



Use of bibliometric modelling for policy making

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Abstract

Bibliometric methods for analysing and describing research output have been supported internationally by the establishment and operation of organisations such as the Institute for Scientific Information (ISI) as well as the continual calculations and release of journal lists, bibliometric indicators and rankings. Policy makers in Australia have been relying on such bibliometric information and analyses in making funding decisions and encouraging the development of research potential and strengths. Does bibliometric modelling of research productivity reflect the real impact research has for Australia's future? The paper is based on a study of three Australian research centres in the field of the geosciences. The analysis reveals a number of anomalies in the generalisations made when ISI models are used for policy decisions.

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1. Introduction

Bibliometric analyses are the main way in which the research performance of Australian researchers is traditionally recognised. This is evident in the quests for academic and/or research promotion, recognition by peers, research grant applications and job applications. The research performance measures of the Department of Education, Science and Training (DEST) which funds higher education in Australia, also include refereed publications.

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There has been concern amongst some Australian academic and research communities regarding the reliance on the bibliometric measure of citation analysis as a useful indicator of true research performance and impact. A study of the research performance of minerals geoscience participants in three Australian research centres, a Key Centre for Teaching and Research (KCTR), a Special Research Centre (SRC) and a Cooperative Research Centre (CRC), was undertaken in 2001–2002 to establish the validity of this concern. The KCTR and SRC were university-based while the CRC was located at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and had a number of participating partners as core parties. The results of this work are used to discuss whether the reliance on bibliometric measures is a reasonable indicator for Australian research performance and whether other trends in research performance are being missed.

2. Bibliometric models and research

The advent of computerisation in the 1970s has assisted the Institute for Scientific Information (ISI) – a prestigious database publisher enabling access to the world’s literature, particularly in scientific and technical information – in its bibliometric modelling resulting in a wide range of bibliometric products now available. Many of them, especially those revealing citation counts, are widely used for the performance measurement of Australian researchers. For example, a series of projects carried out in refs. [1–7] in the 1990s to assist the Australian government in its science funding policy decisions, was based on the citation products.

Bourke et al. [6] admit that the use of bibliometric methods to measure research performance only provides indications of what is involved. They state that there is “little argument” for pursuing a more elaborate count of the research activities undertaken [6, p. 58]. However, others caution against the use of bibliometrics to provide these indicators (e.g. [8–11]).

3. What does a researcher do?

Accepting that refereed publications and in the case of the university academic, external grant successes and research student supervision and completions, are considered important in the Australian government policy environment, what other functions does a researcher perform? The analysis of research for the participants in the study included a range of activities which were not scaled in any order of importance. The perusal of the researchers’ CVs and publication lists, which provided the main data source for the analysis, highlighted the following categories as relevant:

- professional activity, i.e. number and type of professional association memberships, type of professional engagement and visiting positions;
- education, i.e. participation in under- and postgraduate teaching, research student supervision, industry courses and seminars;
- research activity, i.e. research grant successes and research management;
- publication, i.e. formal publication and grey literature.

Formal publications were books—authored; books—edited; book chapters; detailed journal article information. The following journal categories were used: (1) *Indexed international journals*, i.e. ISI

recognised journals. Given ISI's criteria for journal selection, these articles are fully refereed. (2) *Non-indexed international journals*, i.e. non-ISI-indexed journal titles; these articles might be refereed, but are not considered important by the ISI. (3) *Indexed Australian journals*, i.e. ISI-indexed Australian journal titles. The separation between international and Australian titles allowed analysis of publishing preferences. (4) *Non-indexed Australian journals*, i.e. as above for non-ISI-indexed international journal titles. The analysis also covered whether the researcher was the sole and the senior (i.e. first) author of a journal article.

Grey literature is a category used in the library world to describe publications which cannot be readily acquired through normal bookselling channels and are difficult to identify and obtain [12]. This published material is not likely to be included in any of the ISI indices and covers conference proceedings, company/technical reports, maps, preprints, theses and dissertations, field guidebooks and many types of government documents.

4. Are these activities research?

There are many areas of activity over and above publication in which the researchers engaged and they deserve consideration as components of their research activity. They were broadly classified as professional activity, education and securing funding.

4.1. Professional activity

Traditional professional expectations (e.g. [13,14]) have expanded. The ease with which researchers can travel to achieve professional networking or communicate using electronic means brings with it a busyness and an urgency which were not experienced in earlier times. The professional activities of the researchers in the centres were hectic and complex.

The majority of the participants in the study belonged to at least one professional association. A number of them have achieved Fellow status: 25% from the KCTR, 20% from the CRC and 12.5% from the SRC. The senior members of each of the centres have spent time on the national and/or international executive committees of at least one professional association. They and other respondents had also undertaken general committee duties for their respective professional associations at other times. Editorial duties were not as evident, with editorial panel membership being the most common option. In this instance, the main duty described was refereeing papers for a relevant journal. Membership on advisory committees was well represented amongst the senior members of the centres, some examples included liaison committee, Geological Survey; research committee, Minerals and Energy Research Institute of Western Australia (MERIWA), National Seismic Imaging Committee and international scientific committees.

Involvement in all of these activities did not always occur concurrently. It also requires commitment and support with personal time and effort. Professional activity in these various categories indicates a dedication to geoscience and its future. It is through professional association membership that the geoscientists have access to networks, conferences and professional meetings. A number of prestigious awards have been received by individuals and teams within the three centres. These awards contribute to the prestige of the groups, the teaching school and can enhance student numbers.

All of this professional activity is implicitly considered to be part of the researcher's role in geoscience, though it receives scant recognition in bibliometric-based performance studies.

4.2. Education

The university base of the KCTR and the SRC and the conditions of employment for some of the academic researchers in the CRC mean that they must continue their educational role. By following the guidelines of the CRC program, the CRC has adopted teaching as an important way to educate and train new geoscientists in the geoscience research and techniques as well as to up-skill practicing geoscientists.

The qualitative significance of research for undergraduate teaching is largely ignored in policy making. Federal funding is based on an equivalent full time student numbers and does not reflect the original ethos and culture of why universities teach in the first place; namely, to take advantage of and pass on the knowledge and wisdom derived from the research being undertaken, and to encourage the brightest undergraduates to become researchers themselves.

Reif [13] claims that there is a decrease in prestige when one teaches in undergraduate programs, particularly as it is considered as time stolen from research and publications. This attitude still persists in university circles today. While the commitment to teaching and student supervision is mostly at the higher degree level in each of the centres, there was a representation of undergraduate involvement, particularly from the KCTR and SRC, and some of the CRC researchers. Some of the other CRC researchers undertook guest lectures or taught components of undergraduate (and postgraduate) courses as arranged with core party colleagues and as invited by other universities.

Teaching at the postgraduate level is one of the prime ways in which each of the centres conveys its work to the industry that supports it: by educating those employed in the mining industry in their research findings and methods. A number of the researchers undertook considerable postgraduate teaching, either for courses in Masters programs or for industry short courses. The centres accept that industry education is a major component of their research performance, yet it is not without its challenges. It involves the organisation of many technical workshops and field trips, including to international locations in order to best demonstrate the tested theories and practices. The valuable information is compiled in many field and course notes and technical report series (of the KCTR and CRC). This information is reaching a public, but not always in the form of refereed articles.

4.3. Securing funding

There is a need for continuity of funding to carry out strategic research programs (Lisle [15]) and this is the biggest challenge for each of the centres. While they may have been successful in gaining financial support from industry, government funding can provide them with stability. This is not the case for the KCTR which failed in its bid to secure the continuation of government funding. The SRC's and CRC's funding is currently more secure with a nine- and seven-year horizon, respectively. While seven or nine years might seem a long time in the mind of an economist or a policy maker, it is not a long time in the life of a geoscientific research program. Should the SRC and the CRC (which was successful in its renewal bid) fail to secure federal government funding in their next significant rounds, they will need to compete with other entities amongst their host bodies, and for other grants, for continuation of their research programs.

The CRCs are a relatively new phenomenon in Australia. They have been established to break down the pure research orientation said to be a part of the university research culture by forcing researchers to integrate more readily with their relevant industry. Their funding model has matching industry contribution as an essential component. Yet the evidence from the evaluation of the funding data reveals that the KCTR and SRC already rely heavily on their industry for research funding. They also gain strong industry support through their educational programs, advisory committee memberships and research student support.

While success in obtaining external funding is now recognised by DEST for the university-based centres, it also means that the life span of the centres is tenuous. The KCTR now survives on funding from its host university, the state government, industry and whatever federal funding sources it can secure. The SRC was successful in its upgrade from a KCTR and is half way through its nine-year cycle as an SRC. The CRC has recently been renewed, but under the guidelines for CRCs, its research direction has had to change because of this. Its seven-year term as CRC1 became essentially six years because a considerable component of its final year was taken up with the renewal bid for CRC2 as well as the final review of CRC1.

There is thus a collision between funding timelines and continuity in research programs. The centres are successful in obtaining their initial government grants because of the perceived success of the research they plan. They deliver their research programs and in so doing have, in the case of the three centres studied, made a significant international impact in geoscience. Yet the funding is finite and in order to continue the research, the senior researchers in particular are continually seeking external income and funding. This takes up a considerable component of valuable time they could spend undertaking research.

5. Research dissemination

Geoscience researchers have been shown to be heavy users of geoscientific information in order to inform their research process. They also produce considerable quantities of information.

The analysis of publication output of the three centres revealed that the CRC uses 21, the KCTR 11 and the SRC 7 different types of publishing categories. The range is indicative of the projected audiences. The publication production analysis showed continued use of the formal publication types, particularly by the KCTR and the SRC, but there was also an increasing and appreciable use of grey literature.

5.1. Formal publication

A summary of the formal publication output by all participant researchers from the centres is shown in [Table 1](#). It was expected that there would be a significant number of formal publications because of the desire by research geoscientists to have their work in the published, indexed and cited literature. The records from the past, which are represented by the “before” figures, provided an indication of whether the researcher was publishing in the same media prior to joining the research centre.

The formal publication output of the members of the KCTR before and after joining the centre is reasonably static. The consistency is well illustrated in the category book-chapter with 11.2 publications before and 11.1 since joining the centre. Decreases in formal publication output are evident in editing books (a drop from 4.7 to 2.2) and Australian non-ISI-indexed journals (a drop from 6.7 to 2.5).

The formal publication output for the SRC (as shown in [Table 1](#)) has decreased in all categories except Australian ISI and non-ISI-indexed journals where the number of publications is relatively even. This

Table 1
Formal publications use by Australian geoscience research centres

Publications	Centre		
	KCTR, before/during	SRC, before/during	CRC, before/during
Book—author	1.8/3.3	0.5/nil	9.4/2.8
Book—editor	4.7/2.2	1.0/0.5	6.5/2.0
Book—chapter	11.2/11.1	14.5/3.2	63.1/13.7
Journal—international ISI	23.0/29.1	54.6/34.6	121.0/19.4
Journal—international non-ISI	5.1/7.0	8.6/2.2	38.0/4.5
Journal—Australian ISI	3.0/2.6	7.1/6.1	33.1/4.2
Journal—Australian non-ISI	6.7/2.5	5.7/6.4	48.6/26.9
Journal—sole author ^a	7.0/5.0	26.0/16.0	78.7/12.5
Journal—senior author			
Fractionated	15.2/7.1	22.3/11.0	45.0/9.6
Unit count ^a	29.0/24.0	58.0/29.0	107.1/21.9

Note: All counts are fractionated unless otherwise noted.

^a CRC unit counts are pro-rated for researchers' time with the centre.

can be explained by the short-term existence of the centre as a SRC and the newness of some of its participants. As with the KCTR, the favoured publication type are ISI-indexed journal titles.

The participants from the CRC have come from a variety of geoscientific research backgrounds, a number having had a long history with CSIRO and Geoscience Australia. Publishing in the Australian ISI-indexed journals has fallen sharply for the CRC members from 33.1 to 4.2 (82% drop). The drop is even more noticeable in the ISI-indexed international journals (84% from 121.0 to 19.4).

There is a decline in sole authorship in all centres. This decline was more marked for the CRC which shows a fall from 78.7 single authored papers in all journal categories, to 12.5 during the life of the centre. Sole authorship is not a common practice for the KCTR or the SRC. Although many of the journal papers prior to joining the centre had multiple authors (one paper had 28 authors), multiple authorship is becoming a much more common practice. It appeared that publications in earlier years (1960s and 1970s) might have followed a convention for alphabetic order of authorship listing while those in more recent years use an order based on contribution.

When the fractionated count of senior authorships is considered, there is a decrease in this category for researchers from all centres. The KCTR and SRC halved their output in the category (from 15.22 to 7.12 and 22.32 to 11.00, respectively) and the CRC reduced its output in the order of magnitude of 5 (from 44.99 to 9.63).

A detailed study of journal titles used by the researchers was also undertaken. There are two titles in which all centres publish: *The Australian Journal of Earth Sciences (AJES)* and *Economic Geology*. Another title which ranked highly amongst preferred titles used by the CRC researchers was the *Journal of Geochemical Exploration*. In the 2001 ISI journal impact rankings, *AJES* is ranked 39th (of 117 titles) in the Geosciences, Multidisciplinary Category and *Economic Geology* ranked 14th (of 47) and the *Journal of Geochemical Exploration* ranked 43rd (of 47) in the Geology and Geophysics category.

Despite the ISI rankings, each of these titles is respected in the fields of geoscience in which the centres specialise, is widely read and they are captured by the ISI indices. There is little use of additional DEST preferred titles by the researchers in all centres. However, this is not an issue because as a rule the

ISI-indexed journal titles are perceived as better representative of the research areas and override those of DEST.

The geoscience journal analysis revealed that the availability and use of electronic journals in the subject areas of the centres was primarily through the release of electronic versions of the paper edition of the same titles. A number of the geoscience journal titles, particularly those published by the Elsevier and Springer publishing houses, are also available in an electronic format, through personal or library subscription. These journals were not counted in the “electronic” count since the titles are essentially still a paper copy production. This being the case, the funding models for acceptance of these titles would be the same as those for the paper versions.

5.2. Grey literature

The heavy dependence of geoscientists on grey literature is reported by Haner [16] and Bichteler [17]. The contributions to this category are shown in Table 2.

There are a number of electronic journals in the geosciences, with some of the more formal electronic journals following the same refereeing and monitoring procedures as those that appear in the paper domain. Yet as can be seen in Table 2, there is little to no indication that the participants from any of the centres target e-journals.

Conferences play an important role in information exchange for all of the centres. Although the funding model for research in Australian universities distinguishes between refereed and non-refereed conferences, only a few of the researchers make this separation. Published papers in Australian and some international geoscience conferences are for the most part not refereed. There was also a high use of the “extended abstract” and “abstract” refereed conference proceedings, a category which is unrecognised by DEST.

The CRC uses technical reports as a primary medium for information dissemination. Its researchers continue to publish government reports (220.3 before and 64.9 after joining the centre) and company reports (53.2 before and 3.5 after). The SRC also has high figures in the report category (company reports have increased from 27.6 to 78.8). The use of these technical reports is particularly because of the need for the SRC and CRC to report their work through a company-based funding model managed by the

Table 2
Contributions to the grey literature by Australian geoscience research centres

Publications	Centre		
	KCTR, before/during	SRC, before/during	CRC, before/during
Electronic	Nil/nil	Nil/nil	0.3/1.8
Conference—editor	1.6/0.2	Nil/nil	2.7/3.9
Conference—other	10.1/8.2	18.2/34.3	132.0/73.9
Government report	13.9/1.5	1.8/2.9	220.3/64.9
Company report	Nil/1.8	27.6/78.8	53.7/3.5
Maps	Nil/nil	Nil/nil	2.4/0.8
Field guidebook	1.1/2.5	1.4/0.4	17.6/12.6
Other	1.6/10.8	7.4/9.0	61.3/35.4

Note: All counts are fractionated; the main category included under “other” is course notes.

Australian Minerals Industries Research Association Ltd. (AMIRA). They have also emphasised the need for confidentiality for some of their work. This issue is recognised in the literature. Narin et al. [10] and [18] write that because of confidentiality, articles do not always represent all of the research work undertaken. At the political level, Lowe [19] stresses that undertaking industry work and the resultant confidentiality clauses can reduce the freedom to pass on new knowledge.

The commercial advantage of funding research, for example, through the AMIRA scheme, is that the participant companies gain a head start in their geoscientific exploration. This type of research funding is recognised by the centres and all would abide by its conditions. The evidence in the annual reports of the SRC and CRC points to the Directors and their teams successfully striking the shortest possible confidentiality periods, and then in the case of the CRC, releasing the information to open file as soon as possible after that. A researcher from the SRC explicitly noted the importance of producing journal articles once confidentiality periods expired.

Report production exceeds ISI-indexed journal publication for the SRC and CRC since the centres commenced. The SRC's counts for ISI journal publication are 34.6 for international, and 6.1 for Australian, giving a total of 40.7. The total company report count for the SRC for the same period is 81.6. The respective figures for the CRC are 19.4 for international, 4.2 for Australian and a total of 23.6, compared with 68.4 reports.

Geologists are heavy map producers and users but the data from the centres did not explicitly reveal this information. Although the figures for map production are low, geological information is normally accompanied by at least one map. The “other” category includes course notes and teaching aides which are relevant to the dissemination of research results to sponsoring and other interested parties and are considered a component of the research output of the centres. References to web design and web page maintenance are also included here.

What is the quality of today's published paper? One of the participants, an elder statesman in geoscience, emailed that the push to publish for his centre was so intense that whereas one would have published one good paper in the past, one might now be producing three. The maintenance of quality is left to the refereeing process. How does this place papers that, according to researchers from all centres, are “lightly refereed”? How does it place extended conference abstracts which can be fully refereed, yet these conference proceedings are not accepted by ISI or DEST? Where does it place the technical report?

6. In summary

The key observations from the analysis of the three Australian geoscience research centres are outlined below:

- The funding mechanism for geoscientific research encourages refereed publications. The KCTR and SRC have high figures for international and Australian ISI-indexed categories. However the researchers in the CRC, which experiences much more pressure from industry, had lower figures.
- Each centre shows a strong record for conference participation and papers including “extended abstract” refereed geoscientific proceedings.
- The publication of technical reports, while not recognised in the Australian federal funding model, dominates the research output of the CRC and is significant for the SRC. Those publications form a major component of the assessment of each centre's public research dissemination.

- The research outputs of the participant researchers covers considerably more than formal publication. The participant researchers from all centres are highly qualified and committed geoscientists and represent a useful sample of the populations of each centre. They are recognised by their peers and others for the research that they perform. The evidence is that they are committed to their research, their profession and to passing on the results of their work to their respective industries and to students.
- Each centre has a significant commitment to education and plays a major role in passing on research information to their relevant industries through their short course and coursework masters programs.
- Seeking research grant support is a consistent issue for the centres and is of crucial importance to the KCTR whose main federal funding grant was not renewed. The duration of the centres at this stage appears finite. The constant need to seek grant and other support monies for the centres does not diminish, and takes up considerable time particularly of the senior researchers.

7. Conclusions

The study of the research performance of the three Australian geoscience research centres has revealed a number of anomalies in the generalisations made when one uses ISI indices on which to base policy decisions. It has not negated their use as an indicator of events, but there is devil in the detail. The analysis reveals that there are important qualitative aspects in the research process, particularly those of professional commitment, influence, reputation and scientific recognition. These are not captured by the bibliometric models.

There is an apparent conformity with the data produced by the Australian research performance studies. Further reflection reveals that this could be because the researchers are using the system, rather than the system measuring an authentic level of research output. However, the researchers are now publishing in those journals which, although indexed by ISI, are not the highest ranked titles. They are believed to be more relevant titles.

Is the tail wagging the dog? In a novel twist to this question, Eugene Garfield, Chairman Emeritus for ISI asks the same question regarding the impact that the Science Citation Index has had on the study of informetrics [20]. He bolsters his case by quoting Le Pair's 1995 publication: "Citation Analysis is a fair evaluation tool for those scientific sub-fields where publication in the serial literature is the main vehicle of communication" [20, p. 67]. As we have seen in the case of the CRC, publication in the serial (or journal) literature is not the main vehicle of publication. In addition to this:

- there is little choice for the Australian geoscience researcher when it comes to publication in Australian geoscience journal titles indexed by ISI—there is only one such title;
- of the many ISI-indexed international titles in geoscience, only two are significantly preferred by the researchers and these have not ranked highly in the ISI journal impact figures for 2001.

How their research productivity is measured remains the crux of the existence of the three centres. The reliance of the Australian government on the journal indices reports of Bourke et al. means that this method cannot be ignored. The importance of publication is still present, though its emphasis has been reduced. Where do the education and training of industry fit into these criteria? Where do field trips, conferences and technical report writing gain acknowledgment? Australian universities are moving into new performance measurement areas with more emphasis being placed on research student completions

and attracting research funding from diverse sources. The study observed how time exhausting the search for research funding can be.

The flexibility of the modus operandi of the three centres indicates that they will be able to meet the aims of all of these measures: they publish, though for the CRC this is not in the scholarly media as for the other centres; they obtain their research grants from a variety of sources; and they encourage research students into their midst. Publications in the form of course notes do not reach the cited literature, the sharing of research ideas through industry courses, teaching and through student supervision is not easily quantified, yet these remain a significant component of the research output of the participants and many of their fellow researchers. Except for the CRC review process, there is no obvious effort by any government funding body in Australia to give credit for this.

While the university-based centres do not escape being reviewed, their research culture is more accepted and protected under the funding arrangements in which they exist, provided the funding continues. In the case of all three centres, continuity of funding is the main uncertainty and in the case of the KCTR, has become a stark reality. How long is long enough for research funding? The study confirmed what has been often stated: that it takes time to build a solid and successful research profile. It makes one wonder whether the government might not be better served to study the building of strong collaborations and support in university-based research centre environments over the years instead of applying bibliometric models. In the case of all three centres, if they were not providing industry-relevant research and programs, then their industry would not support them. If the CRCs are to become the research centre of the future, then we must expect a decrease in the performance of these centres in the ISI bibliometric measures as their publication in the grey literature increases.

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