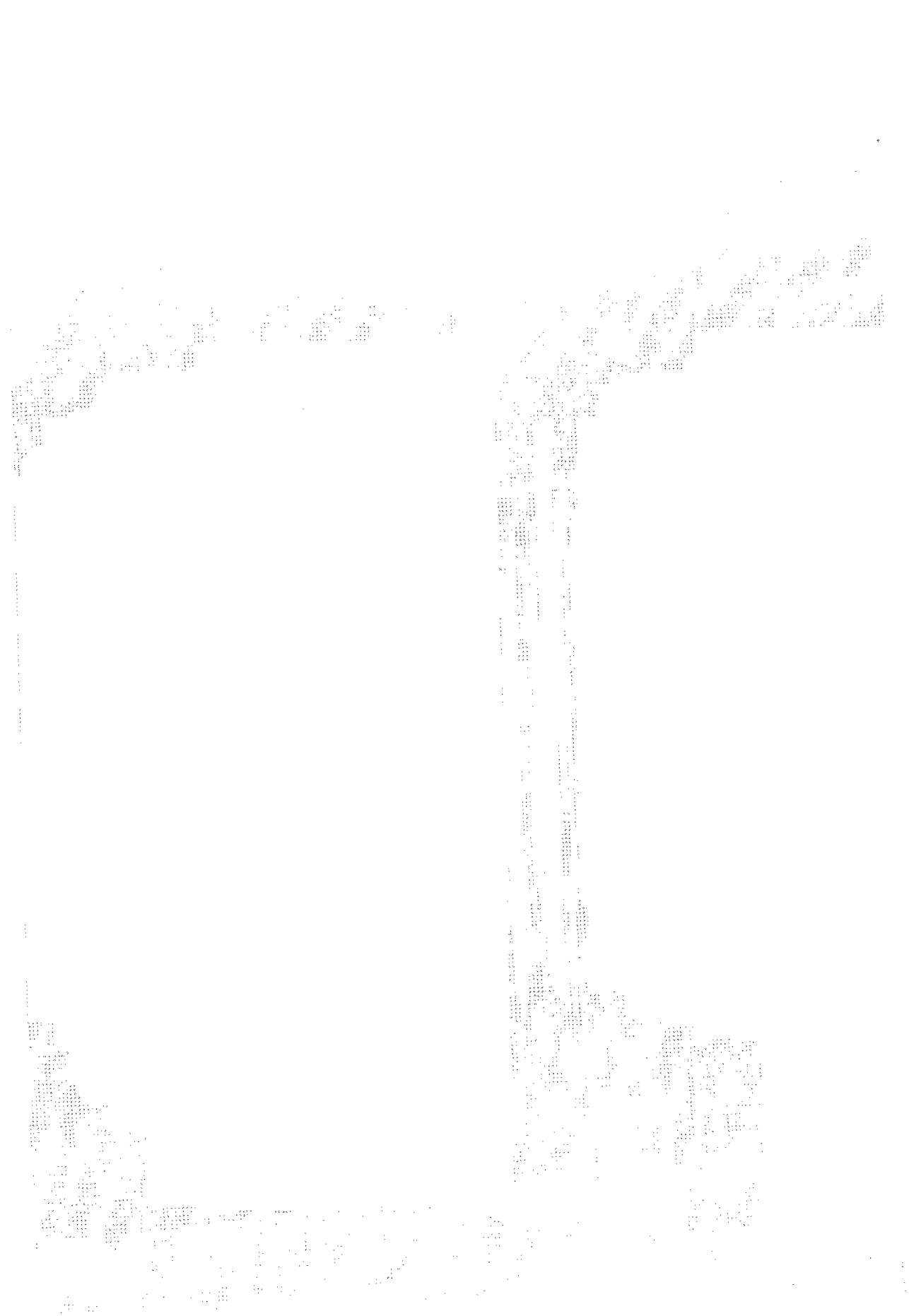
24 Science and technology



Introduction

Science and technology directly influence the strength and competitiveness of industry by providing a basis for technological change and thereby encouraging economic growth and development.

The Department of Industry, Science and Tourism is the key Commonwealth agency responsible for the development of science and technology policy in Australia. There are a number of other agencies, both Commonwealth and State, which have a direct interest in these policies, and in their interrelationships with other government policies relating to employment, education, industry, regional development, energy, communications and defence. There is also a range of social issues dependent on the spread of technology within Australia. These are the responsibilities of other Commonwealth and State departments.

Australia has a range of statistics relating to science and technology issues, most of which are compiled by the ABS and summarised in this chapter. There are a number of other indicators, notably patents and bibliometrics, which are compiled by the Department of Industry, Science and Tourism and reported in the Commonwealth Government's Science and Technology Statement. The latter indicators have not been included in this chapter. It concentrates on the input to Australia's research and development (R&D) effort, both in terms of the human resources devoted to R&D and the expenditure incurred in undertaking that activity. This emphasis reflects the priority given to this data source by analysts the world over.

R&D is one form of innovation. The creation of new or substantially improved products, the acquisition of new technology, and its implementation within the production processes within Australia, are other forms of innovative activity. The overall innovation process has been measured in two surveys undertaken in Australia during 1994 and 1995, the results of which are outlined in a Special Article.

In addition to these indicators there is considerable interest in the diffusion of technology throughout Australia, both in business and in the home. While there is only very limited information available on this topic in Australia, some work has been done on the spread of technology relating to information and telecommunications. A Special Article outlining the results of a household survey on the use of these goods and services in the home, has been included in *Chapter 23, Communications.*

Expenditure and human resources devoted to R&D

The statistics which follow are based on the OECD definitions for national R&D surveys. The OECD defines R&D to comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of people, culture and society, and the use of this stock of knowledge to devise new applications.

Statistics on the amount of expenditure and human resources devoted to R&D in the business enterprise sector are collected annually, in varying degrees of detail. Comparable statistics on the general government, higher education and private non-profit sectors are collected biennially. Tables 24.1, 24.2 and 24.3 summarise the latest statistics available for these four sectors.

Expenditure on R&D — how does Australia compare internationally?

The most commonly used indicator for comparison purposes is the ratio of expenditure on R&D to Gross Domestic Product. As table 24.4 shows, in 1994–95 Australia spent 1.61% of its GDP on R&D, ranking it slightly above Canada, but well below some of the leading industrialised countries such as Japan (2.90%), the United States (2.54%), France (2.38%), Finland (2.35%), Germany (2.33%) and the United Kingdom (2.19%).

In terms of business enterprise R&D, Australia's ratio of R&D expenditure to GDP (0.74%) is again below the ratios for the large industrialised countries referred to earlier, but is also lower than for Canada (0.91%).

In Government sector R&D as a percentage of GDP Australia ranks higher. A ratio to GDP of 0.43% places it fourth in the group of OECD member countries for which data are available, behind only Iceland (0.57%), France (0.50%) and Finland (0.44%). Government sector R&D

as a percentage of GDP is much larger for Australia than for Japan, the United States and the United Kingdom.

For the higher education sector, Australia also ranks quite highly. With a ratio to GDP of 0.40%, it ranks behind only Japan (0.59%), Finland and Germany (both 0.44%). However, the Australian ratio is very similar to the ratios for a number of other countries including the United States, France, the United Kingdom and Canada.

These statistics themselves provide the background to Australian Government policy in the R&D area. It has been focused on finding ways in which Australian firms can be encouraged to invest in their own R&D. The policies have had a positive impact, as the ratio of business enterprise R&D to GDP has increased over the past decade from about 0.34% to the 1994–95 level of 0.74%

24.1 EXPENDITURE ON R&D, At Current Prices

Sector	1986–87 $m	1987–88 $m	1988–89 $m	1990–91 $m	1992–93 $m	1994–95 $m
Business enterprises						
Private sector	1 165.1	1 388.2	1 649.1	1 896.1	2 609.8	3 051.3
Public sector	123.5	117.6	149.2	203.6	244.8	331.8
General government						
Commonwealth	786.5	797.0	869.6	1 034.0	1 151.1	1 178.4
State	368.4	394.6	482.7	670.0	667.6	786.3
Higher education	881.7	983.6	1 076.8	1 332.8	1 695.2	1 829.6
Private non-profit	49.1	53.9	53.3	85.4	101.2	143.7
Total	**3 374.3**	**3 734.9**	**4 280.7**	**5 221.9**	**6 469.7**	**7 321.1**

Source: Research and Experimental Development, All-Sector Summary, Australia (8112.0).

24.2 EXPENDITURE ON R&D, At Average 1989–90 Prices

Sector	1986–87 $m	1987–88 $m	1988–89 $m	1990–91 $m	1992–93 $m	1994–95 $m
Business enterprises						
Private sector	1 406.1	1 530.0	1 785.2	1 811.7	2 361.7	2 673.5
Public sector	141.3	129.6	159.7	190.8	220.5	298.6
General government						
Commonwealth	919.5	892.4	914.4	989.2	1 001.2	1 000.7
State	433.4	435.5	510.9	630.0	589.6	678.4
Higher education	1 044.5	1 121.8	1 166.1	1 312.5	1 608.6	1 651.5
Private non-profit	59.6	62.0	57.5	81.2	89.6	126.2
Total	**4 004.4**	**4 171.3**	**4 593.8**	**5 015.4**	**5 871.2**	**6 428.9**

Source: Research and Experimental Development, All Sector Summary, Australia (8112.0).

24.3 HUMAN RESOURCES DEVOTED TO R&D

Sector	1986–87 person years	1987–88 person years	1988–89 person years	1990–91 person years	1992–93 person years	1994–95 person years
Business Enterprises						
Private sector	16 198	16 952	19 206	19 158	20 665	23 116
Public sector	1 393	1 527	1 597	1 867	2 219	2 123
General government						
Commonwealth	11 529	11 491	10 863	10 670	11 020	10 562
State	6 796	7 133	8 335	8 990	8 779	8 572
Higher education	23 218	24 323	24 902	27 081	35 418	40 096
Private non-profit	945	1 016	1 023	1 282	1 370	1 692
Total	**60 079**	**62 442**	**65 926**	**69 048**	**79 470**	**86 162**

Source: Research and Experimental Development, All Sector Summary, Australia (8112.0).

24.4 EXPENDITURE ON R&D AS A PERCENTAGE OF GDP, OECD Countries — 1994–95

Country	Business %	Government %	Higher Education %	Total(a) %
Japan	1.91	0.26	0.59	2.90
United States	1.80	0.27	0.38	2.54
France	1.47	0.50	0.38	2.38
Finland	1.46	0.44	0.44	2.35
Germany	1.54	0.36	0.44	2.33
United Kingdom	1.43	0.30	0.38	2.19
Australia	**0.74**	**0.43**	**0.40**	**1.61**
Canada	0.91	0.25	0.39	1.57
Iceland	0.43	0.57	0.34	1.40
Italy	0.67	0.27	0.25	1.19
Spain	0.47	0.18	0.27	0.93

(a) Includes Private Non-Profit.

Source: Research and Experimental Development, Business Enterprises (Inter Year Survey), Australia (8114.0); and Research and Experimental Development, General Government and Private Non-Profit Organisations, Australia (8109.0).

Sources of funds for expenditure on R&D

In 1994–95, 93% of funding for R&D carried out by businesses came from the business sector, and it has remained at about this level since 1988–89. General government organisations provided 3% of funding for business R&D expenditure.

About 55% (down from 57% in 1992–93) of general government sector R&D was funded by Commonwealth Government organisations and 31% (up from 29%) by State Government organisations.

About 89% (down from 91% in 1992–93) of higher education R&D funding came from the Commonwealth Government. About 2% came from State Governments, and business enterprises provided 3%.

Commonwealth government organisations funded 30% of the R&D of the private non-profit sector in 1994–95 (down from 34% in 1992–93), while the contribution by State Governments was 16% (up from 13% in 1992–93).

Tables 24.5 and 24.6 show the data for 1992–93 and 1994–95 supporting the above analysis.

24.5 EXPENDITURE ON R&D, Sector by Source of Funds — 1992–93

Sector	Commonwealth government $'000	State government $'000	Business enterprises $'000	Private non-profit and other Australian(a) $'000	Overseas $'000	Total $'000
Business enterprises						
Private sector	n.p.	n.p.	2 460 985	7 851	85 823	2 609 759
Public sector	n.p.	n.p.	229 850	7 479	—	244 771
General government						
Commonwealth	988 008	11 703	74 688	62 757	13 971	1 151 127
State	56 456	509 303	28 968	69 146	3 768	667 641
Higher education	1 544 754	34 771	41 684	63 488	10 512	1 695 209
Private non-profit	33 941	12 750	6 930	44 302	3 312	101 236
Total	**2 677 163**	**577 065**	**2 843 105**	**255 023**	**117 387**	**6 469 744**

(a) Includes funds provided via government levies.

Source: Research and Experimental Development, All Sector Summary, Australia (8112.0).

24.6 EXPENDITURE ON R&D, Sector by Source of Funds — 1994–95

Sector	Commonwealth government $'000	State government $'000	Business enterprises $'000	Private non-profit and other Australian(a) $'000	Overseas $'000	Total $'000
Business enterprises						
Private sector	n.p.	n.p.	2 814 094	34 622	109 936	3 051 279
Public sector	n.p.	n.p.	321 499	397	—	331 846
General government						
Commonwealth	1 006 787	11 401	85 341	63 044	11 821	1 178 394
State	68 685	591 057	44 250	78 405	3 885	786 282
Higher education	1 633 713	42 204	63 940	71 224	18 500	1 829 580
Private non-profit	43 035	22 708	14 034	60 142	3 799	143 718
Total	**2 842 218**	**679 949**	**3 343 158**	**307 834**	**147 941**	**7 321 099**

(a) Includes funds provided via government levies.

Source: Research and Experimental Development, All Sector Summary, Australia (8112.0).

Business sector

Business expenditure on R&D in Australia in 1994–95 (table 24.7) increased by 10% over 1993–94, with an increase of 7% in human resources devoted to R&D.

Expenditure on R&D increased in all industries other than Mining (down 26%), Wood and paper product manufacturing (down 26%), Wholesale and retail trade (down 11%) and Finance and insurance (down 8%). The largest increases occurred in Property and business services ($103m, 3%), Electronic and electrical equipment and appliance manufacturing ($80m, 21%), and Motor vehicle and part and other transport equipment manufacturing ($68m, 25%).

24.7 R&D BY BUSINESS ENTERPRISES

Industry of enterprise	Enterprises			Expenditure on R&D			Effort on R&D		
	1992–93	1993–94	1994–95	1992–93	1993–94	1994–95	1992–93	1993–94	1994–95
	no.	no.	no.	$m	$m	$m	person years	person years	person years
Mining (including services to mining)	91	85	92	176.3	326.5	241.6	850	838	825
Manufacturing									
Food, beverage and tobacco	125	130	178	136.1	140.2	141.6	1 141	1 156	1 131
Textile, clothing, footwear and leather	50	50	60	16.3	17.0	26.9	148	170	197
Wood and paper product	29	31	43	44.4	103.0	76.5	249	224	253
Printing, publishing and recorded media	34	34	44	14.3	10.8	15.1	140	121	174
Petroleum, coal, chemical and associated product	317	306	356	290.8	272.2	309.8	2 123	2 175	2 400
Non-metallic mineral product	48	50	77	31.3	31.3	45.3	299	274	427
Metal product	178	176	235	336.5	294.2	309.5	1 773	1 763	1 970
Motor vehicle and part and other transport equipment	112	125	145	307.7	269.8	338.1	1 694	1 918	2 014
Photographic and scientific equipment	96	108	113	96.5	102.6	123.0	931	989	1 102
Electronic and electrical equipment and appliance	458	444	448	344.1	371.5	451.0	3 483	3 783	4 108
Industrial machinery and equipment	241	249	288	65.2	72.2	73.5	786	835	907
Other manufacturing	58	62	93	10.9	14.6	18.3	147	161	233
Total manufacturing	1 746	1 765	2 080	1 694.1	1 699.5	1 928.6	12 912	13 568	14 914
Other industries									
Wholesale and retail trade	260	263	263	224.1	221.0	196.4	1 716	1 745	1 662
Finance and insurance	27	28	34	119.7	113.0	103.4	1 463	1 175	923
Property and business services	527	574	651	363.0	442.6	545.9	3 644	4 044	4 668
Scientific research	66	70	74	84.0	87.1	114.1	812	805	961
Other n.e.c.	118	108	127	193.3	179.4	253.0	1 487	1 333	1 287
Total other industries	998	1 043	1 149	984.1	1 043.0	1 212.8	9 122	9 101	9 500
Total all industries	**2 835**	**2 893**	**3 321**	**2 854.5**	**3 069.0**	**3 383.1**	**22 883**	**23 507**	**25 240**
Private sector contribution	2 792	2 858	3 273	2 609.8	2 835.7	3 051.3	20 665	21 402	23 116
Public sector contribution	43	35	48	244.8	233.3	331.8	2 219	2 105	2 123

Source: Research and Experimental Development, Business Enterprises (Inter Year Survey), Australia (8114.0).

In terms of socio-economic objectives (table 24.8), most business sector R&D was directed towards Economic development ($3,039m or 90%). Of this, $1,836m was directed towards Manufacturing and $517m towards Information and communication services. About 4% was directed towards Defence and 2% each towards Society, Environment and Advancement of knowledge.

24.8 RESOURCES DEVOTED TO R&D BY BUSINESS ENTERPRISES — 1994–95

	Type of expenditure				
	Capital expenditure $'000	Labour costs $'000	Other current expenditure $'000	Total $'000	Human resources person years
Defence	5 224	44 717	90 029	139 969	674
Economic development					
Plant — production and primary products	1 453	13 029	14 174	28 656	275
Animal — production and primary products	2 575	12 038	20 838	35 451	219
Mineral resources (excl. energy)	39 175	43 115	119 857	202 147	819
Energy resources	22 863	31 851	72 074	126 788	506
Energy supply	39 836	26 818	50 816	117 470	466
Manufacturing	219 251	744 352	872 687	1 836 290	13 848
Construction	5 626	16 907	11 463	33 995	352
Transport	2 075	35 443	23 883	61 401	586
Information and communication services	37 888	304 767	174 561	517 215	4 931
Commercial services	9 136	38 130	22 398	69 663	660
Economic framework	2 173	4 730	2 948	9 851	76
Total economic development	382 052	1 271 179	1 385 697	3 038 928	22 740
Society					
Health	4 881	23 412	24 289	52 583	471
Education and training	342	3 742	1 162	5 246	83
Social development and community services	944	6 610	5 352	12 906	152
Total society	6 167	33 764	30 803	70 734	706
Environment					
Environmental knowledge	6 863	11 613	12 981	31 458	254
Environmental aspects of economic development	3 591	10 089	13 882	27 561	198
Environmental management and other aspects	4 270	7 775	8 893	20 938	150
Total environment	14 724	29 477	35 756	79 957	603
Advancement of knowledge	6 039	30 925	16 572	53 537	517
Total	**414 207**	**1 410 062**	**1 558 857**	**3 383 125**	**25 240**

Source: Research and Experimental Development, Business Enterprises (Inter Year Survey), Australia (8114.0).

General government sector

Expenditure on R&D carried out by government organisations in Australia in 1994–95 was estimated to be $1,965m at current prices, an increase of 8% over expenditure in 1992–93. At average 1989–90 prices, expenditure in 1994–95 increased by 6% compared with 1992–93 (tables 24.1 and 24.2).

The socio-economic objectives on which most government R&D expenditure was carried out were: Economic development ($1,041m), Environment ($370m) and Society ($258m) (table 24.9). Within Economic development, the main objectives were Animal production and primary products ($268m), Plant production and primary products ($270m) and Manufacturing ($223m). Much the same pattern applies in terms of the human resources devoted to R&D (table 24.10). Labour costs continue to be the main component of R&D expenditure (46%), down from 50% in 1992–93.

24.9 EXPENDITURE ON R&D BY GENERAL GOVERNMENT ORGANISATIONS — 1994–95

	Type of expenditure				
Socio-economic objective	Land and buildings $'000	Other capital expenditure $'000	Labour costs $'000	Other current expenditure $'000	Total $'000
Defence	13 348	26 269	95 416	88 065	223 099
Economic development					
Plant — production and primary products	21 485	15 880	126 788	105 811	269 964
Animal — production and primary products	22 846	10 903	124 557	109 649	267 955
Mineral resources (excluding energy)	1 232	7 084	30 874	28 859	68 049
Energy resources	1 004	4 288	23 221	31 147	59 660
Energy supply	605	3 673	14 509	8 370	27 157
Manufacturing	12 930	15 103	109 536	85 383	222 951
Construction	233	2 241	16 317	12 318	31 109
Transport	356	1 991	8 721	7 279	18 347
Information and communication services	2 116	3 928	17 943	13 281	37 269
Commercial services	148	1 141	5 714	3 464	10 468
Economic framework	72	2 168	16 807	8 979	28 027
Total economic development	63 027	68 401	494 987	414 540	1 040 955
Society					
Health	27 156	18 604	96 804	66 787	209 350
Education and training	131	335	4 330	2 632	7 429
Social development and community services	1 015	1 450	20 339	18 322	41 125
Total society	28 302	20 389	121 473	87 741	257 904
Environment					
Environmental knowledge	8 517	14 153	83 848	99 980	206 497
Environmental aspects of economic development	4 709	7 252	54 119	42 330	108 409
Environmental management and other aspects	1 627	3 591	24 556	25 439	55 212
Total environment	14 852	24 995	162 522	167 748	370 118
Advancement of knowledge					
Natural sciences, technologies and engineering	2 724	7 192	30 421	29 336	69 674
Social sciences and humanities	358	171	1 608	788	2 925
Total advancement of knowledge	3 082	7 363	32 029	30 125	72 599
Total	**122 613**	**147 417**	**906 427**	**788 219**	**1 964 676**

Source: Research and Experimental Development, General Government and Private Non-Profit Organisations, Australia (8109.0).

24.10 HUMAN RESOURCES DEVOTED TO R&D BY GENERAL GOVERNMENT ORGANISATIONS — 1994–95

	Type of employee			
Socio-economic objective	Researchers person years	Technicians person years	Other supporting staff person years	Total person years
Defence	1 226	554	229	2 009
Economic development				
Plant — production and primary products	1 103	1 178	469	2 750
Animal — production and primary products	968	1 034	664	2 667
Mineral resources (excluding energy)	239	202	148	588
Energy resources	220	198	76	494
Energy supply	112	73	49	234
Manufacturing	743	772	564	2 079
Construction	91	122	94	306
Transport	95	33	25	152
Information and communication services	159	103	79	341
Commercial services	57	21	22	101
Economic framework	224	57	58	340
Total economic development	4 011	3 793	2 247	10 051
Society				
Health	1 458	859	303	2 620
Education and training	66	16	21	103
Social development and community services	272	50	67	388
Total society	1 796	924	392	3 112
Environment				
Environmental knowledge	726	678	327	1 731
Environmental aspects of economic development	322	432	287	1 042
Environmental management and other aspects	246	184	79	509
Total environment	1 294	1 294	693	3 281
Advancement of knowledge				
Natural sciences, technologies and engineering	328	205	108	641
Social sciences and humanities	25	10	5	39
Total advancement of knowledge	353	215	113	680
Total	**8 680**	**6 780**	**3 674**	**19 134**

Source: Research and Experimental Development, General Government and Private Non-Profit Organisations, Australia (8109.0).

Higher education sector

Estimated expenditure on R&D carried out in Australia by the higher education sector in 1994 was $1,830m, an increase of 8% over expenditure in 1992. At average 1989–90 prices, expenditure increased by 3% over this period (tables 24.1 and 24.2).

Table 24.11 shows that the socio-economic objectives on which most higher education expenditure was carried out in 1994 were Advancement of knowledge ($881m) and Society ($448m). Within the latter, Health accounted for $306m, or 17% of total R&D expenditure.

Direct labour costs accounted for 50% of total expenditure.

Table 24.12 shows the human resources devoted to R&D in terms of socio-economic objective, by type of employee.

24.11 EXPENDITURE ON R&D BY HIGHER EDUCATION ORGANISATIONS — 1994

	Type of expenditure					
Socio-economic objective	Land and buildings $'000	Other capital expenditure $'000	Direct labour costs $'000	Scholarships $'000	Other current expenditure $'000	Total $'000
Defence	114	797	2 096	285	1 544	4 836
Economic development						
Plant — production and primary products	5 185	3 500	22 089	2 253	19 962	52 988
Animal — production and primary products	4 566	1 721	15 984	2 098	15 813	40 183
Mineral resources (excluding energy)	1 091	2 323	8 846	1 529	11 887	25 676
Energy resources	742	1 050	4 080	877	5 065	11 814
Energy supply	439	2 292	7 326	847	6 794	17 698
Manufacturing	2 534	9 080	32 935	3 728	27 165	75 442
Construction	536	2 350	13 583	1 348	9 836	27 652
Transport	71	410	2 205	262	1 882	4 831
Information and communication services	404	3 327	18 433	911	13 465	36 541
Commercial services	369	340	4 518	283	2 675	8 185
Economic framework	1 534	2 419	39 921	1 440	27 699	73 013
Total economic development	17 471	28 812	169 919	15 577	142 242	374 022
Society						
Health	3 566	14 343	159 630	9 781	118 427	305 748
Education and training	2 512	2 851	49 882	1 463	33 063	89 771
Social development and community services	504	2 052	29 727	1 329	19 365	52 976
Total society	6 582	19 247	239 238	12 574	170 855	448 496
Environment						
Environmental knowledge	1 419	5 954	38 819	2 843	32 268	81 303
Environmental aspects of economic development	950	1 137	10 005	842	7 960	20 894
Environmental management and other aspects	523	1 845	8 024	947	7 564	18 903
Total environment	2 892	8 936	56 847	4 632	47 792	121 099
Advancement of knowledge						
Natural sciences, technologies and engineering	15 500	51 007	296 843	26 146	226 904	616 401
Social sciences and humanities	5 374	8 237	148 257	7 940	94 919	264 727
Total advancement of knowledge	20 874	59 245	445 100	34 087	321 822	881 128
Total	**47 933**	**117 037**	**913 201**	**67 154**	**684 255**	**1 829 580**

Source: Research and Experimental Development, Higher Education Organisations, Australia (8111.0).

24.12 HUMAN RESOURCES DEVOTED TO R&D BY HIGHER EDUCATION ORGANISATIONS — 1994

	Type of employee			
Socio-economic objective	Academics person years	Postgraduates person years	Supporting staff person years	Total person years
Defence	20	75	20	115
Economic development				
Plant — production and primary products	187	452	254	893
Animal — production and primary products	183	419	202	805
Mineral resources (excluding energy)	107	231	80	418
Energy resources	57	130	32	218
Energy supply	74	233	87	394
Manufacturing	350	970	338	1 659
Construction	151	431	103	685
Transport	25	53	24	102
Information and communication services	232	456	194	882
Commercial services	60	71	23	154
Economic framework	574	749	216	1 539
Total economic development	2 001	4 196	1 553	7 749
Society				
Health	1 674	2 371	1 635	5 680
Education and training	674	1 493	291	2 458
Social development and community services	412	781	173	1 366
Total society	2 760	4 646	2 099	9 505
Environment				
Environmental knowledge	409	1 201	356	1 966
Environmental aspects of economic development	103	226	94	423
Environmental management and other aspects	96	240	72	408
Total environment	609	1 667	521	2 797
Advancement of knowledge				
Natural sciences, technologies and engineering	2 934	6 389	2 883	12 206
Social sciences and humanities	1 906	5 070	748	7 724
Total advancement of knowledge	4 840	11 459	3 631	19 930
Total	**10 230**	**22 042**	**7 824**	**40 096**

Source: Research and Experimental Development, Higher Education Organisations, Australia (8111.0).

Private non-profit sector

Expenditure on R&D carried out by private non-profit organisations in 1994–95 ($144m) increased by 42% at current prices and 41% at average 1989–90 prices over 1992–93 expenditure (tables 24.1 and 24.2).

Health was the leading socio-economic objective for R&D expenditure of the private non-profit sector, accounting for 79% or $114m of its total R&D expenditure in 1994–95. The same was true for human resource usage. Labour costs continued to be the main component of R&D expenditure (47%) (table 24.13).

Table 24.14 shows the human resources devoted to R&D in terms of socio-economic objective, by type of employee.

24.13 EXPENDITURE ON R&D BY PRIVATE NON-PROFIT ORGANISATIONS — 1994–95

	Type of expenditure				
Socio-economic objective	Land and buildings $'000	Other capital expenditure $'000	Labour costs $'000	Other current expenditure $'000	Total $'000
Defence	—	—	—	—	—
Economic development	180	222	3 070	2 550	6 022
Society					
Health	15 835	5 735	52 036	40 384	113 989
Education and training	486	211	4 159	3 299	8 155
Social development and community services	11	86	1 161	855	2 114
Total society	16 332	6 032	57 356	44 537	124 258
Environment	80	219	1 809	1 081	3 188
Advancement of knowledge	101	739	5 566	3 843	10 249
Total	**16 694**	**7 213**	**67 801**	**52 011**	**143 718**

Source: Research and Experimental Development, General Government and Private Non-Profit Organisations, Australia (8109.0).

24.14 HUMAN RESOURCES DEVOTED TO R&D BY PRIVATE NON-PROFIT ORGANISATIONS — 1994–95

	Type of employee			
Socio-economic objectives	Researchers person years	Technicians person years	Other supporting staff person years	Total person years
Defence	—	—	—	—
Economic development	53	10	11	74
Society				
Health	711	449	172	1 332
Education and training	41	14	22	77
Social development and community services	21	2	7	30
Total society	773	466	200	1 439
Environment	46	4	9	58
Advancement of knowledge	58	48	14	121
Total	**930**	**528**	**235**	**1 692**

Source: Research and Experimental Development, General Government and Private Non-Profit Organisations, Australia (8109.0).

Official organisations and administration

There are many organisations in Australia concerned in some way with the development of science and technology.

The Commonwealth Government's commitment to science and technology is reflected in the functions of the Department of Industry, Science and Tourism. The Department is concerned with the development and maintenance of Australia's scientific and technological capability.

A number of other Commonwealth government organisations either support or carry out scientific and technological activities. State Governments are also involved in science and technology through State government departments, science and technology councils and other organisations. Non-government organisations participating in scientific and technological activities include higher education institutions, professional and learned bodies, private organisations and industry groups.

Department of Industry, Science and Tourism

The Department, responsible for the majority of federally supported technology and industry development programs, has recently undergone a major restructuring, including the reduction of its four Departmental Groups to three. One of the Groups, the Science and Technology Group, covers the Office of AusIndustry, including the

Industry Research and Development Board programs, the Science and Technology Division and the Australian Industrial Property Organisation. The Science and Technology Division, comprising the Science and Technology Policy Branch, the National Science and Technology Programs Branch, the International Science and Technology Branch and the Science and Technology Advisory Branch, is responsible for science and technology strategy, policy, analysis and awareness. It is responsible, inter alia, for the preparation of the annual Science and Technology Budget Statement.

The Department, through AusIndustry, administers the tax concession for research and development scheme and the Strategic Assistance for Research and Development (START) Program. The scientific and technological bodies of the portfolio include the Commonwealth Scientific and Industrial Research Organisation, the Australian Nuclear Science and Technology Organisation and the Australian Institute of Marine Science.

R&D Tax Concession Program

The tax concession for R&D, which commenced from July 1985, is the focus of one of the major programs in the Government's package of measures to encourage R&D in Australia.

The concession allows companies incorporated in Australia, public trading trusts and partnerships of eligible companies, to deduct up to 125% (prior to 21 August 1996, 150%) of eligible expenditure on R&D activities when lodging their corporate tax returns.

Expenditure eligible under the scheme includes: salaries, wages and other overhead costs which are directly related to the company's Australian R&D activities; contract expenditure; and capital expenditure on R&D plant and equipment (over three years). Expenditure on acquiring, or acquiring the right to use, technology for the purposes of the company's own R&D activities is 100% deductible.

The R&D projects must also satisfy a requirement for adequate Australian content. In addition the results of the R&D must be exploited on normal commercial terms and to the benefit of Australia.

To attract the tax concession deduction, annual eligible R&D expenditure must exceed $20,000. Where R&D is contracted to either an approved Registered Research Agency (RRA) or a Cooperative Research Centre (CRC) this expenditure threshold is waived.

Strategic Assistance for Research and Development Program

The Strategic Assistance for Research and Development (R&D START) Program replaced the R&D Syndication Program. It encompasses and builds upon other R&D support measures to provide a flexible package of assistance to industry for research, development and commercialisation.

The program, with total funding of $520m over four years, complements the R&D Tax Concession Program.

Existing R&D grants and loans continue as part of the program, but are refocused on projects by small and medium enterprises with a total project value of less than $2m.

R&D START meets the need for a program capable of funding larger projects, with more flexible funding arrangements, and aims to:

- provide a new competitive R&D scheme to replace the R&D Syndication Program;
- provide a mix of support measures based on large grants, loans and interest rate subsidies; and
- develop additional new market-based support measures in further consultation with industry.

There are three rounds of grants each year (every four months) to provide a timely response to companies in areas of rapidly developing technologies and markets.

The Industry Research and Development Board has flexibility to vary the combination of support to take account of variations in spillovers, closeness to market, nature of the technology and capacity to attract private finance. The basic elements are grants, loans which will normally be at commercial rates but may have repayment deferred, and interest subsidies to lenders who participate in the financing of the projects.

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

CSIRO was established as an independent statutory authority by the *Science and Industry Research Act 1949*, which has been amended on a number of occasions since then. Its primary role is as an applications-oriented research organisation in support of major industry sectors and selected areas of community interest, with a strong commitment to the effective transfer of its results to users.

Briefly, CSIRO's primary statutory functions are to:

- carry out scientific research for the benefit of Australian industry, the community, national objectives, national or international responsibilities, or for any other purpose determined by the Minister; and
- encourage or facilitate the application or utilisation of the results of such research.

Other functions include dissemination and publication of scientific information, international liaison in scientific matters, and provision of services and facilities.

CSIRO's work is planned and prioritised on a sectoral basis and conducted through core business units — CSIRO Divisions. External advice on research priorities is channelled through Sector Advisory Committees. Each sector represents an industry group, market, or natural resource of national significance. There are 22 Sectors covering research in five broad groupings:

- *Agribusiness* — Field Crops; Food processing; Forestry, wood and paper industries; Horticulture; Meat, dairy and aquaculture; Wool and textiles.
- *Environment and Natural Resources* — Biodiversity; Climate and atmosphere; Land and water; Marine.
- *Information Technology, Infrastructure and Services* — Information technology and telecommunications; Infrastructure; Measurement standards; Radio astronomy; Services.
- *Manufacturing* — Chemicals and plastics; Integrated manufactured products; Pharmaceuticals and human health.
- Minerals and Energy — Coal and energy; Mineral exploration and mining; Mineral processing and metal production; Petroleum.

CSIRO has a staff of approximately 7,000 in more than 70 locations throughout Australia. About one-third of the staff are professional scientists, with the others providing technical, administrative or other support. CSIRO's budget for 1995–96 was $660m, of which $417m was provided directly by the Commonwealth Government.

See *Chapter 16, Mining* for information on the research and development activities of the CSIRO.

Australian Nuclear Science and Technology Organisation (ANSTO)

ANSTO was established as a statutory authority under the *Australian Nuclear Science and Technology Organisation Act 1987* No.3 as amended, and replaced the Australian Atomic Energy Commission. Its mission is to benefit the Australian community by the development and peaceful application of nuclear science and technology in industry, medicine, agriculture, science and other fields.

Australian Institute of Marine Science (AIMS)

AIMS is one of Australia's key research agencies and the only one committed primarily to marine research, with emphasis on tropical marine science. The Institute is a federally funded statutory authority governed by a specialist Council appointed by the Australian Government. It was established in 1972 and has its headquarters at Cape Ferguson, 50 km south of the coastal city of Townsville. More recently a laboratory has been established in Dampier, Western Australia.

The Institute's objectives are to promote the conservation and sustainable development of Australia's marine resources and to support internationally competitive Australian industries. Since it was set up, AIMS has established itself in strategic basic marine science supporting both public and private interests, targeting problems that are difficult and are not being addressed by any other agency. The Institute has built strong links to Australian industry and to the wider

Asia–Pacific region; established a long term environmental monitoring program and built skills and knowledge in resource assessment, especially in tropical mangrove and coral reef systems; and it is recognised as a leader in setting environmental assessment standards.

The research and development program is focused on research relating to the tropical coast and continental shelf and the development and application of technology to problems in this zone. Much of it involves long-term research which is geared towards an improved understanding of marine systems and the development of a capability to predict the behaviour of complex tropical marine systems. Priority areas include improving our understanding of the impacts of natural and human-induced changes in the marine environment, assessment of living marine resources and marine biotechnology (e.g. pharmaceuticals). These efforts sit within the following strategic directions:

- *Understanding the marine environment* — physical behaviour of the oceans; nutrient pathways; global climate change; impacts of cyclones and river run-off.
- *Marine resources assessment* — taxonomy, distribution and abundance of key tropical faunas, especially coral reefs, mangroves and fish.
- *Ecologically sustainable development of marine resources* — predicting long term changes in coral reefs; environmental impacts on coastal ecosystems.
- *Marine biodiversity* — evolution; genetic structure; discovery of bio-active compounds for drug development; linkages between populations (replenishment).
- *New marine research technologies* — underwater computing; micro-environment recording; laser technology; links between basic science and industrial applications (e.g. oil spill prediction).

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Additional information

Additional information on topics presented in this chapter may be found in the annual reports of the organisations mentioned, particularly the Department of Industry, Science and Tourism and the CSIRO, and in the annual Science and Technology Statements. Statistical information on R&D for the years 1968–69, 1973–74 and 1976–77 may be found in the reports on Project SCORE published by the (then) Department of Science. Statistical information on R&D relating to 1978–79, 1981–82, and 1984–85 to 1994–95 may be obtained from the Australian Bureau of Statistics. Further statistical information on higher education is obtainable from the Department of Employment, Education, Training and Youth Affairs.

The Department of Industry, Science and Tourism's Australian Science and Innovation Resources Brief 1994 uses science and technology indicators to give a good overview and analysis of science and technology information in Australia. It presents information on R&D effort and expenditure; the science and technology work force; science and technology information resources; scientific equipment and facilities; patent activity; technology training; financial support for technological development; and the transfer of technical knowledge.

Additional information on some technology related issues, particularly on the use of information technology in the home, may be found in *Chapter 23, Communications.*

Understanding the innovation process in manufacturing

Innovation is accepted as one of the important factors stimulating economic and employment growth in Australia and helping Australian businesses compete in international markets. To enhance business growth and competitiveness, government aims to encourage and assist businesses to be innovative. Information about the innovation process is vital to the development and evaluation of government policy in this area. Until recently little was known about the likelihood of a business to be innovative, or about the reasons why a business does or does not undertake innovation.

The ABS conducted its first innovation survey in respect of 1993–94, gathering some basic information about the innovation process in Australia. The survey, which followed international guidelines for the conduct of innovation surveys, focused mainly on technological innovation, that is technologically new, or substantially changed, products or new, or substantially changed, processes. It measured the innovation status of businesses (i.e. their propensity to undertake innovation) over a three year period (1991–92 to 1993–94). The ABS also sought some information about non-technological innovation, that is innovation in organisational and managerial aspects, and broadened the survey's scope to collect information about the rate of innovation in the services sector.

This article presents some findings from the ABS survey regarding technological innovation in the manufacturing sector, in terms of the sources for the impetus to innovate and the reasons why some businesses choose to be innovative while others do not. Differences in the innovation process between small businesses (less than 20 employees), medium sized businesses (between 20 and 99 employees) and large businesses (100 or more employees) are highlighted.

What proportion of manufacturers innovate?

The survey showed that only one third of manufacturers in Australia were technologically innovative. The likelihood that a business was innovative appears to be strongly related to the employment size of the business. Large businesses were more than twice as likely to be innovative as small businesses. Also, compared to small businesses, a higher proportion of large businesses were innovative in relation to both products and processes (table S4.1).

S4.1 PROPORTION OF MANUFACTURERS UNDERTAKING TECHNOLOGICAL INNOVATION

	Innovation type			
Business size	Product only %	Process only %	Product and process %	**Total undertaking technological innovation %**
Small	10.7	3.4	15.0	**29.1**
Medium	10.0	6.0	37.8	**53.9**
Large	12.8	7.8	58.7	**79.3**
All	10.7	3.8	19.2	**33.7**

Source: Innovation in Australian Manufacturing (8116.0), unpublished data.

Although a minority of manufacturers reported undertaking innovation, over 70% of the manufacturing workforce is employed by businesses undertaking technological innovation. This proportion increases from one third of the manufacturing workforce employed by small businesses, to over half that employed by medium sized business, and over 85% of that employed by large businesses. The overall proportion is considerably higher than the proportion of businesses innovating (table S4.1) due to the strong positive correlation between

employment size and the proportion of innovators. The number of workers directly involved in innovation is not known.

The degree of influence of other business characteristics on the overall proportion of businesses undertaking technological innovation is difficult to quantify. If the likelihood that a business has a particular characteristic is related to employment size, then the effects of employment size and the other characteristic are difficult to separate. Of note are those characteristics which increase the exposure of a business to overseas market influences — such as export status, foreign ownership and foreign competitors. For example, the proportion of exporters undertaking technological innovation was almost 70% compared to only 25% for non-exporters. However, while the difference in the proportions of businesses innovating, between exporters and non-exporters is around 40% for small businesses, it drops to 20% for large businesses. It appears that exporter status has less influence on the propensity to be innovative as employment size increases. These relationships are shown in table S4.2.

S4.2 PROPENSITY TO INNOVATE, By Characteristic and Size of Business

	Business size			
	Small %	Medium %	Large %	All %
Exporter	64.5	69.8	85.0	68.8
Non-exporter	24.3	42.4	65.7	26.3
Foreign owned	27.7	73.0	93.5	51.1
Australian owned	37.3	70.5	88.9	42.4
Main competitor — foreign	32.0	54.2	78.4	36.7
Main competitor — Australian	50.0	68.4	85.1	56.9

Source: Innovation in Australian Manufacturing (8116.0), unpublished data.

Reasons for not innovating

A range of reasons was given by manufacturers for not undertaking technological innovation. However it is not known how many manufacturers do not even consider undertaking innovation. Only one quarter of manufacturers, both innovators and non-innovators, reported that there were factors which hampered their innovative activity. The two main factors were a lack of finance and the high cost of innovation. Other significant hindrances reported included a lack of skilled personnel; difficulty controlling the costs associated with the innovation; long pay back period; legislation, regulations, standards and taxation; and excessive perceived risk.

While financial considerations appear to be the main factors hampering technological innovation in the manufacturing sector, small businesses reported these factors to be more significant hindrances than larger businesses. Also, the other factors appeared to be less important to small businesses than to larger businesses. There was no consistent pattern in the views of innovators compared to non-innovators about the significance of any of the factors in hampering technological innovation.

On the other hand, a number of factors were reported as being unimportant in hindering technological innovation. The majority of businesses indicated that their earlier innovations did not remove the need for future innovation. As shown in table S4.3, about half of the businesses considered many other factors to be unimportant.

S4.3 FACTORS HAMPERING INNOVATION, Proportion of Manufacturers Rating Them as Unimportant

	Business size			
	Small %	Medium %	Large %	All %
Lack of skilled personnel	43.3	19.3	15.0	37.0
Lack of information on technologies	51.0	33.7	24.9	46.0
Lack of information on markets	48.9	35.0	31.0	45.2
Deficiencies in the availability of external technical services	59.0	47.2	41.1	55.6
Lack of opportunity for cooperation with other companies and scientific/technological organisations	61.6	52.2	50.6	59.2
Innovation costs hard to control	40.9	31.7	32.8	38.7
Resistance to change in the business	64.7	38.0	24.4	57.0
Excessive perceived risk	41.2	32.0	28.2	38.6
Lack of appropriate sources of finance	27.4	28.7	36.6	28.3
Innovation costs too high	28.8	27.4	24.9	28.3
Pay back period of innovation too long	41.5	34.0	25.1	38.9
Lack of technological opportunities	65.2	50.3	46.6	61.2
No need to innovate due to earlier innovations	77.2	73.8	68.2	75.9
Innovation too easy to copy	58.3	59.5	54.3	58.2
Legislation, regulations, standards, taxation	46.2	45.5	44.4	45.9
Lack of customer responsiveness to new products and processes	49.7	44.8	43.1	48.3
Uncertainty in timing of innovation	55.6	49.7	39.4	53.3

Source: Innovation in Australian Manufacturing (8116.0), unpublished data.

Given the financial hindrances associated with innovation, the actual amount spent on innovation is of interest. Table S4.4 shows, for businesses undertaking technological innovation, the sales and the innovation costs per employee. Also included is the ratio of innovation costs to sales, expressed as a percentage. Large businesses show higher sales per employee, while small businesses show a much higher value for the ratio of innovation costs to sales per employee. The higher proportion of innovation costs for small businesses is related to their relatively short time in operation. Consequently the relatively large costs of innovation per employee for small businesses might be attributed to the relative lack of diversity in their business activities.

S4.4 BUSINESS SALES AND INNOVATION COSTS PER EMPLOYEE

Business size	Sales $'000	Innovation costs $'000	%
Small	153	11	7
Medium	169	7	4
Large	247	8	3
All	225	8	4

Source: Innovation in Australian Manufacturing (8116.0), unpublished data.

What sources of ideas lead businesses to innovate?

For those manufacturers undertaking technological innovation, the main sources of ideas and information which lead to innovation are linked to their day to day operations. Although internal research and development (R&D) has long been considered a major source for technological innovation, it is not the only significant source. Other important sources include requests from and the expectations of clients/customers; the innovations of other businesses in the same industry; suppliers of materials, components and equipment; and other areas within the business not involved in R&D.

Most manufacturers undertaking technological innovation reported obtaining their ideas and information from a small number of sources. For example, one in six technological innovators did not view any single source as very significant while another 40% viewed only one or two sources as being very significant. The majority of innovators considered most sources to be unimportant in providing the impetus for technological innovation. The exceptions were the sources 'clients/customers' and 'R&D', which were, respectively, considered to be unimportant by only 10% and one third of technological innovators.

Compared to small businesses, larger businesses tended to place more importance on individual sources. The exception was the source 'clients/customers'; there were virtually no differences in the significance attributed to this source by businesses of different sizes. This contrasts with 'R&D', which was rated as more important than 'clients/customers' by almost 40% of large businesses but by only one quarter of small and medium businesses.

What objectives lead businesses to innovate?

Just as technological innovation can arise from many different sources, there are also many objectives in undertaking innovation. Improving product quality was seen as the most significant objective of technological innovation, and the least important was to increase overseas market share. Extending product range within main product field was another significant objective, but extending products outside of the main product field was viewed as unimportant. Other significant objectives included maintaining and increasing market share, while objectives considered insignificant included replacing phased out products, reducing energy consumption or environmental damage and meeting government standards, regulations and legislation.

The larger the employment size of the business the greater was the reported importance given to technological innovation in helping to create new overseas markets. The size of the increase is due mainly to the strong relationship between the proportion of exporters who are technological innovators and their employment size. As employment size increases, the proportion of exporters rises, causing the importance of the objective to become more significant. Looking only at exporters among the technological innovators, there is a slight increase in the importance of the objective across the different sizes of business.

Other objectives increased their importance as employment size increased. Again exporters gave more significance to individual objectives than non-exporters, although the increase in importance across sizes was more noticeable among the non-exporters. There appeared to be no difference attributable to employment size in the number of objectives that innovators viewed as significant, though that number is not small. For example, over half the innovators considered at least four objectives to be very significant.

Effects of innovation on business performance

The growth in business performance resulting from technological innovation has not yet been measured adequately. Identifying innovators at a single time point only allows a comparison of the levels of performance between innovators and non-innovators. Before the rates of growth for innovators and non-innovators can be compared a second survey is required at a later time point to measure change. Consequently little can be said currently about whether innovation improves business performance.

Table S4.5 presents some data for the performance measure labour productivity, defined as the value of production per employee. The table shows that there appear to be differences in average labour productivity as between innovators and non-innovators. However, these difference are not statistically significant since there are high standard errors associated with the averages.

S4.5 LABOUR PRODUCTIVITY (PRODUCTION PER EMPLOYEE)

Business size	Innovators $000	Non-innovators $000	All businesses $000
Small	42.0	36.6	38.5
Medium	56.5	48.8	53.5
Large	65.8	51.5	63.9

Source: Innovation in Australian Manufacturing (8116.0), unpublished data.

Summary

The 1993–94 survey identified some of the characteristics of innovating businesses, still in the minority among Australian businesses.

Technological innovation is more prevalent among larger manufacturers. These businesses are likely to have been at least ten years in existence and involved in exporting. The larger manufacturers' more substantial operations and greater propensity to export appear to alter the way they view the innovation process. Large manufacturers have more funds available to support internal R&D and to bear the other costs associated with innovation. Compared to

the smaller innovators, larger innovators report fewer barriers to undertaking innovation and are more positive about the objectives that innovation can help their business to achieve. Their aims include increasing their presence in overseas markets as well as improving product quality and expanding their product range.

Over 70% of all technological innovators in the manufacturing sector are small businesses. These businesses are probably in their first ten years of operation, and likely to be still finding and consolidating their place in the market. Consequently they are interested in using innovation to maintain or increase their market share in Australia by improving product quality or by expanding their product range. Given the small size of these manufacturers' operations and income, cost and financing difficulties are the biggest barriers to undertaking technological innovation. These manufacturers are unlikely to have funds available to support internal R&D, and gain the impetus for innovation from other sources associated with the operations of the business.

The question of the growth in performance for particular types of business resulting from innovation has yet to be answered. Similarly, little is known yet about the innovation process; in particular, what assists an innovation to reach the stage of successful implementation, how innovations become diffused through the business sector, and whether the originality of the innovation affects the growth in business performance. Unfortunately, what is still unknown about the innovation process is also important to the formulation of effective government policy in this area.

The ABS is currently developing a second round of innovation surveys that will be designed to both enhance and extend the information currently available. The surveys will repeat the collection of data in the manufacturing sector and expand the information collected in both the services and manufacturing sectors. The surveys will relate to the 1996–97 reference year.