REVIEW ARTICLE
A CRISIS FOR AUSTRALIAN SCIENCE: THE EROSION OF ORGANIZATIONAL CAPITAL?

D.McL.Lamberton*

Review article of *A Crisis for Australian Science?*, by Paul Bourke and Linda Butler, Performance Indicators Project Monograph Series No.1 (Research School of Social Sciences, Australian National University, Canberra, 1994), pp.75, ISBN 0 7315 2021 1.

"Knowledge, primarily scientific knowledge, provides the new raw material for prosperity. It is a major instrument, to some even a weapon, in the rivalry between social classes, countries and trading blocks" (Eijsvoogel, 1990, p.1). From this perspective, the Bourke and Butler (BB) study of Australian shares of `world' science publication and citations captured in the Science Citation Index (SCI) should command attention, both in Australia and in the rest of the world. There is, however, a difficulty in effecting cross-country comparison. What countries are comparable to Australia? More on this later, after considering BB's findings and offering an alternative interpretation.

AUSTRALIA: AN UNUSUAL PATTERN

The findings (Figure 1) for the period 1982-91, based on the processing of a large database - nearly a quarter of a million records of Australia publications are included - are:

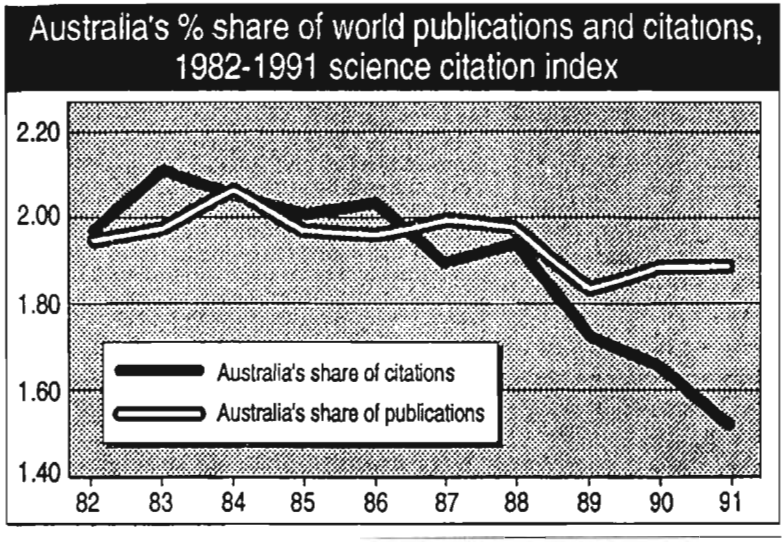
- The Australian share of publications remained relatively stable;
- The Australian share of world citations has fallen by about 25 per cent since the mid-1980s.

BB describe this as "an unusual pattern" by comparison with the scientific profile of some other countries they selected, i.e., "a falling away in the international visibility rather than the productivity of Australian science" (p.1). Their report concludes:

> We believe that there is a crisis of visibility and performance level, though not necessarily of productivity, in Australian science, that this crisis apparently derives from a complex matrix of causes, especially operating in the higher education system in recent years and that these difficulties should be made explicit as an important matter of public policy (p.53).

* I wish to acknowledge helpful comment from Mari Davis, University of Melbourne, who also provided access to some recent papers from the Fourth International Conference on Bibliometrics, Informetrics and Scientometrics, Berlin, 1993.

Figure 1



Source: Bourke and Butler, HES, 1994b, p.32

CENTRAL ASSUMPTIONS

Citation measures have been widely used in research on research, variously labelled bibliometrics, scientometrics, information science, informetrics and even infometrics. Bourke and Butler list three central assumptions informing such evaluative use of the communication networks of scientists:

- That modern science is largely written out in journal-length communications rather than in books or other media.
- That while quality in some absolute sense is not necessarily connected to the frequency with which scientific communications are cited or referred to by others, those frequencies indicate participation in the mainstream conversations in science and the impact of specific pieces of work.
- That there is a pecking order of journals in most scientific disciplines and that the study and classification of these journals is itself an important aspect of the study of publications and citations (HES, 1994b, p.32).

According to BB, "[t]he simplest inference to draw...is that Australian science is declining in quality'" (p.48). However, they make clear that this begs major questions: e.g., the equation of quality with citation shares; active choice among groups and whole systems; and "advantageous access to the appropriate journals and other media of communication such as the international conference circuit, disproportionate membership of the invisible and visible colleges which predominate in the esteem systems of scholarly disciplines (memberships of editorial boards, academies and the like)" (p.48).

There are many well-known technical problems in such bibliometric analysis. Critics almost invariably begin with the trivial matter of self-citation. Of more importance might be the time lags involved. For the most part, these problems do not seem of great relevance to the "unusual pattern" reported in the Australian case.

AN ALTERNATIVE INTERPRETATION

An alternative interpretation can begin with a fourth central assumption: that citation takes place within a network context. This is in contrast to the implicit assumption in such bibliometric research that citation is an outcome of optimal search. Like innovation, citation activity is shaped by prior experience, knowledge that is inevitably incomplete, and by established communication linkages. The individuals and institutions that interact with each other constitute a network, which is part of the organizational capital of their society.

On the occasions when capital is considered, it is usually as infrastructure: major items of equipment, buildings and, in the wider context, telecommunications and power installations, roads, railways and airports. Unfortunately, the organizational capital is neglected (Lamberton 1995), even though it may increasingly be the real wealth of nations (Ramos 1981). The emphasis on the tangible has major consequences, not least the widespread misunderstanding of the relative costs of research, e.g., 'big' science vs. social sciences (Macdonald, Mandeville and Lamberton 1982).

Networks have attracted a good deal of interest in recent years (e.g., Antonelli 1992). This is a consequence both of major developments in computer and telecommunications technologies but also of more pervasive, more subtle changes that come with the increasing information-intensity of economic activity. Whatever kind of technology is involved, networks appear (David 1992) to share some basic characteristics:

- The system has indivisibilities in capacity, with scale economies.
- The system provides benefits to users that are dependent on the access and usage of others, i.e., externalities.
- The performance of the system is dependent upon having some level of interconnectedness or compatibility.

The research community may resent being likened to network industries like canals, pipelines, LANs and WANs. It is, however, necessary to take into account the basic economics of the network resource. To fully do so, one must clearly see "that inasmuch as research and invention are directed to producing information, an economic analysis of R&D activities must inevitably rest upon recognition of the peculiar characteristics of information viewed as an economic commodity" (Dasgupta and David 1987, p.520).

Nobel economics prize-winner Kenneth Arrow had pioneered this perspective (1962) and later provided an explanation of the blinkers that decision-makers and researchers wear - the blinkers that go a long way to define their membership of their corporate body or even their discipline. His theme was

> that the combination of uncertainty, indivisibility, and capital intensity associated with information channels and their use imply (a) that the actual structure and behavior of an organization may depend heavily upon random events, in other words on history, and (b) the very pursuit of efficiency may lead to rigidity and unresponsiveness to further change (1974, p.49).

Put simply, this means that the organizations' decision-makers become locked into their information assets.

How does this link to interpretation of the unusual pattern of the Australian citation experience? The networks within which citation occurs are organizations; like other forms of capital, they have to be built over time and maintained in order to play their part in the scientific enterprise. It is important to recognize that the scope of that enterprise includes both the generation of new information and the enhancement of capability to assimilate and exploit existing information (Cohen and Levinthal 1989).

THE EROSION OF ORGANIZATIONAL CAPITAL?

Could the decline in the Australian share of citations have been caused by an erosion of the network capital? Several reasons can be advanced in support of this possibility.

1. A traditional way in which networks were developed and maintained was by Australians pursuing post-graduate studies abroad. If this practice has diminished in a significant way, a lagged decline in citations would result. Preliminary inquiries suggest that while the available educational statistics can provide much detail on PhD studies within Australia, there is virtually nothing on studies abroad. This is unfortunate as such studies not only contribute to networking but also represent an important importation of knowledge. A very limited canvass of opinion supports the view that there has been a significant shift.

2. Sabbatical leave has also undergone change. Once upon a time special permission had to be obtained to remain in Australia but now 'outreach' thinking has made local leave not only respectable but often preferred. Cost considerations have reinforced this tendency and have possibly shortened the overseas leaves taken.

The 'gatekeeper' literature (e.g., Macdonald and Williams 1992) has emphasized the importance of 'workers' rather than 'visitors' in building informal information networks. It is, therefore, possible that changed sabbatical practice likewise contributed to a decline in citation.

3. Recruitment also builds networks. Given the considerable extent to which Australia's scientific and engineering manpower was recruited from overseas (Lamberton 1970, Ch.6), it would be an interesting exercise to model the ageing process for this component of the research workforce. While "a greying of the research community" could contribute to declining citation (BB, p.53), so too could changes within the grey component, e.g., the retirement of those with good overseas linkages. Nor is there any guarantee that recruitment of young people of talent will raise citation if they are not appropriately positioned in the networks.

PATTERNS OF AUTHORSHIP

BB explore effects relating to what they call the internal structure of Australia's research communications by examining the patterns of authorship: single author; collaborative publications arising from a research group within a single department; collaborative publications arising from several departments within a single institution; collaborative papers across institutions within Australia; and collaborative papers involving an international relationship (pp.50-51).

The findings here are of special interest. Collaborative papers score better than single author papers, with international collaboration performing best of all. Had there been a decline in the proportion of international collaboration in the Australian research effort? The answer was, No: "the reverse is the case...the international share of the total Australian effort across the decade has effectively doubled" (BB, p.51).

BB suggest "the problem of Australian citation impact is not easily dealt with as a function of declining international networks; Australian research was more prominent in terms of these measures at a point when its international collaborations were considerably fewer" (p.52).

Such evidence does not dispose of the argument that the networks that bring about citation are much wider in scope than is captured in these authorship patterns. It is even possible that the very process of curtailment that is eroding these wider networks creates greater pressures for evidence of authorship participation, i.e., in BB terminology, a variation in active choice, through the international collaboration that does take place.

CONCLUSION

The purpose of these comments is merely conjecture: to suggest that an economic interpretation of the citation findings, drawing on the new thinking emerging from information economics and information science may have some merits. Knowledge is cognitive capital; the capability of putting that knowledge to use is organizational capital. "Any theory of knowledge that ignores this economic aspect does so at the risk of its own adequacy" (Rescher, p.4).

This alternative interpretation calls for a rather different approach to cross-country comparison. BB report comparison with a small sample of countries they chose to represent the UK, Europe, North America, North and East Asia (p.49). Australia and Sweden were the only countries in their sample that experienced a constant publication share with a falling citation share.

A recent paper (Lemoine *et al.* 1993) which focussed on the social sciences and stems from the companion research at SPRU, University of Sussex with which BB have been collaborating, is of interest. It has generally been held that the social sciences are different; that they violate the central assumptions listed earlier, e.g., in the relative importance of book and journal publication. The findings from a preliminary analysis of 230 journals indicate that the unusual Australian pattern was replicated: UK share of publication declined as did the citation rate. International collaboration rose between 1981 and 1987 but then levelled off. "Impact"

studies might benefit, therefore, from both cross-country and cross-types of science.

What countries are comparable to Australia? It is a small country and one that has been detaching itself from traditional linkages, fostering endogenous growth and entering into new international relationships. In this process, the organizational capital of the research community may have been eroded. It is difficult to find other countries of similar experience in this respect but the search for them should be part of the study of national S&T systems (cf. Patel and Pavitt 1994).

While these changes may be most evident in terms of trade, investment and migration, the research community too has no doubt been affected. It could hardly be otherwise, now that "Knowledge, primarily scientific knowledge, provides the new raw material for prosperity".

REFERENCES

Cristiano Antonelli (ed.), *The Economics of Information Networks*, North-Holland, Amsterdam, 1992.

K.J.Arrow, 'Economic welfare and the allocation of resources for invention', in National Bureau of Economic Research, *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Princeton University Press, 1962, reprinted in D.M.Lamberton (ed.), *The Economics of Information and Knowledge*, Penguin Books, Harmondsworth UK, 1971.

K.J.Arrow, *The Limits of Organization*, Norton, New York, 1974.

Paul Bourke and Linda Butler, *A Crisis for Australian Science?*, Performance Indicators Project Monograph No.1, Australian National University, Canberra, 1994a.

Paul Bourke and Linda Butler, 'Is Australian science out for the count?', *Higher Education Supplement, The Australian*, September 14, 1994b, pp.32-3.

W.M.Cohen and D.A.Levinthal, 'Innovation and learning: The two faces of R&D', *Economic Journal*, 99, September 1989, pp.569-96.

Paul A.David, 'Information network economics: Externalities, innovation and evolution', in Antonelli, *op.cit.*

Partha Dasgupta and Paul A.David, 'Information disclosure and the economics of science and technology', in George R.Feiwel (ed.), *Arrow and the Ascent of Modern Economic Theory*, Macmillan, London, 1987.

Juurd Eijsvoogel, 'Introduction', in Janny Groen, Eefke Smit and Juurd Eijsvoogel (eds), *The Discipline of Curiosity: Science in the World*, Elsevier Science Publishers, Amsterdam, 1990.

D.M.Lamberton, *Science, Technology and the Australian Economy*, Tudor Press, Sydney, 1970.

D.M.Lamberton, 'Organizational capital: An information-theoretic approach', *International Journal of New Ideas*, 1995 forthcoming.

W.Lemoine, N.Ling and B.R.Martin, 'The output, impact and degree of international collaboration of British social sciences during the 1980s: A preliminary approach', *Fourth International Conference on Bibliometrics, Informetrics and Scientometrics*, Berlin, 1993.

S.Macdonald. T.Mandeville and D.Lamberton, 'The cost of merit in university research', *Australian Journal of Education*, 26, 1982.

S.Macdonald and C.Williams, 'The informal information network in an age of advanced telecommunications', *Human Systems Management*, 11,2 , 1992, pp.77-87.

Parimal Patel and Keith Pavitt, 'National innovation systems: Why they are important, and how they might be measured and compared', *Economics of Innovation and New Technology*, 3,1, 1994, pp.77-95.

Alberto G.Ramos, *The New Science of Organizations: A Reconceptualization of the Wealth of Nations*, University of Toronto Press, Toronto, 1981.

Nicholas Rescher, *Cognitive Economy: The Economic Dimension of the Theory of Knowledge*, University of Pittsburgh Press, Pittsburgh, 1989.