2. HYPOTHESIS 1: *The visibility of Australian science has declined because of a reduction by Australian scientists in the tapping of international networks*

International scientific collaboration and the flows of academic talent among nations are seen as good *per se* and as integral factors in stimulating and maintaining a healthy national science system (see, for example, NBEET, 1995; Colombo, 1995; Luukkonen, Persson, & Sivertsen, 1992; NBEET, 1994; Saha & Klovdahl, 1979). It has also been argued that international collaboration has a particular role to play in enhancing the visibility of aspiring young scientists (Beaver & Rosen, 1979). In many nations, international scientific collaboration has become a political imperative (Bourke & Butler, 1995; Luukkonen, Persson & Sivertsen, 1992).

As noted by Colombo (1995):

> *The communal nature of scientific exploration is a feature of the post war world, when the individual scientist gave way to the team. The team is now giving way to the network, and, electronically linked by ever more sophisticated technologies, these networks make it possible to draw upon expertise across continents. (p.27)*

A recent NBEET report (1995) has also made the point that the understanding of a nation's international links may have less to do with formal policy-driven international collaborations than with informal networks developed through the free market of scholarship. Such a view places the focus on *individuals* in the development of international links. The NWO (1996) has recently highlighted the increasing importance of a focus on individuals within the instruments used to raise the profile of Dutch research.

> *Academic research always revolves around individuals... . Top-class researchers need to be offered ample opportunities at **all** stages of their careers. (p.28)*

While Australian 'instruments' for fostering the profile of research have a strong focus on structural support (university infrastructure, large equipment concentration, research schools and specialisms (as in the Institute of Advanced Studies, and CSIRO), and centres of research excellence of various types including ARC Special Research Centres, and the Co-operative Research Centres), instruments with a focus on individuals such as in the Dutch system while they do exist here (for example, the NH&MRC's C.J. Martin Fellowship, and the ARC's Australian Research Fellowships Scheme) seem to be less obvious. Certainly, specific funding opportunities for Australian researchers to engage in international postdoctoral or other study programs are scarce.

However, informal networking by individuals can be fostered in a variety of ways, and the Bureau of Industry Economics has recently suggested the following avenues:

- *Australian postgraduate students and post-doctoral researchers abroad;*
- *sabbatical leave;*
- *incoming high quality foreign scientists and postgraduate students;*
- *shared use of facilities;*
- *participation in conferences and seminars;*
- *informal discussion groups between scientists; and*
- *mobility between universities and other institutions. (BIE,1996b, p.46)*

Several of these are examined to varying degrees (dependent on data availability) below.

2.1 The origin of Australian academics' qualifications

One method of obtaining information on the structure and quantity of academic networks is to examine the actual amount of talent flow between countries and specific universities. This has been done on a number of occasions by examining the recruitment patterns of Australian universities (see, for example, Saha & Klovdahl, 1979). Saha and Klovdahl found that for the period 1961-1974, there was little variation in the proportion of appointments in Australian universities from overseas, and this proportion hovered between 40-50 percent. Their 'overseas' component, however, also included Australians returning from overseas. The actual proportion of overseas-born academics in Australian universities in 1970 was reported as being around 20 percent. The proportion of 'overseas' appointments who were actually Australians returning to academic appointments from overseas was around 45 percent for the same year.

A recent study (Anderson, 1993) has examined the qualifications profile of academic staff in Australian higher education institutions, both the university and the previous college sector, for the years 1978, 1987, and 1992, and for different fields of study.

The study found, among other things, that more than one-third of university academics gained their highest qualifications from overseas, and that one-quarter of university academics had their first and highest qualification from overseas ('foreign recruits'). These patterns changed little over the period under scrutiny. Moreover, fields with the most foreign recruits were humanities, social studies and engineering.

The Anderson study provides useful aggregate information regarding the academic profile, and also became a useful reference point for data collection for the current study. However, for the purposes of this investigation, data collection needed to start in 1970, and more years needed to be sampled. The focus of this data collection was also on PhD location rather than other types of higher degrees. In addition, while the Anderson survey examined fields of *study*, fields of research were of interest here.

Analysis

The sample of universities used in the current analysis were those 19 universities that existed prior to 1987. Many of these universities now have components added from the former college sector. The time period scrutinised was from 1970 to 1994, and in particular the years 1970, 1973, 1976, 1979, 1982, 1985, 1988, 1991, and 1994.

Field of research was classified according to the ABS Australian Standard Research Classification and the fields examined are at Appendix 1.

Information for the study was obtained from university calendars for the entire population of academic staff members recorded in the calendars as holding PhDs and as being members of departments/schools able to be readily classified into one of the fields of research. (See Appendix 1 for the list of departments.)

The scheme used for analysis is that used by Anderson (1993) and the categories considered are depicted in Table 1. Anderson makes an important point regarding the interpretation of the statistical trends which is worth noting here:

> *...statistical trends over the period of the study are 'muted' because the data are for all staff, not new staff. Thus differences that appear in the tables...are due to incremental changes on a body of data comprised largely of the same individuals. (p.3)*

Table 1. Location of first qualification by location of highest qualification[1]

	Location of highest qualification	
Location of first qualification	**Australia**	**Overseas**
Australia	A (true blue)	B (adventurers)
Overseas	C (migrants)	D (foreign recruits)

[1] Anderson, 1993

Results

Tables 2(a) and 2(b) give an overview of the academic profile for the sample population. The four rows in each table show for each of the years examined the total number [2(a)] and percentage of the total [2(b)] who fell into one of the four groups indicated in Table 1: both qualifications in Australia (Aust-Aust), the first in Australia and PhD overseas (Aust-O'seas), the first overseas and PhD in Australia (O'seas-Aust), and both qualifications overseas (O'seas-O'seas). These data are also graphically depicted in Figures 1(a) and 1(b).

Table 2(a) Location of first and highest qualification for selected years and sample disciplines[1] for pre-1987 universities - number

Location of qualification: First-Highest	1970	1973	1976	1979	1982	1985	1988	1991	1994
Aust-Aust	363	463	576	598	619	667	797	861	879
Aust-O'seas	168	202	227	242	233	229	237	208	198
O'seas-Aust	32	44	63	76	87	87	101	107	117
O'seas-O'seas	218	271	369	369	392	399	423	497	504
Total	781	980	1235	1285	1331	1382	1558	1673	1698

[1] See Appendix 1

Table 2(b) Location of first and highest qualification for selected years and sample disciplines[1] for pre-1987 universities - percentages

Location of qualification: First-Highest	1970	1973	1976	1979	1982	1985	1988	1991	1994
Aust-Aust	46.5	47.2	46.6	46.5	46.5	48.3	51.2	51.5	51.8
Aust-O'seas	21.5	20.6	18.4	18.8	17.5	16.6	15.2	12.4	11.7
O'seas-Aust	4.1	4.5	5.1	5.9	6.5	6.3	6.5	6.4	6.9
O'seas-O'seas	27.9	27.7	29.9	28.7	29.5	28.9	27.2	29.7	29.7
Total	100	100	100	100	100	100	100	100	100

[1]See Appendix 1

Figure 1(a). The origin of academics' qualifications across selected disciplines: 1970-1994

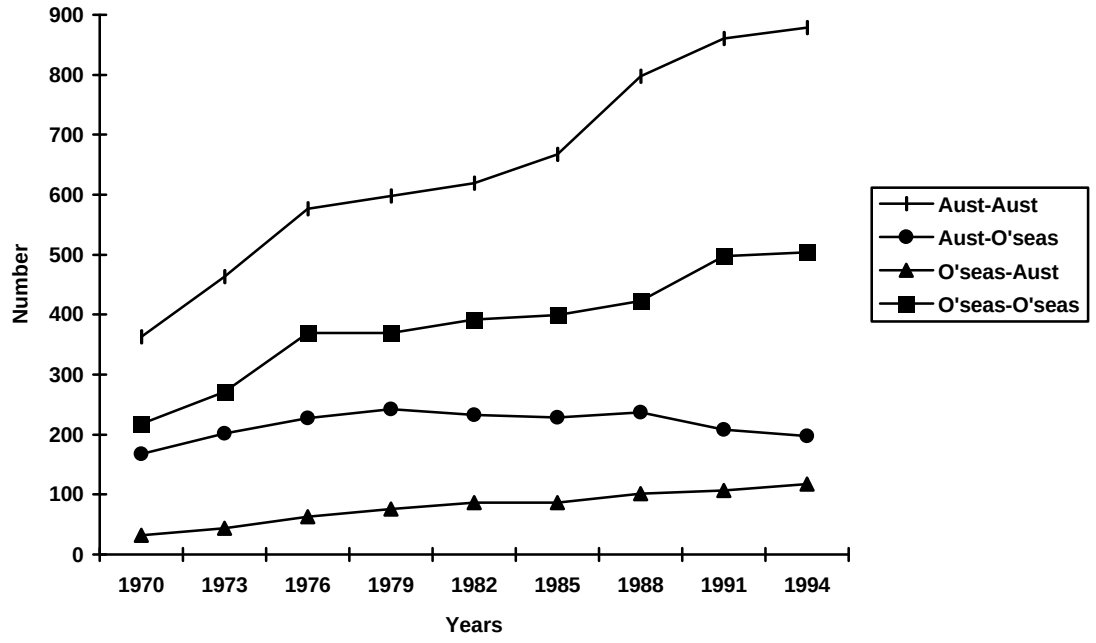
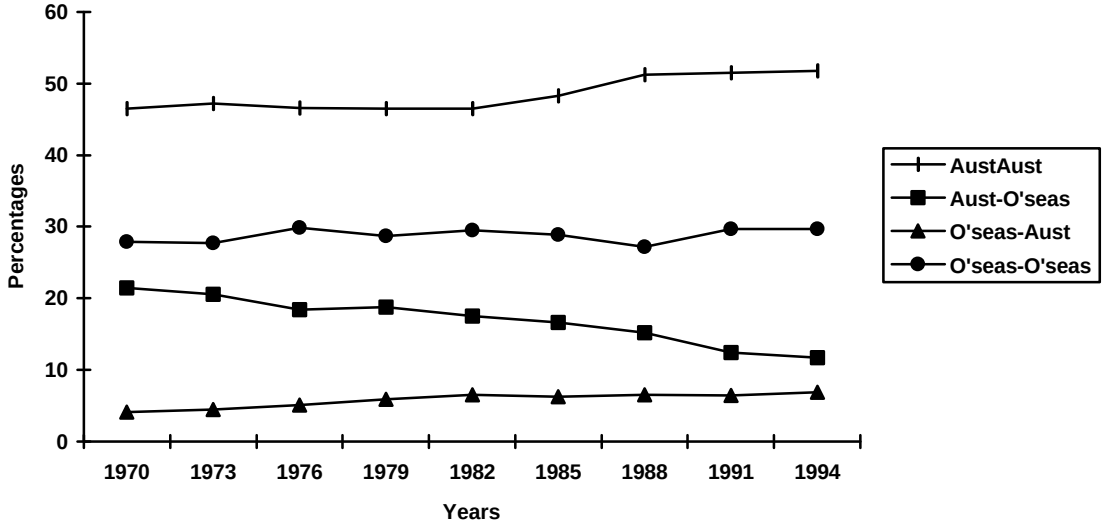


Figure 1(b). The origin of academic's qualifications in selected disciplines: 1970-1994



For the period under examination, the proportion of academics in Australian universities who received both their undergraduate and PhD education at an Australian university ranged from 46.5 percent in 1970 to 51.8 percent in 1994. This represents an increase of 11.4 percent, and has been largely at the expense of academics who travel overseas from Australia for their PhD training. This group's share has decreased by 45.6 percent between 1970 (21.5 percent) and 1994 (11.7 percent). This result will be examined in more detail later in this report. Australia as a location for internationally mobile scientists (both qualifications overseas) has remained as

attractive in 1994 as it was in 1970 with a slight increase in the proportion of this group of 6.5 percent. This is in line with immigration data in a recent Bureau of Industry Economics report (BIE, 1996) which suggests that Australia is a net gainer of scientific personnel. The proportion of personnel with an overseas undergraduate and Australian PhD has increased substantially from a low base over the period (68 percent), although this group's share of academic places remains quite low (4.1 percent in 1970 to 6.9 percent in 1994).

Overall, the findings generally mirror those of Anderson (1993) (see Table 3), with the most noticeable difference being in the Australia-Overseas group with the proportion of personnel in this group in the Anderson study reducing by 31.5 percent over the time period (1978-1992) and as mentioned previously, by 45.6 percent in this study.

Table 3. Patterns of recruitment: Comparison of Anderson[1] (1993) study (whole university system) and current study (selected science and engineering departments)

	1978/79		1987/88		1992/94	
Location of : First qual. - Highest qual.	**Anderson**	**Current**	**And.**	**Current**	**And.**	**Current**
	%		**%**		**%**	
Australia-Australia	50	46.5	49.1	51.2	54.9	51.8
Australia - Overseas	18	18.8	15.7	15.2	12.5	11.7
Overseas - Australia	7	5.9	7.5	6.5	7.4	6.9
Overseas - Overseas	26	28.7	27.7	27.2	25.3	29.7

[1]Anderson study also included Masters (Research) qualifications

The variations among research fields, as well as the change over time between 1970 and 1994 can be seen in Tables 4(a) and 4(b). In 1994 the proportion of completely Australian educated academics (Aus-Aus) ranges from 44 percent in Engineering to 69 percent in the Medical Sciences. This latter finding reflects that reported by Anderson (1993).

Table 4(a) Location of first qualification by location of Phd for selected disciplines: 1970

Field	No.	A Aus-Aus	B Aus-O'seas	C O'seas-Aus	D O'seas-O'seas
		%	%	%	%
Physics	207	47.4	15.9	3.9	32.9
Chemistry0	272	47.1	23.5	3.3	26.1
Earth Sciences	92	42.4	21.7	3.3	32.6
Electrical Engineering	47	34.0	31.9	6.4	27.7
Agricultural Sciences	62	48.4	29.0	4.8	17.7
Medical Sciences	83	53.0	18.1	4.8	24.1
Computer Science	18	44.4	16.7	11.1	27.8

Table 4(b) Location of first qualification by location of PhD for selected disciplines: 1994

Field	No.	A Aus-Aus	B Aus-O'seas	C O'seas-Aus	D O'seas-O'seas
		%	%	%	%
Physics	310	49.0	11.6	7.1	32.3
Chemistry	315	52.4	15.9	4.4	27.3
Earth Sciences	260	45.0	11.5	10.8	32.7
Electrical Engineering	170	44.1	10.0	6.5	39.4
Agricultural Sciences	179	59.8	12.9	7.8	19.6
Medical Sciences 1	223	69.0	7.2	4.9	18.8
Computer Science	241	45.2	10.8	7.1	36.9

1 (Immunology, Neurosciences, Physiology, and Pharmacology)

Conversely, the group receiving both undergraduate and PhD education overseas (O'seas-O'seas), ranges from 19 percent in the Medical Sciences to 39 percent in Electrical Engineering. This result for Electrical Engineering is contrary to the result found by Anderson for the Engineering field as a whole where in 1992 only 27 percent of academics are reported as having both undergraduate and postgraduate qualifications from overseas.

All fields have relatively low proportions of Australians undertaking PhD training overseas (Aus-O'seas), and 'migrants' (O'seas-Aus) coming to Australia for PhD training.

As discussed previously (Table 2(b)), the proportion of academics from the 'foreign recruits' (O'seas-O'seas) category remained very stable over the time period under scrutiny. Saha and Klovdahl (1979) in their study of international networks and flows

of academic talent between 1961 and 1974 found a similar stable pattern for this group and suggested the following:

> *This pattern might signify that there is a maximum number of overseas scholars which universities can absorb or tolerate, or that there exists a finite pool of potential overseas recruits who would merit appointment over local talent (assuming, of course, a meritocratic appointment system). In either case, there appears to be a saturation point in overseas recruitment beyond which there is a greater reliance on local candidates to fill staff vacancies. (p.62)*

If, as it appears, the proportion of international talent from recruiting (talent *to* Australia) has remained static, then in the interests of maintaining the flow of international values and knowledge and the corresponding networking behaviour, other avenues of international talent flows (talent *from* Australia, and back) become even more significant.

Where Anderson's study placed quite a deal of emphasis on the proportion of 'foreign recruits' in Australian universities (O'seas-O'seas), of major interest to this study is the change in the pattern of behaviour of 'Australian' academics (both Aus-Aus and Aus-O'seas). International collaborations and continuing (though limited) international networks based on Australians travelling overseas to gain PhDs have been reported as important as launching both a publications career, and a foray into the international literature and other networking possibilities (NBEET, 1995).

Table 5 contains information on that proportion of the sample regarded as of Australian origin and the location of their PhDs. Place of first degree is used as a measure of nationality, as it has been found to correlate highly with country of birth (around 90 percent accuracy reported in Saha & Klovdahl, 1979). The data are also depicted in Figure 2.

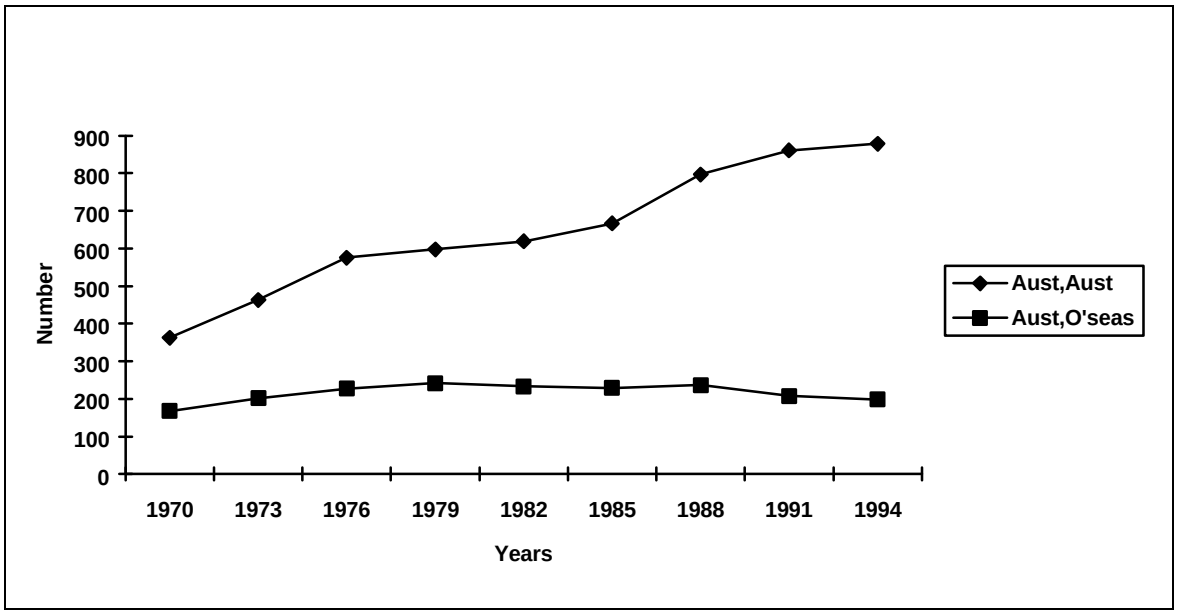
There has been a 142 percent increase in the number of Australian academics with both qualifications from Australia (from 363 in 1970, 879 in 1994). On the other hand the actual number of Australians travelling overseas to obtain PhDs has only increased by 17.8 percent in the same time period (from 168 in 1970, to 198 in 1994).

Table 5 Location of PhD qualification of those academics in australian university departments whose first qualification is Australian[a]

	Year								
Location of qualification	**1970**	**1973**	**1976**	**1979**	**1982**	**1985**	**1988**	**1991**	**1994**
Australia	363 (68.4)[b]	463 (69.6)	576 (71.7)	598 (71.2)	619 (72.7)	667 (74.4)	797 (77.1)	861 (81.0)	879 (81.6)
Overseas	168 (31.6)	202 (30.4)	227 (28.3)	242 (28.8)	233 (27.3)	229 (25.6)	237 (22.9)	208 (19.0)	198 (18.4)
Total	531	665	803	840	852	896	1034	1069	1077

[a] Sample - see Appendix 1
[b] Percentages in brackets

Figure 2 Location of PhD qualification of those academics in selected university departments whose first qualification is Australian



Tables 5(a)-(e) contain information on Australian academics within the specific disciplines. The pattern of the 'Australianisation' of academia is repeated for all disciplines, with only small increases reported in the number of Australians receiving overseas PhDs in most areas. However, while there has been a small increase in the number of overseas-educated Australians, all fields show a change in the *balance* in the academic staff profile, with an increasing proportion of academics with Australian-Australian qualifications.

Table 5(a) Location of PhD qualification of those academics in Australian *Physics* whose first qualification is Australian

Location of highest qualification	1970	1973	1976	1979	1982	1985	1988	1991	1994
Australia	98 (74.8)[1]	116 (72.0)	137 (74.5)	146 (74.5)	144 (74.6)	136 (74.7)	152 (77.9)	172 (78.5)	152 (80.1)
Overseas	33 (25.2)	43 (28.0)	47 (25.5)	50 (25.5)	49 (25.4)	46 (25.3)	43 (22.1)	47 (21.5)	36 (19.9)
Total	131	159	184	196	193	182	195	219	188

Table 5(b) Location of PhD qualification of those academics in Australian *Computer Science* whose first qualification is Australian

Location of highest qualification	1970	1973	1976	1979	1982	1985	1988	1991	1994
Australia	8 (72.7)[1]	10 (71.4)	17 (80.0)	24 (82.8)	40 (80.0)	49 (79.0)	71 (81.6)	78 (86.7)	109 (80.7)
Overseas	3 (27.3)	4 (28.6)	4 (20.0)	5 (17.2)	10 (20.0)	13 (21.0)	16 (18.4)	13 (23.3)	26 (19.3)
Total	11	14	21	29	50	62	87	91	135

Table 5(c) Location of PhD qualification of those academics in Australian *Chemistry* whose first qualification is Australian

Location of highest qualification	1970	1973	1976	1979	1982	1985	1988	1991	1994
Australia	128 (66.7)[1]	163 (70.3)	185 (70.9)	181 (70.4)	179 (71.9)	173 (72.3)	201 (76.4)	203 (79.6)	165 (76.7)
Overseas	64 (33.3)	69 (29.7)	76 (29.1)	76 (29.6)	70 (28.1)	64 (27.7)	62 (23.6)	52 (20.4)	50 (23.3)
Total	192	232	261	257	249	237	263	255	215

[1] Percentages in brackets

Table 5(d) Location of PhD qualification of those academics in Australian *Agricultural Sciences* whose first qualification is Australian

Location of highest qualification	1970	1973	1976	1979	1982	1985	1988	1991	1994
Australia	30 (62.5)[1]	41 (60.3)	53 (62.4)	48 (65.7)	43 (56.6)	66 (71.7)	78 (70.3)	79 (73.8)	107 (82.3)
Overseas	18 (37.5)	27 (39.7)	32 (37.6)	25 (34.3)	33 (43.4)	26 (28.3)	33 (29.7)	28 (26.2)	23 (17.7)
Total	48	68	85	73	76	92	111	107	130

Table 5(e) Location of PhD qualification of those academics in Australian *Medical Sciences* (Immunology, Pharmacology, Physiology and Neurosciences) whose first qualification is Australian

Location of highest qualification	1970	1973	1976	1979	1982	1985	1988	1991	1994
Australia	44 (74.6)[1]	51 (72.9)	73 (79.3)	77 (76.2)	95 (82.6)	112 (82.4)	143 (86.1)	156 (90.7)	154 (90.6)
Overseas	15 (25.4)	19 (27.1)	19 (20.7)	24 (23.8)	20 (17.4)	24 (17.6)	23 (13.9)	16 (9.3)	16 (9.4)
Total	59	70	92	101	115	136	166	172	170

Table 5(f) Location of PhD qualification of those academics in Australian *Earth Sciences* whose first qualification is Australian

Location of highest qualification	1970	1973	1976	1979	1982	1985	1988	1991	1994
Australia	39 (66.1)[1]	51 (66.2)	66 (67.3)	68 (63.0)	66 (64.7)	77 (64.7)	92 (68.7)	103 (76.3)	117 (79.6)
Overseas	20 (33.9)	26 (33.8)	32 (32.7)	40 (37.0)	36 (35.3)	42 (35.3)	42 (31.3)	32 (23.7)	30 (20.4)
Total	59	77	98	108	102	119	134	135	147

[1] Percentages in brackets

Table 5(g) Location of PhD qualification of those academics in Australian *Electrical Engineering* whose first qualification is Australian

Location of highest qualification	1970	1973	1976	1979	1982	1985	1988	1991	1994
Australia	16 (51.6)[1]	31 (68.9)	45 (72.6)	54 (71.1)	52 (77.6)	54 (79.4)	60 (76.9)	70 (77.8)	75 (81.5)
Overseas	15 (48.4)	14 (31.1)	17 (27.4)	22 (28.9)	15 (22.4)	14 (20.6)	18 (23.1)	20 (22.2)	17 (18.5)
Total	31	45	62	76	67	68	78	90	92

[1] Percentages in brackets

A University of Sydney academic has recently described six 'golden threads' that purport to run through Australia's first class universities (Jackson, 1995, cited in IDP Report, 1995), one of which is that

> *Australia's universities recruit staff from Australia and from overseas and do not inbreed. Academics at Australian universities have experience at home and abroad, an international dimension maintained through study leave.*

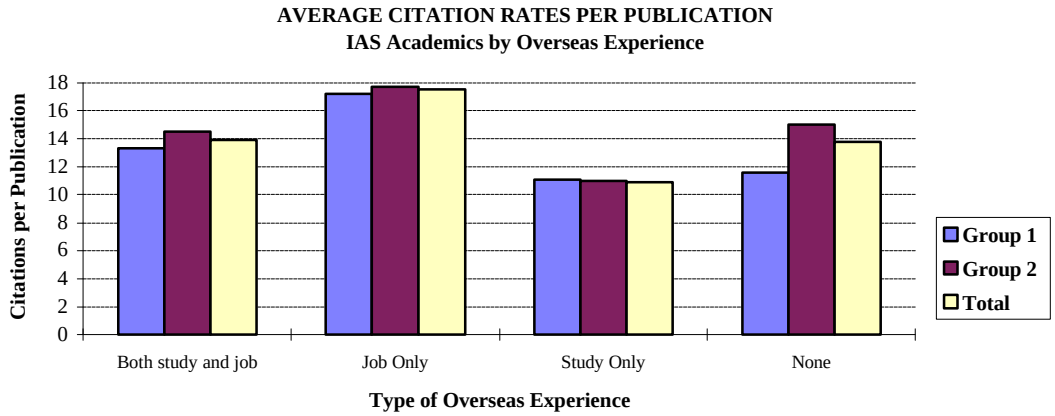
However, what we appear to have here is a picture of academic insularity within Australia's university system, at least as far as one measure of Australian academic training experiences goes. It should be noted here that fields shown to be strong in the Bourke and Butler study show the same pattern as those shown to be declining in international visibility. It should also be acknowledged that disciplines may differ in terms of the importance they attach to international experience at this level.

An interesting question now is how and if this lack of overseas experience at the postgraduate level, and combined with other measures of international experience, impacts on the visibility of Australian scientists in the international literature. Unfortunately, systematic data on other measures of the international research experience of Australian academics, such as sabbatical leave and overseas postdoctoral training, was not possible to retrieve for the whole system for this study. However, data of this kind were available for staff at the ANU's Institute of Advanced Studies (IAS), and the next section reports results of an examination of the research performance (as measured by publications and citations) of IAS staff taking into account their international experience. The full report of this data is contained in Appendix 2. In addition, the Graduate Careers Council of Australia (GCCA) was able to provide some very limited data on PhD graduates who were overseas at the time of the GCCA census, and engaged there in full-time work or study, and this data is also presented in the following sections.

2.2 The relationship between international research experience and research 'visibility'.

In the previous section the data are clear in showing that the proportion of Australian academics who travel overseas to obtain a higher degree has significantly declined in recent years. Whether or not lack of international experience at this level impacts on citation rates is not known. No system-wide data is available to address this question. Neither does a change in the networks mean a decline in the quality of research. Bourke and Butler (see Appendix 2) have derived a data base for Institute of Advanced Studies staff that allowed an analysis to be conducted on 343 academics categorised according to the location of their higher degree, whether or not they had worked (had a postdoctoral position) overseas prior to appointment at the IAS, and their level of appointment at the IAS in 1980-82 (Group 1 - Research/Postdoctoral Fellow; Group 2 - Higher than Research Fellow). The results are summarised below in Figure 3. In this figure, 'study' refers to higher degree training, and 'job' refers to postdoctoral position.

Figure 3



The main finding appears to be that overseas postdoctoral experience may be important in the ability to attract higher rates of citation. Those who had both studied and worked overseas did considerably better than those who only studied overseas, but, surprisingly, only as well as those who had no overseas experience at all. For academics whose higher degree qualifications were Australian, those that had overseas postdoctoral experience attracted citations at a greater rate than those who had not. It is a surprising finding that overseas study at the postgraduate level did not appear to be beneficial in respect of attracting citations.

Bourke and Butler (Appendix 2) tentatively conclude, considering the non-representativeness of the sample, that an increased visibility at the postdoctoral level in the international community can be the key to higher levels of citations, and that the ability of Australians to obtain overseas posts early in their careers is important. The researchers also stress the importance of testing this hypothesis on a larger and more representative sample.

2.3 Australian PhD graduates overseas

Reliable time-series data on the number of Australians undertaking postdoctoral study overseas were not available. The Graduate Careers Council of Australia does, however, survey all graduating students on 30 April each year, including graduating PhD students. Table 6 provides data on a sample of such students. While the data tell us nothing in terms of trends since the 1980s in Australian PhD graduates travelling overseas for study (postdoctoral work), the very low numbers under this category, compared to the total number of course completions, are revealing in themselves.

Table 6 The number and proportion of Australian PhD graduates by their location overseas (work/study/other) at the census datea and for selected years

Destination					**Years**					
	1982		**1985**		**1988**		**1991**		**1994**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
O/seas ft[1] work	64	(90)	55	(86)	58	(88)	49	(100)	57	(73)
O/seas ft study	2	(3)	2	(3)	0	(0)	0	(0)	2	(3)
O/seas other	5	(7)	7	(11)	8	(12)	0	(0)	19	(24)
Total O/seas	71	(100)	64	(100)	66	(100)	49	(100)	78	(100)
Course completions[2]	-		***1122***		***2089***		***2558***		***3931***	

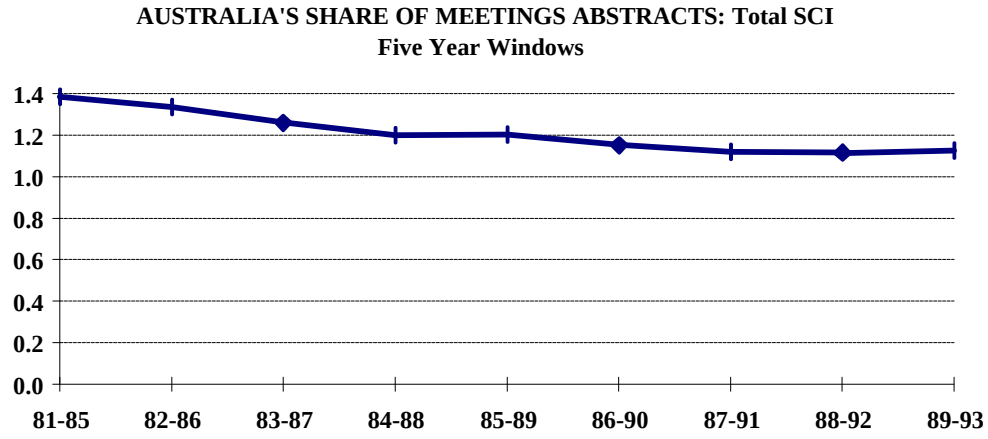
a 30 April each year; Source:Graduate Careers Council of Australia
[1] ft = full-time
[2]Source: Selected Higher Education Statistics - Commonwealth Teriary Education Commission and DEETYA.

The category ‘full-time work’, shows a decline between 1982 and 1985 of 14 percent. A problem in interpreting the data is that there is no indication of what type of work those in the ‘full-time work’ category are engaged, for example, are they engaged as postdoctoral fellows? The GCAA does try to ensure that respondents doing research and funded via scholarships are noted as being involved in ‘study’ as opposed to ‘employment’ (Bruce Guthrie, personal communication, July 1996). An additional problem arises with interpretation, as the response rate to the survey from which the data were extracted is unknown for PhD graduates as a separate group.

2.4 Attendance at international conferences

International conferences provide a valuable opportunity for Australian academics to establish and maintain contacts and networks with colleagues from overseas. Bourke and Butler (see Appendix 2 for full report) have analysed data related to publications classified as ‘meeting abstracts’, an indication of presentation at international conferences, and have examined Australia’s share of these compared to the rest of the world. Figure 4 contains the results, which indicate that Australia’s share of meeting abstracts is small and in decline.

Figure 4



2.5 International co-authorship

Internationally co-authored papers have been found to receive a larger share of citations in the international literature (NBEET, 1995). Recent data from a study of over 30 countries by Luukkonen, *et al.* (1992), indicates that the percentage of international collaborations as measured by joint publications has doubled over all fields in the ten-year period 1973-1983. The NBEET (1995) study of Australian publications found an increase in the percent change of the share of international collaborations by Australian researchers during the period 1981-1992 of 59 percent, with variations in increase between fields of 43 percent for Mathematical Sciences and 101 percent for Agricultural Sciences. There is no available Australian data for the period 1973-1983. However, no Australian field showed a doubling in the proportion of internationally co-authored papers over the time period 1981-1992 (unlike the 30 country study for the period 1973-83).

A recent *Science Watch* (1996) analysis notes that Australia, along with the People's Republic of China, vied for the lowest international collaboration of several nations (apart from the G7 nations) examined over the period 1981-1994, with approximately 22 percent of publications with international co-authorship by 1994.

In addition, the trend in the pattern of international collaboration by region has changed in the last decade, with a significant fall in the proportion of Australian collaborations with the United States of America and with the United Kingdom (NBEET, 1995). This is an important finding, and may have some influence on 'visibility' in the literature, as these countries dominate the international scholarly literature, and are the traditional collaborators for Australian scientists (NBEET, 1995). The NBEET report also contains relevant discussion of the policy implications for Australia for the future of the redirection of the major foci of the world's research towards the developing countries.

2.6 Discussion: Hypothesis 1

There appears to be mixed evidence for the hypothesis that there has been a decline in the tapping of international networks by Australian academics. On the one hand, studies reported in the literature suggest that Australian scientists do not publish in idiosyncratic local/regional journals thereby not receiving adequate representation in the journals of the ISI (Bourke, *et al., 1996)*; rather, Australian scientists report 75 percent of their research in international journals. Neither is our international collaboration in decline overall (NBEET, 1995), with evidence of a considerable increase in the share of internationally co-authored journal articles by Australians over the past decade. (NBEET, 1995).

From a more pessimistic angle, however, international co-authored publications with our traditional partners, the key players on the international research stage (USA, UK), has fallen off significantly (NBEET, 1995). In addition, Australia's presence at international conferences (measured by 'market' share of conference abstracts) is also shown to be low and in decline.

There is also strong evidence of a systematic 'Australianisation' of academia when viewed from a research training perspective. While the networks developed at the PhD training level are thought to only last around a decade, they are also viewed as critical for launching young academics into the international literature (NBEET, 1995).

As pointed out recently by Blume (1995), the internationalisation of research training has taken on new significance, with governments in most OECD countries treating the international aspect of the activity as an important and complex policy issue. Where most networks, structures and resources for international mobility used to be at the postdoctoral level, and driven largely by the scientific community, Blume points out that the impetus now is also coming from the centre, with governments becoming more directive with regard to international exchange and mobility, and research training programmes becoming the focus of serious interest and debate in this regard.

Australia has at least one program with a focus on developing international links through postgraduate research training. The Overseas Postgraduate Research Scholarships (OPRS) Scheme, administered by DEETYA, has as its purpose the attraction of top quality overseas students to areas of research strength in Australian universities. A recent review of this program (Grigg, in press) has provided evidence of the opportunities for the development of international partnerships that are generated through programs of this type. There are currently only limited programs and structures in place, however, that provide funding for top quality Australian students to receive their postgraduate research training at overseas universities.

There is also some indicative evidence that international postdoctoral experience may contribute in some way to larger citation rates for individuals. While systematic data on the volume of Australians travelling overseas for postdoctoral experience was not available, the GCAA data reported here, while scanty, indicates that there may not be large numbers of Australian PhD graduates doing so. This is in spite of considerable evidence of the importance of such experience for future successful international collaboration (NBEET, 1995), and the attraction of citations (IAS data, Appendix 2).

There is currently only one visible funding scheme available for the purpose of providing international postdoctoral opportunities to Australian scientists, the C.J. Martin Fellowships Scheme[1], and this scheme has been reported by medical researchers as being critical to their academic careers (NBEET, 1995).

The issue of international postdoctoral traning experience is of significant policy importance to warrant a detailed examination of the current situation within Australia at the institutional level. Apart from a fine-detail analysis of the origins of Australian scientists' postdoctoral training, the resources available for maintaining any networks established through this route should also be examined.

In addition, obstacles facing the recruitment of overseas scientists *to* Australian postdoctoral appointments, also a major linking mechanism, need highlighting. Australian labour market and immigration policies are not consistent with a view that research is an international activity, with heavy restrictions placed on university employers over appointments from overseas at this level. Other countries, such as Japan and the United States, have moved to overcome restrictive practices by setting up special categories of entry for postdoctoral fellows that do not conflict with their respective countries' immigration policies.

While there has perhaps been a change in the networks within Australian universities, it does not automatically follow that there has been a decline in the quality of Australian research. It cannot be left to chance, however, that Australia's research effort, both in terms of quantity and quality, will continue to be good.

The important point being made as far as international linking is concerned is that it is critical for Australia to be involved at an international level, not only with large scale projects such as the human genome project and the ocean drilling project, but also at the smaller-scale, individual level where information transfer is equally important (ASTEC, 1990). With regard to the former, ASTEC states that

> *Scientists, postgraduate students and technicians who undertake research at large (international) facilities not only acquire technical expertise by conducting experiments and keeping up-to-date with the relevant literature but they also talk to one another. Out of the conversations, new experiments are born. Technical specialisations, frequently reflecting know-how developed for local industrial reasons, are shared. Opportunities for future scientific and industrial collaboration are discovered. Membership of this informal*

[1]Administered by the National Health and Medical Research Council

> *information network is one of the important spin-offs from research at any major international facility. (p.6)*

It should be noted that Canada, a country whose publication and citation share were found to be rising in the Bourke and Butler study, is at the 'top end' in terms of its involvement in international projects. At the discipline level in Australia, Earth Sciences, also found to be faring well in terms of citation share, partakes in projects at the international level to a somewhat greater extent than other disciplines.

What may be required at the policy level is that apart from support to broad-based structures like centres of research excellence as a means of highlighting and internationalising Australian science, we need an increase in concentrated forms of assistance to *individuals* at all stages of their research careers, beginning at the postgraduate training level, focussing at the critical postdoctoral level, and continuing with Australia's top researchers having ample opportunities at all stages of their careers.