5. HYPOTHESIS 4 *There has been an inadequate funding of research so that researchers do not have adequate resources to undertake high quality science*

The vast majority of those involved in research in the higher education sector believe this hypothesis to be the case. Comprehensive studies of higher education research infrastructure have been conducted (NBEET, 1993) indicating a funding shortfall of over $120 million. However, as far as convincing government is concerned this appears to be a no-win argument. The most recent denial that substantial cuts in funding had been experienced by the higher education sector in the last thirteen years comes from the new Minister in a discussion of a report prepared by the Higher Education Council (*The Australian,* 19 June, 1996) on total higher education funding.

What appears to be a large part of the problem in accepting the hypothesis of inadequate funding is the lack of detailed, reliable data on research funding and research infrastructure spending. The BIE Report (1996) found that there was a high positive correlation between citation rates and R&D spending per head of population, which of course has risen in recent years.

This section looks at data at the *field* level for the pre-1987 universities derived from Australian data bases, and also examines some ABS-derived OECD data on the trends in the amount of funding per Australian research scientist and engineer (RSE) over certain fields.

5.1 Trends in research expenditure

All of the data reported in this section required special data runs either by the ABS or DEETYA, and then further manipulation in order to present it in a form suitable for the purposes of this study. Caveats surrounding the accuracy and reliability of the data have already been mentioned, and extreme caution is required in interpretation. For example, trends in research expenditure may simply reflect trends in staff numbers, simply because of the way the data was collected and recorded originally.

Table 12(a) contains trends in the total amount of research expenditure from all sources from 1978 to 1992 for the selected fields of research for the pre-1987 universities. Figure 7 depicts the same data as a proportion of total research expenditure.

In actual dollar terms, Table 12(a) depicts evidence of increases in all fields with the exception of Physics. Table 12 (b), on the other hand, indicates that all fields except Medicine (and to a lesser extent, Earth Sciences) have experienced a decline in their *share* of available research funds across all disciplines in pre-1987 universities. This is particularly noticeable in the field of Physics where between 1981 and 1986, this field's share of total research expenditure went from 10.9 percent in 1981 to 6.1 percent in 1986, with no recovery since then (4.6 percent share in 1992). Applied

Science and Engineering also experienced a sharp decline between 1981 and 1984 (from 11.0 percent to 8.1 percent), although it appears recovery is taking place.

Table 12(a) Trends in expenditure in selected fields of research for pre-1987 universities

Field of research	1978	1981	1984	1986	1988	1990	1992
Elec Eng						15525	19586
All Applied Sci/ Eng	81343	89436	72582	86931	101443	118045	158535
Computing			15826	19443	26482	30203	43023
Chemistry	56613	52797	56694	61760	65584	66374	80769
Physics	80642	89225	62290	61215	65719	61262	73129
Composite Earth Sciences	32346	34293	44584	56311	55448	62440	69235
Selected Ag Fields			37244	44020	42056	48630	53136
All Agriculture	58142	61009	54890	66495	67956	78884	89060
Selected Medical Fields			49176	51424	59913	77166	88449
All Med Fields*	106467	107373	136683	155394	186612	241921	286933
Total**	762899	815515	894740	1000197	1102459	1206494	1501802

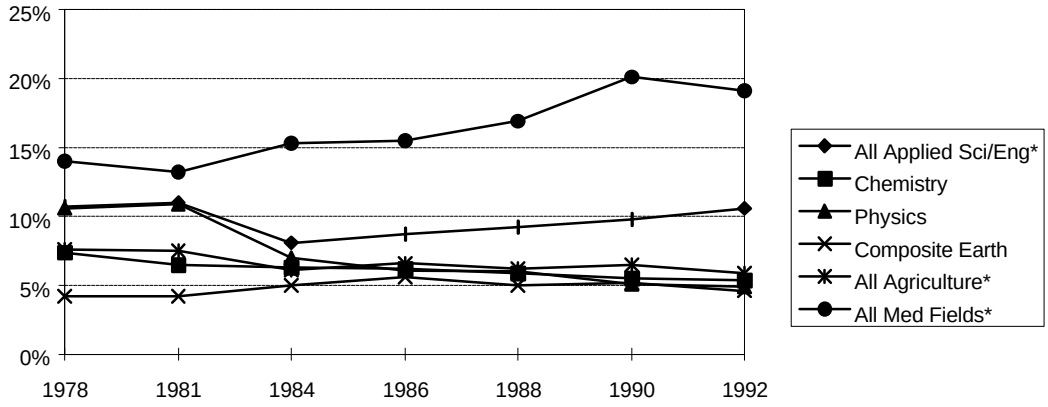
$(000) at Constant 1989-1990 Prices; includes salary component
Note: ** Total is for all fields of research represented in the system, not just those indicated in the Table.
Selected fields are those of interest to this study as indicated in Appendix 1 (disaggregation was not always possible)

Table 12(b) Pre-1987 universities - trends in expenditure in selected fields of research (as a percentage of total research expenditure)

	1978	1981	1984	1986	1988	1990	1992
All Applied Sci/ Eng*	10.7	11.0	8.1	8.7	9.2	9.8	10.6
Chemistry	7.4	6.5	6.3	6.2	5.9	5.5	5.4
Physics	10.6	10.9	7.0	6.1	6.0	5.1	4.9
Composite earth	4.2	4.2	5.0	5.6	5.0	5.2	4.6
All Agriculture*	7.6	7.5	6.1	6.6	6.2	6.5	5.9
All Med Fields	14.0	13.2	15.3	15.5	16.9	20.1	19.1

Notes:
* Aggregate data has been included because data for selected fields is not available for earlier years due to classification changes.
** Total research expenditure of pre 1987 universities for all fields of research, including humanities and social sciences.
Source: Australian Bureau of Statistics, unpublished statistics for the Research and Experimental Development Collection.

Figure 7 Pre-1987 universities - percentage of total research expenditure by field



Data on funding by source and field for the years 1984, 1988, and 1992 for pre-1987 universities are contained in Tables 13(a) and 13(b). Figure 6 depicts the percent of Commonwealth funding by field for the same three years. Clearly, research in these fields relies heavily on Commonwealth funding compared to other sources with proportions of Commonwealth expenditure in these fields ranging from 87.9 percent for Medicine to 97.7 percent for Chemistry. This is not new or surprising information. Once again, in absolute dollars (corrected for inflation), Commonwealth expenditure in each field has increased. However, in percentage share terms (see Figure 8), there is evidence of a declining trend in Commonwealth expenditure across most fields with the notable exception of Agricultural Sciences between 1988 and 1992.

A slight and probably not significant increase in expenditure is noted in the fields of Physics and Chemistry between 1988 and 1992. The share of funds from other sources such as Business is still exceptionally small, and it would seem pre-emptive that the Commonwealth's share is reducing when expenditure from other sources is almost insignificant by comparison.

Table 13(a) Funding by source for selected fields of research and years, for the pre-1987 universities

	1984						1988						1992					
Field of research	**Total***	**C'wealth govt**	**State & local govt**	**Bus. enter-prise**	**Private non-profit and other Aust.**	**Overseas**	**Total**	**C'wealth govt**	**State & local govt**	**Bus. enter-prise**	**Private non-profit and other Aust.**	**Overseas**	**Total**	**C'wealth govt**	**State & local govt**	**Bus. enter-prise**	**Private non-profit and other Aust.**	**Overseas**
Elec Eng													19586	17358	783	703	294	447
Computing	15826	15392	60	82	204	89	26482	25366	210	318	419	169	43023	39653	512	2280	402	176
Chemistry	56694	55416	272	535	391	80	65584	61988	177	1793	1447	180	80769	77093	562	1352	1136	626
Physics	62290	59506	51	129	1163	1442	65719	62335	266	948	867	1304	73129	70342	206	1430	862	290
Earth	44584	42198	479	1172	445	290	55448	51768	487	1285	1538	370	69235	64024	967	2200	1479	565
Agriculture	37244	33454	2112	635	927	116	42056	36338	2391	1663	1354	311	53136	48453	2017	891	1462	312
Selected Medical	49176	44789	148	435	3411	393	59913	52634	916	1495	4301	568	88449	79076	521	1647	6399	806
Total	894740	843399	8788	11030	24660	6863	######	1017677	12835	20218	44342	7387	######	1376576	27169	31783	57012	9262

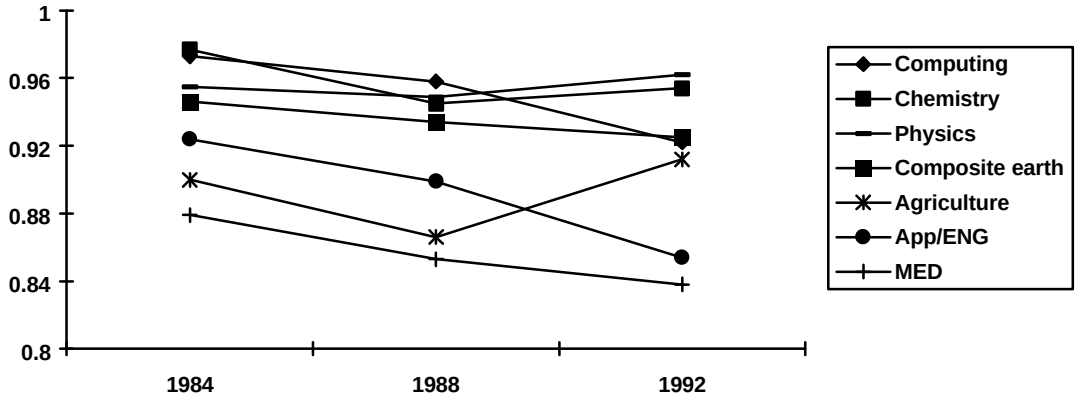
Source: Australian Bureau of Statistics, unpublished statistics from the Research and Experimental Devellopment Collection.
Total = Total for allfields represented in the R&D system
Note: In constant 1989-90 dollars

Table 13(b) Proportion of funding by source for selected fields and years, for the pre-1987 universities

	1984						1988						1992					
Field of research	**Total***	**C'wealth govt**	**State & local govt**	**Bus. enter-prise**	**Private non-profit and other Aust.**	**Overseas**	**Total**	**C'wealth govt**	**State & local govt**	**Bus. enter-prise**	**Private non-profit and other Aust.**	**Overseas**	**Total**	**C'wealth govt**	**State & local govt**	**Bus. enter-prise**	**Private non-profit and other Aust.**	**Overseas**
Elec Eng													19586	88.6%	4.0%	3.6%	1.5%	2.3%
Computing	15826	97.3%	0.4%	0.5%	1.3%	0.6%	26482	95.8%	0.8%	1.2%	1.6%	0.6%	43023	92.2%	1.2%	5.3%	0.9%	0.4%
Chemistry	56694	97.7%	0.5%	0.9%	0.7%	0.1%	65584	94.5%	0.3%	2.7%	2.2%	0.3%	80769	95.4%	0.7%	1.7%	1.4%	0.8%
Physics	62290	95.5%	0.1%	0.2%	1.9%	2.4%	65719	94.9%	0.4%	1.4%	1.3%	2.0%	73129	96.2%	0.3%	2.0%	1.2%	0.4%
Earth	44584	94.6%	1.1%	2.6%	1.0%	0.7%	55448	93.4%	0.9%	2.3%	2.8%	0.7%	69235	92.5%	1.4%	3.2%	2.1%	0.8%
Agriculture	37244	89.8%	5.7%	1.7%	2.5%	0.3%	42056	86.4%	5.7%	4.0%	3.2%	0.7%	53136	91.2%	3.8%	1.7%	2.8%	0.6%
Selected Med & hlth	49176	91.1%	0.3%	0.9%	6.9%	0.8%	59913	87.8%	1.5%	2.5%	7.2%	0.9%	88449	89.4%	0.6%	1.9%	7.2%	0.9%
Total	894740	94.3%	1.0%	1.2%	2.8%	0.8%	######	92.3%	1.2%	1.8%	4.0%	0.7%	######	91.7%	1.8%	2.1%	3.8%	0.6%

Source: Australian Bureau of Statistics, unpublished statistics from the Research and Experimental Development Collection
*Total = Total for all fields represented in the R&D system

Figure 8 Percentage of Commonwealth funding by field and year



The Bureau of Economics Report (1996b) used expenditure on fixed assets in public sector research to conclude that 'there has been strong growth in expenditure per researcher from 1978-79 to 1990-91 followed by a fall in 1992-93' (1996b, p.44). The ARC (1996) believes that 'expenditure on fixed assets' is a very narrow definition of research infrastructure and that findings based on such a definition are misleading. It ignores, for example, growth in postgraduate student numbers and the consequential increase in demand on space and equipment, as well as the increased requirement for technical support and research space that has not kept pace with the increase in overall research activity (ARC, 1996).

The BIE (1996a) also used ABS-derived OECD data to take a snapshot (one year, 1993) of OECD countries' gross expenditure on R&D per R&D worker.
Tables 14 and 15 also depict ABS-derived OECD data, and provide *trend* information on the expenditure on R&D in the Australian higher education sector by broad field of research, and on the R&D expenditure per research scientist and engineer (RSE) respectively. Figure 9 graphically depicts the information contained in Table 15.

Table 14 Gross expenditure on R&D in the Australian higher education sector by field of research

Million A$ (1990 prices)

Field of research	1981	1984	1986	1987	1988	1990
Natural sciences	227.0	265.2	286.2	-	286.8	171.7
Engineering	67.6	83.5	104.4	-	115.8	240.0
Medical sciences	78.0	109.7	125.6	-	141.2	184.4
Agricultural sciences	44.4	44.4	53.0	-	52.3	61.8
Sub-total NSE	417.0	502.8	569.2	612.9	596.1	657.8
Social sciences	-	145.5	154.1	-	153.5	215.0
Humanities	-	80.3	95.1	-	95.2	88.2
Sub-total SSH	182.6	225.8	249.2	229.7	248.7	303.2
Total NSE + SSH	599.6	728.6	818.4	842.8	844.8	960.9

Source: OECD; Basic Science and Technology Statistics; Australian data derived from the ABS
Figures for 1988,1989 include all universities in the current Unified National System.

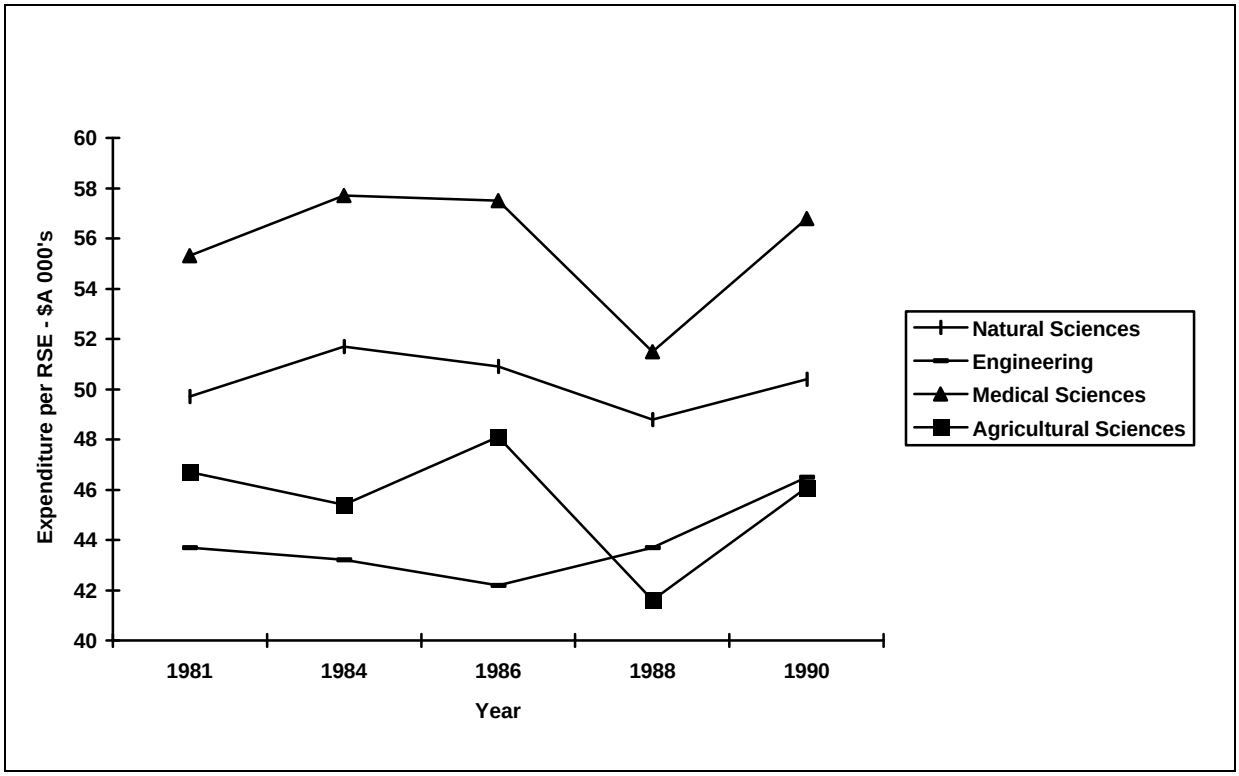
Table 15 Gross expenditure on R&D per research scientist and engineer (RSE) in the Australian higher education sector by field of research and year

A$ (1990 prices)

Field of research	1981	1984	1986	1987	1988	1990
Natural sciences	49 726	51 666	50 907	-	48 800	50 426
Engineering	43 669	43 242	42 182	-	43 682	46 503
Medical sciences	55 319	57 706	57 509	-	51 533	56 773
Agricultural sciences	46 688	45 445	48 094	-	41 640	46 119
Sub-total NSE	49 209	50 573	50 000	-	47 597	50 011
Social sciences	-	45 158	42 853	-	39 059	43 788
Humanities	-	35 993	36 105	-	33 240	33 897
Sub-total SSH	35 553	41 408	40 000	-	36 606	40 357
Total NSE + SSH	44 056	46 520	46 489	45 628	43 731	46 497

Figures for 1988, 1989 include all universities in the current Unified National System

Figure 9 Gross expenditure (in 1990 $'s) on R&D per research scientist and engineer (RSE) in the Australian higher education sector by field of research and year



All fields experienced substantial increases in gross expenditure on R&D during the period of interest - 1981-88 (Table 14). However, when the data are examined per RSE, the opposite effect is witnessed with the majority of fields experiencing a decline in funding per RSE between 1981 and 1988, and one field remaining constant (Electrical Engineering). This is in spite of escalating costs in many areas of science during the same time period (ASTEC, 1989; Palca, 1990).

An analysis of price movements for chemicals, periodicals, equipment and salaries serves to confirm the latter point for the field of Chemistry (Larkins, 1988, 1991). The major findings are listed below for a ten-year time period (1977-1987):

- the cost of periodicals in Chemistry increased over the ten-year period by 2.13 times;
- the cost of a parcel of eight chemicals increased by 1.54 times in real terms;
- average equipment costs rose in real terms by 1.35 times over the period;
- the salary of a university professor decreased by 12 percent over the ten-year period; and
- the cost of the *Journal of Chemical Physics* increased in real terms by 188 percent in the time period 1980-1990.

As Larkins (1990) notes

> *Lack of infrastructure resources results in a decrease in the quality of our postgraduate education and the quality of our chemical research. Ultimately our international economic competitiveness suffers.*

5.2 Discussion: Hypothesis 4

The total level of funding of research has increased across all fields over the time period 1984-1992. From 1978 to 1984, however, expenditure decreased for Applied Science/Engineering, Physics, and Agricultural Sciences. Across the period 1981 to 1990, there has been little change in the total research expenditure per research scientist and engineer, indicating no change in the intensity of the funding in spite of the obvious escalation of the real (inflation corrected) costs of research. The hypothesis receives partial support from this point of view.

The increasing 'sophistication factor' at the top-end of the scale of research equipment cannot be underestimated when examining this data. ASTEC (1989) made the point that restricted access to expensive facilities was a factor making it difficult for Australia to maintain a place in or near the leading edge of science. This is particularly the case in those disciplines such as Physics, Chemistry, Materials Science and Biotechnology, which are dependent on the use of specialised techniques (ASTEC, 1990). It is believed by many that Physics in Australia is being priced out of the market, with scientists forced into less expensive research activity, and away from the leading (and expensive) edge. Fields such as Optical Astronomy are at the point of dropping from the leading edge.

The sophistication factor, coupled with the devaluation of the Australian dollar, make the flat growth witnessed in Table 15 considerably worse than it may appear. However, apart from the increasing sophistication and cost of research equipment, the problem of lack of technical support in the major universities for such equipment is also concerning. Future large national research facilities should also take into account the provision of modest technical support as well as the provision of equipment in their requests for funds.

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