The successful development of a nation is, to a considerable extent, dependent on the knowledge and skills it develops. Creative thinking and innovation help a country take advantage of the opportunities that are presented. They also help it cope with the outside influences and internal pressures which impact on it. The ability of a society to deal with difficulties and with the innate disadvantages of its environment reflects the extent to which these are understood and prepared for. The tertiary education sector is the largest sector in our country’s innovation system. It is a major creator of knowledge and innovation. The two chapters in Section Four examine the performance of the sector as a contributor to New Zealand’s research and innovation effort.
INTRODUCTION

Most developed countries have recognised the importance of their research and innovation sector to long-term economic and social development. Improving the performance of the innovation system has, therefore, become an increasingly important priority for many countries. In New Zealand, as in most countries, the tertiary education sector plays a key role in the innovation system. The sector is a significant producer of research and, consequently, of new knowledge and is responsible for around 63 percent of the nation’s research papers. It also has the responsibility for training most of the researchers for the innovation system — producing graduates from research degrees with skills, knowledge and attributes that enable them to contribute to a knowledge-based society. As a result, the sustainability of the country’s research and innovation sector depends on a strong and improving research culture in the universities.

The advancement of knowledge through education and research is a core function of the tertiary education sector. The sector also undertakes significant research focused on adapting, transferring and exploiting domestic and international knowledge and technology. It does this alongside, and sometimes in partnership with, other research organisations, industry and business, community organisations and government.

This chapter focuses on the contribution of the tertiary education sector to the national innovation system and, in particular, it considers the research performance of the universities, which are the most significant producers of research in the sector. It explores the sector’s role in knowledge creation and innovation, looking at indicators of research output and productivity. It also explores the implications of the new system for funding of research in tertiary education — the Performance-Based Research Fund (PBRF) — and reports on the information the PBRF measures provide about the quality of research in tertiary education.

THE PLACE OF RESEARCH IN THE TERTIARY EDUCATION SYSTEM

The primary roles of tertiary education research activities are to:

- support degree-level teaching and ensure that degree graduates are of high quality and informed by up-to-date scholarship and developments in the knowledge base
- train New Zealand’s future knowledge-creators and innovators
- contribute to improving the knowledge base through high-quality research that generates new knowledge, and
- interpret new knowledge and disseminate it as a means of influencing people in communities and business.

The Education Act 1989, which sets out the statutory framework for all tertiary education in New Zealand, describes degrees as ‘primarily taught by those active in research’. The Act also states, in its characterisation of universities, that ‘...their research and teaching are closely interdependent and most of their teaching is done by people who are active in advancing knowledge ... [and] meet international standards of research ...’.

Thus, the legislation states that teaching at degree level and above is to be shaped and informed by research and that the universities are to have a major role as providers of research across a wide range of disciplines.

One traditionally important contribution of the universities to the national research effort is in the area of basic research, which involves exploring and expanding the frontiers of knowledge. Whereas the Crown Research Institutes (CRIs) and many other research providers are more likely to focus on applied or strategic research, the traditional role of the universities in postgraduate training and the nature of the funding for research in the universities mean that university-based researchers have greater opportunity to work in basic research. The Ministry of Research, Science and Technology (MoRST) and Statistics New Zealand (SNZ) estimate that more than 60 percent of all research conducted in the tertiary education sector is basic research. The MoRST/SNZ survey reports that just over a half (51 percent) of the basic research in New Zealand was conducted in the universities.

One of the challenges faced by a small country is how to create greater focus in its research effort as a means of increasing

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1 This information was supplied by the Ministry of Research, Science and Technology. It is drawn from a study of New Zealand data in the National Science Indicators published by Thomson Scientific and using data from the Institute for Scientific Information (ISI) database.
2 Refer to Section 162 of the Education Act 1989.
3 Education Act 1989, section 254(3)(a).
4 Ibid, section 162(4).
5 MoRST and SNZ (2005), Research and Development in New Zealand 2004. The report estimates that about 35 percent of all New Zealand research is basic research. It makes these estimates by calculating the expenditure on research activities by research type, as reported in the responses to its survey.
the benefits deriving from a limited investment in research. Research also tends to flourish where there is a critical mass of people active in common research areas. Inevitably, creating world-class research performance in the New Zealand context poses a challenge – because we have a small and widely dispersed population and because most of the tertiary education organisations are small by international standards. MoRST data shows\(^8\) that for papers published in 2003, New Zealand ranked second out of 22 developed countries for research output per dollar invested and 10th for research output per head of population – close to Canada and Australia. In terms of research impact – as measured by citations\(^7\) – however, New Zealand ranked 20th. As a means of lifting performance – within the constraints imposed by New Zealand’s size and location – the government has developed two major new means of promoting and funding research in the sector.

The first is the Centres of Research Excellence (CoREs) established during 2002 and 2003. The CoREs have been designed to support world-class research that will contribute to New Zealand’s development as a knowledge society. The CoREs are inter-institutional research networks focused on areas of acknowledged research strength and in areas important for New Zealand’s growth. The CoREs provide funding to encourage researchers from several institutions to work together on a commonly agreed research plan. Information on the seven CoREs is set out later in this chapter.

The second is the PBRF which is being phased in over the period 2004 to 2007 and which, over that phase-in period, is shifting the basis of research funding from a system based on student enrolments to one where funding will be allocated on the basis of research performance.\(^6\) One consequence of the shift to the PBRF is that the Tertiary Education Commission (TEC) and the tertiary education sector have agreed on a new standard definition of research. Research in the PBRF is defined as ‘original investigation undertaken in order to gain knowledge and understanding. It typically involves enquiry of an experimental or critical nature driven by hypotheses or intellectual positions capable of rigorous assessment. It is an independent, creative, cumulative and often long-term activity conducted by people with specialist knowledge about the theories, methods and information concerning their field of enquiry’.\(^9\) Another consequence of the introduction of the PBRF is that much more information is now collected on research in tertiary education, for example the quality of the research, the people conducting research in tertiary education organisations (TEOs) and the relative research performance in different research fields and organisations. Much of the material in this chapter is drawn from information gathered as part of the implementation of the PBRF.

In the PBRF research quality evaluation, scores are assigned to each eligible staff member by the panel of experts that assesses a portfolio submitted by the staff member. The scores take account of the quality of the research outputs in the evidence portfolio, the contribution made to the research environment and the standing of the researcher in the community of researchers in that subject area. Research outputs include articles in peer-reviewed journals, books, chapters, commissioned reports and periodicals. Theses, conference presentations and creative works count as research outputs. Research outputs can also include contributions to the intellectual infrastructure of subject areas, such as new scholarly editions, and investigation that leads to new materials, devices, products or processes. Those scores are used to assign a quality category to each researcher, with the quality category A representing the highest quality standard. Where a researcher does not meet a threshold for the A, B or C quality categories, an R category was assigned. Those assigned an R category include those who are embarking on a research career and hence have not yet had the opportunity to produce many research outputs or to acquire the research standing that would lead to the award of an A, B or C.\(^10\)

In order to aggregate and average performance across fields of study and between providers and for comparative purposes, these categories are translated into numerical quality scores. The maximum possible quality score for a provider or a subject area is 10; this would occur if every single PBRF-eligible staff member in that provider or subject area were awarded an A quality category.

As well as assessing the quality of the research work of each researcher, the PBRF uses two other indicators of the research quality of a provider. One is the number of research degree completions. Research degree completions are an important indicator of research activity as they are a measure of the extent to which the provider is meeting its research training function.

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6 The source of the data quoted in that report is the National Science Indicators project conducted by the Institute for Scientific Information (ISI) and published by Thomson Scientific.

7 Counts of the number of times a given research paper is cited in subsequent research outputs is an accepted proxy measure for the impact of research.


9 The full definition, from which the comment above was drawn, can be found in Tertiary Education Commission (2004), Performance-Based Research Fund: Evaluating Research Excellence – the 2003 Assessment, p 22. Page 33 of the report lists the types of research outputs considered in the 2003 quality evaluation.

10 Refer to Tertiary Education Commission (2004), Performance-Based Research Fund: Evaluating Research Excellence – the 2003 Assessment, pp 19-21 and 37-38 for an account of the scoring system. That explanation includes the weightings assigned to each of the elements of the PBRF scoring system. For the next quality evaluation, new categories are to be added for new and emerging researchers.
Research degree students are important contributors to the provider’s total research activity. The other PBRF indicator is the amount of money generated by the provider by way of external research income. Research contract funding is a good proxy measure of research quality as it is usually won through competitive bidding and is often subjected to rigorous peer review.\(^\text{11}\) The largest part of research contract income is provided by firms and not-for-profit organisations who contract universities to conduct specific pieces of research on their behalf, in order to meet their business needs, ie they ‘purchase’ the research outputs. Trends in that form of external research income provide a good proxy measure for the extent to which the research performed by the universities meets a test of relevance.

The PBRF research quality evaluation counts for 60 percent of the weighting in the funding allocation while the research degree completions and external research income measures are weighted as 25 percent and 15 percent respectively. The first quality evaluation took place in 2003. There is to be a second, partial quality evaluation in 2006 and then full evaluations will be conducted every six years. The research degree completions measure is compiled annually as a rolling average of the number of completions in the three preceding years, while external research income is also recorded on an annual basis. These two measures are combined with the most recent quality evaluation scores to determine the amount of funding to be provided to each of the participating TEOs.

THE RESEARCH OUTPUT OF THE NEW ZEALAND TERTIARY EDUCATION SECTOR

The annual reports of tertiary education institutions (TEIs) provide information on the research activities undertaken and the research outputs produced in 2004. That information is complemented by information on the quality of research outputs of tertiary education providers (TEPs) drawn from the 2003 PBRF quality evaluation. These sources of information are also triangulated by independent studies of research output, and, in particular, bibliometric studies.\(^\text{12}\)

A quantitative measure of research outputs will not capture the quality, scale or impact of the research behind those outputs. In addition, there are differences in publishing conventions and practices between disciplines. As a result, the information on trends in numbers of research outputs is balanced by data from the PBRF quality evaluation. It should be noted, however, that a recent study\(^\text{13}\) that compares annual report counts of research outputs at the provider level and PBRF scores found that the annual report measures are a good proxy measure for quality as measured by the PBRF.

The annual reports of the universities indicate a significant increase in research output over the last eight years. While output appeared to have levelled off between 2000 and 2003, it rose in 2004.\(^\text{14}\) A total of 19,375 university research outputs were produced in 2004, compared with the 16,887 reported for 2003, 16,686 in 2001 and 14,747 in 1997. The number of research outputs reported by the universities increased by 31 percent over the eight years between 1997 and 2004.

11 In this context, it needs to be noted that some research funding is commissioned by industry or by public sector agencies and hence is not won in competitive tender. The capacity of providers to maintain income from these sources over time depends on their reputation for delivery of research of high quality. It should also be noted that the main public research funds are oriented towards certain types of disciplines or outcomes. This limits the extent to which external research earnings can be used as a measure of research quality.

12 Bibliometrics is the term given to the quantitative study of research output. Refer to MoRST (2004), National Bibliometric Report, 1997 to 2001: International Benchmarking of New Zealand Research, for a detailed account of bibliometrics, the methods used in bibliometrics and the limitations of bibliometric data.


14 Caution needs to be exercised in attributing an output to a particular year. In many cases the work needed to create that output took place over several years. There are also often significant delays in the appearance of completed publications. The existence of the PBRF and the quality evaluation will have increased focus on research outputs and hence will have contributed to the increase in outputs.
According to MoRST’s bibliometric study, clinical medicine was the largest single category for tertiary education sector indexed research publications in 2003, representing 19 percent of all tertiary education sector publications. Out of the 24 subject categories, the top five in terms of output are: clinical medicine; plant and animal science; social sciences; biology and biochemistry; and psychology and psychiatry.

Using the 2003 PBRF quality evaluation scores, a sense of the quality of research produced in each of the 41 research subject areas can be gained. The highest-scoring subject area was philosophy, with an average quality score of 4.74 against an overall average for all subject areas of 2.59. Many of the highest-performing subject areas were sciences, with five of the 10 highest-ranked subjects in scientific fields. Of the 12 PBRF panels, the four panels with the highest average quality scores were in scientific and technological areas.
MoRST\textsuperscript{19} notes that research papers from the New Zealand tertiary education sector published in 2001 were cited on average 4.1 times each over the period 2001 to 2004.\textsuperscript{20} The rate of citation of tertiary education sector publications was a little less than that of papers internationally, given the journals that they are published in.

The MoRST report also notes that the tertiary education sector is responsible for the largest share of the research output of the country. Over the period covered by the report, the tertiary education sector was responsible for 63 percent of indexed research papers produced in New Zealand. Figure 14.3 shows the relative size of the output of the main research sectors in 1997, 2000 and 2003.\textsuperscript{21}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure143.png}
\caption{Number of Indexed New Zealand Research Publications by Research Sector 1997, 2000, 2003}
\end{figure}

Source: Ministry of Research, Science and Technology

While the information above is primarily concerned with research conducted by the universities, other TEIs were also active in research, albeit on a smaller scale.

\textsuperscript{19} The information was supplied by MoRST and used data from the Thomson-ISI National Citation Report.

\textsuperscript{20} The figure cited here for citations of tertiary education sector papers is lower than that quoted in MoRST’s 2004 bibliometric study – 6.1 cites per paper. The two figures are not, however, comparable; in the previous bibliometric report, the number of citations was recorded over a five-year period, whereas the figure in the latest report counts the cites over a four-year period.

\textsuperscript{21} The definition of research outputs used in the PBRF is broader than that used in bibliometric studies, which are focused on research publications.
The institutes of technology and polytechnics (ITPs) produce a modest but increasing volume of reported research output, primarily focused in the area of applied research. Two of the largest producers of research output are Unitec New Zealand and Waikato Institute of Technology, which reported 859 and 370 research outputs respectively in 2004, compared with 842 and 336 respectively in 2003.

An SNZ survey of business practices in 2003 found that 14 percent of New Zealand businesses that were classified as innovators considered universities an important, or very important, source of information for innovation. This compared with 72 percent who found their suppliers an important, or very important, source of innovation information, 53 percent for other New Zealand businesses in the same industry, 60 percent for books, journals, conferences and shows, and 28 percent for research institutes.

Research productivity

One measure of research productivity is the number of research outputs for each academic staff member. In 2004, there were 2.6 publications per full-time equivalent (FTE) academic staff member in New Zealand universities. This compares with 2.2 in 2003, 2.5 in 2002 and 2.5 in 1997. Figure 14.4 shows the number of publications per FTE in each of the universities in 1997 and 2004.

FIGURE 14.4: PUBLICATIONS PER FTE ACADEMIC STAFF MEMBER PRODUCED IN NEW ZEALAND UNIVERSITIES IN 1997 AND 2004

Notes:
1 Auckland University of Technology (AUT) was granted university status in 2000. No count is included of publications of its predecessor institution, AIT.
2 There may be substantial lags between research activity and the resulting research output.
3 Universities have different approaches to counting research outputs in their annual reports. As a result, there is some inconsistency between the ratios shown in the graph above.

Source: Annual reports of universities

One key measure of the research productivity of TEOs is the amount of PBRF funding generated per FTE staff member eligible for consideration under the PBRF. This indicator takes account of the quality and significance of the research produced as it includes the quality evaluation scores. It also takes account of the research degree completions and the external research earnings of the organisation, which broaden the picture of research activity in the organisation. Figure 14.5 displays the 2004 results for the eight universities earning funding from the $18.2 million available for distribution.24

22 Only two ITPs chose to participate in the PBRF quality evaluation in 2003.
24 The sum of $18.2 million (including GST) was the amount of contestable funding available under the initial PBRF distribution. For 2005, the sum rose to $43.6 million. The sum reflects the gradual phase-in of the PBRF over the years 2004 to 2007. The 2009 amount available for distribution under the PBRF is expected to be of the order of $220 million, including GST. In interpreting Figure 14.5, it is important to note that the dollar sums are being used as an index of performance only, so it is the relative (rather than the absolute) size of the allocation that matters.
Among the non-university TEOs participating in the PBRF round, Whitecliffe College of Arts and Design earned $1,605 per FTE while Unitec New Zealand earned $1,147 per FTE.

The following graph gives an indication of the research performance of the eight universities across a number of dimensions by looking at four different performance indicators:

- research outputs per academic FTE over the period 1997 to 2002\(^{25}\)
- external research income per academic FTE over the period 1997 to 2002
- research degree completions per academic FTE in 2002, and
- PBRF quality evaluation score per academic FTE in the 2003 quality evaluation.

For each indicator, the score for each university is expressed as a multiple of the average score – so that the university sector average on each indicator is 1.0.

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\(^{25}\) There are small differences among the universities in the definitions applied to research outputs.
Research training

Formal training in research is mainly carried out through postgraduate research degrees. Between 1998 and 2004, enrolments in doctoral studies in the eight universities increased by 38 percent, from 3,202 to 4,423. Growth between 2003 and 2004 was 7 percent.

In 2004, enrolments in doctoral degrees by women reached half of the total for the first time. While women represented 57 percent of all formal enrolments in tertiary education, they constituted 50 percent of doctoral enrolments. Enrolments by women in doctoral degrees grew by 11 percent between 2003 and 2004 and by 57 percent between 1998 and 2004.

Māori remain under-represented in enrolments in research degrees, but the trends are positive. In 2004, Māori made up 6.4 percent of all doctor of philosophy (PhD) enrolments by domestic students, whereas Māori constituted more than 20 percent of all domestic enrolments in tertiary education. The rate of participation of Māori in postgraduate study in 2004 was about two thirds that of the sector as a whole, nearly 0.7 percent of the population over the age of 15, compared with 1.0 percent for all ethnic groups. While these statistics show that Māori are still not engaging in postgraduate study to the same extent as the whole population, Māori enrolments in postgraduate qualifications have grown faster than for the whole population – enrolments by Māori grew by 53 percent between 1998 and 2004, the rate of the population as a whole. The proportion of domestic PhD students who were Māori in 1998 was 5.2 percent.

The trend is similar for Pasifika peoples. Domestic Pasifika students constituted only 2.1 percent of doctoral enrolments in 2004 but 6.3 percent of all domestic tertiary enrolments. At the doctoral level, Pasifika enrolments rose by 116 percent (from 37 to 80) over the period 1998 to 2004, while doctoral enrolments grew by 31 percent among domestic students as a whole. The rate of participation by Pasifika peoples in postgraduate study was low; only 0.5 percent of the Pasifika population aged 15 or over was enrolled in postgraduate study in 2004. The rate for all ethnic groups was twice that – 1.0 percent.

Enrolments in doctoral programmes by international students grew by 26 percent in 2004 (following growth of 28 percent the previous year) and by 120 percent over the seven years from 1998 to 2004, a rate higher than the population as a whole. International students now constitute 13 percent of all PhD students in the universities, compared with 11 percent in 2003 and 8.2 percent in 1998. International doctoral students make a particular contribution to the research culture in the institutions in which they work.

Notes:
1. Each student is shown in each ethnic group he/she identifies with.
2. Pasifika and Asian enrolments include domestic and international students of those ethnic groups.
The number of PhD degrees awarded by New Zealand TEIs rose by 6.6 percent between 2002 and 2003. The number of awards has risen by 33 percent since 1998.

The number of women awarded PhD degrees as a proportion of all those earning doctoral qualifications was 48 percent in 2004, compared with 45 percent in 2003, 48 percent in 2002 and 39 percent in 1998. The gradually increasing representation of women among those awarded doctoral qualifications reflects the enrolment trends. It is not out of line with other countries. Organisation for Economic Cooperation and Development (OECD) data26 shows that the proportion of women among advanced research degree graduates in 2002 in New Zealand was 47 percent. This was more than in Australia (44 percent), more than in the United Kingdom (42 percent) and roughly the same as in the United States (46 percent). The mean for all OECD countries was 40 percent.

The number of Māori awarded PhD degrees is very low in relation to the number of Māori completing all qualifications, but has risen sharply since 1998. In 2004, there were 32 PhD degrees awarded to Māori, up from 27 in 2003, 21 in 2002 and from only seven in 1998. The share of domestic students earning doctoral qualifications who were Māori was 6.1 percent in 2003, compared with 2.0 percent in 1998. The number of domestic Pasifika students awarded PhD degrees is also low – seven in 2004, four in 2003 and six in 1998.

The most common broad areas of study for doctoral degrees completed over the period 1998 to 2004 were the social sciences (18 percent), the biological sciences (21 percent), the physical sciences (15 percent) and the humanities (11 percent). These four areas collectively represented two thirds of all doctoral completions from New Zealand TEIs over those seven years. Medicine and health-related sciences constituted 9 percent of the doctoral completions, while engineering and architecture represented 8 percent of the total. Other fields with significant shares of the total were agriculture, horticulture, forestry and environment (4 percent), mathematics and information/computer science (6 percent) and law, business and commerce (7 percent).

Notes:
1 Each student is shown in each ethnic group he/she identifies with.
2 Pasifika and Asian enrolments include domestic and international students of those ethnic groups.

26 OECD, Education at a Glance: OECD Indicators 2004, Table A4.2, page 84.
Research and knowledge creation

Figure 14.12 gives an idea of the work of the universities in producing PhD graduates by comparing the number of doctoral graduates with the number of academic staff in each university.

**FIGURE 14.12: PhD COMPLETIONS PER FULL-TIME EQUIVALENT ACADEMIC STAFF MEMBER BY UNIVERSITY 1998 AND 2004**

Note: No reading is given for Auckland University of Technology for 1998 as it was not granted university status until 2000.

An examination of the rate of completion of doctoral students shows that, of domestic students who started a doctorate in 1998, 40 percent had completed successfully by 2004. The long-term completion rate for doctoral students is estimated at between 54 and 57 percent. That rate is similar to estimates of long-term completion rates for doctoral degrees in Australia. The OECD reports that in New Zealand the proportion of the population at the expected age of graduation that hold advanced research degrees is 0.9 percent, compared with 1.5 percent in Australia, 1.2 percent in the United States, 1.8 percent in the United Kingdom and 2.8 percent in Sweden. The mean of OECD countries on this indicator was 1.3 percent. The corresponding ranking for New Zealand in 1999 was 14th out of 23 countries.

The impact of tertiary sector research

One common means of analysing the impact of research is through measuring citation rates – that is, the number of times a research paper has been cited or referred to in subsequent research publications. MoRST conducts periodic studies of citation rates using information from Thomson Scientific’s publications National Citation Report and National Science Indicators. However, the calculation of citation rates is never absolutely precise. Further, the number of citations is, at best, only a proxy measure for the impact of research. Trends in citation rates, however, are a well-accepted indicator of the extent to which a research community is building its research impact and, thus, its research quality.

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The probability of a paper being cited is dependent on a number of factors, particularly on the journal or other publication in which the paper appears and on the field of research. The MoRST analysis notes that tertiary education sector research publications that appeared in 2001 were cited during the period 2001 to 2004 on average 4.1 times. This is slightly fewer than the number of citations expected, given the fields of research concerned and the journals used.31

The citation rate for tertiary education sector publications of 4.1 citations per 2001 paper compares with 5.0 for the CRIs and 5.6 citations per paper for all New Zealand 2001 papers.

![Figure 14.13: Citations per 2001 Indexed Research Paper by Research Sector between 2001 and 2004](image)

Source: Ministry of Research, Science and Technology

MoRST data shows that the amount of patenting by New Zealand universities is increasing, although their share of domestic patenting has been stable since 1992 at around 2 to 3 percent per annum. Between 1993 and 1997, Auckland Uniservices Ltd (a subsidiary of the University of Auckland that manages the university’s research contracts) ranked second in the list of New Zealand’s top patenting organisations. Most university patents are in biotechnology and scientific instruments.32

The SNZ survey of innovative businesses conducted in 200333 asked innovative businesses about the types of organisation they had collaborative or co-operative arrangements with. Around 20 percent reported that they had collaborative arrangements with a university or ITP. This was about the same as reported collaborations with a CRI or other public research provider.

Nearly 70 percent of respondents claimed to have collaborations with suppliers of equipment, components or software.

Collaboration and interaction within the innovation system

One of the key themes underpinning the Tertiary Education Strategy 2002/07 is the importance of enhancing collaboration both within the tertiary education sector and between the sector and other groups. The ‘change messages’ that describe the government’s expectations for the sector include ‘greater collaboration ... within the sector’ and ‘stronger linkages with business and other external stakeholders’. Objective 3 of the strategy calls for ‘greater collaboration with the research sector ...’ while objective 32 calls for ‘a more focussed tertiary research investment through world-class clusters and networks of specialisation’.

Collaboration is of particular importance in research. The MoRST citations analysis notes that research papers that result from collaboration between authors receive more citations on average than those with a single author.

The report shows that papers produced in the tertiary education sector were more likely to have involved collaboration with overseas bodies than with a CRI or another university in New Zealand. Around 11 percent of collaborations on university papers were with CRIs and 11 percent with other universities. By contrast, 62 percent of collaborations were with overseas authors. The Universities of Auckland and Otago had especially large numbers of collaborations with authors overseas.

While the level of collaboration in research among universities in New Zealand has not been high, the CoREs are now encouraging a high level of domestic collaboration, both among the universities and among the universities and CRIs.

The seven CoREs have been established to support leading research that will contribute to New Zealand’s development as a knowledge society. The CoREs are designed to facilitate greater networking and hence to encourage a concentration of research resources focused on areas of established research strength that are important for the country’s future development. The CoREs are inter-institutional research networks with researchers from a number of organisations working together on a commonly

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31 The ratio of actual citations to expected citations for university publications in this study was 1.03. This means that the number of citations made of New Zealand tertiary education sector research publications was 1.03 times the number of citations made of other publications in the same journals. The corresponding ratios for other research sub-sectors were: CRIs 1.13; health sector 1.12; government 1.08; private 1.06.


33 Statistics New Zealand (2003), Innovation in New Zealand, page 42.
agreed research plan. The CoREs are also expected to facilitate knowledge transfer.

The initial funding allocation was $40.6 million over four years with a $20 million capital contingency fund available to purchase strategic research assets. A further $27 million over three years, plus an additional $40 million in capital expenditure, was committed in Budget 2002 to provide for the creation of additional CoREs.

All of the CoREs are hosted by universities; five out of the seven CoREs involve formal partner institutions, including universities and research organisations, while one other involves a cluster of multidisciplinary research teams across one institution. For instance, Nga Pae o te Maramatanga – The National Institute of Research Excellence for Māori Development and Advancement is hosted by the University of Auckland. This CoRE involves the participation of two wānanga (Te Whare Wānanga o Awanuiarangi and Te Wānanga o Aotearoa), four universities (Victoria University of Wellington, the University of Otago and the University of Waikato, in addition to the University of Auckland) and one CRI (Landcare Research).

The following CoREs have been established:

**The Allan Wilson Centre for Molecular Ecology and Evolution** – Host institution: Massey University. Partners: the University of Canterbury, the University of Auckland, the University of Otago, and Victoria University of Wellington. Annual funding: $2.4 million.

**The Centre for Molecular Biodiscovery** – Host institution: the University of Auckland. Annual funding: $3.1 million.


**Nga Pae o te Maramatanga (Horizons of Insight)** – The National Institute of Research Excellence for Māori Development and Advancement – Host institution: the University of Auckland. Partners: Te Whare Wānanga o Awanuiarangi, Te Wānanga o Aotearoa, Victoria University of Wellington, the University of Otago, the University of Waikato and Landcare Research. Annual funding: $4 million.


**The National Centre for Advanced Bio-Protection Technologies** – Host institution: Lincoln University. Partners: Massey University, New Zealand Crop and Food Research Ltd, and AgResearch Ltd. Annual funding: $3.3 million.

**The National Research Centre for Growth and Development** – Host institution: the University of Auckland. Partners: Massey University and the University of Otago, with contributions from AgResearch Ltd. Annual funding: $4.8 million.

Objectives of the Tertiary Education Strategy 2002/07 that are relevant to the CoREs include:

- Objective 29 – Excellent research performance is rewarded
- Objective 3A – A more focussed tertiary research investment through world-class clusters and networks of specialisation
- Objective 23 – Greater alignment of tertiary education research with national goals, and
- Objective 34 – Improved knowledge uptake through stronger links with those who apply new knowledge or commercialisation of knowledge products.

In 2004, the TEC, in consultation with the Ministry of Education, undertook a review of the performance of each of the CoREs. The review has found that, by and large, the establishment of the CoREs has been a success. CoREs have, among other things, encouraged the production of well-focused, excellent research, concentrated researchers on areas of excellence, and increased collaboration within institutions, with other institutions, with CRIs and with businesses. The CoREs have contributed to the training of New Zealand’s future researchers and innovators, and improved knowledge output and transfer from TEOs.

One notable finding of the review was that the CoREs had taken a different approach to research and related activities and that this promotes different outcomes. Success in the first three years of operation depended on overcoming traditional barriers between disciplines and institutions and building new relationships with end users and international collaborators. The advances made by the CoREs in their first three years suggest that it is in the boundary areas between disciplines, and between stages in the development of knowledge, where real untapped opportunities exist. Collaboration among research groups and across disciplines also has the potential to avoid duplication and make best use of
New Zealand's resources, tackling the problem of scale that can be a barrier to the success of New Zealand's research programmes.

The CoREs have engaged in new activities above and beyond those associated with conventional research outputs. In addition to many notable publications in leading scientific journals in the last three years, CoRE researchers have developed high media profiles. Broadcasting the discovery and potential impact of new knowledge further outside the research community is an effective way of increasing understanding of the role of research and science in developing a knowledge economy. Linking with different sectors of the wider community also supports the unique goals of the seven different centres. While some have positioned themselves to make a significant contribution to facilitating the creation of wealth, others have outcomes that are directly related to the betterment of social policy.

Case Study: The National Research Centre for Growth and Development

The National Research Centre for Growth and Development (NRCGD) was established in February 2003. Its vision is to be the premier, internationally-ranked, research centre focused on the biology of early development and its lifelong consequences for health and disease. Increasing understanding of the biology of early development and translating this new knowledge into novel strategies, technologies and products has the potential to impact on health care and the agriculture sector in New Zealand. The research is applicable to specific aspects of livestock productivity such as meat composition, milk production and lamb survival rates, and human health concerns including type 2 diabetes, obesity, cardiovascular disease, neurodegenerative disorders and cancer. To achieve its vision, the NRCGD comprises a multi-disciplinary team of scientists from three universities (University of Auckland, University of Otago and Massey University) and a CRI (AgResearch Ltd). The centre benefits from an international panel of pre-eminent researchers who supplement the centre's strategic planning capability and monitor the performance of scientific projects.

The centre's research covers the following themes:

Theme 1. The causes and consequences of low birth weight and prematurity
Theme 2. Gene/environment interactions in growth and disease
Theme 3. Saving newborn babies from brain injury
Theme 4. Treatment of neurodegenerative disease in adults.

In its first two years, a number of significant new collaborations have been formed. These are illustrated in the following diagram:
The first year of operation focused upon creating systems and processes, building collegiality and co-operation across seven sites, developing a science plan and building infrastructure. Subsequently, the NRCGD has shifted its focus towards building on the new research platform and increasing outputs. The momentum of the NRCGD’s science has since increased, achieving notable successes recorded in a number of areas. In 2004, the centre’s research was published in a number of high-impact scientific journals including *Pediatric Research*, *Matrix – Evolution, Development and Disease*, and *Developmental Plasticity and Human Health*, among others. Investigators from the NRCGD have received a number of national and international accolades. Of note is the election of the NRCGD’s director, Professor Peter Gluckman, as a Foreign Member of the Institute of Medicine of the National Academy of Sciences (USA). Professor Gluckman is the first New Zealander to achieve this recognition.

Crossing the traditional barriers between disciplines and forging new links with end-users is contributing to significant achievements by the NRCGD’s researchers. The combined efforts of Professor Gluckman and NRCGD Scientific Advisory Panel member Professor Mark Hanson from the University of Southampton resulted in the publication of the first in a series of books by the pair, *The Fetal Matrix – Evolution, Development and Disease*. In addition, the pair co-authored two of the centre’s high-impact publications in the journals *Science* and *Pediatric Research* during 2004. The association with the biopharmaceutical company Neuren is enabling the commercialisation of NRCGD innovations. Early research by scientists from the University of Auckland’s Liggins Institute, now funded by the NRCGD, has resulted in the neuro-pharmaceutical lead, Glypromate, which Neuren has now successfully steered through Phase 1 clinical trialling. The association with Neuren will also enable the pre-clinical development and clinical transfer of pharmaceutical leads resulting from NRCGD brain research.

The NRCGD has also made significant contributions to knowledge transfer and capability-building within the research and education sectors. The NRCGD has enabled wide dissemination of new knowledge. This profile was enhanced through more than 25 interviews with the press, TV and other popular media in 2004. The NRCGD has also funded Chiasma, a student-led initiative providing career training, a biomedical innovation challenge, Biotech Expos, and numerous other networking opportunities. More than a hundred students have already joined Chiasma. The NRCGD is also supporting the next generation of researchers by providing classrooms where local high school students can experience first-hand what a career in a research laboratory offers.

34 The NRCGD was involved in the publication of 126 research papers of all types in 2004.