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Australian University–Industry Research Links: Researcher Involvement, Outputs, Personal Benefits and 'Withholding' Behaviour

GRANT HARMAN

ABSTRACT *Using data from two surveys of science and technology academics in major Australian research universities, an assessment is made of researcher involvement in industry–research partnerships, the outputs and personal benefits that result, and the occurrence of delaying publications and withholding data and materials from colleagues. An estimated 40% of academics currently have industry research funding, with many also having other sources of funding. Some 60% of respondents with industry funding have attracted individually, or within a research group, funding of more than $250,000 over the past three years. About 35% of principal investigators with industry funding have total annual research budgets of over $101,000. While about 20% of academics have produced research results of commercial value, most of these have been less successful in increasing their personal incomes through research commercialisation and consulting, and equity in companies. Almost 40% with industry funding report having conducted research where the results are the property of a sponsor and cannot be published for a period without consent. Almost 20% of academics in 1997 and just over 20% in 2000 admitted having delayed publications for more than six months. However, safeguarding the researcher's self-interest appears to be as common a motive for delaying publication or failing to share research results or materials with scientific colleagues as protecting the property of a sponsor.*

Keywords: university–industry research links, research budgets, research commercialisation, research sponsors, delaying publications, withholding data.

Introduction

This paper assesses the extent to which science and technology academics in leading Australian universities are involved in research funded by industry and in producing research results of commercial value. The paper also explores the extent to which researchers are able to increase their incomes from patents and consulting, their involvement in companies with products or services based on their research results, and the extent to which they admit to delaying publication of

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research results and withholding research results and materials from other scientists. Data come from two separate postal surveys of random samples (one in three) of academic staff in science and technology departments from Group of Eight (Go8) universities. The Go8 universities are an organised grouping of the eight leading research universities within Australia's system of public higher education that is made up of 37 universities and a small number of non-university degree granting institutions.

In many countries over the past decade or so, government and university attempts to enhance university–industry research links have produced impressive results. In particular, they have provided avenues for academics to be more involved in R&D, attracted substantial additional financial resources for universities, provided important financial support and career opportunities for Ph.D. students and stimulated major expansion in technology transfer and research commercialisation. In addition, universities have benefited from access to highly specialised technical know-how while industries have benefited from gaining access to the results of basic research and research facilities, securing access to new processes, and gaining the opportunity to work with Ph.D. students.[1]

Various performance indicators point to considerable success in Australia at the national level from the Commonwealth (Australian) government efforts to enhance university–industry links while officially sponsored evaluations and reviews have reported a high level of overall success for particular programmes. The initial evaluation of the Cooperative Research Centre (CRC) Program, for example, concluded that the main achievement of the programme had been in producing a major culture change in Australian research,[2] while more recently an evaluation of joint Australian Research Council (ARC) and Department of Education, Training and Youth Affairs industry-linked research schemes concluded that both universities and industrial partners were positive about their experiences.[3] Between 1992 and 1999, total funds attracted by universities from industry increased from \$108.6 million to \$280.3 million while funds attracted from the public sector outside the Commonwealth education portfolio increased from \$70.5 million to \$142.9 million.[4]

On the other hand, university–industry research links pose a number of risks, particularly the possibility of compromising academic freedom and the free flow of research information, placing undue pressures on academics to follow the directions or wishes of corporations, taking up too much of the time of academics and adversely affecting academic commitment to the key tasks of teaching and research. With industry funding, academics are more likely to find themselves in financial conflict of interest situations. In many situations, industry partnerships may cause tension for academics between the need for industry funding and the strong urge to preserve intellectual freedom.[5] While on balance, the positive effects appear generally to outweigh the negative effects, it is important for universities to be aware of the risks involved and to monitor the various impacts of industry partnerships and increased emphasis on research commercialisation.

In this new environment, many features of academic research activities within science and technology fields continue in their traditional ways but, at the same time, it is important to recognise that a number of significant changes are at work within the social structure of academic science. For example, some key aspects of traditional science as described by scholars such as Robert Merton have been radically changed. In a classic study originally written in the 1940s, Merton likened the culture of science more to the ideals of communism than to capitalism because intellectual property was commonly shared and discoveries were freely exchanged. 'The scientist's claim to intellectual property', Merton wrote, was 'limited to that of recognition and esteem'.[6] Merton also said that the 'substantive findings of science are a product of social collaboration and are assigned to the community. They constitute a common heritage in which the equity of the producer is severely limited'.[7]

But today many university scientists involved in industry-sponsored research routinely sign confidentiality agreements requiring them to keep both the methods and results of their work secret for specified periods of time. In the United States, the National Institutes of Health recommend that universities allow corporate sponsors to delay publication for no more than one or two months (the amount of time needed to apply for a patent) but lengthier delays appear to be becoming standard. An American survey of 210 life science companies sponsoring research, for example, found that 58% of companies sponsoring university research required delays of more than six months before publication.[8] Another study of 2,167 university scientists found that one in five had delayed publication for more than six months to protect proprietary information and that researchers who receive funding from industry, or are pursuing the development of a product, are more likely than others to engage in withholding research results.[9]

Survey Data and Characteristics of Respondents

Two separate social surveys were conducted in 1997 and 2000 using samples drawn from staff lists of Go8 universities. The first survey which used three universities (University of Adelaide, University of Melbourne and University of New South Wales) distributed 513 questionnaires and secured a 40% response rate, while the second which used five universities (University of Sydney, Monash University, University of Western Australia, University of Queensland and the Australian National University) sent out 900 questionnaires and achieved a 25% response rate. The lower response rate in the second survey can be attributed to the fact that unavoidably the questionnaires were mailed late in the academic year. In both cases, better response rates were achieved amongst senior staff, with staff at the lecturer level and below being significantly under-represented. These two limitations require caution in interpretation of some results.

Table 1 summarises key demographic data. Both survey groups were relatively senior in age and rank, with almost 60% of the 1997 group and almost 70% of the 2000 group being 45 years or older. Almost 20% of the 1997 group and over 25% of the 2000 group were professors. The main disciplinary concentrations for both groups were in biological sciences, engineering, mathematics/computer science, medicine/medical sciences and physical sciences.

Both the 1997 and 2000 groups were heavily involved in research and had substantial research achievements. They reported a high degree of interest in research and writing and found these two activities far more interesting than any other aspects of their academic work including teaching. Both groups spent a considerable proportion of each working week on research and related activities. Full-time staff in 2000, for example, on average spent 10.6 hours per week out of a total of almost 50 on research and writing. Another 2.9 hours were spent on consulting and industry-related activities, 6.9 hours on postgraduate supervision, and 5.2 hours on interacting with colleagues including post-doctorals and technical

Table 1. Demographic variables for two samples (%)

	1997	2000
Gender		
Male	80.0	85.5
Female	20.0	14.5
Age		
25–34	11.7	5.5
35–44	30.1	24.9
45–54	39.3	44.2
55–59	11.7	12.5
60 or more	7.1	12.9
Current academic rank		
Professor	19.4	25.3
Associate professor	21.9	34.4
Senior lecturer	38.3	31.2
Lecturer	16.3	7.7
Associate lecturer	4.2	1.4
Formal qualifications		
Proportion with doctorate	88.8	94.0
Field of teaching and/or research		
Agriculture/veterinary science	3.1	7.6
Biological science	14.3	20.6
Engineering	17.9	25.1
Earth sciences	4.1	4.0
Mathematics/computer science	15.8	12.1
Medicine/medical science	23.5	11.2
Physical sciences	9.7	16.2
Social/behavioural sciences	6.1	–
Other	5.5	3.2

staff. About 10 hours were spent on administration including research project administration and 11.7 hours on undergraduate teaching. Respondents from the 1997 survey on average supervised the research of 3.1 Ph.D. students, 2.3 masters students and 2.4 bachelors honours students while 2000 respondents on average supervised the research of 7.2 doctoral students, 0.7 masters students and 1.7 bachelors honours students. Research achievements were impressive. Respondents from the 1997 survey, for example, on average had published some 59.0 scholarly or scientific papers during their careers and 9.0 papers in the past three years, while respondents from the 2000 survey had published on average 79.9 papers during their careers and 12.6 papers in the past three years.

Research Links with Industry and External Research Funding

While official data and reports indicate the growing importance of industry research links for Australian universities, little is known about the proportion of academics actively involved in working with industry and in receipt of industry funds. Neither is there available detailed information on the actual extent of industry funding per staff member or research group.

Table 2. Respondents with research support from various sources (%)

	1997 N = 196	2000 N = 224
ARC Large Grant	29.6	46.9
ARC collaborative, APA (Industry) or SPIRT grants	8.2	30.8
NHMRC grant	16.8	10.7
Funding from a rural industry R&D corporation	7.1	NA
Grants/contracts with government agencies	35.7	24.1
Funding from industry/business	32.7	34.1
Private foundations	NA	10.7
International organisations	NA	12.5
Internal university funding (including ARC Small Grants)	NA	62.1
Combined National Competitive Grants	45.7	62.1
Combined government/industry funding	45.4	46.4

In both surveys, science and technology academics were asked to indicate their main sources of external research support and the results are summarised in Table 2. In both cases, the questionnaire items asked about sources of funding for the respondent's work, rather than whether they held the grants or contracts individually as a principal investigator or co-principal investigator. It will be noted from Table 2 that the categories used varied slightly between the two surveys.

Taken together, the two sets of data indicate the importance of industry funding. In both surveys, about 45% of respondents reported that their work was supported by industry funding or by grants or contracts from government departments. Grants and contracts with government departments do not include National Competitive Grants awarded by the ARC or the National Health and Medical Research Council (NHMRC). In contrast, between about 46 and 62% reported funding from National Competitive Grants.

Before proceeding further it is necessary to comment on the validity of these results. One minor problem with the data is that about 10% of respondents in both surveys did not answer the item or items about research funding. However, it can be assumed that generally respondents with external funding would be more likely than not to answer the various parts of the question item and so proportions with particular funding have been calculated as percentages of the total number of respondents rather than percentages of those who answered the particular item. A second problem is about the likely effects of the relatively low response rates with over-representation of more senior staff amongst respondents. The data on sources of funding indicate that considerably higher proportions of professors and associate professors compared with other academic staff had funding both from National Competitive Grants and from industry and government agencies. For example, in the year 2000 survey, 55.2% of professors and associate professors compared with 38.2% of other staff had ARC Large Grant funding, 41.9% of professors and associate professors compared with 25.8% of other staff had grant or contract funding from government departments, and 36.6% of professors and associate professors compared with 32.5% of other staff had funding from industry. While it is probably true that senior lecturers and below find it considerably easier to attract funds from industry narrowly defined rather than from the ARC or government departments, some discount allowance should possibly be made in estimating the proportion of science and technology academics in the target population that received funds from industry and government departments and National Competitive Grants. Various calculations suggest a discount rate of about 5%. Using such a discount rate would mean that about 40% of academics are in receipt of funding from industry or government departments and about 40–55% are funded from National Competitive Grants.

Comparative international data on the extent to which academics are involved in industry partnerships is limited mainly to the United States where Blumenthal and colleagues[10] reported, from a survey in the mid-1980s of 1,200 faculty in 40 research intensive universities, that 23% of biotechnology faculty compared with 17% of other life science respondents were principal investigators on projects with funding from industrial sources. Another study by Blumenthal[11] a decade later found that, of 2,052 faculty in life sciences in 50 US universities, 28% of respondents received support from industry. This data suggests that a slightly higher proportion of Australian science and technology academics may receive industry funding.

In terms of the various individual sources of funding reported in Table 2, the most important sources of external funding for 1997 were in rank order: grants and contracts from government departments, industry funding, ARC Large Grants, NHMRC grants, ARC 'SPIRT' grants (for collaborative projects with industry) and grants from rural industry R&D corporations, while for the year 2000 the rank order was: ARC Large Grants, industry funding, ARC SPIRT grants, grants and contracts from government departments, funding from international organisations, and NHMRC grants and private foundation support. Overall, the pattern of funding was reasonably stable between 1997 and 2000, although the percentage of respondents with funding from the ARC and the NHMRC appears to have increased. However, some variations between 1997 and 2000 results may simply reflect slightly different discipline mixes between the two samples and particularly in relation to medicine/medical science (see Table 1).

Another important conclusion from manipulation of data summarised in Table 2 is that many Australian science and technology academics have multiple sources of funding and that many of those with industry funding and government contacts and grants also receive funding from the National Competitive Grants. Multiple sources of funding provide access to increased amounts of funding and give greater security of funding from year to year but, as explained elsewhere,[12] multiple sources of funding also increase workload in terms of time spent in identifying funding sources and preparing applications and proposals. Data from the 1997 survey show that about 25% of respondents spent at least three hours per week in identifying sponsors and preparing grant and contract applications, with those having industry funding spending even more time. Data from the 2000 survey reveal that almost 22% of respondents with research funding from industry or government departments also held an ARC Large Grant or an ARC SPIRT grant, while a significant proportion of respondents with ARC SPIRT grant funding also had industry funding or government grants or contracts. On the other hand, not surprisingly, it appears that when academics are funded entirely by either National Competitive Grants or by funding from industry, their work differs substantially in terms of the emphasis on basic as opposed to applied research. Of respondents in the 2000 study, 54.9% of those with ARC Large Grants as opposed to 25.3% of those with funding from industry said their research could be best described as basic research.

Table 3. Total amounts attracted in grants, contracts and other means by respondents individually or as a member of a research group during the past three years: 2000 survey (%)

	Respondents with funds from gov agencies *N* = 54	Respondents with industry funds *N* = 78	All respondents *N* = 204
Less than $10,000	5.6	2.6	5.9
$10,000–$49,000	5.6	3.8	12.3
$50,000–$99,000	9.3	11.5	11.8
$100,000–$249,000	27.7	21.9	25.0
$250,000–$499,000	25.9	26.9	19.6
$500,000 +	25.9	33.3	25.5

The importance of industry funding varies between different science and technology disciplines, as does the importance of support from different sources. In the year 2000 survey, 55% of academics in earth sciences were in receipt of industry funding. Industry funding was also important for many academics in agriculture/veterinary science and engineering, but of less importance for those in the physical sciences, medicine and biological sciences. At the other end of the spectrum, less than 10% of academics in mathematics and computer science reported being in receipt of industry funding.

In addition to the industry research funding described above, three other important forms of funding come into academic departments. First, 13% from the 1997 respondents said they received research support from a Cooperative Research Centre (CRC) while 14.4% of respondents from the year 2000 reported that they were members of a CRC or received support from a CRC. While substantial Commonwealth government's funds are allocated to the CRC program, partners in each CRC must contribute substantial funds. Generally partners include industry and government agencies as well as universities. Second, postgraduate students and/or postdoctoral fellows of about one in five of 1997 respondents were directly supported by funds from industry while in 2000 almost 40% of respondents said they had received industry support for students. Third, about 26% of respondents in 1997 and about 35% in 2000 reported that in the past three years they had received industry support, independent of grants or contracts, taking the form of equipment, discretionary funds or funding for trips to professional meetings. This compares with figures reported in a recent American study of 2,167 life science faculty in 50 major universities which found that 43% of respondents had received research-related gifts from industry in the last three years independent of grants and contracts.[13]

Science and technology academics in Go8 universities attract considerable total sums in research funds. The year 2000 questionnaire asked respondents to estimate the total sum that they had attracted in the last three years in research grants, contracts and other support, either individually or as part of an academic group. The results are summarised in Table 3, showing separately those with funding from government agencies and those with industry funding as well as the results for all respondents combined. Those with industry funding and government grants and

Table 4. What is the total budget for this year for grants and contracts funded by industry for which you are the principal investigator? (%)

	All respondents	Respondents with funding from industry in past 3 years
Nil	51.2	14.5
$1,000–$20,000	6.8	9.2
$21,000–$50,000	14.0	25.0
$51,000–$100,000	11.0	17.1
$101,000–$200,000	8.7	17.1
$201,000–$1,000,000	6.8	14.5
Over $1 million	1.5	2.6

contracts appear to enjoy much higher levels of support than all respondents combined, with about 52% of respondents with government grants and contracts and over 60% industry funded academics attracting more than $250,000 in the past three years compared with about 45% of all respondents. However, significantly, of respondents with National Competitive Grants (i.e. with ARC Large Grants, ARC SPIRT grants and NHMRC grants) alone and no other support for the last three years, 61% reported receiving total grants of more than $250,000 over the past three years. This finding suggests that in terms of total funding, those with industry and government department funding and those with National Competitive Grants do equally well on average in terms of the total sums of research support attracted.

Total amounts of research funding attracted vary considerably across different disciplines, with 50% or more for staff in earth sciences, agriculture/veterinary science and engineering having attracted $250,000 or more. About 40% of staff in the physical sciences had attracted $250,000 or more, while for medicine/health the figure was 32%, for biological sciences 30%, and less than 10% for mathematics/computer science.

In the 2000 survey, staff were asked to report on the total budget for the current year for grants and contracts funded by industry for which they were the principal investigators. The item specified inclusion of projects funded only through their university. The results are summarised in Table 4, showing both the percentages for all respondents and percentages for respondents who had previously indicated in the questionnaire that in the last three years they had received funds from industry either individually or as a member of a research team. Of those with industry funding (narrowly defined so as not to include government grants and contracts) in the past three years, 34.1% reported that the total budget from industry for the current year for projects where they were the principal investigator was over $101,000 and 17.1% that it was over $201,000.

Respondents to the year 2000 survey who received funding from industry for current projects were asked to estimate the proportion of total support excluding overheads and infrastructure that industry provided. They were provided with the opportunity to report on up to three separate projects. Just over 42% reported that they had current projects funded by industry. For project 1, industry support varied from about 3 to 100%, with the mean being 60% and the median 50%. For those

Table 5. Has your research resulted in any of the following? Percentages of respondents who said 'yes'

	1997 *N* = 196	2000 *N* = 222
Patent applications	19.5	21.5
Patents or licences	11.7	16.1
A product or service that is currently being marketed	20.5	22.7
Software with commercial applications	20.9	13.6
A start-up or spin-off company	3.2	5.4
Trade secret (information kept secret because of its proprietary/other value)	13.0	12.0

who reported a second and or third project, industry support, on average, was about 60%. Of those who reported receiving current support from industry, about half said the support came entirely from one company, about 25% from two companies and the remainder from three or more companies.

Research Results with Commercial Value

Australian science and technology academics produce considerable amounts of research results with commercial value. Respondents in both surveys were asked whether their research had resulted in various outcomes and the results are summarised in Table 5. About 20% in both groups said that their research had resulted in patent applications and between half and three quarters of those said that the outcome had been patents or licences. About one in five respondents said that the result had been a product or service being marketed but only 5% or less said that their work had resulted in a start-up or spin-off company. The results for both years are highly similar.

Industry and government department respondents are considerably more likely than other respondents to have produced work with commercial value, but so are respondents who have ARC Large Grants or ARC SPIRT funding. Table 6 provides information and one striking feature of the data is that those with industry/government funding are only marginally more likely than those with National

Table 6. Has your research resulted in any of the following? Percentage of respondents who said 'yes' in the 2000 survey, by source of funding

	ARC Large Grant *N* = 104	ARC SPIRT grant *N* = 69	Industry/government department funding *N* = 103
Patent applications	28.6	35.6	32.0
Patents of licences	22.1	26.9	27.5
Product or service that is currently marketed	19.4	33.8	31.0
Software with commercial application	16.7	17.9	14.0
Start-up or spin-off company	5.8	11.9	6.9
Trade secret	10.6	17.9	17.8

Table 7. Indicate to what extent you are able to increase your income with royalties from licensed patents, consulting with industry and other similar means (%)

	1997 $N = 188$	2000 $N = 219$
Nil	66.0	74.0
Less than 5%	10.6	15.1
5–20%	17.0	7.3
21–50%	4.8	2.7
More than 50%	1.6	0.9
Total	100.0	100.0

Competitive Grant funding to have produced results of commercial value. These results differ from an American study of the mid-1980s which reported that biotechnology faculty with industry funding were more likely than other biotechnology faculty to report that their research resulted in trade secrets.[14]

Personal Financial Benefits

While respondents have been highly successful in producing research results with commercial value, most have been far less successful in generating additional wealth for themselves—at least, if what was reported was truthful. In both surveys, respondents were asked to indicate to what extent they had increased their personal income with royalties from licensed patents, sale of patents, consulting with industry and other similar means. The results are summarised in Table 7. It will be noted that while 6.4% in 1997 and 3.7% in 2000 reported that they had been able to increase their salary by more than 20%, 66.0% in 1997 and 71.9% in the year 2000 reported that they had not increased their income at all. Not unexpectedly, those academics with industry research funding did better financially for themselves than others. In 1997, for example, 34.3% with industry research funding compared with 18.5% without such funding were able to increase their income by 5% or more while in 2000 the corresponding figures were 19.7% for those with industry funding and 10.9% for all respondents.

In the year 2000 survey, respondents were asked whether or not they held equity in a company whose products or services are based on their research, and whether they were members of any advisory board of a company. Only about 4% said yes to both questions.

Delaying Publication

Delaying publication is an important issue in scientific research but to date there is relatively little empirical data apart from that produced by Blumenthal and various colleagues, although a number of other studies refer to the phenomenon and the moral and public interest issues involved.[15]

In both surveys, respondents were asked whether or not they had personally conducted research at their university where the results were the property of the sponsor and could not be published for a period of time without the consent of the

Table 8. 'Has your research resulted in any of the following?': Chi-square analysis run on particular variables

	Not industry funded	**Industry funded**	**Total**
Research resulted in patent applications			
Yes	13	21^{H}	34
No	93	49	142
Total	106	70	176
$\chi^2 = 8.5$, $p = 0.004$			
Research resulted in product or service that is being marketed			
Yes	11^{L}	25^{H}	36
No	94	45	139
Total	105	70	175
$\chi^2 = 16.4$, $p < 0.001$			
Research resulted in trade secret			
Yes	4^{L}	18^{H}	22
No	100	49	149
Total	104	67	171
$\chi^2 = 19.3$, $p < 0.001$			
Research results that cannot be published for period			
Yes	8^{L}	30^{H}	38
No	97	42	139
Total	105	72	177
$\chi^2 = 19.3$, $p < 0.001$			

Superscripts: L = lower count than expected; H = higher count than expected.

sponsor. In 1997, 19.3% answered yes while in 2000, 24.1% answered yes. Not surprisingly, in both surveys the percentages were much higher for those who had industry research funding—37.7% with industry funding compared to 6.0% without industry funding in 1997 and 39.7% with industry funding compared to 24.3% for all respondents in 2000. In terms of disciplinary differences, the highest proportion in the year 2000 saying they had conducted research where the results were the property of the sponsor and could not be published without the consent of the sponsor were in engineering and earth sciences and the lowest in mathematics and computer science. For the biological sciences, medicine and the physical sciences the proportions varied between 20 and 25%.

Further analysis explored differences between industry funded and non-funded respondents in relation to research results that cannot be published for a period and related items using Chi-square tests. The results are summarised in Table 8. It will be noted that the relationships for research results that cannot be published for a period are particularly significant, with $\chi^2 = 19.3$, $p < 0.001$.

In 1997 respondents who indicated that they were not free to publish results without the consent of the sponsor, were asked to identify the type of sponsor for the particular research. Overwhelmingly, the main sponsor turned out to be industry although in small numbers of cases the sponsor was a government department or agency.

Table 9. How many times has publication of your research results been delayed by more than six months for the following reasons (%)

	1997 N = 188				2000 N = 224			
	Never	**Once**	**2–5**	**More 5**	**Never**	**Once**	**2–5**	**More 5**
To allow time for patent application	90.1	7.3	2.1	0.5	87.1	7.4	5.1	0.5
To protect the proprietary or financial value of the results (other than by patent application)	88.5	4.7	6.8	–	87.6	6.9	4.1	1.4
To allow time for licence agreements	94.8	3.7	1.6	–	94.0	3.2	1.8	0.9
To resolve disputes over ownership of intellectual property	93.2	6.3	0.5	–	94.0	3.2	1.9	0.9
To protect the investigator's scientific lead	93.2	4.2	2.6	–	95.4	3.7	0.9	–
To delay the dissemination of undesired results	96.3	2.6	1.0	–	90.2	3.7	4.7	1.4
Because the results are the property of a sponsor	NA	NA	NA	NA	86.2	7.8	3.7	2.3

In both surveys, respondents were asked the number of times that publication of research results had been delayed by more than six months, indicating the reasons. The results are summarised in Table 9. Withholding behaviour for particular reasons varies between about 3 and 12%. However, for both surveys the data for the various reasons for delaying publication as set out in Table 9 were recoded, giving '1' if respondents answered affirmatively for any reason, and '0' otherwise. This analysis gave surprising results—19.4% of respondents in the 1997 survey and 28.3% in the year 2000 had been engaged in delaying publication. This figure is probably higher than often assumed. Similar results were found in an American study carried out over 1994–95 where in a large national sample of biotechnology academics 19.8% reported that over the past three years publication of their research results had been delayed for more than six months.[16]

The results from the 2000 survey are particularly interesting, as an additional item of 'because the results are the property of the sponsor' was included. Taken together, these results suggest that protecting the self interest of the researcher and the research group may be as important a reason for delaying publication as protection of the property of the sponsor.

Not surprisingly, delaying publication is more common among industry respondents than the survey population as a whole, but significantly it is also more common amongst respondents with National Competitive Grants than with the survey population as a whole. Of the respondents of the 2000 survey, 29.9% of those with industry research funding had been involved in delaying behaviour to allow time for a patent application, 33.6% to protect proprietary value, 10.5% to allow time for licence agreements, 10.4% to resolve disputes over intellectual property, 14.9% to protect the investigator's lead, 12.2% to delay dissemination of

Table 10. Reasons for not sharing research results or materials with other researchers (%)

To protect the financial interests of the university	8.5	(47)
Because of informal agreement with the company	16.2	(43)
Because of formal agreement with the company	20.9	(43)
To protect my scientific lead	43.2	(44)
To protect my own financial interests	15.9	(44)

undesired results and 16.0% because the results are the property of the sponsor. Of respondents with National Competitive Grants, 20.2% had been involved in delaying behaviour to allow time for a patent application, 17.3% to protect proprietary value, 8.7% to allow time for licence agreements, 4.9% to resolve disputes over intellectual property, 13.6% to protect the investigator's lead, 4.9% to delay dissemination of undesired results and 16.3% because the results are the property of the sponsor. These data lend further support to the conclusion that protection of self interest is as important, and perhaps more important, than protection of the sponsor's intellectual property.

In terms of disciplinary fields, on the basis of year 2000 data, delaying publication is more common amongst engineering and physical science academics than academics in other fields and least common amongst those in medicine and mathematics/computer science. However, delaying publication seems to be equally common across academic ranks.

Withholding Research Results and Materials

The 2000 survey questionnaire asked respondents whether or not in the last three years they had refused to share research results or materials when requested by another researcher. Those who indicated that they had been involved in such withholding behaviour were then asked about the reason for not providing results or materials. Rather surprisingly, 24.3% admitted withholding results or materials from colleagues but for those with industry research funding narrowly defined it was a considerably higher at 39.7%. On the other hand, only 15.5% of those holding National Competitive Grants reported that they had been involved in withholding behaviour. The reasons given for withholding behaviour are summarised in Table 10. Again it appears that self-interest in many cases may be the main driver. Almost half said the reason was to protect the researcher's own scientific lead, although the second most important reason was because of a formal agreement with the company.

Two studies in the United States have reported on withholding research results and materials from colleagues. The first, based on a 1994–95 national survey of life science faculty in 50 universities, found that 8.9% of respondents admitted refusing to share research results with other university scientists in the last three years.[17] The second, based on a 1995 survey of faculty in 117 medical schools, found that 12.5% of researchers had been denied access to other investigator's data within the last three years, although senior faculty were less likely than younger faculty to have been the victims of data withholding.[18]

Discussion

This article has attempted to assess the extent to which science and technology academics in leading Australian universities are involved in research funded by industry, produce research results of commercial value. They are able to increase their personal income from patents and consulting and are involved in delaying publication of research results by withholding results and materials from scientific colleagues.

While official data and reports indicate the importance of industry research links for Australian universities, little is known about the proportion of academics actively involved in working with industry and the actual extent or scale of industry funding. From both the 1997 and year 2000 surveys, about 45% of respondents reported industry research funding or grants and contracts from government agencies while between 46 and 60% reported National Competitive Grant funding. Because of the relatively low response rates and over-representation of senior staff in both surveys, possibly the figures should be discounted by about 5%, giving a figure of about 40% for industry funding broadly defined and about 40–55% for those with National Competitive Grants. Clearly both National Competitive Grants and industry and government department funding are of major importance for many academics and the research efforts of their universities. Many respondents have multiple sources of funding, which provides larger total funding and greater continuity from year to year but considerably increases workloads in terms of time taken in identifying funding sources and preparing proposals and grant applications.

The importance of different funding sources varies considerably between disciplines and academic ranks. Industry funding narrowly defined is particularly important for researchers in earth sciences, agriculture and engineering. Staff in medicine depend heavily on the NHMRC while those in agriculture on rural industry R&D corporations. In addition to research project support, project funds come via CRCs while other funds come directly to support research students and post-doctoral fellows, and provide equipment and conference travel.

Science and technology academics attract considerable total sums in external research funds. About 52% of those with grants and contracts from government agencies, about 60% of those with industry funding, about 61% of those with National Competitive Grants had total funds over the past three years of more than $250,000. Of those with industry funding but not including government grants and contracts in the past three years, 34.1% reported that the total budget from industry for the current year for projects where they were the principal investigator was over $101,000 and 17.1% that it was over $201,000.

Science and technology academics produce considerable amounts of research with commercial value. About 20% of respondents in both surveys reported that the research had resulted in patent applications and between half and three quarters of these said that patents or licences had resulted. However, research with industry or government department funding is only marginally more likely than National Competitive Grant funding to have produced research results of commercial value. While respondents have been highly successful in producing research results of commercial value, they have been far less successful in generating wealth for themselves. In 1997, 66% of respondents and in 2000 74% of respondents had not increased their income at all while only 6.4% in 1997 and 3.7% in 2000 had increased their income by more than 20%. Not unexpectedly, academics with industry funding did considerably better for themselves financially than other academics. Only about 4% of academics hold equity in a company engaged in commercialising their research.

According to critics of industry funding, one of the most serious issues about industry partnerships is the possibility of blocking or slowing down the free flow of research results amongst members of the academic community and beyond. About 20% of respondents in the 1997 survey and about 24% in the year 2000 survey reported that they had conducted research where the results were the property of the sponsor and could not be published for a period without the consent of the sponsor. Not surprisingly, in both surveys the proportions were higher for industry funded academics than others—37.7% with industry funding compared with 6.0% without in 1997 and 39.7% with industry funding compared with 24.3% without in the year 2000.

In both surveys, respondents were asked how many times publication had been delayed and what the reasons were. Surprisingly, just under 20% in 1997 and just over 28% in 2000 reported delaying publication at least once but only a handful more than five times. Yet, significantly, safeguarding the researcher's self-interest appeared to be as common a motive for delaying publication as protecting the property of a sponsor. Such self-interest includes allowing time for a patent application to be lodged, protecting the researcher's scientific lead, and delaying dissemination of undesired results. At the same time, it should be noted that delaying publication is considerably more common amongst respondents with research funding from industry.

In the year 2000 survey respondents were asked whether or not in the last three years they had refused to share research results or materials with scientific colleagues. Almost 25% reported they had done this, with the figure for those funded by industry being almost 40%. By far the most important reason was to protect the researcher's scientific lead although the next important reason was because of a formal agreement with a company.

Overall the results are largely positive for industry funding which is important even to many academics who attract National Competitive Grants. Total sums of industry funding are often considerable, with much of the research leading to results of commercial value. Relatively little, however, is known about what proportion of this effort actually leads to commercial outcomes and what factors are of key importance in determining commercialisation success. Delaying publication of results and failing to share research results and materials is a matter for concern, and these trends obviously need to be monitored carefully. But it is important to recognise the importance of scientific and personal self-interest as motives in both delaying and withholding behaviour.

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