

APPENDIX 2

**Bibliometric analyses undertaken for the Academy
of Science by:**

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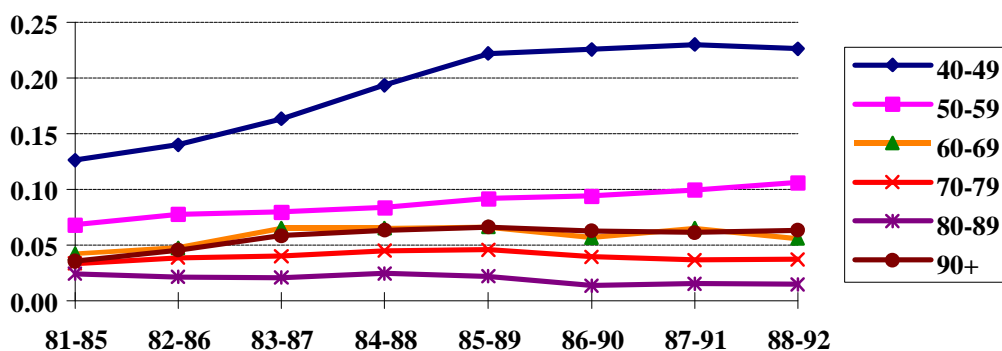
**BIBLIOMETRIC ANALYSIS UNDERTAKEN FOR:
THE IMPACT OF AUSTRALIAN SCIENCE: A STOCKTAKING**

1. Hypothesis: There has been a decline in the proportion of Australia’s publications that are very highly cited (‘big bangs’), leading to a decline in citation shares

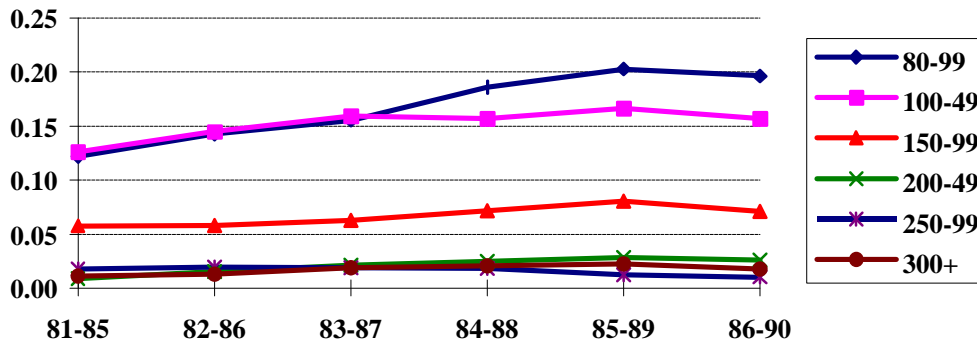
This hypothesis was proposed because of the very skewed nature of citation practice and the influence in overall ratios of a small number of very highly cited items, particularly at lower levels of aggregation. We completed two runs on the total Australian data to analyse the distribution of very highly cited items. In the first run, we limited citations to the year of publication and the subsequent two years. In the second run, we expanded citations to the year of publication and the subsequent four years. The strategy was aimed at trying to find out if there had been a decline in the number of ‘big bang’ publications from Australia, ie, that small number of publications achieving exceptionally high citation rates. The citation window was limited to enable a sufficient run of years to be analysed. We focussed on citation counts above 40 for data on citations in the first two years, and on counts above 80 for data on citations in the first four years.

We had expected that if the declining ‘big bang’ theory held any currency, then we would see a decline in the proportion of Australian publications in the top bracket.

Distribution of citation levels (received in first two years): Total SCI



Distribution of citation levels (received in first four years): Total SCI

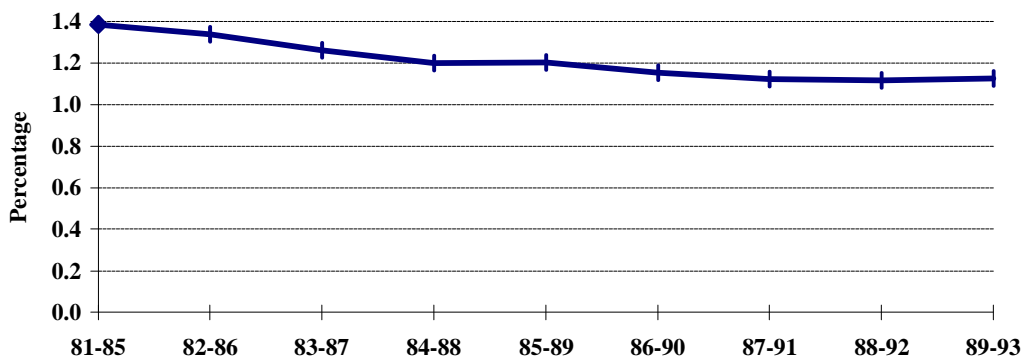


The hypothesis did not hold true. In data based on a two-year citation period, Australia actually exhibited an increase in the proportion in all but one band (80-89) in this top bracket between the beginning and end of the period. A similar trend was exhibited when the citation period was increased to four years.

2. Hypothesis: Australia’s share of SCI ‘meetings abstracts’ has declined indicating reduced contact with international experts

In the Journal Citation Reports volume of the SCI, the number of items classified as ‘meetings abstract’ are noted. From our database we can count the number of Australian publications classified to the same publication type and calculate the proportion these represent of the total. The information for the ‘world’ is published only for the total SCI, with data not being available at field or sub-field level. There is a break in the time series at 1989. Prior to this, meetings abstracts in all SCI source journals were indexed; from 1989 onwards, only those in the ‘top 500’ journals were indexed.

AUSTRALIA'S SHARE OF MEETINGS ABSTRACTS: Total SCI
Five Year Windows



The data show that Australia's representation is low and declining (from 1.4% in 1981-85 to 1.1% in 1989-93) which supports the proposed hypothesis.

3. *Hypothesis: Australians are finding it harder to publish in the 'top' journals and this is a major contributing factor to the decline in Australia's citation shares*

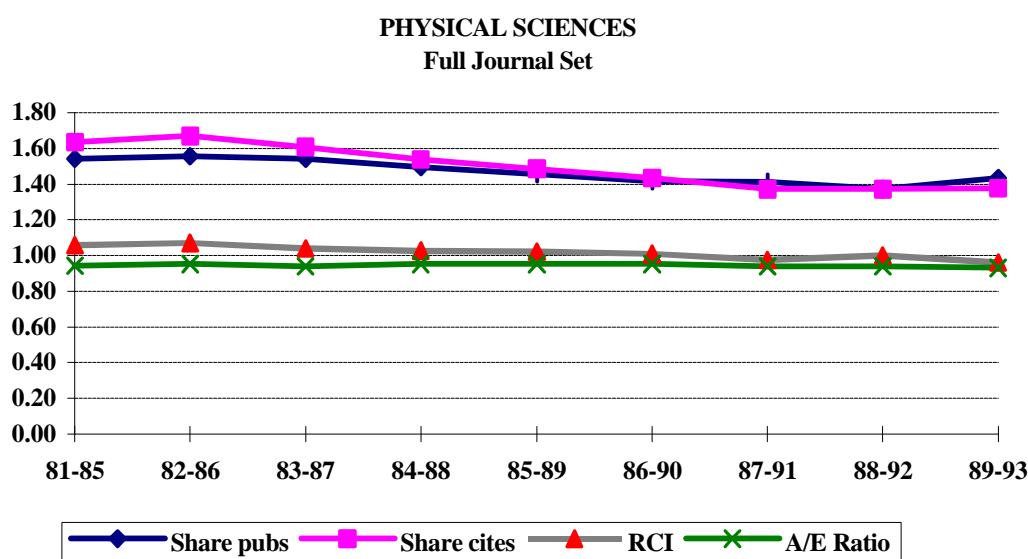
The hypothesis we wished to test was that Australians were finding it harder to get their research published in the high impact journals leading to a decline in its share of citations. This hypothesis was proposed because of the very skewed nature of citation practice and the influence in overall ratios of a small number of very highly cited items/journals. The signs that this might be the case for a given discipline would be a declining relative citation impact (RCI) due to a declining citation share with a constant ratio of 'Actual' to 'Expected' (A/E) citations for the full journal set, coupled with a declining share of publications in the high impact journals.

The results for a selection of fields and sub-fields is set out in the following pages.

(a) *Physical Sciences*

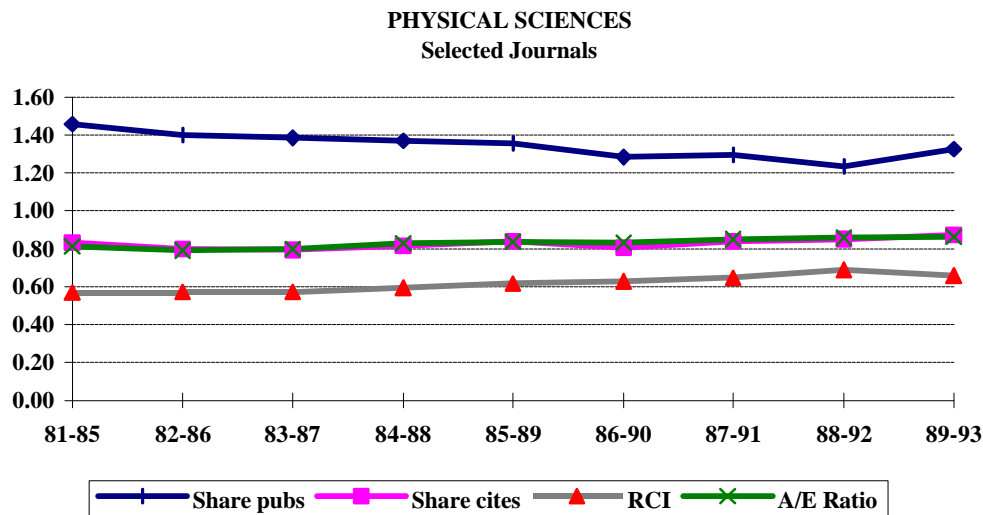
The selected journals:

Annual Review of Nuclear and Particle Science
Journal of Physics A-Mathematical and General
Journal of Physics B-Atomic Molecular and Optical Physics
Journal of Physics C-Solid State Physics
Journal of Physics D-Applied Physics
Journal of Physics E-Scientific Instruments
Journal of Physics F-Metal Physics
Journal of Physics G-Nuclear Physics
Physical Review A
Physical Review B-Condensed Matter
Physical Review C-Nuclear Physics
Physical Review D
Physical Review E
Physical Review Letters
Physics Letters A
Physics Letters B
Reports on Progress in Physics
Reviews of Modern Physics
Rivista Del Nuovo Cimento
Zeitschrift Fur Physik A-Hadrons and Nuclei
Zeitschrift Fur Physik B-Condensed Matter
Zeitschrift Fur Physik C-Particles and Fields



The full Physics journal set used in *Crisis* showed a declining RCI, particularly since 1986. Both the share of publications and citations fell over the period, but

the share of citations fell at a greater rate. The A/E ratio shows a much steadier course over time. This suggested that in more recent years Australia’s publications might be appearing more in journals at the lower impact end of the scale.



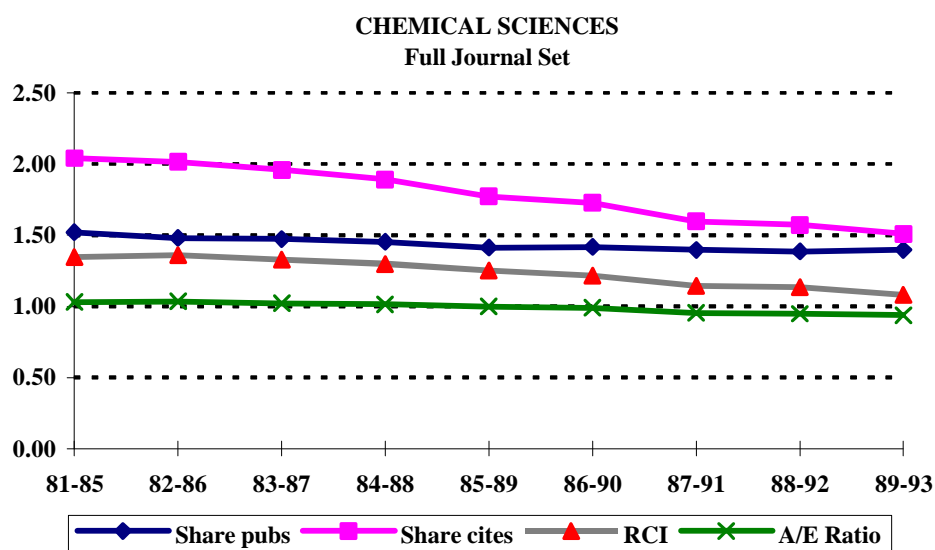
Australia’s share of publications in the selected ‘high impact’ journal set declined from a peak of 1.6% in 1981 to a low of 1.1% in 1990, though there has been an upturn in the 1990s.. This data suggests there may be some validity in the hypothesis for Physical Sciences.

It is interesting to note that in the 1990s the relative impact of articles in these journals has improved — there may be fewer of them, but their share of citations has increased. This improvement was too recent to have affected the trends shown in *Crisis*, but does give hope that they are now being reversed.

(b) Chemical Sciences

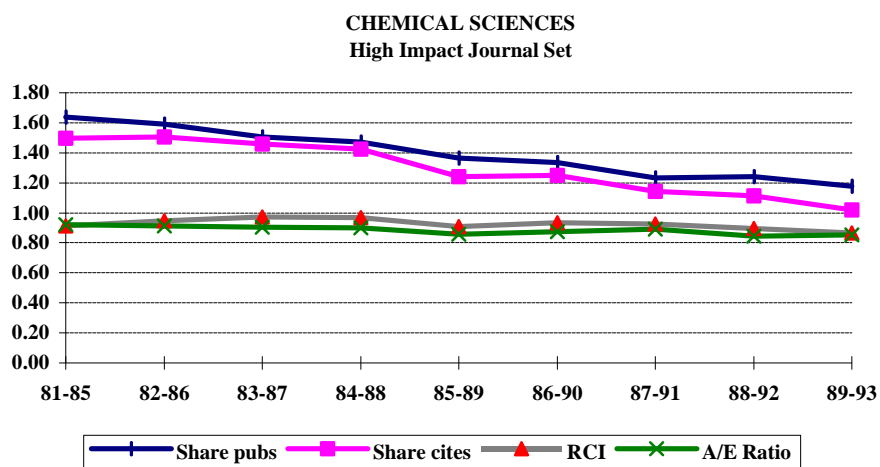
The selected journals:

Accounts of Chemical Research
Advances in Carbohydrate Chemistry and Biochemistry
Advances in Catalysis
Advances in Colloid and Interface Science
Advances in Heterocyclic Chemistry
Advances in Inorganic Chemistry and Radiochemistry
Advances in Organometallic Chemistry
Advances in Physical Organic Chemistry
Advances in Polymer Science
Annual Review of Physical Chemistry
Catalysis Reviews-Science and Engineering
Chemical Reviews
Chemical Society Reviews
Coordination Chemistry Reviews
Journal of the American Chemical Society
Journal of Computational Chemistry
Macromolecular Review
Metal Ions in Biological Systems
Progress in Energy and Combustion Science
Progress in Nuclear Magnetic Resonance Spectroscopy
Progress in Solid State Chemistry
Structure and Bonding
Surface Science



The full Chemical Sciences journal showed a declining share of citations and a stable share of publications. The resulting decline in the RCI over time is

mirrored in part by a declining A/E Ratio, though the extent of the decline for the A/E Ratio is far smaller (under 10% compared to 25%). The pre-conditions for our hypothesis have been met.

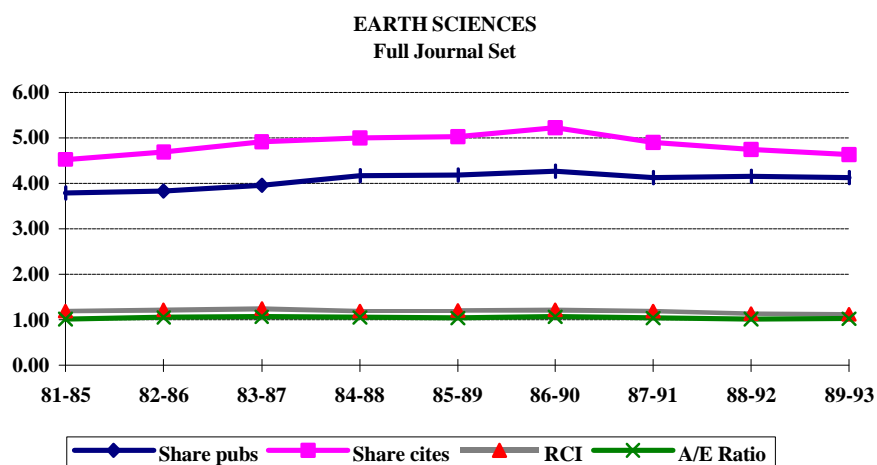


Australia's share of publications for the selected journals has declined to a much greater extent (by 28%) than has the total journal set (by 8%). The fall in the share of citations mirrors the fall in publications share. This data for Chemical Sciences lends credence to the hypothesis.

(c) Earth Sciences

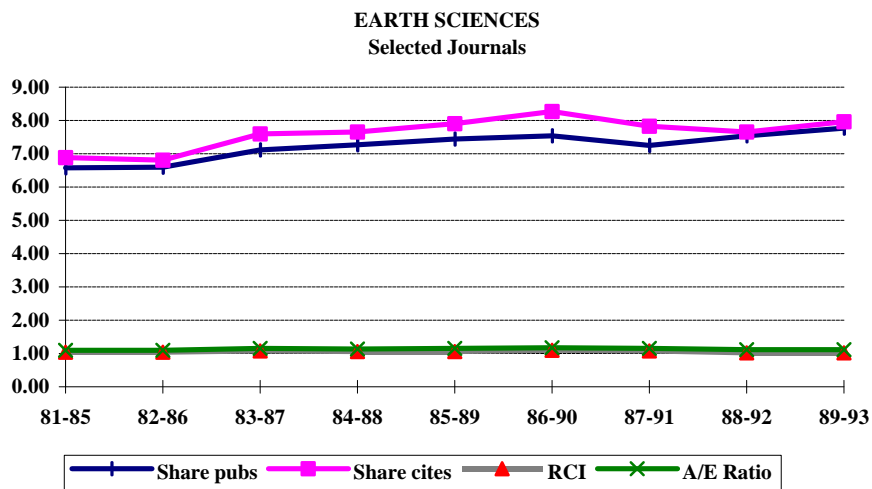
The selected journals:

Australian Journal of Earth Sciences
Contributions to Mineralogy and Petrology
Earth and Planetary Science Letters
Economic Geology
Economic Geology and the Bulletin of the Society of Economic Geologists
Geochimica et Cosmochimica Acta
Geology
Geophysics
Journal of the Atmospheric Sciences
Journal of Geophysical Research-Planets
Journal of Geophysical Research-Space Physics
Journal of Geophysical Research-Solid Earth
Journal of Geophysical Research-Atmospheres
Journal of Geophysical Research-Oceans
Journal of Hydrology
Journal of Paleontology
Journal of Physical Oceanography
Journal of Sedimentary Petrology
Journal of Structural Geology
Mineralium Deposita
Palaeontology
Sedimentology
Tectonophysics



This was a discipline that had exhibited a strong performance in the period covered by *Crisis*. The share of publications in the full journal set has risen and the increase in the share of citations has almost kept pace. The general stability of its RCI across time was mirrored by the A/E Ratio. The A/E ratio was however consistently lower than the RCI which suggested that Australia's presence in the

high impact journals might be greater than its presence in the full journal set. This was confirmed by the data extracted for the high impact journal set.



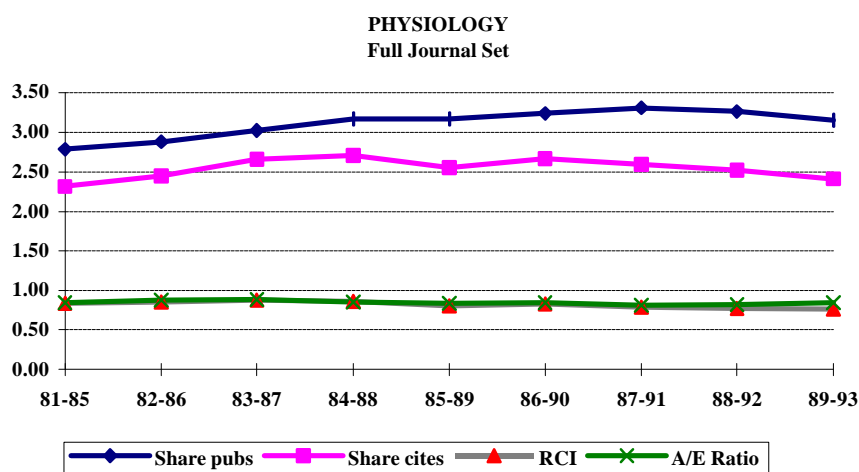
Whilst Australia's share of the full journal set was around the 4% level, its share of the high impact has been increasing across the period to nearly 8%. The share of cites in this select journal set is increasing at the same rate as that for publications and has remained above the publications share. The RCI and A/E Ratio for this set were very similar across time, remaining above 1.00 for the whole period.

Earth Sciences is a field that was counter-trend in Crisis and is a useful comparison for those fields that were in 'decline'. It does not exhibit any declining presence in the higher impact journals - in fact, quite the opposite.

(d) *Physiology*

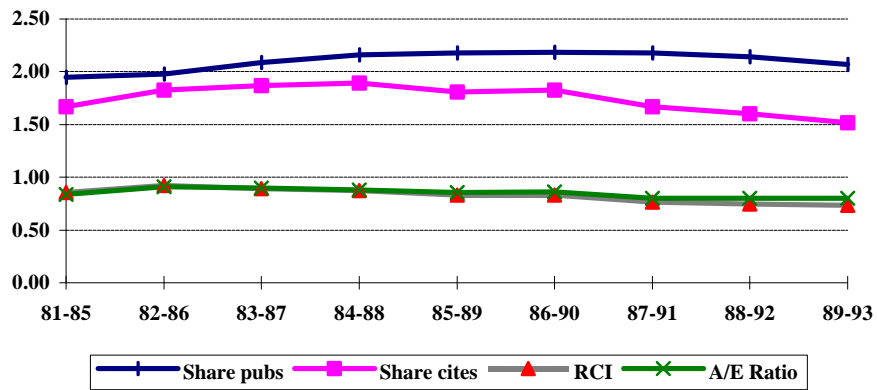
The selected journals:

American Journal of Physiology
Annual Review of Physiology
Biophysical Journal
Brain Research
Circulation Research
Developmental Biology
European Journal of Neuroscience
Experimental Brain Research
Journal of Applied Physiology
Journal of Clinical Investigation
Journal of General Physiology
Journal of Neurophysiology
Journal of Neuroscience
Journal of Physiology-London
Kidney International
Neuron
Neuroscience
Pflugers Archiv-European Journal of Physiology
Physiological Reviews



In *Crisis*, the sub-field of Physiology had shown an increasing share of publications, to a level well above the average for Australian science. The increase in the share of citations had not kept pace with that for publications, and had remained at a significantly lower level. The A/E ratio has not declined to quite the same extent as the RCI, but there is not a great deal of difference and both are significantly below 1.00. The hypothesis is unlikely to hold the explanation for the poor performance in this sub-field.

PHYSIOLOGY
Selected Journals

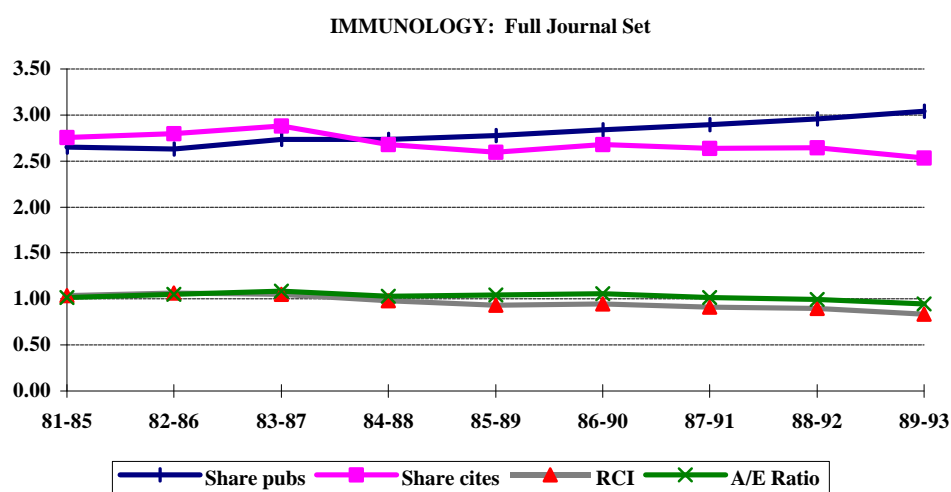


Australia has a smaller presence in the selected journals than the full journal set. Otherwise the trends for both are similar. The explanation underlying Australia's performance in this sub-field lies elsewhere than in the hypothesis.

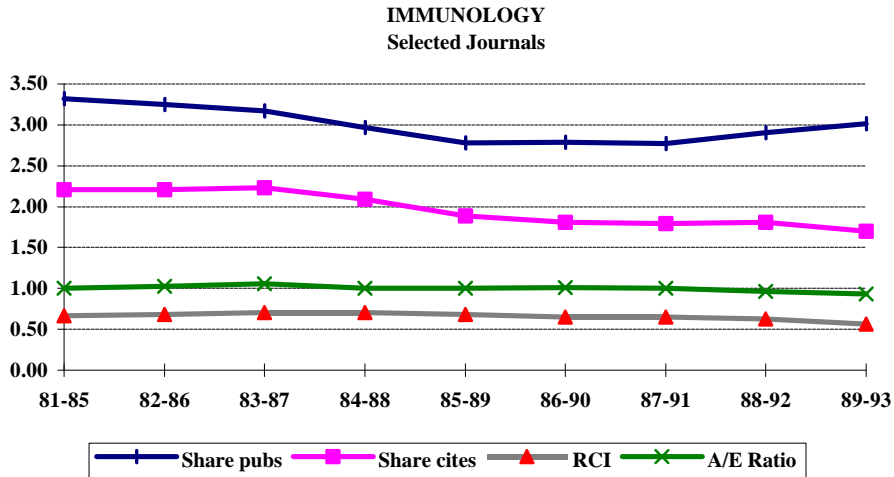
(e) Immunology

The selected journals:

Advances in Immunology
Annual Review of Immunology
Cell
Current Opinion in Immunology
European Journal of Immunology
Immunity
Immunogenetics
Immunological Reviews
Immunology
Immunology Letters
Immunology Today
International Immunology
Journal of Experimental Medicine
Journal of Immunological Methods
Journal of Immunology
Molecular Immunology
Transplantation



In *Crisis* we show a declining RCI for the full Immunology journal set due to an increasing share of publications but a declining share of citations. This decline is particularly evident for the period 1983-87 to 1987-91. However, for this same period Australia's A/E remained fairly constant at around 1.00 (the decline in recent years is post-*Crisis*). This suggests an investigation of the hypothesis may prove fruitful.



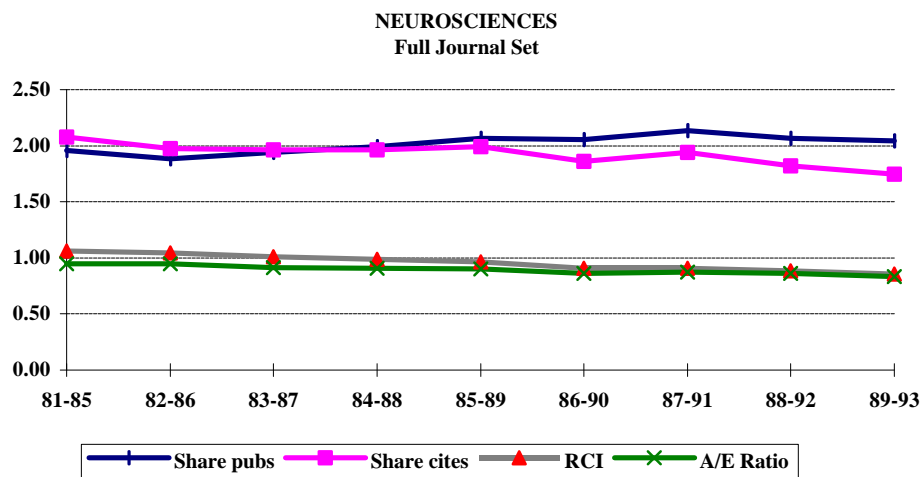
For the period in which we are directly interested: there has been a reduction in Australia's share of publications in these high impact journals; its share of citations is considerably less than its share of publications; the RCI remained relatively steady but at a very low level; the A/E ratio was also steady, but at a much higher level of around 1.00. The above scenario suggests that Australia's presence is in the lower impact journals of this group and is declining. Whilst Australia's presence in the full set of journals has increased by 10% in the period being studied, its presence in the selected journals has decreased by 16%. The data here supports the hypothesis.

The addition of data for two additional years does not improve the position of this sub-field. While the decline in Australia's share of publications in the selected journals appears to have reversed, its share of citations continues to decline. For the full journal set Australia's A/E has fallen below 1.00 for the first time and the RCI continues to decline.

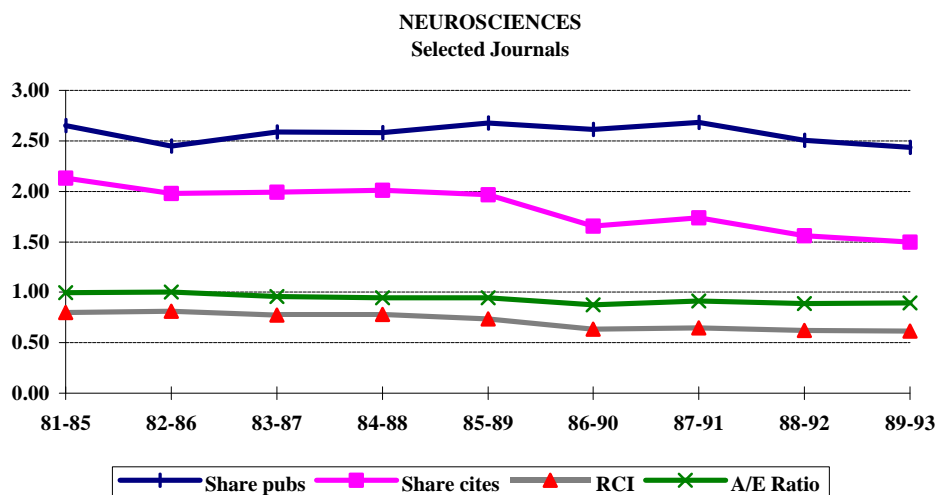
(f) Neurosciences

The selected journals:

Behavioural and Brain Sciences
Brain
Brain Research
Cell
Cell and Tissue Research
Developmental Brain Research
European Journal of Neuroscience
Experimental Brain Research
Journal of Comparative Neurology
Journal of Neurocytology
Journal of Neuroscience
Journal of Neurobiology
Journal of Neurology
Journal of Neurophysiology
Journal of Neuroscience Methods
Neuron
Neuropeptides
Neuroscience
Neuroscience Letters
Neuroscience Research



The full journal set exhibited a marked decline in RCI over the period covered by *Crisis*, due to the share of citations falling at the same time as the share of publications was rising. The RCI and A/E Ratios exhibited almost identical trends over time so we would not expect the decline in RCI to be due to the effect of a decreasing presence in high impact journals.



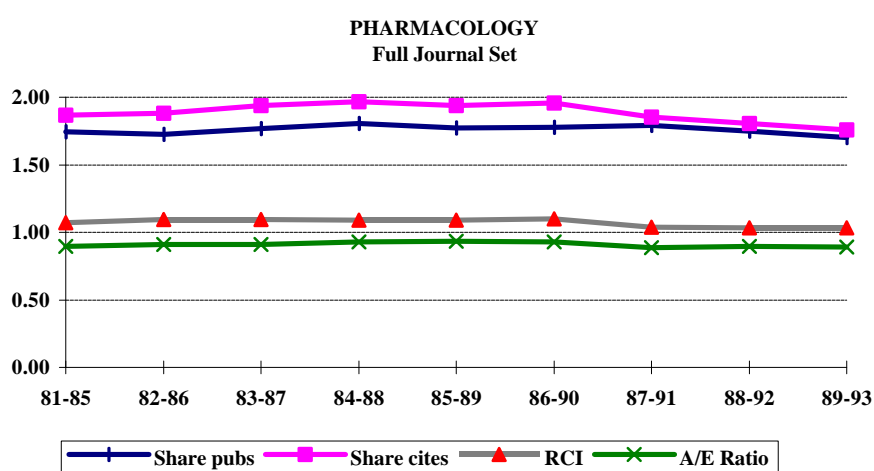
For the period covered by *Crisis*, Australia's share of citations declined whilst the share of publications appearing in the selected journals remained constant leading to a declining RCI similar to that for the full journal set. A comparison of RCI and A/E rates over time showed matching trends. It is interesting to note that Australia's share of publications in the selected journal set is higher than for the full journal set (2.5% level compared to 2% level) but it has a lower share of citations. The fact that the A/E, though exhibiting the same trend as the RCI, is much higher suggests that Australia's publications are appearing in journals at the lower-impact end of this set.

Recent data suggest the performance in this sub-field continues to worsen - there is no sign of a reversal occurring.

(g) Pharmacology

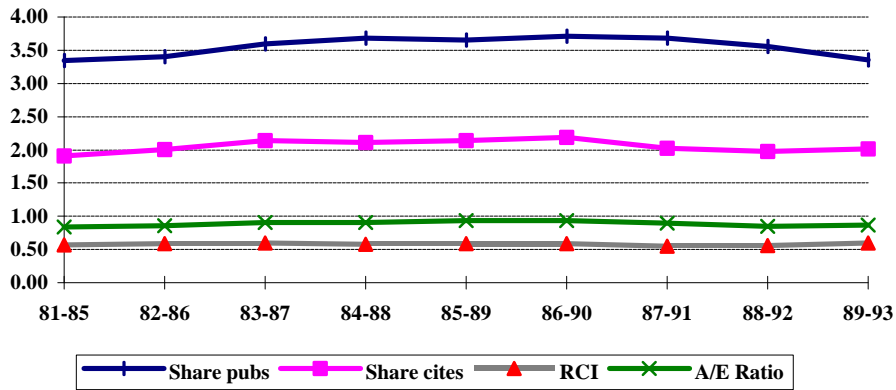
The selected journals:

Annual Review of Pharmacology and Toxicology
Biochemical Pharmacology
British Journal of Pharmacology
Cardiovascular Research
Circulation Research
Clinical and Experimental Pharmacology and Physiology
European Journal of Pharmacology
Journal of Autonomic Pharmacology
Journal of Cardiovascular Pharmacology
Journal of Neurochemistry
Journal of Neuroscience
Journal of Pharmacology and Experimental Therapeutics
Molecular Pharmacology
Naunyn-Schmiedebergs Archives of Pharmacology
Neuropharmacology
Pharmacological Reviews
Trends in Pharmacological Sciences



The trends for citation and publication shares in this sub-field are similar across the period of *Crisis*, though it can be seen that the decline shown for citation shares in 1987-91 anticipated a decline that would also occur in publication shares (this becomes apparent with the addition of data for an extra two years). It was interesting to note that while the RCIs trend over time was mirrored by the A/E Ratio, the A/E Ratio was lower. This led us to expect that Australia's share of the high impact journals would be higher than for the full journal set, but that it would not be achieving the commensurate number of citations.

PHARMACOLOGY
Selected Journals

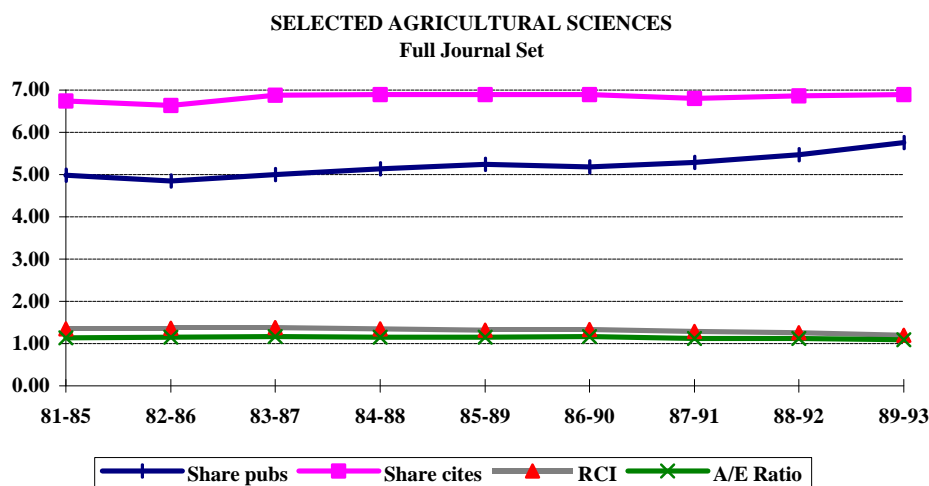


Australia's share of the selected journal set was very high at around 3.5%, compared to 1.8% for the full journal set, but its share of citations was only at the 2% level. The A/E rate for Australia's publications in these journals whilst not quite at the 1.00 level was much higher than the RCI, suggesting that it is appearing in journals at the low-impact end of the spectrum. However, there was little change over the period covered by *Crisis*.

(h) Agricultural Sciences¹

The selected journals:

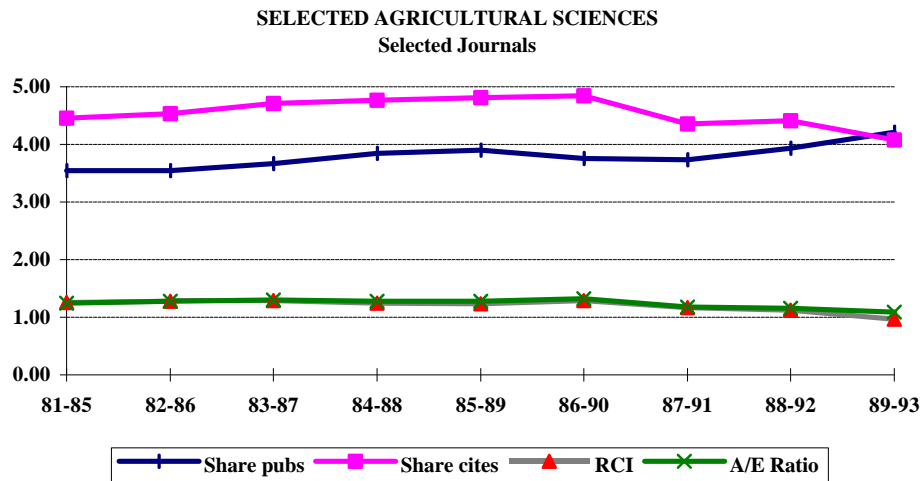
Advances in Agronomy
Agronomy Journal
Environmental Entomology
Journal of Agriculture and Food Chemistry
Journal of Environmental Science and Health (Part B: Pesticides, Food Contaminants and Agricultural Wastes)
Pesticide Science
Plant and Soil
Plant Pathology
Weed Research
Animal Production
Journal of Animal Science
Journal of Dairy Science
Livestock Production Science
Journal of the American Society for Horticultural Science
Journal of Horticultural Science
Biology and Fertility of Soils
Journal of Soil Science
Soil Biology and Biochemistry
Soil Science
Soil Science Society of America Journal



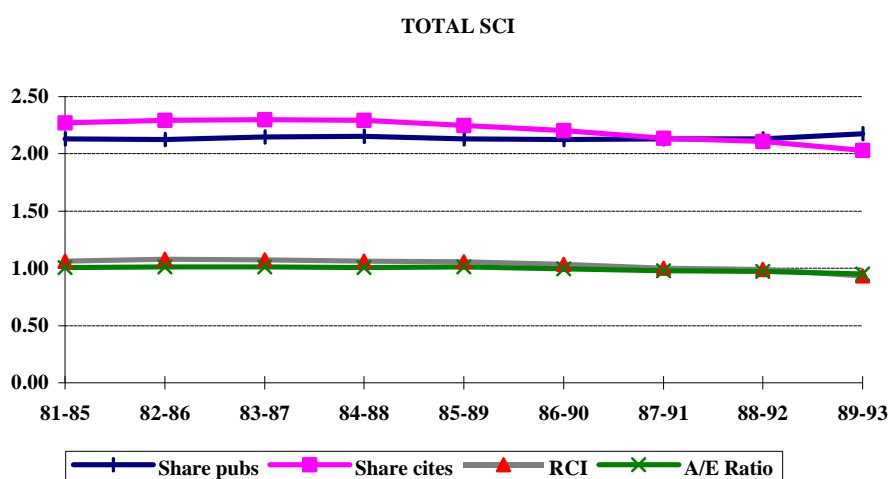
In *Crisis*, Agricultural Sciences was one of Australia's strongest fields. The four selected sub-fields of agricultural science exhibited similar trends: increasing publication shares coupled with constant citation shares (or citation shares not rising as rapidly as publication shares). All showed a decrease in RCI though still

¹ Only selected sub-fields of Agricultural Sciences were covered, namely Soil & Water Sciences, Crop & Pasture Production, Horticulture and Animal Production.

at a level well above 1.00. These trends are shown in the above graph for the four sub-fields combined. The RCI and A/E have followed similar trends across the period, hence we did not expect the hypothesis to hold true in this case.



Australia increased its share of the selected journal set, though this share remains below the level for the whole journal set. There is some cause for concern with the addition of the two additional years data. Whilst the share of pubs has increased, the share of citations has decreased significantly. The A/E ratio has remained above 1.00 but the RCI has fallen below, suggesting that Australia's presence in this set has in recent years moved to the lower impact end of this group of journals.



In *Crisis*, the picture for Australia’s science output in total showed a steady share of publications and a sharply declining share of citations, resulting in a declining RCI. However, at the same time the A/E rate declined to a much lesser extent. The preconditions have been set for the hypothesis to be an answer **in part** to Australia’s declining citation share.

General Conclusion: We set out to test whether the decline in RCI shown in *Crisis* for Australian science could be explained by a declining presence in the high impact journals. This hypothesis does appear to provide a clue to part of the explanation. Of six case studies of declining fields that were studied in detail, three suggested the hypothesis could be part of the answer - Chemical Sciences, Physical Sciences and Immunology. For the other three - Physiology, Neurosciences and Pharmacology - the answer has to be looked for elsewhere. Both the two case-studies of fields that had remained strong - Earth Sciences and Agricultural Sciences - showed an increasing presence in their high impact journals.

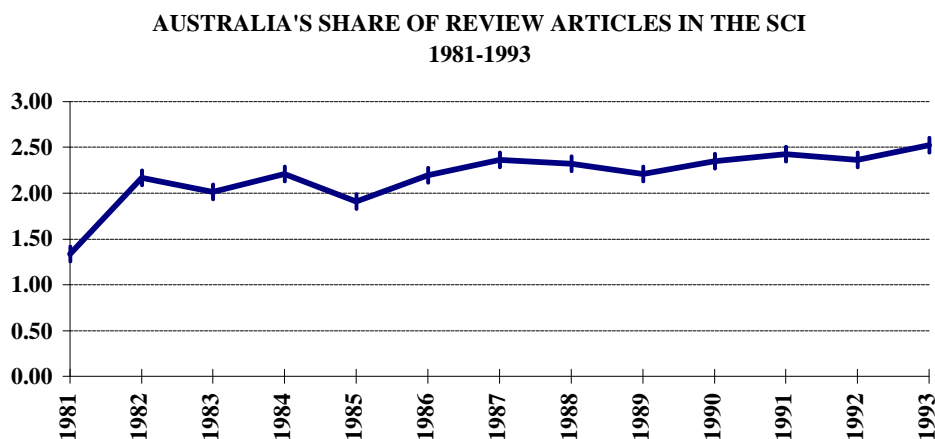
Even though the hypothesis does appear to provide part of the explanation for Australia’s decline in citation shares, there remains the question of cause: is it a decline in quality? or is it a displacement effect, with more and more researchers competing for an outlet in the ‘top’ journals?

4. Hypothesis: Australians may be publishing fewer review articles, leading to a reduction in citation shares

Review articles are the most highly cited type of SCI publication. The table below shows the distribution of Australian publications in the SCI by type of publication. It also details the citations per publication rates for each type of publication.

Type of Publication	No.	cpp	% Dist
Articles (incl Proceedings Papers)	86798	8.08	71.1
Meeting Abstracts	13049	0.29	10.7
Notes	8416	5.25	6.9
Letters	8356	1.74	6.8
Editorials	2017	2.33	1.7
Reviews, Bibliographies	2480	17.97	2.0
Discussions	397	1.04	0.3
Book Reviews	506	0.12	0.4
Biographical Items	59	0.19	0.0
Software Reviews	11	2.60	0.0

Australia's share of review articles in the SCI over the period 1981-1993 is shown in the graph below.



Rather than a declining share of review articles, Australia's share has increased significantly across the period and is at a higher level than that for the average of all publication types. This hypothesis is not supported by the evidence.

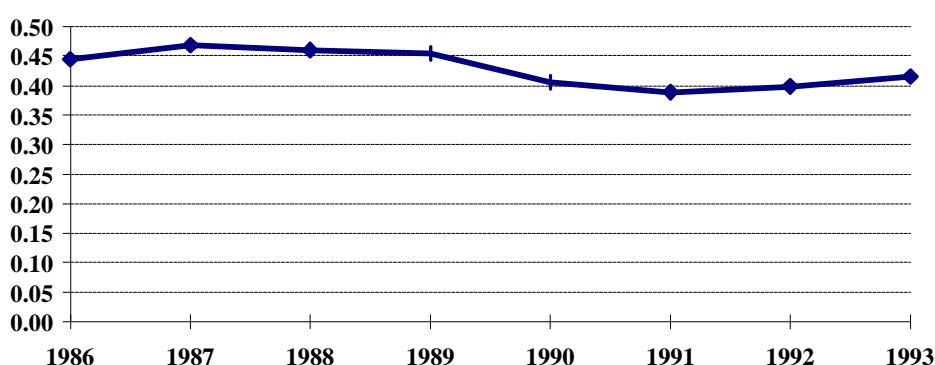
5. Hypothesis: CSIRO has moved away from basic research and this has affected Australia's share of citations

CSIRO has historically been a strong performer in basic science as measured in the SCI. A move to more applied research will have a two-fold effect in the current context. Firstly, journals at the applied end of the spectrum attract citations at a lower rate than those that have a more basic focus; secondly, less of CSIRO's output may be appearing in journals captured by SCI - more may be in the form of government reports, consultancies, etc.

It is not possible at this stage to test the first of these aspects, though it may be so in the future. Dr Francis Narin of Computer Horizons Inc produces lists of

publications assigned to four levels of research from basic through to strategic which he has available for purchase. An analysis of the pattern of CSIRO's recent publications using this information could prove instructive. In relation to the second aspect, we have undertaken a very crude analysis based on the number of CSIRO publications in the SCI and the number of 'professional' staff of the organisation to see if there has been a reduction in the number of publications per person appearing in the SCI across time. Unfortunately, at this stage we only have staff numbers going back to 1986, and are unsure if the category 'professional' is a true reflection of the number of staff undertaking research.

CSIRO PUBLICATIONS PER 'PROFESSIONAL' STAFF MEMBER - TOTAL SCI



The result of this analysis does heighten concern over the staff numbers used in the calculations as a level of 0.40-0.45 publications per staff seems low - the term 'professional' may be too broad in its catchment. However the downward trend in the figures does suggest that this avenue is worth pursuing if more reliable staff figures can be obtained.

6. Background Information on 'tapping international networks'

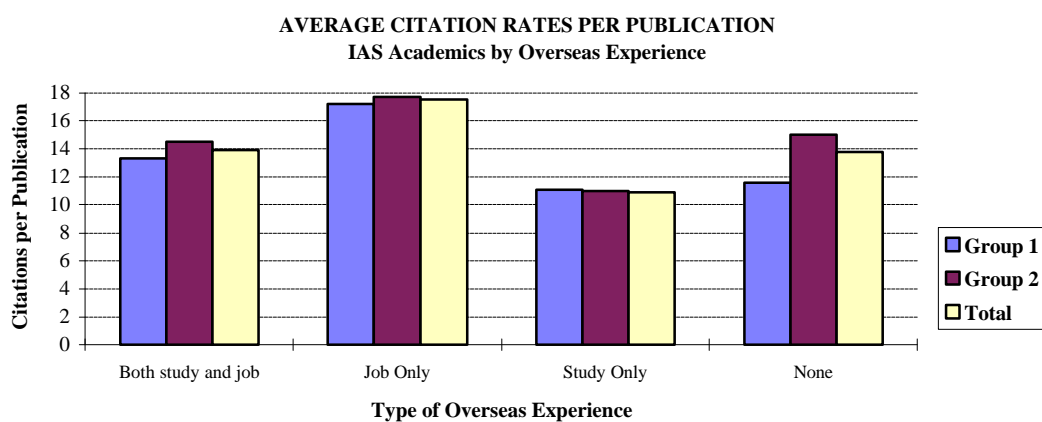
Data obtained by Dr Grigg show that the proportion of Australian academics who obtained their higher degrees overseas has significantly declined in recent years. The inference that could be drawn from this is that the extent of their international networks has also declined, leading to the reduction of citation rates. There is no system-wide database that allows us to test the theory that academics who obtained their degree and/or did post-doctoral work overseas attract citations at a greater rate than those who did not. However, the database we constructed for the 1990 review of the Institute of Advanced Studies does allow us to examine this question in relation to the staff of the IAS.

From this database we were able to study the citation rates of 343 academics who we classified according to where they obtained their higher degree and whether or

not they had worked overseas prior to taking up a position in IAS. These academics were further divided into two groups:

- Group 1: Academics appointed at the level of research fellow or post-doctoral fellow in the period 1980-1982
- Group 2: Academics who, in the period 1980-82, were at a level higher than research fellow

We limited the analysis to academics from the IAS's five science schools, and the spread across the different disciplines was fairly even for the number of academics covered. The table below shows the breakdown of citation per publication rates for each of the categories listed above.



The main finding to come out of this analysis was the seeming importance of overseas work in the ability to attract higher rates of citation - those who had both studied and worked overseas did considerably better than those who only studied. For academics whose higher degree qualifications were Australian, those that had worked overseas attracted citations at a greater rate than those who had not. The location of the higher degree appeared to have less importance. While we are reluctant to draw any conclusions from analysis based only on academics from the IAS, it is supported by anecdotal evidence we collected and reported in *International Links in Higher Education Research (ILHER)*. In the *ILHER* study we were told by a number of researchers that their strongest international links were forged during post-doctoral postings overseas, and that links formed during PhD studies were far less important. An increased visibility in the international community can be the key to high levels of citations. The above analysis would suggest that the ability of Australians to obtain overseas posts early in their careers is important, though we would like to test this on a larger sample. We do not, however, have any data to show whether the number of Australians obtaining overseas posts has declined in the period of this study, so we cannot test whether this could play a part in Australia's declining citation shares.