999 and cited in the 3 years following publication, broken down by subject field (Source: NZNCR database).

	0 cites	1-4	5-8	9-12	13-16	17-20	21-30	31-40	41-50	>50
NUMBER OF ARTICLES										
Agric/Vet/Env	424	880	213	34	19	10	4	1	1	0
Biology	623	1358	391	131	56	33	28	13	6	9
Chemistry	153	532	145	60	20	8	14	3	1	3
Earth Sci	140	361	118	36	15	3	8	1	0	0
Eng & Tech	382	346	41	5	2	3	0	0	0	0
Humanities	236	57	0	0	1	0	0	0	0	0
IT/Comp/Comm	61	48	8	0	0	0	0	0	0	0
Maths	121	101	5	1	1	0	0	0	0	0
Med & Health	1003	1879	599	235	111	72	74	24	10	14
Physics	164	343	123	39	30	13	15	7	2	3
Soc Sci	602	571	69	22	10	4	2	0	0	0
Multidisciplinary	56	86	23	2	2	0	0	0	0	0
No Category	673	218	13	7	3	0	1	0	0	0
PERCENT OF ARTICLES										
Agric/Vet/Env	26.7	55.5	13.4	2.1	1.2	0.6	0.3	0.1	0.1	0
Biology	23.5	51.3	14.8	4.9	2.1	1.2	1.1	0.5	0.2	0.3
Chemistry	16.3	56.7	15.4	6.4	2.1	0.9	1.5	0.3	0.1	0.3
Earth Sci	20.5	52.9	17.3	5.3	2.2	0.4	1.2	0.1	0	0
Eng & Tech	49	44.4	5.3	0.6	0.3	0.4	0	0	0	0
Humanities	80.3	19.4	0	0	0.3	0	0	0	0	0
IT/Comp/Comm	52.1	41	6.8	0	0	0	0	0	0	0
Maths	52.8	44.1	2.2	0.4	0.4	0	0	0	0	0
Med & Health	24.9	46.7	14.9	5.8	2.8	1.8	1.8	0.6	0.2	0.3
Physics	22.2	46.4	16.6	5.3	4.1	1.8	2	0.9	0.3	0.4
Soc Sci	47	44.6	5.4	1.7	0.8	0.3	0.2	0	0	0
Multidisciplinary	33.1	50.9	13.6	1.2	1.2	0	0	0	0	0
No Category	73.6	23.8	1.4	0.8	0.3	0	0.1	0	0	0

Figure AIV.1. Citation distributions for Marsden-funded and New Zealand-authored articles published in the years 1997-1999 and cited in the 3 years following publication, broken down by subject field. Distributions are not given for the Humanities or IT/Computing/Communications subjects because they contained very few articles which, in addition, received only low numbers of citations. The quantity of Marsden-funded articles in the fields of Agriculture/Vet/Environment, Earth Sciences, Engineering & Technology, and Social Sciences was also low (see Table AIV.5)



(SOURCE: NZNCR database).

Appendix V Sectors

Table AV.1. Articles by sector (Source: NZNCR database).

	Marsden 1997-2001		NZ 1997 & 2001 ^I		α ^{III}
	# articles	% articles ^{II}	# articles	% articles ^{II}	
Tertiary	1177	93.7	5726	67.8	<0.001
CRI	142	11.3	2058	24.4	<0.001
Government	12	1.0	912	10.8	<0.001
Local	3	0.2	41	0.5	0.127
Private	9	0.7	902	10.7	<0.001
<i>All sectors</i>	<i>1256</i>		<i>8448</i>		

^I Sectorised data for New Zealand-authored articles is only available for 1997 and 2001 (MoRST *et al.*, 2003).

^{II} percent of all Marsden-funded or NZ-authored articles published in given year-range, that have one or more authors from the sector

^{III} The probability that a random sample of 1256 New Zealand-authored articles would contain the same percentage of articles from a given sector as in the Marsden sub-set of articles is given by α (binomial test, two tail). Normally a score of $\alpha \leq 0.05$ is considered significant.

Table AV.2. Intersectoral collaborations within New Zealand (Source: NZNCR database).

	Marsden 1997-2001		NZ 1997 & 2001 ^I		α ^{II}
	# articles	% articles	# articles	% articles	
Articles with intersectoral collaborations	84	6.7	1129	13.4	<0.001
<i>Total articles</i>	<i>1256</i>		<i>8448</i>		

^I Sectorised data for New Zealand-authored articles is only available for 1997 and 2001 (MoRST *et al.*, 2003).

^{II} The probability that a random sample of 1256 New Zealand-authored articles would contain the same percentage of articles with intersectoral collaborations as the Marsden sub-set of articles is given by α . (binomial test, two tail). Normally a score of $\alpha \leq 0.05$ is considered significant.

Appendix VI International Collaborations

Table AVI.1. International Collaborations, 1997-2001 (Source: NZNCR database).

	Marsden-funded		NZ-authored		α^1
	# articles	% articles	# articles	% articles	
Articles with international collaborations	598	47.6	8436	37.5	<0.001
<i>Total articles</i>	<i>1256</i>		<i>22503</i>		

¹ The probability that a random sample of 1256 New Zealand-authored articles would contain the same percentage of articles with international collaborations as the Marsden sub-set of articles is given by α (binomial test, two tail). Normally a score of $\alpha \leq 0.05$ is considered significant.

Table AVI.1. International Collaborations by region, 1997-2001 (Source: NZNCR database).

Region	Marsden		NZ		α^{II}
	# collabs	% collabs ^I	# collabs	% collabs ^I	
Pacific	121	10.6	3234	18.7	<0.001
Asia	115	10.1	1480	8.6	0.088
Eastern Europe & Central Asia	21	1.8	233	1.3	0.150
Western Europe	419	36.7	5557	32.2	0.002
Near East & North Africa	12	1.1	148	0.9	0.668
Sub-Saharan Africa	14	1.2	263	1.5	0.540
Latin America	22	1.9	209	1.2	0.046
North America	417	36.5	6147	35.6	0.522
<i>Total int'l collaborations</i>	<i>1141</i>		<i>17271</i>		

^I percent of international collaborations that are with authors from the region (one article may contribute more than one collaboration).

^{II} The probability that a random sample of 1141 collaborations on New Zealand-authored articles would contain the same percentage of collaborations with the region as the Marsden sub-set of articles is given by α (binomial test, two tail). Normally a score of $\alpha \leq 0.05$ is considered significant.

Countries collaborated with

The 1256 Marsden-funded articles published in 1997-2001, and covered by the NZNCR database, had collaborations with the following 46 countries:

ARGENTINA	DENMARK	ITALY
AUSTRALIA	ENGLAND	JAMAICA
AUSTRIA	FINLAND	JAPAN
BELGIUM	FRANCE	MEXICO
BRAZIL	GERMANY	NETHERLANDS
CANADA	HONG KONG	NORTHERN IRELAND
CHILE	HUNGARY	NORWAY
COLOMBIA	INDIA	OMAN
CROATIA	IRELAND	PEOPLES REP CHINA
CZECH REPUBLIC	ISRAEL	PERU
PHILIPPINES	SOUTH AFRICA	U.S.
POLAND	SOUTH KOREA	WALES
PORTUGAL	SPAIN	
RUSSIA	SWEDEN	
SCOTLAND	SWITZERLAND	
SINGAPORE	TAIWAN	
SLOVAKIA	THAILAND	

The 22503 New Zealand-authored articles published in 1997-2001, and covered by the NZNCR database, had collaborations with the following 115 countries:

ALGERIA	IRAN	ROMANIA
ARGENTINA	IRELAND	RUSSIA
AUSTRALIA	ISRAEL	SAUDI ARABIA
AUSTRIA	ITALY	SCOTLAND
BANGLADESH	JAMAICA	SENEGAL
BARBADOS	JAPAN	SEYCHELLES
BELGIUM	JORDAN	SINGAPORE
BOTSWANA	KENYA	SLOVAKIA
BRAZIL	KUWAIT	SLOVENIA
BRUNEI	LATVIA	SOLOMON ISLANDS
BULGARIA	LEBANON	SOUTH AFRICA
CANADA	LITHUANIA	SOUTH KOREA
CENTRAL AFR REPUB	MALAWI	SPAIN
CHILE	MALAYSIA	SRI LANKA
COLOMBIA	MALTA	SUDAN
COOK ISLANDS	MAURITIUS	SURINAM
COSTA RICA	MEXICO	SWAZILAND
CROATIA	MOLDOVA	SWEDEN
CUBA	MONACO	SWITZERLAND
CYPRUS	MONGOL PPL REPUB	SYRIA
CZECH REPUBLIC	MYANMAR	TAIWAN
DENMARK	NAMIBIA	TANZANIA
ECUADOR	NEPAL	THAILAND
EGYPT	NETHERLANDS	TUNISIA
ENGLAND	NEW CALEDONIA	TURKEY
ESTONIA	NIGERIA	U ARAB EMIRATES
ETHIOPIA	NORTHERN IRELAND	UGANDA
FIJI	NORWAY	UKRAINE
FINLAND	OMAN	URUGUAY
FRENCH POLYNESIA	PAKISTAN	U.S.
FRANCE	PALAU	UZBEKISTAN
GERMANY	PANAMA	VENEZUELA
GHANA	PAPUA NEW GUINEA	VIETNAM
GREECE	PEOPLES REP CHINA	WALES
HONG KONG	PERU	WESTERN SAMOA
HUNGARY	PHILIPPINES	YUGOSLAVIA
ICELAND	POLAND	ZIMBABWE
INDIA	PORTUGAL	
INDONESIA	REUNION	

Appendix VII Subject Categorisation

The 106 ISI subject categories were mapped to ASRC subject categories as follows:

Agriculture/Vet/Environment

AGRICULTURE/AGRONOMY
ANIMAL & PLANT SCIENCES
ENVIRONMENT/ECOLOGY
VETERINARY MEDICINE/ANIMAL HEALTH

Biology

BIOCHEMISTRY & BIOPHYSICS
CELL & DEVELOPMENTAL BIOLOGY
MOLECULAR BIOLOGY & GENETICS
ANIMAL SCIENCES
AQUATIC SCIENCES
BIOLOGY
BIOTECHNOLOGY & APPLIED MICROBIOLOGY
ENTOMOLOGY/PEST CONTROL
EXPERIMENTAL BIOLOGY
MICROBIOLOGY
PLANT SCIENCES

Chemistry

AGRICULTURAL CHEMISTRY
CHEMISTRY & ANALYSIS
CHEMISTRY
INORGANIC & NUCLEAR CHEMISTRY
ORGANIC CHEMISTRY/POLYMER SCIENCE
PHYSICAL CHEMISTRY/CHEMICAL PHYSICS

Earth Sciences

EARTH SCIENCES

Engineering & Technology

AEROSPACE ENGINEERING
AI, ROBOTICS & AUTOMATIC CONTROL
CIVIL ENGINEERING
CHEMICAL ENGINEERING
ENVIRONMENTAL ENGINEERING & ENERGY
ELECTRICAL & ELECTRONICS ENGINEERING
ENGINEERING MANAGEMENT/GENERAL
GEOLOGICAL, PETROLEUM & MINING ENGINEERING
MECHANICAL ENGINEERING
METALLURGY
MATERIALS SCIENCE & ENGINEERING
NUCLEAR ENGINEERING

Humanities

GENERAL
ARCHAEOLOGY
ART & ARCHITECTURE

CLASSICAL STUDIES
HISTORY
LANGUAGE & LINGUISTICS
LITERATURE
PERFORMING ARTS
PHILOSOPHY
RELIGION & THEOLOGY

IT/Computing/Communications

COMPUTER SCIENCE & ENGINEERING
INFORMATION TECHNOLOGY & COMMUNICATIONS SYSTEMS

Mathematics

ENGINEERING MATHEMATICS
MATHEMATICS

Medical & Health Sciences

FOOD SCIENCE/NUTRITION
ANESTHESIA & INTENSIVE CARE
NEUROSCIENCES & BEHAVIOR
CARDIOVASCULAR & RESPIRATORY SYSTEMS
ONCOGENESIS & CANCER RESEARCH
CARDIOVASCULAR & HEMATOLOGY RESEARCH
DENTISTRY/ORAL SURGERY & MEDICINE
DERMATOLOGY
MEDICAL RESEARCH, DIAGNOSIS & TREATMENT
ENDOCRINOLOGY, NUTRITION & METABOLISM
GASTROENTEROLOGY AND HEPATOLOGY
GENERAL & INTERNAL MEDICINE
HEMATOLOGY
HEALTH CARE SCIENCES & SERVICES
IMMUNOLOGY
CLINICAL IMMUNOLOGY & INFECTIOUS DISEASE
RESEARCH/LABORATORY MEDICINE & MEDICAL TECHNOLOGY
MEDICAL RESEARCH, GENERAL TOPICS
NEUROLOGY
ENDOCRINOLOGY, METABOLISM & NUTRITION
MEDICAL RESEARCH, ORGANS & SYSTEMS
ONCOLOGY
OPHTHALMOLOGY
ORTHOPEDICS, REHABILITATION & SPORTS MEDICINE
OTOLARYNGOLOGY
PEDIATRICS
PHARMACOLOGY & TOXICOLOGY
PHARMACOLOGY/TOXICOLOGY
PSYCHIATRY
PHYSIOLOGY
PSYCHOLOGY
CLINICAL PSYCHOLOGY & PSYCHIATRY
RADIOLOGY, NUCLEAR MEDICINE & IMAGING
REPRODUCTIVE MEDICINE
RHEUMATOLOGY
ENVIRONMENTAL MEDICINE & PUBLIC HEALTH
SURGERY

UROLOGY & NEPHROLOGY
PUBLIC HEALTH & HEALTH CARE SCIENCE
REHABILITATION

Multidisciplinary

MULTIDISCIPLINARY

No Category

NO CATEGORY

Physics

APPLIED PHYSICS/CONDENSED MATTER/MATERIALS SCIENCE
INSTRUMENTATION & MEASUREMENT
OPTICS & ACOUSTICS
PHYSICS
SPACE SCIENCE
SPECTROSCOPY/INSTRUMENTATION/ANALYTICAL SCIENCES

Social Sciences

ENVIRONMENTAL STUDIES, GEOGRAPHY & DEVELOPMENT
ECONOMICS
EDUCATION
MANAGEMENT
COMMUNICATION
LAW
POLITICAL SCIENCE & PUBLIC ADMINISTRATION
SOCIOLOGY & ANTHROPOLOGY
SOCIAL WORK & SOCIAL POLICY
LIBRARY & INFORMATION SCIENCES
PUBLIC HEALTH & HEALTH CARE SCIENCE
REHABILITATION
PSYCHOLOGY

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