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Explaining Australia's increased share of ISI publications—the effects of a funding formula based on publication counts

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Abstract

Australia's share of publications in the Science Citation Index (SCI) has increased by 25% in the last decade. The worrying aspect associated with this trend is the significant decline in citation impact Australia is achieving relative to other countries. It has dropped from sixth position in a ranking of 11 OECD countries in 1988, to 10th position by 1993, and the distance from ninth place continues to widen.

The increased publication activity came at a time when publication output was expected to decline due to pressures facing the higher education sector, which accounts for over two-thirds of Australian publications. This paper examines possible methodological and contextual explanations of the trends in Australia's presence in the SCI, and undertakes a detailed comparison of two universities that introduced diverse research management strategies in the late 1980s. The conclusion reached is that the driving force behind the Australian trends appears to lie with the increased culture of evaluation faced by the sector. Significant funds are distributed to universities, and within universities, on the basis of aggregate publication counts, with little attention paid to the impact or quality of that output. In consequence, journal publication productivity has increased significantly in the last decade, but its impact has declined.

Keywords: Research funding; Bibliometrics; Effects of evaluation; University research; Productivity

1. Introduction

In 1993, the Research Evaluation and Policy Project (REPP) published a monograph, '*A Crisis for Australian Science*?', which alerted the Australian research community to concerns about its scientific performance (Bourke and Butler, 1993). This followed on from similar warnings issued by the American journal *Science Watch* (ISI, 1993). Both publications showed a decline in the late 1980s of the impact of Australian scientific publications as measured by citations in the indices of the Institute for Scientific Information (ISI). There was general acceptance in the research community that Australian science was 'in crisis', and a number of questions raised in the monograph were taken up by the Australian Academy of Science, which commissioned a study in 1995 to test some of the hypotheses put forward (Grigg, 1996).

The perception of a crisis persisted in the research community throughout the remainder of the 1990s. The university sector is the site of most basic research activity in Australia, currently accounting for three-quarters of all the nation's publications. A recent government enquiry established in response to concerns within the sector, published its findings

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in a report titled 'Universities in Crisis' (Australian Senate, 2001), and recommended that

> the Government end the funding crisis in higher education by adopting designated Commonwealth programs involving significant expansion in public investment in the higher education system over a 10 years period.

The enquiry noted that government outlays on higher education have declined from a peak of 1.50% in 1974–1975 to a level of only 0.89% in 1997–1998. In the last 5 years, universities have been required to seek private funding to make up the shortfall in public investment, but as government reports concede, in Australia this type of funding is "volatile, uncertain and hard to win" (Gallagher, 2000). The pressure on university academics can also be seen in the deterioration of student-staff ratios which have risen from 12.81 in 1990 to 17.81 in 1999 (Considine et al., 2001).

It was in this context that the earlier analysis was updated to include an additional 7 years data. Given the perception of a continuing crisis in the research sector in general, and in universities in particular, it was expected that the trends apparent in 1993 would have persisted.

2. Data and methodology

Two databases have been accessed to undertake the analyses presented in this paper. The principal source used is the REPP database, which is updated annually and contains all Australian publications indexed in ISI's three main indices: the Science Citation Index (SCI), the Social Sciences Citation Index (SSCI), and the Arts and Humanities Citation Index (A&HCI). Data from ISI's National Science Indicators (NSI) database have also been used. It provides the international context against which to judge Australia's recent performance in the journal literature. It differs from the REPP database in that its journal coverage is more extensive.

The analysis covers four types of publications—articles, notes, reviews and proceedings papers. These publication types account for 78% of all Australian entries in ISI indices and, most importantly, attract 97% of all Australian citations. Counts are based on tape year (the year in which the publication was indexed by ISI) rather than publication year.

The analysis is primarily based on whole publication counts, i.e. each country collaborating on a publication is given a count of one for that publication. In '*A Crisis for Australian Science*?', publications were fractionated: where authors from two countries were listed on a publication, each was allocated a count of 0.5; where three were listed, each was allocated 0.33 of a publication; and so on. The affects of this on publication and citation shares and trends are discussed later in this paper.

Publications are classified to a field of research on the basis of the journal which carries the publication. ISI has its own descriptive classification system involving approximately 200 subject categories and REPP has, for a number of previous exercises, translated these as closely as possible into the fields and sub-fields of the Australian Standard Research Classification (ASRC) (ABS, 1998). The ASRC is a classification scheme prepared by the Australian Bureau of Statistics (ABS) for use in the measurement and analysis of research and experimental development undertaken in Australia.

The bibliometric measures used in this paper are as follows.

- *Shares of world publication and citation totals*: the number of publications and citations assigned to Australia as a percentage of the world total (i.e. the total in the ISI database).
- *Relative citation impact* (*RCI*): the comparison of publication and citation shares, calculated by dividing Australia's share of world citations by its share of world publications.
- *Relative journal impact*: a comparison of the average citation rates for the journals Australia is publishing in with the average citation rate for all journals.

3. Analysis

The trends in Australia's publication and citation shares of ISI's SCI over an 18 years period are shown in Fig. 1.

The coverage of the previous analysis extended only to 1991. Fig. 1 depicts unexpected and significant changes in the trends over the last decade. Australia's share of publications has risen markedly since its low-point in 1988, from 2.18 to 2.72%, an increase

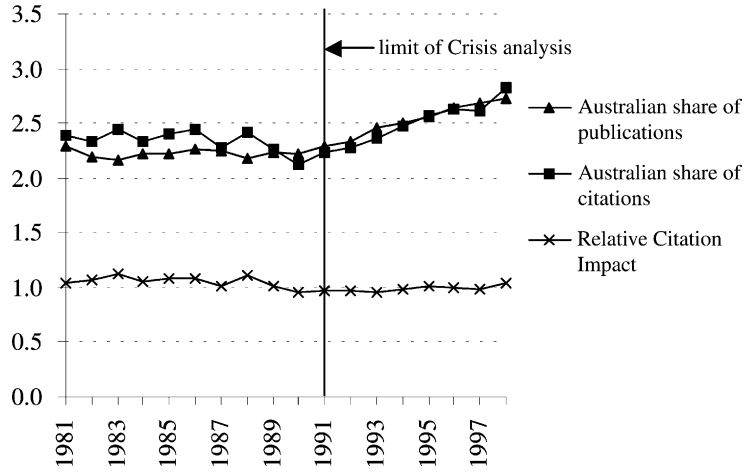

Fig. 1. Australia's share of publications and citations, and RCI in the SCI, 1981–1998.

of 25%. The trend in Australia's share of citations also showed a turn-around, with an increase of 33% between 1990 and 1998. But though Australia's share of total citations has kept pace with the increasing publication share, it has not yet regained the ground lost in the late 1980s.

At a superficial level, the result could be summarised as 'crisis averted'. Australia's share of world publications has increased considerably, and while the RCI has not regained the level of the early 1980s, it has stabilised at close to unity during the 1990s. However, this result is somewhat at odds with the general acceptance that Australian science was 'in crisis' when the original monograph was produced. And as has been illustrated in the introduction to this paper, the pressures on the main sector involved in basic research, the higher education sector, have increased rather than diminished.

Because the trends are counter-intuitive, it is essential to delve more deeply into the data. It will be demonstrated that these trends do not result from any decision made on the methodology used in the analysis. Some aspects of the data will then be examined in more detail to search for clues to explain the dynamics at work in the Australian research system.

3.1. Method of counting—fractional versus whole

There has been much discussion on the way in which internationally-collaborative publications should be treated when calculating national shares of world publication output (Martin, 1994). Should all publications listing at least one author from a country be counted in full for that country (whole counting); or should each country be allocated a share of the publication (fractional counting)?

In 1981, only 11.4% of Australia's publications involved international collaboration, but by 1999 the level had reached 34.9% and is still rising. Given the level and rise in this proportion, it is possible that the choice of method for counting such publications might affect the interpretation of a nation's contribution to the world scientific output. Fig. 2 compares the use of fractional and whole counting of Australian publications.

Using fractional counting almost invariably results in a lower share of publications and an even lower share of citations for a country as only a proportion of internationally-collaborative publications is counted. This is due to the well-established fact that such publications are, on average, more highly cited than those involving authors from a single country (Hicks and Katz, 1996; van Raan, 1997). Australian data for the period 1995–1999 can be used to illustrate the effects of fractional counting. In that period, Australia produced a total of 79,232 publications; 53,343 involved only Australian authors and this group had an average citation per publication rate (cpp) of 4.22. There were also 25,889 internationally co-authored publications featuring Australian researchers, with an average cpp

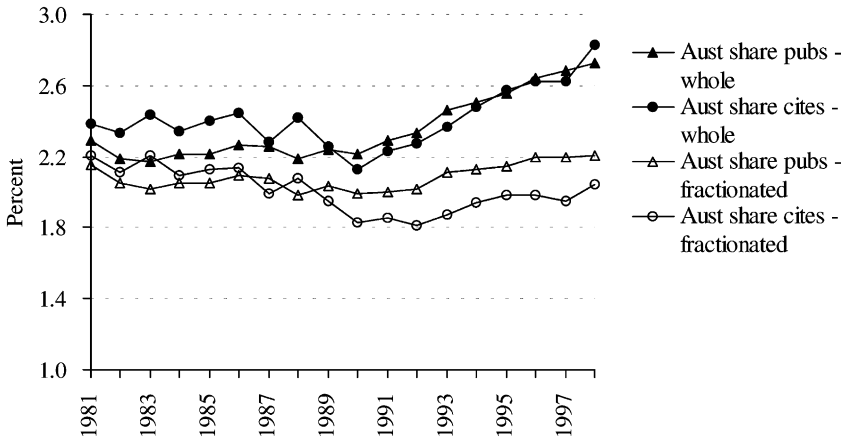

Fig. 2. Australia's share of publications and citations in the SCI, fractional and whole counting, 1981–1998.

of 5.53. In this scenario, where the cpp rate for these publications is significantly higher than the cpp rate for single country publications, the fractionation of counts relating to internationally co-authored publications will inevitably have a more marked effect on citations than on publications. In the case illustrated, fractionation leads to a 17.8% reduction in publication numbers, but a 24.5% reduction in the citation total.

The use of whole counting rather than fractionation does at first sight appear to affect the perception of Australia's scientific performance. Both methods of counting show parallel trends in publication output, with a marked increase in the 1990s. With whole counting, the increase is 25%, compared to 13% if fractional counting is used. However, using whole counting, Australia's citation performance seems somewhat rosier, though appearances can be deceptive as the following analysis will demonstrate.

3.2. International comparisons

To have a clearer understanding of its performance, Australia's trends in publication and citation performance need to be placed in a global context. This enables us to judge the relative effect of world-wide trends on national data.

Fig. 3 compares Australia's trend in publication shares to 10 other OECD countries. For pragmatic

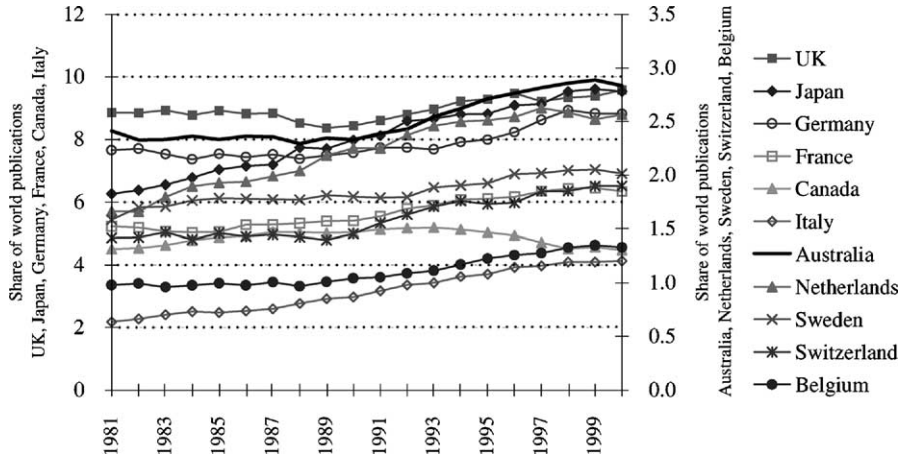

Fig. 3. National shares of ISI publications, selected OECD countries, 1981–2000 (source: NSI database).

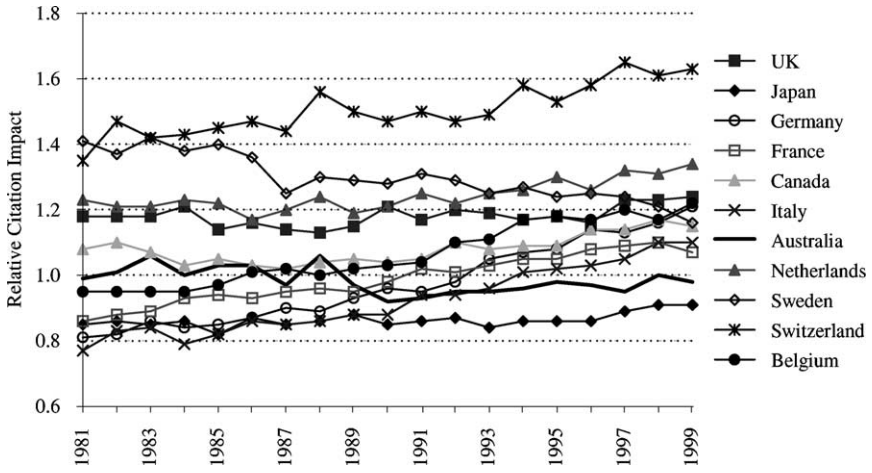

Fig. 4. National trends in RCI, selected OECD countries, 1981–1999 (source: NSI database).

reasons, the USA has not been included in these figures due to its size. In addition, Fig. 3 employs a technique charting time series trends using two different *y*-axes. This allows for an easier comparison of trends between countries with markedly different publication counts.

Australia's publication trend (a steady share of the worlds output in the 1980s, followed by a rapid increase in share in the 1990s) can be found in a number of other OECD countries, though for most the size of the recent increase is not as large: UK, Germany, Sweden, Switzerland, France and Belgium. Other countries have been showing a steady increase in ISI-indexed publication output right across the two decades covered by the analyses—The Netherlands, Italy and Japan. The share attributed to Canada is lower in 2000 than it was in 1981, with the decline most apparent in the 1990s.[1]

As already noted, internationally co-authored publications are more highly cited than those with no collaboration, or where joint authorship is contained within national boundaries. Where the proportion of a country's publications involving international collaboration increases significantly, this will result, all other things being equal, in their share of citations increasing relative to their publication share. The result is an improved RCI rate. Hence, it is possible, with the widespread phenomenon of increasing internationalisation, for most major nations to exhibit improving RCIs. Fig. 4 analyses trends in RCI over the last two decades for the countries studied in Fig. 3.

Of the six countries that, in addition to Australia, exhibit increasing publication shares, only Sweden shares its declining RCI (though in Sweden's case, the actual level remains high). For the other five countries, increasing publication shares have been accompanied by an improved RCI. As already explained, with increasing international collaboration, this result is plausible. Australia is the one country that goes against this trend. From being ranked sixth on this measure in 1988, Australia had dropped to 10th position by 1993, and the distance from ninth place has continued to widen.

Herein lies the most worrying aspect of the current analysis—Australia's share of publication output is increasing, at a greater rate than for many comparable countries, but its share of the world's citation pool increasingly lags behind. The internationalisation of research should have led to an increase in RCI, but this has not eventuated. Australia's increase in output appears to be at the expense of impact.

3.3. Relative citation impact unpacked

There are two quite distinct components of citation analysis that can effect a country's relative performance, and it is important to determine which is having the most effect on the Australian trend. Fig. 4 showed that the impact of Australia's publications is

[1] Though not shown in Fig. 3, the trends for the USA are similar to those for Canada.

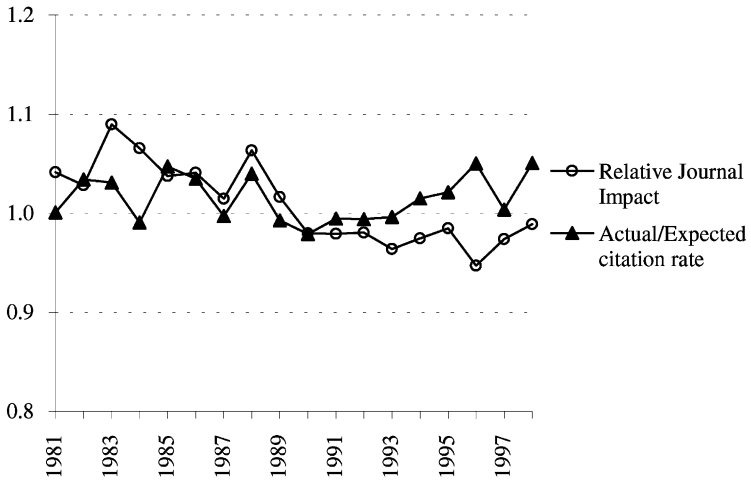

Fig. 5. Aspects of Australia's citation performance, Science Citation Index, 1981–1999.

losing ground relative to other OECD countries. This could be due to either: (i) Australians publishing in lower impact journals; or (ii) Australian publications not attracting as many citations as expected for the journals in which they appear; or (iii) a combination of (i) and (ii). Fig. 5 examines this issue.

Comparing the actual citations received by Australia's publications to the level expected for the journals in which these appear (actual/expected citation rate), suggests little movement in this indicator. There is a degree of yearly volatility, but the rate has fluctuated around one for the whole period, with levels in the late 1990s similar to those in the early 1980s.

In contrast, the average citation rate of journals carrying Australian publications fell below the aggregate world average in 1990 and has remained below since. Even though other analysis has shown that Australia's publications were attracting at or above the expected citation rate for its journals, Australia's relative citation performance continued to slide because the journals which carried its articles were of lower impact (Butler, 2001). This finding is central to

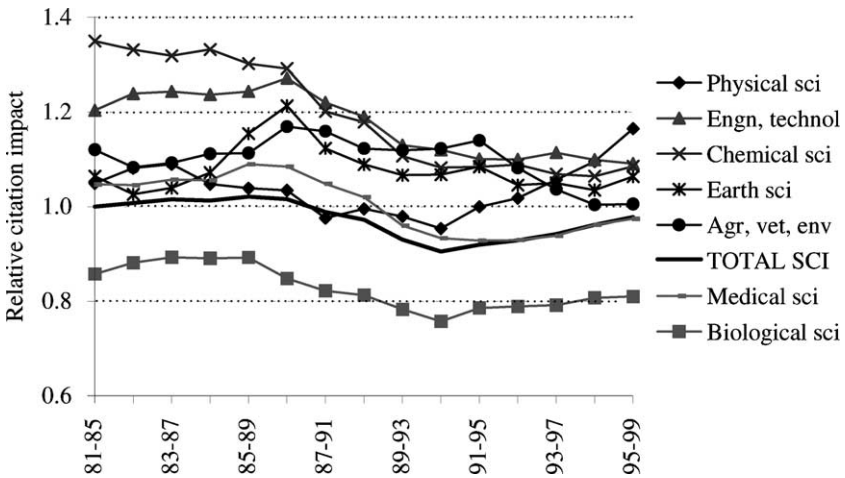

Fig. 6. Australia's RCI for major fields of science, 1981–1985 to 1995–1999.

the discussion on the effects of increased evaluation of university research performance which is addressed later in this paper.

3.4. Fields of research

While Australia's relative decline in citation impact is apparent in the aggregate data, it is worth examining whether that trend is also uniform across all fields of science, or whether the overall trend is principally driven by the large biomedical fields. Fig. 6 disaggregates RCI trend data to the field level.

The decline in relative impact in the *late 1980s* is carried through to all fields of science except the agricultural sciences. In contrast, Australia's performance in the different fields in the *1990s* has been more varied. The biomedical sciences show an upturn in line with aggregate scientific trends. The impact of physical sciences publications also rose, but far more sharply, and now stands at a level well above that of the early 1980s. In chemical sciences and engineering and technology, the decline in citation impact has not yet been arrested. For earth sciences, citation impact peaked at a very high level in the mid-1980s and has since reverted to a level slightly above that which existed at the start of the earlier decade.

The decline in impact of the late 1980s was seen across most fields of science, but the upturn that has occurred in the 1990s is largely driven by the large biomedical fields and the physical sciences.

4. Discussion

It is within the university sector that any explanation for Australian publication and citation trends is likely to be found. The sector currently accounts for three-quarters of research publications, a rise from its historic level of two-thirds.

At the end of the 1980s, a Unified National System was established in the Australian higher education sector, with the old distinctions between universities, colleges of advanced education and institutes of technology abolished. One possible explanation for the increased output from the sector is the entry into the sector of these 'new' universities. Since 1990, the sector's share of SCI publications has increased by 40%, from 1.47 to 2.06%. The share of publications associated with Australia's pre-1987 universities increased by one-third (from 1.43 to 1.91%). The share of publications from 'new' universities increased nearly three-fold in the same period, but from a very small base, rising from 0.06 to 0.22% of the world total. This understates the contribution of the 'new' universities as a number of similar institutions also amalgamated with the pre-1987 universities. Nevertheless, while the creation of the 'new' universities has increased the sector's research capacity, it accounts for less than one-third of the expanded research output.

Some of the explanation could lie in the increased human capital devoted to research in universities. Between 1989 and 1996, research only staff numbers in the university sector rose by 46% and teaching and research staff by 52% (CTEC, 1979–1985, 1986–1987; DEET, 1988–2000). But in the corresponding period of the preceding decade, from 1979 to 1986, research only staff numbers also increased, by a massive 85%, while teaching and research staff (including advanced education academic staff) increased marginally by 3%. If the explanation for increased output in the sector was related primarily to the number of research active staff, then a significant increase would have been expected in both periods. Hence, the sudden jump in the rate of increase in the last decade cannot be attributed to the level of human capital.

4.1. Effect of increased evaluation

One factor that must be taken into account when analyzing Australia's research performance is the effects of increased performance evaluation on the scientific community, particularly in the university sector. Is this increased surveillance causing researchers to change their publication habits?

The data indicate that the beginning of the 1990s is a pivotal time for universities and in that context it is worth noting changes in the culture of research evaluation that have occurred in the sector. The first major study that examined the issues of performance measures for universities appeared in the mid-1980s (Bourke, 1985). Bourke reported little systematic use of research performance measures at the level of department or institution, and for the first time suggested the use in the Australian context of measures then being developed at the University of Leiden (Moed et al., 1983). By 1991, the use of a wide range of

performance indicators was being proposed, including the introduction of a research publications collection (Linke et al., 1991). In 1996, a study undertaken on behalf of the National Board of Employment, Education and Training reported that most universities used some research performance measures as a basis for the distribution of a portion of their research funds within the institution, and publication output was one of the two most commonly used indicators (Anderson et al., 1996).

Since 1992, all universities have been required to supply details of their publication output, initially through the Australian Vice-Chancellors' Committee, to the Department of Employment, Education and Training. The distribution of that part of the operational grants of universities earmarked for research (known as the Research Quantum) has to a limited degree depended on this information. As the categories covered by this collection have been refined and reduced in number, the importance of ISI-indexed journal publications has increased. It is possible for university researchers to put a dollar value (either to themselves or to their university) on their ability to place an article in an ISI journal.[2] Other refereed journals provide similar rewards, but the difficulty of having their status accepted by independent auditors results in an increasing focus on the ISI journal literature.

Australia's approach in this area of higher education policy is rare. A recent survey of 14 countries by Geuna and Martin (2001) identified only two which used ex post quantitative evaluation for allocating core research funds, Finland and Australia. Unlike Australia's mechanistic system of quantitative measures, Finland employs a series of agreed indicators focusing on the quality and impact of teaching and research. The Australian experience is not mirrored in other countries, and may well be part of the explanation for the atypical publication and citation trends seen in Figs. 3 and 4.

It is difficult, perhaps impossible, to quantify precisely the effect that the introduction of the Research Quantum collection and other internal quantitative evaluation procedures has had on the research output from universities. However, it is possible to see some clues in the data.

4.2. Sector comparisons

One pointer is whether university trends are repeated elsewhere. The output from the Australian university sector remained constant at around 1.5% of world publications between 1981 and 1991, but has shown a rapid increase in the last decade. If this trend is not mirrored by the other research sectors, then it provides some evidence that increased performance evaluation in the University sector has been a factor in increased publication in ISI-indexed journals. Fig. 7 analyses the increase in publication output of the four most active Australian research sectors. Together these four sectors account for over 90% of Australia's output.

Growth in the SCI as a whole has remained fairly steady at just above 2% across the two decades, though with an apparent downturn at the end of the period. In contrast, growth in Australia's publication output jumped to over 4% in 1988–1992 and has remained well above the general SCI growth rate. Australian university output increased at an even greater rate, reaching almost 8% in 1992–1996. Publication output from CSIRO has rarely matched the growth in the index, and has slipped into negative territory in a number of periods. While exhibiting strong growth in earlier periods, the government sector's growth also evaporated in the latter half of the 1990s. The hospital sector exhibited strong growth in the 1980s, higher than for the SCI in general and Australia as a whole. However, like CSIRO and the government sector, its growth fell away in the 1990s and is now well below the university trend, though still increasing at a rate similar to the SCI as a whole. In summary, none of the other major Australian research sectors exhibit the sudden and sustained increase in publication output seen for the universities in the 1990s.

4.3. Trends across indices

Analysis to this point has focussed on the SCI. If increased performance evaluation is a major factor in the rise in publications from the university sector, then the increase should also be apparent in the sector's

[2] In 2000, an article in a refereed journal was 'worth' just over AUS$ 800 in research funding to a university; a book from a recognised commercial publisher was 'worth' just over AUS$ 4000.

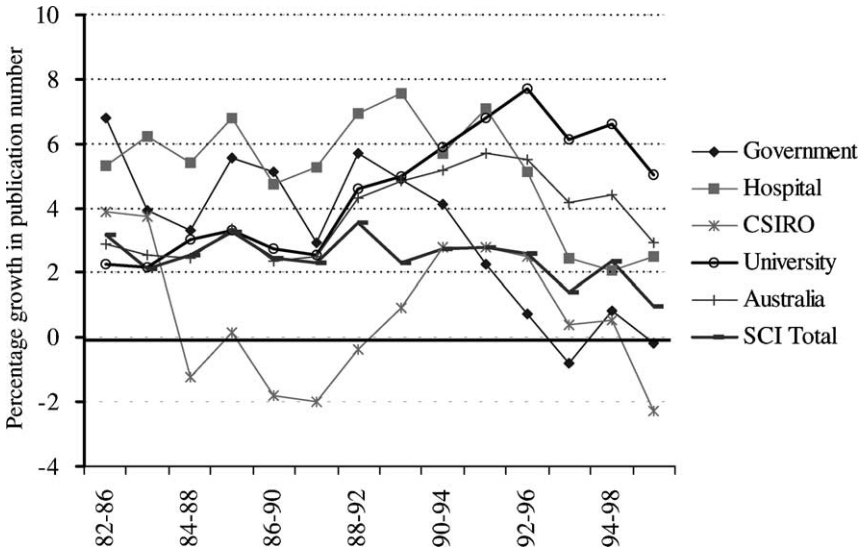

Fig. 7. Growth in SCI publications for selected Australian research sectors, 1982–1986 to 1995–1999.

share of the other two major ISI indices—the SSCI and the A&HCI. Fig. 8 plots the university sector's share of world output in the three major indices.

The increase in Australian universities' presence in the journals indexed in the SSCI is even more dramatic than in the SCI during the 1990s. The small number of publications involved in the calculations for the A&HCI leads to a much greater volatility from year-to-year, but the increased presence of Australian universities in 1990s is still very evident. The increased publication activity has occurred across all fields of university research.

4.4. Comparison of two universities

Another pointer to the validity of the hypothesis can be gained by examining two individual universities. The Universities of Queensland and Western Australia

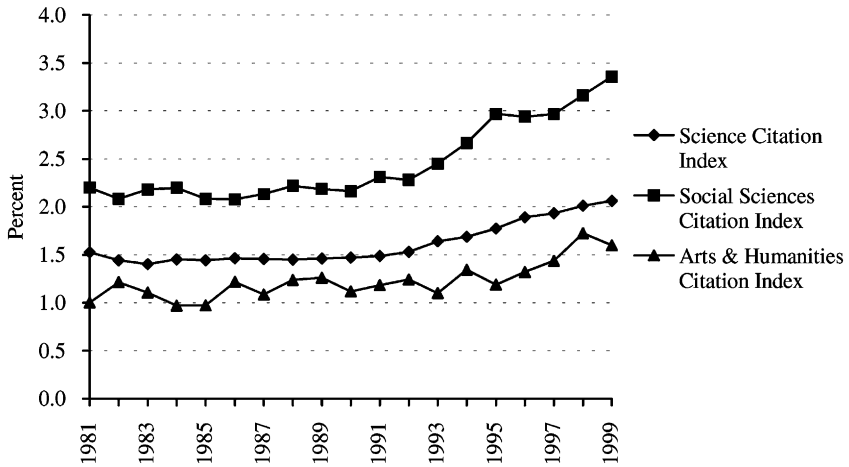

Fig. 8. University share of publications in ISI's three main indices, 1981–1999.

have broadly similar research interests with large medical schools and activities across a diverse range of fields. In the late 1980s, both universities introduced major, but quite different, changes to their research management policy, though both sought the same outcome: to strengthen and enhance their research profile.

The University of Western Australia introduced a formula for distributing a significant proportion of research funds, one major component of which was a publication count. The formula was much more sophisticated than the government's Research Quantum exercise, with many more publication categories and different weightings for each category in the different fields of research. Nevertheless, the formula was based on quantity, not quality. In direct contrast, the University of Queensland strategy was to instigate a strong recruitment drive targeting the brightest young researchers, including a significant number from overseas, and providing them with a strong resource base.

Fig. 9 shows trends in publication rates per academic staff member for the two universities. Size-adjusted trends have been used as growth in staff numbers between 1988 and 1998 differed significantly between the two institutions. Both teaching and research and research only staff at the University of Western Australia rose uniformly by approximately 44%, while at the University of Queensland, an overall rise of similar magnitude (42%) disguised quite different trends in the two research active components—research only staff more than doubled (up by 113%), while teaching and research staff increased by only 13% (CTEC, 1979–1985, 1986–1987; DEET, 1988–2000).

Both universities, and the overall trend for the sector, was relatively stable across the early part of the 1980s, but the advent of the unified national system in the late 1980s resulted in a marked decline in productivity rates for the sector as a whole. The former colleges of advanced education and institutes of technology joined the sector adding a large number of staff classified as 'teaching and research', but with little in the way of a research culture. A study undertaken in 1992 has shown that the productivity of the 'new' universities entering the system was less than one-quarter the rate of the pre-1987 research intensive universities (Ramsden, 1992). In addition, their focus was on fields of study that had a traditionally low level of journal output, particularly that captured by ISI indices—the humanities, social sciences, and applied sciences (Fox, 1983).

These effects would lead to an expectation of productivity rates stabilizing, post-unification, at a level lower than that which existed when only staff in the pre-1987 universities were included in the calculation, and this appeared to be occurring at the beginning of the 1990s. However, at the same time as the introduction of the Research Quantum collection, productivity rates for the sector as a whole increased significantly and have now attained a level higher than existed prior to unification.

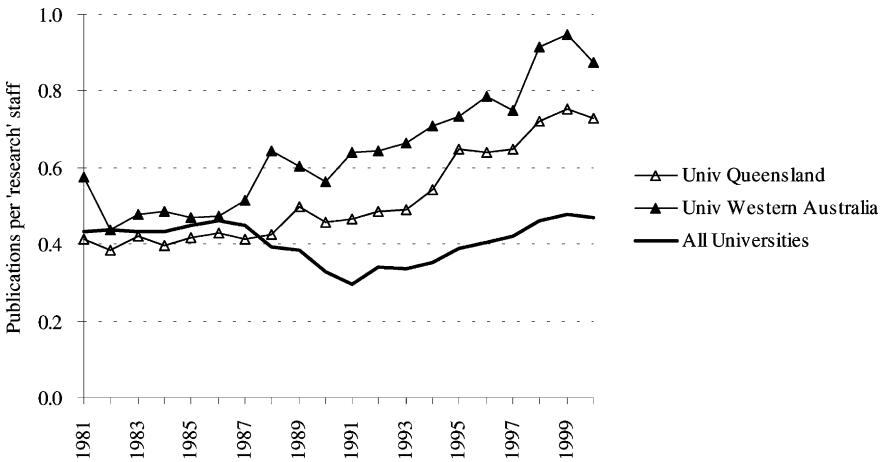

Fig. 9. Comparison of publications per staff for two universities with the overall university trend, 1981–1999.

Neither of the two universities highlighted in this analysis was affected in a major way by the many institutional mergers that occurred in the implementation of the unified national system. The University of Western Australia did not participate in any mergers, and the University of Queensland joined with only one small institution, the Queensland Agricultural College. Rather than falling, productivity rates in both institutions increased markedly. The increase was more marked for the University of Western Australia, which has seen its publications per research staff rate more than double since the introduction of its new system for the internal allocation of research funds. The institutions researchers quickly responded to a system of reward based on productivity, a system reinforced at the sectoral level by the introduction of the Research Quantum collection in the mid-1990s.

Productivity at the University of Queensland also increased, though to a lesser degree. The university had sought to enhance its research performance through the recruitment of strongly performing early career researchers. Sociological investigations suggest that such a strategy will increase productivity for two reasons (Fox, 1983). Firstly, the studies suggest that the productivity of scientists is strongly influenced by the attitudes and practices of co-workers; and secondly, early career researchers who have already established a strong publication record will continue to actively publish. Assembling an increasing group of bright young researchers gives an institution a cumulative advantage—a group of active researchers is further influenced to even higher rates of productivity through the close association of like-minded individuals. It is these influences that may be driving, at least in part, the trend evident in Fig. 9.

Fig. 10 moves from a simple productivity comparison of the two universities, to look more closely at what has been occurring in relation to the impact of their publications. It shows the trends in RCI over an 18 years period for the two universities, and contrasts these to the trend for the university sector as a whole.

As already noted, the RCI for the university sector declined through the 1980s and in the 1990s stabilised at just below unity. The RCI for the University of Western Australia followed a similar, though more exaggerated trend. Its RCI declined from a peak in 1985 and declined at a faster and longer rate than for universities in general, though it has regained a measure of the lost ground in recent years. In stark contrast, the University of Queensland's RCI remained steady but very low at less than 0.8 through until the end of the 1980s, followed by a significant improvement in the 1990s. It exhibits none of the decline shown for the sector as a whole or for the University of Western Australia. Fig. 11 provides more insight into these trends.

Fig. 11 depicts trends in the relative impact of the journals in which researchers from the two universities are placing their publications. It provides a significant

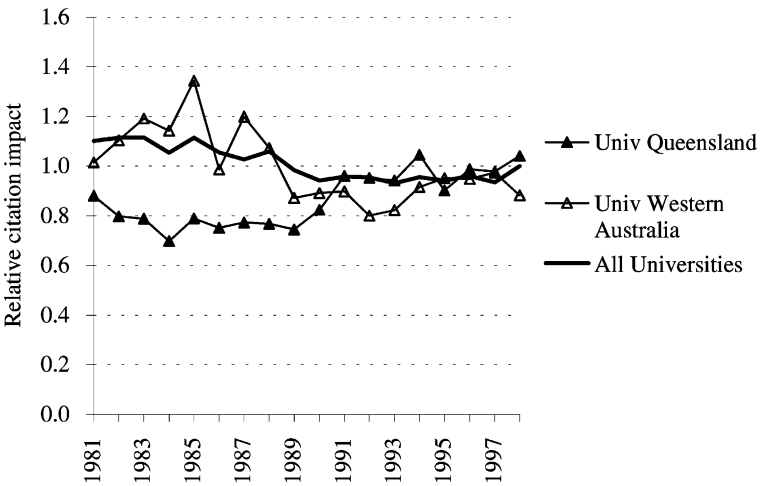

Fig. 10. Comparison of RCI trends for two universities with the overall university trend, 1981–1998.

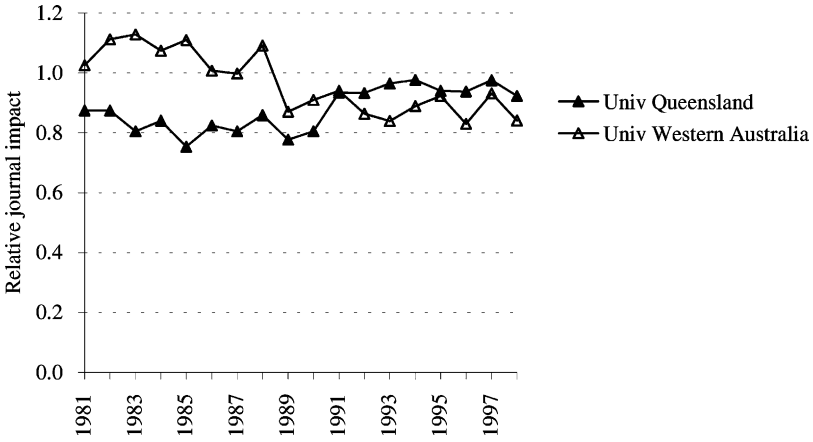

Fig. 11. Comparison of relative journal impact trends for two universities.

pointer to the explanation for the RCI trends shown in the previous figure. The University of Western Australia's falling RCI is matched by a reduction in the average impact of the journals in which its output is appearing. In contrast, the University of Queensland's publications started appearing in higher impact journals from 1991, with a matching improvement in its RCI. An examination of actual citation rates for the two universities showed that in both cases they matched closely the average rates (or 'expected' levels) for the journals in which they published.

A focus on productivity at the University of Western Australia has succeeded in lifting its publication output significantly, but that output has been placed increasingly in journals of lower impact, with a subsequent loss of relative visibility in the research community. In contrast, the University of Queensland's concentration on staffing strategies has also raised productivity, but this has been achieved in concert with an increase in the impact of its publication output.

5. Conclusion

Much of the driving force behind the trends in Australia's research performance as measured by ISI publications derives from the university sector. The increased productivity of the sector is at odds with the perceived crisis in which it currently stands. A detailed case study of two universities, and a closer examination of the data for the sector as a whole, points strongly to the major influence being the changing context in which the sector is operating. Increased system-wide and institutional performance evaluation based on aggregate output measures appears to be altering researchers' publication habits. The indications are that there is an increasing emphasis on refereed journals, in particular ISI-indexed journals as a vehicle for reporting academic research. Theorists expect 'publication inflation' from a performance-based system where aggregate publication counts are a key component (Geuna and Martin, 2001). The rise in publication numbers is not in itself a negative outcome. What is of concern for Australia is that while journal output has grown rapidly, it is increasingly appearing in lower impact journals.

This analysis also highlights the danger for policy analysts in taking simple bibliometric measures at face value. To do so for the basic analysis presented in Fig. 1 could result in the belief that Australian scientific output has dramatically increased in the last decade and that its impact has also improved significantly. But a more detailed examination of the data reveals that Australia's *RCI* continues to decline, and raises important questions on the wisdom of a policy that rewards quantity, with scant regard to quality. Even the apparent increase in productivity must be treated with caution, as it may merely indicate a change in their publication practices, with a greater reliance on ISI-indexed journals. The rewards for this latter course of action are obvious.

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