8. CONCLUDING COMMENTS

The purpose of this discussion paper is to provide a starting point for a dialogue on those policy issues that may be critical for the future conduct and support of research within Australian universities. The examination of reasons for the decline in Australia's 'visibility' in international science, first indicated in *A Crisis for Australian Science?* (Bourke & Butler, 1993), has probably raised more questions than it has provided answers. Nevertheless, indirect evidence on phenomena currently present within the research system is indicated, and some of these phenomena are discussed briefly below.

A change in the international networks

International networks are critical for a country of the size and location of Australia in order to benefit from advances of knowledge from around the world and to promote and stimulate excellence in Australian science. Apart from ensuring the exchange of leading-edge knowledge, international links enhance a country's ability to attract to its laboratories and universities the world's top scientists and scholars. Through excellent international science, we are able to 'contribute to, and benefit from, international deliberations on complex social, legal and ethical questions' and to 'discriminate between first rate and third rate science' (Science and Technology Review, Canada, 1994). To manage and fund a presence on the international research stage requires a long term perspective, and deliberate strategies.

The major findings regarding international networks in this study include:

- strong evidence of a systematic 'Australianisation' of academia, with a large increase (142%) since the 1970s, in the number of Australian academics with both undergraduate and postgraduate qualifications from Australia;
- evidence that overseas postdoctoral experience may be important in maintaining visibility in the international literature;
- evidence to suggest that Australia's share of international conference abstracts is small and in decline;
- evidence that while Australia's international collaboration (measured by co-authorship of publications) is increasing, it is low in world terms, and in line with the performance of China; and,
- indications that there has been a fall in the proportion of collaborations with the United States and the United Kingdom, the key players in the international research arena.

While the appearance of a change (and decrease) in the international 'networks' over time does not imply a decline in the quality of Australian academics or their research, it does raise several fundamental questions. Does Australia need to build better linkages to international science and technology? What are the appropriate roles of the universities, the funding agencies, and the Government in this regard? What weaknesses in the current system present obstacles to the free flow of people and ideas

between countries? In terms of developing and sustaining international networks, what is the appropriate balance between (a) funding individuals (and at what stage of their careers)? (b) funding projects and teams? and (c) funding participation in international large-scale research facilities?

Steady-state research funding

In spite of escalating costs in most fields of science and technology over the last decade, the level of funding in Australian higher education per research scientist and engineer has remained constant (in real terms) in the majority of disciplines. The increasing 'sophistication factor' at the top-end of the scale of research equipment, together with the devaluation of the Australian dollar, make such flat 'growth' a matter of considerable concern.

While the issue of the erosion of research infrastructure has been canvassed more than any other in recent times, important management questions remain.
What *is* the state of Australia's science infrastructure? Can it be enhanced or improved through existing budgets, and if so, how? Are cost-savings achieved through collaborations? Are some fields of endeavour in danger of dropping from the leading edge because of inadequate levels of research infrastructure, and does this matter?

Before definitive conclusions can be made concerning the erosion of infrastructure and its extent, an examination of the adequacy and significance of research infrastructure at the field level is required. Detailed figures on infrastructure spending by field are currently not available (BIE, 1996b). In addition, a major attempt by policy advising bodies such as the ARC to obtain comparable data from overseas countries is urgently required.

In the meantime,

> *'While money is not an unambiguous determinant of quality in research', it is well understood and accepted in advanced European nations that 'investment in research is taken as a guarantor of competitiveness' (Maddox, 1995).*

A shift to applied research

The shift in *emphasis* from basic research to applied research activity was noted in this study for Chemistry, Physics, Earth Sciences, Medical Sciences, and Agricultural Sciences for the period 1984-1988. However, from 1988 to 1992, there has been a return to basic research activity for all fields with the exception of Chemistry.

It is very difficult to devise an appropriate test for the hypothesis of a shift from basic to applied research. Apart from the difficulty of comparing data across years, the classification of research activity into the various categories of research is a self-classification system by respondents, with all the attendant problems of such data. In

addition, the collection methodology has varied from year to year, and between institutions. Suffice it to say that it may be the case that

> *...several recent policy changes have had the effect of shifting the centre of gravity of university research further towards the applied end. (Industry Commission Report, 1995, p.C.5)*

The question is raised of the role of government and funding agencies in facilitating such shifts, and are they necessary anyway? If one answers 'yes' to the latter, the question of the appropriate balance between 'basic' and 'applied' research needs to be addressed.

While the contribution of basic research to industry in particular, and society in general, is incredibly hard to measure, Pavitt (1996) has recently reported on two separate studies both of which found that most of the 'useful' basic research (that is, cited by 66 American companies as research that generated 'know-how', and also, research that was cited in American patents in 1993 and 1994) came from university departments that were highly rated by the US National Academy of Sciences, proving, according to Pavitt, that 'useful' science is good science. Moreover, the federal government was found to be overwhelmingly the source of funding for this research, largely through the National Science Foundation, and the National Institutes of Health. Collaboration between academic researchers and industry was also found to emerge as a matter of course from this academic research. There are numerous other well known instances of how the discoveries of basic science have changed the way we view the world.

The point being made is that if governments, or funding agencies for that matter, wish to be catalysts in generating a shift to more applied areas of science, by investing, for example, in collaborative research between universities and industry, how should we select and evaluate such research investments? What unique approaches are required to best respond to the needs and opportunities of the different sectors? What is the appropriate balance between investments of this nature and investments in basic research, and do we have it right?

Australians are not publishing in 'top' journals

Many fields of Australian research were shown in the Bourke and Butler study to be in decline in terms of shares of citations in the international literature. Because of the very skewed nature of citation practice, and the influence in overall ratios of a very small number of highly cited journals, it was hypothesised that the decline in citation share may be a result of Australians finding it harder to publish in these high impact journals. Of the six case studies of 'declining' fields which were studied in detail for this project, three - Chemical Sciences, Physical Sciences, and Immunology - had declined in their presence in top journals over the last decade. Such a result, however, does not define the cause. For example, is this a decline in the quality of Australian research in these fields? or, is it a displacement effect, with more and more researchers competing

for an outlet in the 'top' journals? We should look urgently for the answers to these questions.

In conclusion, if Australia is to sustain its more than creditable contribution to international science, and to strengthen its collaboration in world-class scientific endeavours, it is time to develop deliberate and long-term successful strategies in important areas of contemporary research. Many countries, including those in the developing nations, now possess world-class research capabilities. It is only sensible that we restate our commitment to investment in scientific research, and that we quickly come to grips with the movement towards a knowledge-based economy in a *global* environment.

> *...there must be no gaps in the ability to either make the fundamental discovery, to bring the idea from elsewhere, or in the ability to apply the discovery or to translate the discovery into jobs, products, improved government services etc....As with any process which requires a chain of events, our national system of innovation is as weak as the weakest link. It is therefore absolutely critical that we identify and address any weak links and that we put in place a strategy that will correct any deficiencies. (Gerrard, 1994, cited in Science and Technology Review, 1994)*