# New Zealand's bibliometric record in research and development: 1990–2008

**Shaun C. Hendy**
MacDiarmid Institute for Advanced Materials and Nanotechnology, Victoria University of Wellington, Wellington

*Over the last two decades, the New Zealand government has sought to achieve improved outcomes in science and technology through structural reform, rather than increased levels of investment in the sector. How successful has this strategy been? Here we look at New Zealand's bibliometric output over the last two decades, using the Thompson Reuters Web of Science database. The database reveals that bibliometric productivity has remained static over this time period, with changes in publication rate driven by increasing levels of full–time equivalent staff members, principally through growth in the tertiary sector. Although the citation impact of university publications has increased, the citation impact of the Crown research institutes has grown at a similar, if not faster, rate, suggesting that the performance-based research fund is not responsible for this increase.*

## Introduction

The strength of a country's innovation system is thought to be a major determinant of its economic growth. Indeed, the percentage of gross domestic product (GDP) spent on research and development across countries in the Organisation for Economic Cooperation and Development (OECD) is rising, and is now approaching 4% in several of these countries (OECD 2008).

However, relative to other countries in the OECD, New Zealand under-invests in research and development, both as a percentage of its GDP and in absolute terms (Ministry of Research, Science and Technology, MoRST 2008). Nonetheless, New Zealand has sought to achieve improved outcomes in research and development through structural and operational reforms. In 1992, the Department of Scientific and Industrial Research was broken up into ten Crown research institutes (CRIs). Shortly thereafter, a significant portion of the Crown funding for science became contestable (the public good science fund, PGSF), open to the CRIs, universities, and businesses or other organisations conducting research and development. More recently, there has been a shift in university funding from levels set largely by full-time student numbers to levels partially determined by a research performance assessment exercise. This performance-based research fund (PBRF) was based on the quantity and quality of research performed by individual researchers, with assessments taking place in 2003 and 2006.

At the same time, there has been a reduction in the contestability of the PGSF in response to concerns that a volatile funding environment was adversely affecting the viability of the CRIs (Davenport & Bibby 2007). It is clearly important to understand how these reforms have affected the quality and quantity of research being performed in New Zealand universities and CRIs, particularly since it has been these reforms, rather than increased investment in the sector, that have been relied on to produce improved outcomes in science and technology. Currently, the sector is undergoing perhaps the most significant reforms since 1993 (Crown Research Institute Taskforce 2010; Gluckman 2010; Mapp 2010 a, b). Will these reforms produce changes in New Zealand's bibliometric output? In this article, we examine New Zealand's bibliometric productivity and citation rates in order to better understand the effect of previous reforms on New Zealand's innovation system.

## Bibliometric studies

The New Zealand Ministry of Education has recently undertaken a bibliometric study of the tertiary education sector (Smart 2008). This study reported an increase both in the number of publications by New Zealand-based authors, and in their citation impact relative to Australian universities, but it did not examine the CRI sector. Nor did it look at productivity in terms of papers per researcher full-time equivalent (FTE).

Here we attempt to examine the bibliographic productivity of the CRI and tertiary education sectors in New Zealand since 1990. The article will examine the published outputs of the CRIs and universities in New Zealand using the Thompson Reuters Web of Science (2009) database. Although annual bibliometric data are provided by most of the research providers themselves, use of the Web of Science database avoids institutional ambiguities that may occur due to differences in reporting mechanisms (e.g. Jordan & Atkinson 2003).

We begin by looking at New Zealand's publication rates as a whole, before examining the CRI and university sectors independently. In 2008, university researchers were co-authors

**Shaun Hendy** is a Distinguished Scientist at the Industrial Research Institute Ltd, and Deputy Director of the MacDiarmid Institute for Advanced Materials and nanotechnology, hosted by Victoria University of Wellington. Shaun research interests include computational materials science, nanotechnology, granular flows, bionanotechnology and complex systems. In 2010, he was awarded an inaugural Massey University Distinguished Young Alumni award for his research into nanotechnology. Shaun is active in science communication, with a regular slot on Radio New Zealand Nights and a blog called A Measure of Science at Sciblogs.co.nz. He may be contacted at shaun.hendy@vuw.ac.nz.

on approximately 75% of New Zealand's publications in the Thompson Reuters Web of Science, CRIs researchers were co-authors on a further 15%, with the remainder of papers typically having authors at public hospitals or privately operated research institutes.

## New Zealand's bibliometric output

Figure 1 shows the total number of publications with New Zealand-based authors in the Web of Science database from 1990 to 2008. A steady rise in publication rates from 1992 to 1998 seems to reflect the effect of both the creation of the CRIs and the introduction of the contestable funding system over 1992–94. However, the publication rate remained relatively steady between 1998 and 2003. From 2003 the publication rate rose from a steady 6000 papers per year to more than 8000 in 2008. This increase coincides with the introduction of the PBRF.

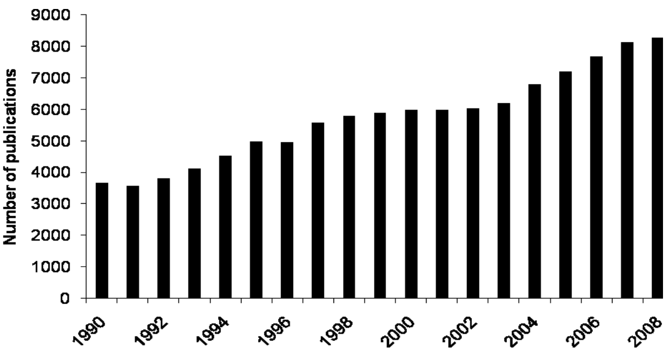


*Figure 1. Total number of publications with New Zealand-based authors 1990–2008.*

It is of further interest to examine whether the sector has achieved these increases in output through increases in productivity or in workforce. Figure 2 shows the total number of reported university and government sector researchers (Statistics NZ 2008) in FTEs and the corresponding number of papers per FTE. The number of FTEs has almost doubled over the period from 1994 to 2006, while the productivity (in papers per FTE) has remained relatively static. Thus it is evident that the increase in New Zealand's bibliometric output over the period 1994–2008 can largely be attributed to an increase in researcher FTEs, with no significant gains in productivity.

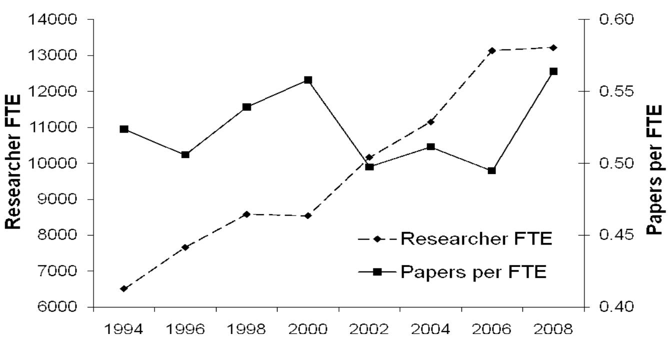


*Figure 2. Total university and CRI researcher FTEs (Statistics NZ 2008) and papers per FTE.*

### The Crown research institutes

Figure 3 shows the number of papers published by the CRIs since 1993. It can be seen that the publications per year rose

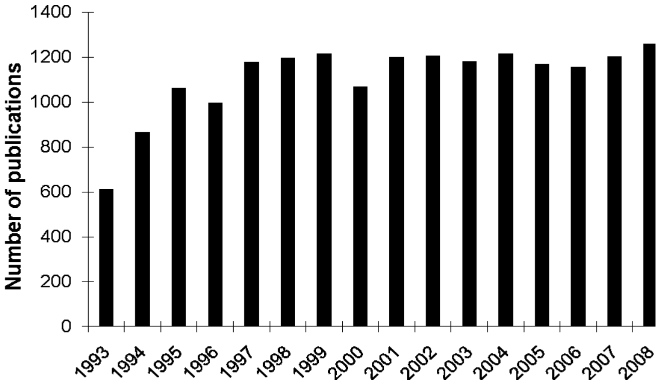


*Figure 3. The number of publications by Crown research institute researchers from 1993 to 2008.*

from 1993 to 1997, after which it levels off at about 1200 papers per year from 1997 to 2008. Figure 4 shows the total researcher FTEs in the CRI sector from 1994 to 2008, and the corresponding productivity (in papers per FTE) over the same time period. Researcher FTEs increased from 1996 to 2002, declining from 2002 to 2006, but increasing significantly in 2008. Note that the productivity of researchers remains relatively static over the period in question. This largely reflects the New Zealand situation as a whole, where productivity remained steady and changes in levels of published outputs were driven by changes in FTEs.

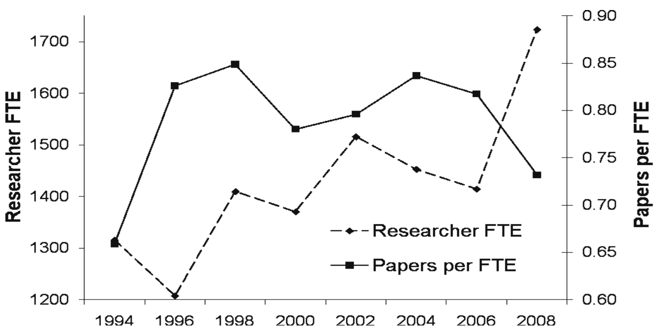


*Figure 4. CRI researcher FTEs (Statistics NZ 2008) and papers per FTE.*

### The universities

Figure 5 shows the total number of publications for the universities from 1990 to 2008. The figure reveals a steady increase in publications, although there is slower growth during the period

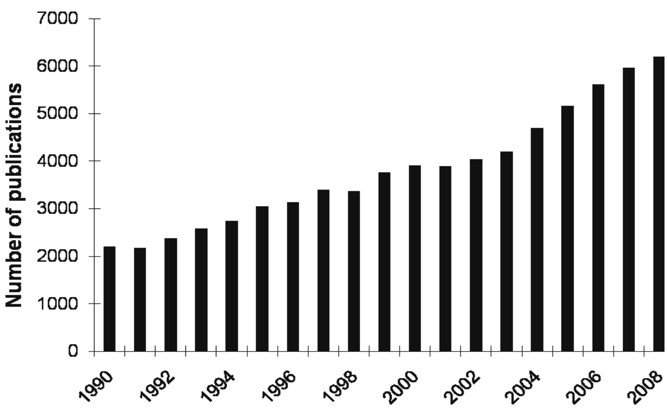


*Figure 5. Total number of publications from university researchers from 1990 to 2008.*

1999–2003. The database shows that in 2008 approximately 10% of university-authored papers had co-authors from a second New Zealand university while 4% had a co-author at a CRI.

Again, it is interesting to examine how the productivity of university researchers has changed over time. Figure 6 shows that the total number of researcher FTEs in the university sector has more than doubled in the period 1994-2008. Most of this FTE gain comes from a substantial increase in postgraduate student numbers, although the ratio of postgraduate students to other researchers in the university sector has declined overall: the postgraduate student to researcher ratio was approximate 3.4 in 1994 but this had dropped to 2.7 in 2006 (Statistics NZ 2006). Despite this large increase in FTEs, productivity in papers per FTE has remained relatively static.

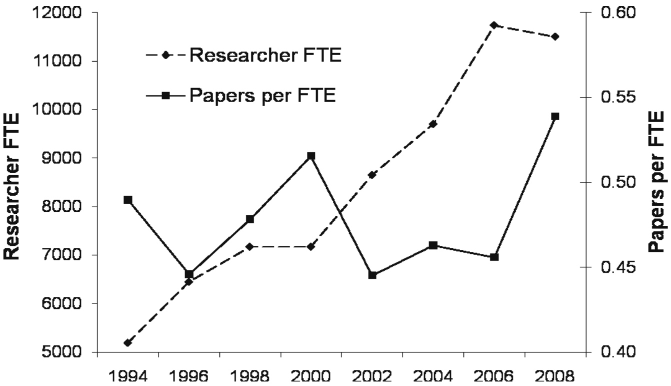


***Figure 6. Total university researcher FTEs (including post-graduates) and papers per FTE from 1996 to 2008.***

## Discussion

We observe that the bibliometric productivity of researchers in New Zealand has remained static since 1994. Increases in output can be attributed almost entirely to increases in researcher FTEs. At the same time, government funding for the CRIs has only just kept pace with inflation, with increases in researcher FTEs occurring at the expense of technical and support staff (Statistics NZ 2008). Figure 7 shows the decline in inflation-adjusted government revenue per researcher FTE for the CRIs. Nonetheless, despite this decline in funding, the bibliometric productivity of CRI researchers has remained relatively unchanged over the period 1996–2006. Certainly, this decline in funding per FTE suggests that the CRI sector has become considerably more

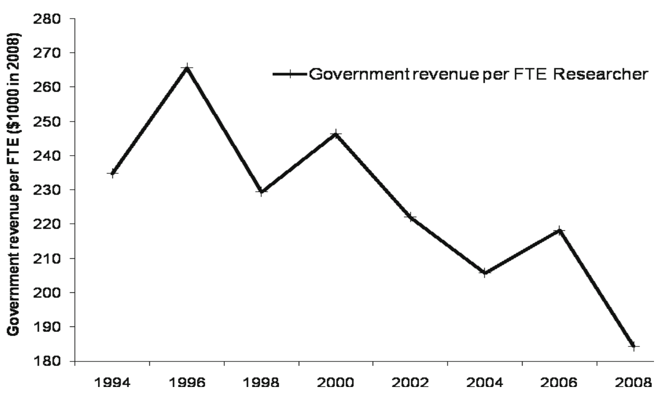


***Figure 7. Inflation-adjusted government revenue ($1000 in 2008) per researcher FTE for the CRIs.***

efficient, at least in terms of funding per published paper. The data suggest that it is staffing levels rather than how researchers are organised that determines bibliometric productivity.

How have the reforms affected research quality? A recent report by New Zealand's Ministry of Education (Smart 2008) showed that New Zealand university citation rates have increased relative to universities in Australia since the introduction of the PBRF. However, over the period 1995–2008, it is evident that the CRIs have also substantially increased their citation rates, as shown by the impact factors in Figure 8. Thus, as it is difficult to see how the PBRF could have a strong effect on CRI impact factors, it seems likely that the reasons behind the increases in university and CRI citation rates are more complex.

For instance, the current advantage that the CRIs seem to hold over the universities in impact factor may be due to the greater diversity of research disciplines within the university system. Papers from different disciplines attract different rates of citation per paper. For example, papers in the agricultural sciences have a higher average number of citations than papers in mathematics or engineering (Thompson Reuters Essential Science Indicators 2009). Thus the recent widening of the gap in impact factors between CRIs and universities may be due to the bibliographic output of the universities becoming more diverse. This may be a response to the PBRF, where subject areas with traditionally lower publication rates (which would also have lower citation rates) may have increased their outputs relative to other areas. Another possibility is that the recent attrition in CRI researcher FTEs has occurred in fields with lower citation rates, such as mathematics or engineering.

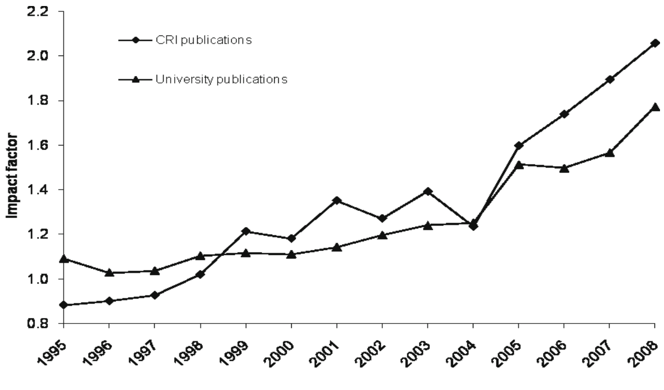


***Figure 8. A comparison between the university and CRI bibliometric impact factors 1995-2008.***

Of course, while the dissemination of research in the scientific literature is important, there are many other outputs required from an innovation system that have not been considered here. In general, the task of assessing the impact of institutional research and development on economic growth is difficult, as much of the benefit of publicly-funded research and development is often captured by spill-over processes (Wieser 2005).

## Conclusions

New Zealand's bibliometric output has undergone two periods of growth (1993–1998 and 2003–2008) in the last two decades. The first is associated with the creation of the CRIs and the establishment of the PGSF. The second coincides with the introduction of the PBRF in the tertiary education sector. However, the publication rate over the last decade reveals static researcher productivity, with increases in bibliometric output attributed to increases in university researcher FTEs. The widening gap in impact factor between the CRIs and the universities suggests an on-going diversification of research activity in New Zealand.

## Methodology

Publications and citations were aggregated using the Thompson Reuters Web of Science in March 2009. All the available databases were used (including the conference proceedings databases, which extend back to 1990 at the time of study). We note that Lincoln University was created in 1990, and the Auckland University of Technology in 2000. Both these institutions are included in the calculations only from the point where they became universities. Conversely, two of the CRIs, Crop and Food Research and HortResearch, merged in 2008 to form a new CRI, Plant and Food Research. However, as the merger occurred in December 2008, no papers from Plant and Food Research appear in the Web of Science databases until 2009.

Data on FTE researcher positions was obtained from Statistics New Zealand, which undertakes a biennial survey of research institutions and businesses in New Zealand. In this survey, Statistics New Zealand defines researchers as staff members 'engaged in the conception and /or creation of new knowledge/products; personnel involved in the planning or management of scientific and technical aspects of research and development projects, and software developers'. CRI revenue was also sourced from Statistics New Zealand.

Finally, when computing bibliometric output per researcher in the university sector, postgraduate student FTE numbers were included in the total researcher FTEs. With this inclusion, bibliometric productivity is similar across the university and CRI sectors. If instead, one neglects postgraduate student FTEs, productivity in the university sector naturally appears much larger than that of the CRI sector. However, in this case, the productivity appears to drop by 25% over the period 1994–2006. Thus it appears most appropriate to include postgraduate student FTEs in productivity calculations.

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