the Board said that in view of the attitude of the two Commissions and the Board's desire to effect an appropriate rationalization of tertiary education facilities in Armidale, it invited the Council to reconsider the question of the most desirable form of association between the University and the College.[19]

As a consequence of such letters, merger discussions are once more taking place within universities at Armidale, Newcastle and Wollongong. (Merger debates are not confined to N.S.W.; in Queensland a possible amalgamation of Townsville C.A.E. and the James Cook University has been considered.[20])

The arguments and issues discussed by academics which are outlined above were raised during a particular national economic climate when there were expectations of expanding numbers of tertiary students. Since then, the economic climate has changed considerably and so have predictions of future tertiary student numbers.[21] Student expectations and demands for courses are also changing. If these new conditions are incorporated by academics in their appreciation of the current situation their views of the arguments and issues on merger could well differ from those recounted here.

REFERENCES

1. These institutions were:
   The Armidale Teachers' College — now Armidale College of Advanced Education (C.A.E.);
   The University of New England (U.N.E.);
   The Newcastle Teachers' College — now Newcastle C.A.E.;
   The University of Newcastle;
   The Wollongong Teachers' College — now Wollongong Institute of Education.
2. *Armidale Express*, 16th August, 1971.
3. **L. N. Short**, *'Universities and colleges: variations on a theme'* in *Universities and Colleges of Advanced Education* speech notes from a seminar conducted by Convocation of the University of Newcastle on 10th March, 1972. The University of Newcastle Research Associates.
4. U.N.E., Professorial Board (P.B.), source book, 6752-6758.
5. **L. N. Short,** *Development of teacher education,* 19th June, 1971, Newcastle University documents.
6. **Alec Lazenby,** *Some academic advantages of the University of New England/Armidale Teachers' College incorporation,* 17th July, 1972, U.N.E., Council, source book, 17,579.
7. Cf. N.S.W. Parliament, *Report of the Committee of inquiry into teacher education* (Chairman: Dr. H. F. Bell) Parliamentary Paper no. 48, September 1971, pp. 12, 35, 51.
8. U.N.E., P.B., 6755
9. Cf. The Bell Report, *op. cit.*
10. U.N.E. P.B., minute book, 2004.
11. **G. H. Duncan** (Principal of Newcastle Teachers' College), *Submission to the Senate Committee of the University of Newcastle appointed to consider a proposal to incorporate Newcastle Teachers' College within the University*, 9th February 1972. Newcastle University documents.
12. U.N.E., Faculty of Education, P.B., source book 6761.
13. **John Steinke,** statement to the Wollongong University College/Wollongong Teachers' College Joint Working Party, 10th March 1972.
14. U.N.E., P.B., 6749, 6761.
15. U.N.E., Staff Association (U.N.E.T.A.) documents U.N.E.T.A. allowed me to read some of their documents relating to merger for the purpose of an M.A. thesis, *N.S.W. Universities and Teachers' Colleges: some merger proposals 1969-1975,* **W. E. Gibson,** U.N.E., 1976. (Publication forthcoming)
16. Newcastle University, Joint Council/Senate Committee established to advise on merger, minutes. 11th August, 1972; **J. M. Lee,** *Submission to the Joint Council/Senate Committee,* 7th February, 1972.
17. Wollongong University College, Department of Geography statement to the Wollongong University College Secretary, 26th October, 1973.
18. Australia, Commission on Advanced Education, 1977-79 Report, (Chairman: E. S. Swinburne), Canberra, 1976, 4.22, p. 18. Australia,, Universities Commission, Report for the 1977-79 triennium, (Chairman: P. Karmel), Canberra, 1976, 6.35, p. 83.
19. U.N.E., P.B., Business paper, 21st February 1977, pp. 2, 3.
20. Australia, Universities Commission, *Report, op. cit.,* 6.34; and Townsville C.A.E., *Report of the special committee on amalgamation.* Townsville, 1976, unpublished.
21. Australia, Parliament, *Population and Australia. A demographic analysis and projection,* Report of national population inquiry (Chairman: W. D. Borrie) Canberra, 1965, 9.59-9, vol. 1, pp. 390-398.

THE PRODUCTIVITY OF UNIVERSITY RESEARCH

Carmel Maguire
Associate Professor,
School of Librarianship,
University of New South Wales.

Robin Kench
Research Assistant,
School of Librarianship,
University of New South Wales.

The value of university research tends to be taken for granted by those who pursue it. Researchers readily accept the view which has twice been advanced in Reports of the Universities Commission, namely that:

> *Research is an essential activity of a university . . . the extension of knowledge is at the very heart of university work; indeed learning can only be experienced at the higher levels if the minds of students are stretched at its frontiers. Accordingly there is little need to justify the role that research plays in universities or the allocation of funds for research purposes.'*

The Commission's complacency was in fact short-lived. In the August 1975 federal budget, the Government proposed cuts in research expenditure. A change of Government has not changed the economic climate in which universities have to justify their needs for funds for research as for all other purposes. Indeed if the traditional respect paid to research and researchers in universities is to survive, more attention may have to be paid than ever before to the productivity of university research.

Australian universities are very dependent on Government for research funds. The Universities Commission has produced figures which show that of the total research expenditure of $28.5 m in 1973 by universities other than the Australian National University, 77.5% came from Government sources.[2] The OECD Examiners found the level of Australian research funding low and offered the following advice as a basis for improvement:

> *Since the normal way of financing universities' recurrent expenditure allows just a relatively small part for research work, ways have to be found by which the prevailing situation might be improved. To ask for more money is certainly the easiest way, but it will have success only when the Government as well as the Parliament are convinced —*
> *(a) that the money is needed for purposes worthy of additional funding:*
> *(b) that every other way to achieve greater efficiency in using available funds and means has been tried.*[3]

The OECD Examiners' advice thus seems to suggest that analysis of both inputs and outputs of university research ought to form the basis of submissions to Government.

Input/Output Measures

The development of measures of research input on a national scale has been relatively recent in Australia. The Department of Science is continuing the work begun by the Department of Education and Science on a national inventory of resources devoted to R & D as part of Project SCORE. The first inventory covered the year 1968/1969 and another has been prepared for 1973/1974. Research inputs are more amenable to measurement than outputs but there are difficulties. How, for example, is the cost of unsuccessful research to be allocated? Should it be charged to the final cost of a successful research effort, regardless of whether the previous research was carried out by the same people, or in another department, or in another university? and regardless of whether previous research made any contribution to the successful project? Research sponsors have been known to be disappointed, not to say suspicious to the point of litigation, when work they have funded has proved unproductive while work done under other auspices on the same problems has proved successful. Measurement of the totality of research inputs must therefore be recognized as at least difficult.

While efforts like Project SCORE are important in contributing overall information on research inputs, there have been suggestions other than those of the OECD Examiners that responsibility for the efficient management of research resources lies with the researchers themselves. An Australian professor has recently observed that "the academic staff are the key people in determining the productivity in research. They are subject to a number of constraints and must optimise within those constraints".[4] The authors can offer no certain prescription for optimisation of scarce research resources. They can only observe that optimisation of time and effort is likely to be difficult in many Australian university departments where researchers combine heavy teaching loads with research commitments and where there is a high degree of uncertainty about future funding. Perhaps optimisation is rather to be sought in the choice of projects and in allocation of funds to competing projects. Implicit in this suggestion is of course the assumption that there are valid measures of research output which can be applied to individuals and to projects.

Whether the outputs of university research can be measured can be examined in relation to the achievements often claimed or at least assumed to result from it. These are (1) additions to knowledge; (2) improvements in university teaching; and (3) improvements in the life of the community generally.

Additions to Knowledge

Universities are not modest in their aims of adding to knowledge. Nathan Pusey has expressed the aim of science in universities as "to seek everlastingly for fundamental explanations, to keep working at basic levels until men are able to understand fully and deeply the processes of nature".[5] Obviously in this context the university researcher need not be concerned if the results of his work are not immediately applicable. Moreover in the face of Pusey's eloquence the attempts made so far to measure additions to knowledge by universities may well seem crude.

Freeman has reviewed methods based on counts of scientific papers resulting from research.[6] While such methods hold the appeal of susceptibility to statistical analysis, they have grave deficiencies. There is the overall danger of equating quantity with quality. Some subjects are likely to lend themselves to more papers than others. Publication will be restricted where a patent application is likely. Some institutions will exert more pressure on researchers to publish and ambitions to achieve the greatest number of articles from the smallest piece of research may result. For such reasons Freeman concluded that "great caution is necessary in applying these measures."[7]

Another difficulty in measuring a piece of research as an addition to knowledge is the fact that its significance may not be recognized at the time or for years after discovery. Interesting examples in the history of research on ferrites and on human fertility are cited in the United States investigation called TRACES.[8] In these circumstances the peer review system may also prove deficient although it is probably the best mechanism so far devised for control of the quality of research output.

Publication in learned journals and to a lesser extent in scholarly monographs remains the principal method by which findings of university research are announced. These scholarly sources are read by scholars and not by the community generally. Langrish and his team at the University of Manchester conducted case studies in firms that had won the Queen's Awards for outstanding achievement in technological innovation. They found only 10 of the 69 important ideas from external sources had come from universities and none of them had come via the literature.[9]

It might be supposed that the findings of university research expounded in papers at conferences and seminars would prove more effective communication channels than the literature. There is some evidence that, at least when such papers include attention to the economic aspects of new products and processes, this may be so. Yet there is apparently a danger that like the literature, conferences may be effective mainly as means of communicating with other academic researchers. Swan has lamented that at conferences of professional bodies "regrettably, the industry faces are never present in numbers anywhere to match the number of university faces". He also reported in 1975 that "at the last national meeting of the Division of Organic Chemistry of the Royal Australian Chemical Institute, two only of the 120 participants were employed in industrial laboratories".[10]

Perhaps a corollary of this evidence is that the additions to knowledge represented by the bibliographies of research publications issued by universities can be counted and evaluated as additions to the knowledge of other university researchers. The extent to which they are likely to represent additions to the knowledge of society will be further examined later in this paper.

Improvements to Teaching

Within universities it is generally accepted as an article of faith that research activity improves the quality of teaching. In a study at the Carnegie-Mellon University in Pittsburgh, Hayes found evidence that this belief was widespread and he attributed it mainly to the fact that individuals with high research ability are likely to be promoted in academic rank. He also found, however, that academics of high rank and high research ability are likely to do considerably less undergraduate teaching and to carry lighter teaching loads.[11]

Measurement of the nature and extent of improvements brought to teaching by concurrent research will have to wait solution of the serious methodological problems with which measurement of the effectiveness of teaching is fraught. Yet it would be foolish at this stage to refuse to admit as evidence the fact that universities not only teach the research workers of tomorrow but also play a major role in generalizing, synthesizing and disseminating knowledge through the textbooks produced by their staff. Furthermore within universities teachers seek to expose students to the latest knowledge in their fields. There is reason in the Universities Commission's argument already cited that in order to do this teachers need to be actively engaged at the research front themselves. Evidence of this interaction between research and teaching, while it defies measurement, has been found by the authors in a study of the dissemination of research findings from the School of Chemical Engineering and the School of Food Technology in the University of New South Wales. (A report of this study is in preparation). Teachers with research interests and skills were able to raise the curiosity of students and encourage them with their research projects. The teachers also thrived on the stimulation provided by the inquiries of their students.

The terms of reference of the federal Government's Committee of Inquiry into Education and Training have been carefully framed to concentrate on such apparently practical matters as "the provision of

educational facilities and services" and "the relationship between the educational system and the labour market". Even so it will be surprising if the universities do not devote substantial portions of their submissions to arguments on the importance of research as part of the education process. It is a pity that they will find available to them little objective evidence of the interrelationship of the two activities. It is to be hoped that the Inquiry will at least hear some anecdotal evidence from students whose researching teachers have given them the opportunity to participate in problem-solving projects involving the latest technology. There can be no doubt that students are important as carriers of new technology to the world outside the universities. Examples occur in the authors' project mentioned above and in the work of Langrish [12] and Jervis.[13]

Community Benefits

The third outcome often claimed of university research is improvement in the life of the community in general. The practical application of knowledge has an immediate appeal and advocates of this claim point to the great improvements in the material standard of living as a result of new uses for natural resources, new manufacturing processes providing wider ranges of goods, medical discoveries improving the health of the community and so on. The types of measures used for these outcomes will need to vary with the goal of the research. Reductions in mortality attributable to specific discoveries in medicine might be a measure for the output of medical research. The flow of successful innovations to industry could be measured in terms of cost reduction in the production of certain goods, or improvements in goods. The contributions of university research in this process can be difficult to measure quantitatively owing to the multiplicity and complexity of other contributing factors such as outputs from research institutes, from industrial R & D, and so on, and the need to measure the contributions of each is often dependent on the type of subjective evaluation of "quality" and "importance" of research output which bedevils so many output measurement techniques. Even within one firm Mansfield found that the productivity of research and development "is an extremely important variable which is plagued by unusually difficult measurement problems".[14]

In addition to these problems of measurement of positive contributions, in recent years many have suggested that contributions leading to improvements in the material standard of living have created new problems which more than counterbalance the the advantages gained, such problems as pollution and depletion of resources leading to despoliation of the environment and detracting from the "quality of life". It can at least be argued that university researchers have been quick to accept the research challenges presented by these problems whereas industry in many cases has not.

Diffusion of Findings

Unfortunately research capable of saving our environment is probably as little likely to be applied in industry as any other type of university research. The OECD Examiners noted that contacts between industry, universities and government laboratories are sporadic and often confined to personal relationships. They also commented that:

> *with regard to relations between universitiies and industry, several references were made to barriers of a cultural or psychological nature between the academic world and the world of industry.*[15]

These views are supported by other evidence, notably a survey commissioned by the federal Government in 1972 which reported that

> *there is little contact between universities and industry in Australia. Industry does not appreciate work done at universities and university staff does not appreciate the needs of industry.*[16]

If the OECD Examiners erred, it was rather in leaving an impression that the Australian situation was unusual. In the voluminous literature on diffusion of innovations few studies have focussed on university research. The few include two British studies, both of which revealed misunderstandings between universities and industry. The 1969 study at Imperial College found few researchers interested in developing and maintaining contacts with industry.[17] The other study carried out by the Confederation of British Industry in 1970 commented on "differences in outlook" and "differences in time scale and objectives" as obstacles to greater co-operation between universities and industry.[18]

T. J. Allen also sounds a warning note in his report of a recent study of technology transfer in the Republic of Ireland. He concludes:

> *Most small countries have attempted to aid the technological development of their industry through support of research in universities and research institutes. What evidence there is on the effectiveness of these measures would indicate that this strategy has generally failed. The universities and research institutes may develop a very high degree of technological competence, but this is seldom successfully utilized by industry.*[19]

If measures of direct industrial application are applied as measures of the productivity of university research, universities may have some very poor scores to explain. Remember, for example, that Langrish in his study of Queen's Award-winning firms found that out of the 69 important innovative ideas from sources outside the firms, only 10 had come from universities.[9]

There are therefore serious limitations in attempts to quantify outcomes of university research as additions to knowledge, improvements in teaching and improvements to life in general. This is not to say that such benefits do not exist or that they cannot be demonstrated and increased. Universities

provide consulting services to the community through direct arrangements with academics. Some universities, such as the University of New South Wales through Unisearch Limited and the University of Newcastle through TUNRA, have set up special units to communicate with industry and to organize contract research and consultancies.

There remain, however, many problem areas in the diffusion of the results of university research and of the knowledge and skills of members of universities. There may be problems in contract research when the funding body wishes the results to remain confidential and seeks to impose limitations on publication. Opinions differ on whether universities ought to patent inventions developed with public funds. In the use of research students on problem-solving projects conflicts of objectives can arise between universities and the organizations with the problems. There is also imperfect knowledge within university departments of research activities in other departments. Whether such knowledge is shared seems often to depend on coincidence and personal contacts, or even on requests from students for permission to work on projects in other departments. The productivity of any university's research might be improved by the creation of a data base of ongoing projects and available expertise. So might the quality of the consultancy services provided.

There are also peculiarly Australian problems in making university research more productive. The OECD examiners suggested that:

> *it may reasonably be assumed that enterprises controlled from abroad concentrate their development work mainly on adapting foreign products and processes to local conditions, whereas the low level of resources devoted to development work in independent Australian firms suggests that in many cases their development effort is not sufficient to exploit fully and rapidly the results of fundamental and applied research.*[20]

In these circumstances opportunities for Australian academics to become entrepreneurs and set up their own companies to take high technology into the community are likely to be severely limited. By contrast in the United States Roberts identified in 1966 in the Boston area 105 companies which were spin-offs from Massachusetts Institute of Technology laboratories and 51 which were spin-offs from MIT academic departments.[21]

In considerations of increasing the productivity of university research, however, there is the more serious general problem of the inadequacy of our knowledge of the process by which diffusion of innovations takes place. Simple linear models of relationships between basic research and applied research and development have been discarded. Schon has pointed out how complex diffusion models must be if they are to cope with "the dynamically conservative plenum into which information moves".[22] Burns has questioned beliefs about technology transfer based on assumptions that transmission of information from research to industry will lead to commercial exploitation and eventual use. Burns also rejects the notion of technology as an assemblage of pieces of information which can be extracted or expelled from one sector of organized creativity and transposed to another to produce different outputs.[23] Burns has suggested as "a simple, clarifying notion" that "the mechanism of technological transfer is one of agents, not agencies; of the movement of people among establishments, rather than the routing of information through communication systems".[24]

Conclusion

Acceptance of this notion implies that in order to improve the productivity of their research universities might have to be much more open to the community generally and much more flexible in their tolerance of movements of staff and students in and out of academic environments. In the present economic and political climate universities may find their best form of defence lies in more strenuous efforts to demonstrate what their research contributes to knowledge, to teaching and to the community. What they are defending can be narrowly viewed as their share of public funds. On the other hand, it may be the essence of universities which is at stake — at least for those of us who subscribe to Nathan Pusey's belief that:

> *A university was, and is, first of all an association of scholars. It is their essential function not to produce goods or perform practical services, but simply to keep a life of mind vigorous and functioning among us. Though it is a cardinal article in this basic faith that from this kind of activity, pre-eminently, other kinds of goods now associated with the university are apt to flow, the first justification for it is not this, but simply that mental activity of this sort becomes our full humanity.*[25]

1. **Australia. Universities Commission.** *Fifth Report,* May 1972. quoted in its *Sixth Report,* May 1975, p. 233
2. **Australia. Universities Commission.** *Sixth Report,* May 1975, Table 14.1, p. 235.
3. **O.E.C.D.** *Examiners' report on science and technology in Australia.* Canberra, 1974, p. 29.
4. **Nicklin, D. J.** Research and related activities within the Department of Chemical Engineering, University of Queensland. *Pace* vol. 3 no. 3, March 1977, pp. 24-25.
5. **Pusey, N. M.** Science in the university. *In his The Age of the Scholar: observations on education in a troubled decade.* Cambridge, Mass., Belknap Press, 1963, p. 132.
6. **Freeman, C.** *Measurement of output of research and experimental development: a review paper.* Paris, Unesco, 1970.
7. *Ibid* p. 31.
8. **Illinois Institute of Technology Research Institute.** *Technology in retrospect and critical events in science* (TRACES) Chicago, 1968. vol. 2 pp. 16 and 23.
9. **Langrish J.** et al, *Wealth from knowledge: studies of innovation in industry.* London, Macmillan, 1972, p. 80
10. **Swan, J. M.** *Discovery, invention, innovation and development: is there a university-industry interface?* Paper delivered at ANZAAS meeting, Canberra, 24 January 1975, p. 2
11. **Hayes, J. R.** Research, teaching and faculty fate. *Science,* vol. 172, 16 April 1971, pp. 227-230.
12. **Langrish, J.** et al. *Op. cit.* pp. 44-45, 278-279.
13. **Jervis, P.** Innovation in electron-optical instruments — two British case histories. *Research Policy* vol. 1, 1971/1972, pp. 193-194.
14. **Mansfield, E.** *Industrial research and technological innovation: an econometric analysis.* New York, Norton & Co., 1968, p. 198.
15. **O.E.C.D.** *Op. cit.* p. 22.
16. **International Technical Services Ltd.** *A study of the rate of difusion of new technology within Australian industry. Section 1. General Summary.* Conducted by International Technical Services Ltd., for the Office of Secondary Industry, Department of Trade and Industry. Canberra, Australian Government Publishing Service, 1972, pp. 62-63.
17. **Launder, B. E.** and **Webster G. A.** *University research and the considerations affecting its commercial exploitation: a survey of six departments at Imperial College.* London, Technical Development Capital Ltd., 1969
18. **Confederation of British Industry.** *Industry, science and universities: report of a working party on universities and industrial research to the Universities and Industry Joint Committee.* London, 1970, p. 56
19. **Allen, T. J.** *Research program on the management of science and technology: transferring technology to the firm: report of a pilot study in Irish industry.* Cambridge, Mass., Sloan School of Management M.I.T., 1975. Working Paper No. 815-75, p. 35.
20. **O.E.C.D.** *Op. cit.* p. 11.
21. **Roberts, E. B.** Entrepreneurship and technology. *In* W. H. Gruber & D. G. Marquis *eds. Factors in the transfer of technology.* Cambridge, Mass., M.I.T. Press, 1969, p. 225.
22. **Schon, D. A.** *Beyond the stable state: public and private learning in a changing society.* Harmondsworth, Penguin, 1973, p. 90
23. **Burns, T.** Models, images and myths. *In* W. H. Gruber and D. G. Marquis *eds. Factors in the transfer of technology.* Cambridge, Mass., M.I.T. Press, 1969, p. 13.
24. *Ibid* p. 12.
25. **Pusey, N. M.** Utility and the university *In his The Age of the scholar: observations on education in a troubled decade.* Cambridge, Mass., Belknap Press, 1963, p. 109.