
SCIENCE AND TECHNOLOGY

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. They can be seen as making major contributions to the achievement of many of Australia's social, economic and industrial goals.

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

The Commonwealth Government's conviction of the importance of science and technology is reflected in the functions of the Department of Industry, Technology and Commerce. Apart from having general responsibility for science and technology, 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 via 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.

Information on scientific and technological activities presented in this chapter includes:

- Australian Bureau of Statistics data on resources devoted to research and experimental development (R&D) and other innovative activities. The R&D surveys cover organisations in the business enterprise, general government, private non-profit and higher education sectors.
- Department of Industry, Technology and Commerce statistics on expenditure on R&D and other scientific and technological activities carried out or funded by Commonwealth Government organisations.
- Australian Bureau of Statistics information on manufacturing industry technology operations and trade categorised into high technology, medium technology and low technology (industries or commodities).

The Department of Industry, Technology and Commerce—DITAC

Following the Administrative Arrangements Order of 24 July 1987, the Industry, Technology and Commerce portfolio has primary responsibility for advising the Government and implementing policy in relation to Australian science and technology; manufacturing and service industries; export services and customs and excise.

Within the portfolio, DITAC is the central point of contact for industry, unions, other Commonwealth departments, and State and local governments on matters relating to manufacturing, and service industries. DITAC incorporates parts of the former Departments

of Science, Trade, and Housing and Construction. The major scientific and technological aspects of the portfolio include the following bodies and activities.

The Commonwealth Scientific and Industrial Research Organisation—CSIRO

CSIRO was established as an independent statutory authority by the *Science and Industry Research Act 1949*. The Act has been amended on a number of occasions since then, including in 1978, following the government-instigated 'Birch Committee of Inquiry' and in November 1986, following the 'Review of Public Investment in Research and Development in Australia', specifically including CSIRO, carried out by the Australian Science and Technology Council (ASTEC).

The 1986 amendments to the Act confirm that CSIRO's primary role is to continue as an applications-oriented research organisation in support of major industry sectors and selected areas of community interest, but with a stronger commitment to the effective transfer of its results to users. The most recent amendments have also included changes to the top management structure and the organisation's advisory mechanisms.

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.

The research work of the organisation is carried out in Institutes, each headed by a Director and each specifically established to undertake work in support of industry or community interest sectors of the Australian economy. Institutes are composed of Divisions, which are individually responsible for broad programs of research in support of the objectives of the Institute.

Institute of Information, Science and Engineering: Divisions of Information Technology; Radiophysics; Mathematics and Statistics; CSIRO Office of Space Science and Applications; Australia Telescope.

Institute of Industrial Technologies: Divisions of Manufacturing Technology; Materials Science and Technology; Applied Physics; Chemicals and Polymers; Biomolecular Engineering.

Institute of Minerals, Energy and Construction: Divisions of Building, Construction and Energy (now incorporates National Building Technology Centre); Exploration Geoscience; Mineral and Process Engineering; Mineral Products; Coal and Energy Technology; Geomechanics.

Institute of Animal Production and Processing: Divisions of Animal Health; Animal Production; Wool Technology; Tropical Animal Production; Food Processing; Human Nutrition.

Institute of Plant Production and Processing: Divisions of Plant Industry; Tropical Crops and Pastures; Horticulture; Entomology; Soils; Forestry and Forest Products.

Institute of Natural Resources and Environment: Divisions of Water Resources; Fisheries; Oceanography; Atmospheric Research; Wildlife and Ecology; Centre for Environmental Mechanics.

CSIRO has a total staff of more than 7,000 in more than 100 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 1988-89 was \$466 million.

The Australian Nuclear Science and Technology Organisation—ANSTO

ANSTO was established on 27 April 1987 as a statutory authority by the Commonwealth Parliament under the *Australian Nuclear Science and Technology Organisation Act Number 3 of 1987*. ANSTO replaces the Australian Atomic Energy Commission which had been in existence since 1953.

ANSTO has its headquarters at the Lucas Heights Research Laboratories, 30 kilometres south-west of Sydney. Of its staff of some 800, about 250 are qualified scientists and engineers. 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. In this mission, ANSTO maintains a high regional and international standing in nuclear matters and both provides advice to and carries out tasks as required by the Commonwealth Government.

The five major research program areas of ANSTO are:

- isotope technology;
- industrial technology applications of nuclear physics;
- biomedicine and health;
- environmental science; and
- advanced materials.

ANSTO is broadening its commercial ethos with research being directed to achieve the organisation's social and corporate goals. Because its multidisciplinary body of expertise is located at one centre, together with its two nuclear research reactors and other specialised laboratory equipment, ANSTO can provide a range of unique and essential techniques and services to the Australian community. Established under the ANSTO legislation is the independent Nuclear Safety Bureau which is responsible for monitoring and reviewing the safety of nuclear reactor plant operated by ANSTO. The Bureau reports to the Minister responsible for administration of the ANSTO Act. ANSTO's annual expenditure is in the order of \$67 million with sales revenue of approximately \$12 million.

The 150 per cent tax concession for Research and Development

The 150 per cent tax concession for Research and Development (R&D) is the major initiative in the Government's package of measures to encourage industrial R&D in Australia. The incentive which commenced in July 1985, was originally due to end on 30 June 1991. In May 1989, the Government announced that the concession will be available at 150 per cent until 30 June 1993. A reduced incentive of 125 per cent will then be available until 1995.

The concession allows companies incorporated in Australia, public trading trusts and partnerships of eligible companies to deduct up to 150 per cent of eligible expenditure incurred on R&D activities when lodging their corporate tax return.

To attract the full 150 per cent deduction, annual eligible R&D expenditure must exceed \$50,000, with a sliding scale operating from 100 to 150 per cent where annual R&D expenditures range from \$20,000 to \$50,000.

Where eligible R&D is contracted to an approved Registered Research Agency (RRA) the expenditure threshold is waived with all expenditure attracting the full 150 per cent concession.

Grants for Industry, Research and Development—GIRD

Discretionary Grants

The Discretionary Grants scheme provides support to companies which have insufficient taxation liability to obtain adequate benefit from the 150 per cent tax concession for research and development but have the potential to fully exploit the results of their research and development. Discretionary grants may be available to companies who are carrying on or intending to carry out the following activities:

- manufacture of goods;
- mining operations or operations for natural oil or gas recovery;
- construction operations relating to buildings or works; and
- production of software for computers or similar equipment.

Supported projects must be directed to internationally competitive and internationally traded goods, systems and services.

Generic Technology Grants

The Generic Technology Grants Scheme provides support for the development of enabling technologies (i.e. technologies with a pervasive and multiplying effect) by funding early-stage, strategic research. A major objective of the scheme is also to foster collaboration between industry and public sector research institutions.

The scheme currently provides support for research and development in the areas of:

- biotechnology;
- new materials technology;
- communications technology; and
- information technology.

The scheme may be extended in the future to include other technology areas.

Grants are provided to Australian research organisations for approved research projects. All projects are required to be supported by commercial interests.

National Teaching Company Scheme

The National Teaching Company Scheme (NTCS) which is administered by the Department of Industry, Technology and Commerce, is part of the Australian Government's program to facilitate the growth and competitiveness of Australian industry. The Scheme fosters the development of links between companies and supporting institutions such as tertiary education institutions and public research agencies, by subsidising the cost of employing and supervising high calibre graduates in *projects designed to improve company performance* through the adoption of appropriate technology or methodology in manufacturing, marketing, management accounting, design and strategic planning.

The NTCS provides up to \$50,000 grant support over a maximum of two years. Of this, \$34,000 is paid to the employer (i.e. either the company or institution) towards the salary and short term employment on costs of the graduate, \$10,000 is paid to the participating department of the supporting institution for the provision of academic support costs and equipment and an additional \$6,000 is paid to the employer towards administrative costs of employing the graduate.

National Procurement Development Program—NPDP

The NPDP was established in September 1987 following the Government's consideration of the Inglis Report on High Technology Purchasing by government departments and agencies.

The program is a competitive grants scheme aimed at improving the international competitiveness of Australian industry by supporting the research, development, trialing and demonstration of innovative Australian products or services which have substantial local content and are directed towards meeting government purchasing requirements.

Projects are to be developed by a commercial partner in conjunction with a government agency. To qualify for grant support, projects must demonstrate a sustainable competitive advantage in international markets. Grants are available for projects which exceed \$50,000 and can be completed in less than three years. The maximum grant rate is 50 per cent of project expenditure.

Patent, Trade Marks and Designs Offices

The Offices, through their Central Office in Canberra and office in each State capital, administer Australia's industrial property systems for the protection of patents, designs and trade marks.

The Offices maintain an information database on inventions and industrial designs to facilitate the transfer and diffusion of technology. A database of registered trade marks is also maintained. This information is available to the public through the Offices.

Policy, Planning and Coordination Branch develops policy initiatives for making industrial property laws more relevant to the needs of Australian industry and commerce. The Branch coordinates the office's participation in international cooperation on industrial property issues bilaterally and through Australia's membership of international agreements and organisations.

The National Industry Extension Service—NIES

The competitive edge for Australian manufacturing industry lies as much in the quality of its management as it does in other economic factors. In pursuing an export culture, the Australian Government in partnership with each of the State and Territory Governments has established the National Industry Extension Service (NIES) to deliver the best management advice and assistance to Australian manufacturers.

NIES encourages Australian manufacturers to take a strategic view of their enterprises and to implement strategies for marketing, manufacturing, product innovation, human resources and quality. Companies are assisted by a network of service providers including private sector consultants, academic institutions and government agencies. NIES expects a long term association with companies and works collaboratively with AUSTRADE to prepare companies to meet the rigours of international markets.

The Management and Investment Companies Program

In 1984, the Government established the Management and Investment Companies Program. The objectives of the Program are:

- to promote the development of a private sector venture capital industry in Australia; and
- to encourage the provision of management skills and equity finance to young, fast growing, export-oriented businesses using innovative technology.

The Program will terminate on 30 June 1991.

The Bureau of Industry Economics

Primary responsibility for the Department's Industry Research Program lies with the Bureau of Industry Economics which was established in 1977 as a centre for research into the Australian manufacturing and commerce sectors of the economy. The Bureau is assisted in devising its research program by a Council of Advice, comprising business and union leaders and prominent academics.

The Bureau's research program is concerned with a broad range of industry policy issues, including:

- individual industry studies as well as the investigations of general issues affecting a broad range of manufacturing and service industries;
- forward-looking studies on the likely future development of Australian industry, as well as detailed investigations of the factors responsible for the performance of industry in the recent past; and
- aspects of industrial technology and production as well as pricing and marketing issues.

Evaluation of the effectiveness of existing government policies and programs is an important part of the Bureau's research. The Bureau also contributes to policy reviews, including Industries Assistance Commission and other public inquiries, and assesses the economic aspects of papers put to it by industry and trade unions.

The Snowy Mountains Engineering Corporation—SMEC

SMEC is a public company fully owned by the Australian Government which operates as engineering consultants and project managers in Australia and overseas. Since its development from the Snowy Mountains scheme in 1970, SMEC has now grown into a *multidisciplined consulting organisation of international standing in civil, electrical and mechanical engineering*. SMEC has completed some 1,350 projects in 48 countries, including Australia. These projects have a capital value of \$A4,500 million and involved fees of \$A320 million.

A full range of expert engineering consulting services are provided by SMEC for pre-feasibility investigations, feasibility studies, field and laboratory investigations, design, project management, construction supervision, operation and maintenance, training and many individual tasks.

Projects have included hydro-electric and multipurpose water resources development, river basin studies, dams and power stations, power transmission and distribution, irrigation and flood control, roads and bridges, tunnels, shafts and underground works and pipelines.

SMEC, as well as working on projects in all States of Australia, has provided consulting services for projects throughout Asia and the Pacific islands, in Africa, the Middle East, and in North and South America.

SMEC is registered as an engineering consultant with United Nations agencies, World Bank, Asian Development Bank, Commonwealth Fund for technical cooperation, Kuwait Fund for Arab Economic Development, Arab Bank for Economic Development in Africa and the Australian International Development Assistance Bureau. Projects have been successfully carried out in many countries, using finance from these donor and lending institutions.

The Corporation was a recipient of two Australian Government Export Awards in 1977 and 1982, and the Governor-General's Award for Export Excellence in 1984.

SMEC has a staff of over 220 professionals, technical and administrative support staff. Its headquarters are in Cooma, NSW. Branch offices are located in Sydney, Brisbane and Canberra. International branch offices are located in Dhaka, Gaborone, Jakarta and Kuala Lumpur, with project offices in many other locations.

Marine Industries Program

The objective of the Marine Industries Program is to encourage the development of internationally competitive marine based manufacturing and service industries through the application of science and technology.

The review of marine industries, science and technology by the McKinnon Committee published in 1989 as 'Oceans of Wealth' showed that marine industries generate some \$16 billion of economic wealth annually for Australia, of which \$4.5 billion is in exports.

The review found that there was significant potential for further development but that to achieve this development would require stronger linkages between science and technology and industry.

The heads of the Government's marine science and technology agencies will be asked to work with the Department of Industry, Technology and Commerce to examine areas of potential industry development, to bring marine research and development more closely into line with industry requirements, and to play a key role in inter-cooperation in marine science and technology.

The Government allocated \$3.9 million over the ensuing five years to support relevant projects and activities.

The Commission for the Future

The Commission's objective of raising community awareness of all aspects of the social and economic impacts of technological change is based on the premise that industrial restructuring and technological development alone are insufficient for the development of a productive Australian culture. A need exists for an information and education program directed at increasing support for, and understanding of, scientific and technological change and long-term options for Australia.

The Australian Space Office

The Office was established in 1987 to oversee Australia's general space effort under the guidance of the Australian Space Board. It is responsible for developing an Australian space industry and managing the \$6.3 million National Space Program. It provides policy and secretariat support for the Space Board and implements agreements for the support of foreign civilian space programs, particularly for NASA and ESA.

A space industry development strategy has been prepared and is now being implemented. The strategy focuses on the priority areas of remote sensing, satellite based communications and launch site services. The Office is also examining a number of potential 'national interest' space projects.

The Office is the key Commonwealth Government body responsible for monitoring and facilitating developments in the proposal by Cape York Space Agency (CYSA) to build a commercial spaceport at Cape York in north Queensland.

The National Standards Commission

The Commission is a Commonwealth Statutory Authority established in 1948 and presently located at North Ryde, Sydney. The Commission operates under the National Measurement Act and is directed by a Board comprising a part-time chairman and seven commissioners. The Commission has responsibility for advising the Government on the scientific, technical and legislative requirements of the Australian National Measurement System and for coordinating that system. In addition, the Commission has specific responsibilities for legal metrology, the completion of metrication and uniformity of trade measurement. The Commission also examines and approves the patterns of measuring instruments used for trade to ensure the instruments will maintain their calibration and will not be affected by environmental factors (e.g. temperature, humidity or electromagnetic interference).

The Commission provides Australia's representative on the International Committee of Legal Metrology and ensures that Australian legal measurement requirements are nationally uniform and internationally harmonised. Through conferences and liaison with government authorities the Commission aims to ensure the traceability of all legal measurements to Australia's primary standards of measurement.

The Commission maintains close liaisons with government authorities, industry and commerce and consumer groups to ensure adequacy of measurement throughout Australia. The Commission provides the Chairman and secretariat for the Standing Committee on Trade Measurement, the Trade Measurement Consultative Committee and Working Parties on oil and gas flow measurement and time measurement.

The Commission is currently developing a National Metrology Policy that will include a policy for the training of metrologists and calibration technicians.

Other Commonwealth Government Science and Technology Activities

Many other Commonwealth Government agencies play a significant role in the science and technology area. A number of these agencies are involved with R&D activities either as funders, performers or both; others are active in the S&T areas of information dissemination, scientific services and scientific training.

Total Commonwealth government expenditure on research and development measured in the ABS Research and Development Survey for 1987-88 amounted to \$807 million.

State Government science and technology activities

State Governments are major performers and supporters of scientific and technological activities. Many States have particular departments established for the purpose of encouraging and coordinating the use of technology in industry (e.g. the Victorian Department of Industry, Technology and Resources). Several States (New South Wales, Queensland, Western Australia and South Australia) have also established science and technology councils which provide advice to State Governments on science and technology matters and promote the expansion of technology.

In addition to fostering science and technology, many State government departments are large performers of scientific and technological activities. Traditionally, for instance, those departments involved with agriculture (e.g. the Victorian Department of Agriculture and Rural Affairs and various State departments of agriculture) spend large sums on the R&D which they perform and also have a high profile in the general S&T activities of extension and laboratory services.

The total 1987-88 expenditure for R&D carried out by State government organisations measured in the ABS Research and Development Survey was \$378 million.

Tertiary education institutions' science and technology activities

Tertiary education institutions play a vital role in the two major S&T areas. These being R&D and scientific and technical training.

Higher education institutions receive direct funding for research purposes from a number of sources, the major one being the Commonwealth Government. Commonwealth funds include those grants and awards distributed through the Australian Research Council; and grants awarded by the National Health and Medical Research Council and through the National Energy Research, Development and Demonstration Program.

Indirect research funding for higher education institutions includes both the proportion of general funds from the Higher Education Funding Act allocated by institutions to research and the amount attributable to research but coming from general teaching-and-research funds (e.g. the estimated research portion of the salaries of teaching-and-research staff). The latest available figures for total higher education research expenditure (direct plus indirect sources) came from the ABS Research and Development Survey for 1987 which gives an estimated expenditure of \$984 million.

Institutes of TAFE receive very little research funding from the Commonwealth. The Australian Bureau of Statistics does not measure R&D effort for institutes of TAFE.

Data on higher education and TAFE enrolments are presented in Chapter 10, Education. That chapter also gives a more detailed picture of higher education facilities in Australia.

Other Organisations' Science and Technology Activities

There are many other non-government organisations playing an important part in Australia's scientific and technological development. They include various learned and professional

bodies such as the Australian Academy of Science, the Australian Academy of Technological Science, the Academy of Social Sciences in Australia and the Australian and New Zealand Association for the Advancement of Science. Their activities include provision of advice in the relevant scientific fields, dissemination of scientific information and enhancement of communication on scientific matters.

A number of private organisations from time to time provide advice to government on specific matters relating to science and technology. Examples from the business sector are the Australian Chamber of Manufacturers, the Business Council of Australia and the Confederation of Australian Industry. Other organisations with an interest in scientific and technological issues include trade unions, industry groups with an interest in specific technologies and individual private organisations.

As performers of research and experimental development, private organisations in Australia are making an increasingly important contribution to Australia's R&D effort. Private business enterprises, for instance, spent an estimated \$1,218 million on R&D in 1987-88, a figure which, whilst still relatively low compared with the spending of comparable OECD countries, represents an increase of 14 per cent over 1986-87 expenditure. Private non-profit organisations in 1987-88 spent \$50 million on R&D.

Statistics on Science and Technology

Expenditure and human resources devoted to research and experimental development

The Australian Bureau of Statistics' Surveys of Research and Experimental Development provide comprehensive data on research and experimental development activities in Australia by organisations in the business enterprise, general government, higher education and private non-profit sectors. They also provide some data on other innovative activities, such as technical know-how payments and receipts and patenting activity. Activities not covered by the survey include scientific or technological services, extension services, education and training, etc.

The first comprehensive survey on R&D was carried out for the financial year 1968-69. There have been seven major surveys since then, the latest for which comprehensive results are available being in respect of 1988-89 (1988 calendar year for the Higher Education Sector). Less detailed data in respect of 1987-88 are available from the smaller 'inter year' R&D survey conducted by the Bureau.

The estimate of gross expenditure on R&D (GERD) carried out in Australia, as derived from the results of the 1988-89 survey, is \$4,187 million. This represents a 14 per cent increase compared with the 1987-88 survey. At constant (1984-85) prices, GERD increased by nine per cent over the same period. The total estimate of human resources devoted to R&D during 1988-89 in Australia was 64,820 person years; this represented a five per cent increase compared with the 1987-88 survey.

See *Year Book* No. 70 for a detailed description of survey methods and concepts.

Definitions

The survey's definitions follow guidelines described by the OECD for national R&D surveys. The OECD defines R&D as comprising 'creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications'. The Bureau provides sector specific definitions which clarify the OECD definitions for respondents and users (see *Research and Experimental Development, All Sector Summary, Australia* (8112.0)).

Survey results

A summary of results from the 1984-85 to 1988-89 surveys is presented below.

**HUMAN RESOURCES OF EFFORT DEVOTED TO RESEARCH AND EXPERIMENTAL
DEVELOPMENT, AUSTRALIA**
(person years)

<i>Sector</i>	<i>1984-85</i>	<i>1985-86</i>	<i>1986-87</i>	<i>1987-88</i>	<i>1988-89</i>
Business Enterprises—					
Private Sector	11,324	13,431	16,070	16,650	18,357
Public Sector	1,238	1,353	1,395	1,327	1,352
General Government—					
Commonwealth	11,119	11,182	11,518	11,491	11,498
State	6,018	6,337	6,627	7,125	7,643
Higher Education—					
Universities	19,814	20,143	21,690	22,435	22,939
CAEs	1,030	(a)	1,529	1,888	1,963
Private non-profit	712	812	997	1,023	1,068
Total	51,255	53,258	59,824	61,939	64,820

(a) Estimates for Colleges of Advanced Education were not collected this year.

**GROSS EXPENDITURE ON RESEARCH AND EXPERIMENTAL DEVELOPMENT (GERD)
CARRIED OUT IN AUSTRALIA**
GERD AT CURRENT AND AVERAGE 1984-85 PRICES
(\$ million)

<i>Sector</i>	<i>1984-85</i>	<i>1985-86</i>	<i>1986-87</i>	<i>1987-88</i>	<i>1988-89</i>
AT CURRENT PRICES					
Business Enterprises—					
Private Sector	653.7	852.2	1,147.0	1,317.5	1,602.5
Public Sector	77.3	95.7	122.6	111.0	136.0
General Government—					
Commonwealth	669.4	729.0	785.9	797.0	862.0
State	285.9	315.8	357.9	394.6	453.2
Higher Education—					
Universities	663.1	707.6	844.9	929.8	1,022.3
CAEs	22.7	(a)	36.7	53.8	54.5
Private non-profit	43.5	47.1	52.8	54.2	56.7
Total	2,415.6	2,747.4	3,347.9	3,657.9	4,187.1
AT AVERAGE 1984-85 PRICES					
Business Enterprises—					
Private Sector	653.7	793.9	983.8	1,051.4	1,214.0
Public Sector	77.3	89.2	105.8	91.6	108.1
General government—					
Commonwealth	669.4	688.3	693.2	654.2	672.8
State	285.9	297.1	312.6	323.6	354.2
Higher Education—					
Universities	(b)679.8	700.7	750.8	788.7	819.7
CAEs	(b)23.3	(a)	32.2	40.3	41.0
Private non-profit	43.5	44.2	48.7	47.4	47.3
Total	2,432.9	2,613.4	2,927.1	2,997.2	3,257.1

(a) Estimates for Colleges of Advanced Education were not collected this year. (b) Average 1984-85 price details are not the same as Current Price details because the Higher Education subsections are on a calendar year basis.

**GROSS EXPENDITURE ON RESEARCH AND EXPERIMENTAL DEVELOPMENT (GERD)
CARRIED OUT IN AUSTRALIA
GERD BY SECTOR BY SOURCE OF FUNDS
(\$'000)**

<i>Sector</i>	<i>Common-wealth</i>		<i>State</i>	<i>Business</i>	<i>Higher</i>	<i>Private non-profit and other</i>	
	<i>Total</i>	<i>government</i>	<i>government</i>	<i>enterprises</i>	<i>education</i>	<i>Australian</i>	<i>Overseas</i>
1986-87							
Business Enterprises—							
Private Sector	1,146,970	53,370	} 3,924	1,077,040	} 269	} 459	12,903
Public Sector	122,646	8,664		112,986			—
General Government—							
Commonwealth	785,920	754,378	3,833	22,881	108	347	4,374
State	357,884	30,487	294,573	17,968	413	13,641	802
Higher Education—							
Universities	844,949	788,970	9,010	9,659	8,943	22,121	6,245
CAEs	36,732	6,305	2,975	8,806	17,300	1,167	180
Private non-profit	52,809	20,042	6,712	2,472	411	18,703	4,468
Total	3,347,909	1,662,216	321,027	1,251,811	27,444	56,439	28,973
1988-89							
Business Enterprises—							
Private Sector	1,602,457	57,737	2,689	1,496,180	} 168	} 5,912	40,321
Public Sector	136,017	2,900	1,642	130,926			—
General Government—							
Commonwealth	861,998	809,305	3,862	40,617	—	2,651	5,563
State	453,193	42,859	368,340	22,092	228	18,513	1,162
Higher Education—							
Universities	1,022,275	943,958	11,856	18,676	—	40,961	6,824
CAEs	54,518	11,228	4,779	8,906	28,057	1,180	369
Private non-profit	56,688	19,741	5,660	4,834	632	23,628	2,193
Total	4,187,145	1,887,728	398,828	1,722,230	29,084	92,843	56,431

Business enterprise sector

The estimate of expenditure on R&D carried out in Australia by private and public business enterprises during 1984-85, 1986-87 and 1988-89 are shown in the next table at *current* prices. At average 1984-85 prices, R&D expenditure is estimated to have increased by 81 per cent and 21 per cent over 1984-85 and 1986-87 respectively.

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY BUSINESS ENTERPRISES(a), AUSTRALIA, DETAILS OF RESOURCES DEVOTED TO R&D BY INDUSTRY OF ENTERPRISE

Industry of enterprise ASIC Code	Description	Enterprises (number)			Expenditure on R&D (\$m)			Person years of effort on R&D		
		1984-85r	1986-87r	1988-89	1984-85r	1986-87r	1988-89	1984-85r	1986-87r	1988-89
11-15	Mining (excluding services to mining)	31	39	46	30.4	55.6	67.8	303	524	582
	Manufacturing—									
21	Food, beverages and tobacco	92	106	101	30.9	56.7	82.7	658	815	832
23-24	Textiles, clothing and footwear	27	35	41	5.6	12.9	7.8	57	119	107
25	Wood, wood products and furniture	29	47	45	3.4	6.4	9.8	69	118	111
26	Paper, paper products, printing and publishing	22	32	29	6.4	10.0	21.1	139	158	234
27	Chemical, petroleum and coal products	180	270	255	91.1	120.1	148.0	1,576	1,857	1,664
28	Non-metallic mineral products	33	39	45	12.69	15.3	22.3	223	178	206
29	Basic metal products	32	47	52	46.1	63.7	91.7	681	865	966
31	Fabricated metal products	92	129	131	15.6	23.0	25.7	309	392	376
32	Transport equipment	65	98	120	90.1	127.9	159.6	1,476	1,562	1,753
334	Photographic, professional and scientific equipment	30	67	69	16.5	25.7	37.5	283	433	512
335	Appliances and electrical equipment	286	590	560	84.4	174.5	228.3	1,611	2,835	3,319
336	Industrial machinery and equipment	177	254	252	28.5	43.3	54.9	566	720	783
34	Miscellaneous manufacturing	77	102	112	8.5	21.6	26.1	178	329	379
C	Total manufacturing	1,142	1,816	1,812	440.1	701.1	918.5	7,824	10,380	11,243
	Other industries—									
F	Wholesale and retail trade	194	293	290	36.5	96.8	152.3	641	1,230	1,642
63	Property and business services	450	588	503	82.0	178.4	211.8	1,352	2,376	2,553
8461	Research and scientific institutions	43	80	97	28.8	45.3	127.9	497	640	1,109
(b)	Other n.e.c.	126	213	217	113.3	192.4	260.1	1,946	2,315	2,580
16, D-L	Total other industries	813	1,174	1,107	260.6	513.0	752.1	4,436	6,561	7,884
	Total all industries	1,986	3,029	2,965	731.1	1,269.6	1,738.5	12,563	17,465	19,709
	Private Sector Contribution	1,939	2,967	2,491	653.7	1,147.0	1,602.5	11,324	16,070	18,357
	Public Sector Contribution	47	62	54	77.3	122.6	136.0	1,238	1,395	1,352

(a) Excludes enterprises in ASIC Division 'A'. (b) ASIC codes 16,D,E,G,H,61-62,J,8141-8306,8462-8495,L.

Payments and receipts for patent licence fees and other technical know-how

Many Australian business enterprises supplement their R&D efforts by either purchasing or licensing foreign or Australian technology. Data for 1984-85, 1986-87 and 1988-89 are presented below.

PAYMENTS AND RECEIPTS FOR TECHNICAL KNOW-HOW BY BUSINESS ENTERPRISES(a), AUSTRALIA, PAYMENTS AND RECEIPTS BY INDUSTRY OF ENTERPRISES (\$ million)

Industry of enterprise ASIC Code Description	Payments for technical know-how			Receipts for technical know-how		
	1984-85r	1986-87r	1988-89	1984-85r	1986-87r	1988-89
Manufacturing—						
21 Food, beverages and tobacco	16.8	23.6	26.7	1.1	2.8	2.6
23-24 Textiles, clothing and footwear	8.9	n.p.	n.p.	n.p.	n.p.	n.p.
25 Wood, wood products and furniture	0.1	0.2	1.6	n.p.	0.6	n.p.
26 Paper, paper products, printing and publishing	4.1	4.0	n.p.	n.p.	n.p.	n.p.
27 Chemical, petroleum and coal products	39.1	53.3	67.8	6.6	6.2	2.1
28 Non-metallic mineral products	7.8	1.8	7.8	n.p.	n.p.	1.0
29 Basic metal products	4.7	9.8	23.8	6.1	n.p.	2.6
31 Fabricated metal products	2.3	3.9	8.6	1.1	1.2	1.1
32 Transport equipment	17.4	35.5	49.8	n.p.	1.0	3.9
334 Photographic, professional and scientific equipment	n.p.	n.p.	3.1	n.p.	n.p.	n.p.
335 Appliances and electrical equipment	28.3	48.4	34.8	n.p.	3.8	13.5
336 Industrial machinery and equipment	n.p.	8.7	9.6	1.4	n.p.	5.3
34 Miscellaneous manufacturing	4.9	11.0	15.2	n.p.	n.p.	3.0
C Total manufacturing	146.6	236.5	258.6	23.8	48.6	36.2
Other industries—						
F Wholesale and retail trade	4.3	11.3	14.7	0.5	4.2	6.6
63 Property and business services	8.0	7.7	n.p.	6.2	37.0	60.4
8461 Research and scientific institutions	n.p.	n.p.	n.p.	n.p.	3.0	13.5
(b) Other n.e.c.	n.p.	n.p.	22.5	n.p.	8.7	7.9
11-16, Total other industries D-L	19.9	41.0	79.2	12.3	53.0	88.5
Total all industries	166.5	277.5	337.8	36.1	101.6	124.7

(a) Excludes enterprises in ASIC Division 'A'. (b) ASIC Codes 11-16,D,E,G,H,61-62,J,8141-8306,8462-8495,L.

General government sector

The estimate of expenditure on R&D carried out in Australia by organisations in the general government sector during 1984-85, 1986-87 and 1988-89 are shown in the next table at *current* prices. At average 1984-85 prices, R&D expenditure is estimated to have increased by eight per cent and two per cent over 1984-85 and 1986-87 respectively.

**RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY GENERAL
GOVERNMENT ORGANISATIONS, AUSTRALIA
DETAILS OF RESOURCES DEVOTED TO R&D BY SOCIO-ECONOMIC OBJECTIVE**

<i>Socio-economic objective</i>	<i>Expenditure on R&D (\$m)</i>			<i>Person years of effort on R&D</i>		
	<i>1984-85r</i>	<i>1986-87r</i>	<i>1988-89</i>	<i>1984-85r</i>	<i>1986-87r</i>	<i>1988-89</i>
<i>National security (Defence)</i>	151.0	175.1	202.5	3,232	3,146	3,078
<i>Economic development—</i>						
Agriculture	320.8	387.7	440.2	5,846	6,505	6,835
Forestry and fisheries	48.1	63.3	75.2	924	1,055	1,169
Mining (prospecting)						
Energy sources	12.8	14.9	14.2	202	187	139
Other	23.2	27.0	43.1	344	371	515
Mining (extraction)						
Energy sources	7.9	2.8	4.0	120	42	55
Other	8.4	7.6	8.3	138	127	110
Manufacturing	103.8	119.1	129.1	1,725	1,696	1,770
Construction	13.3	15.5	19.9	265	280	283
Energy	51.8	47.0	43.7	644	546	478
Transport	16.9	16.6	22.0	220	281	288
Communications	0.3	1.3	1.8	6	10	21
Economic services n.e.c.	20.2	18.0	23.0	404	409	419
<i>Total economic development</i>	627.4	720.6	824.5	10,836	11,509	12,082
<i>Community welfare—</i>						
Urban and regional planning	0.4	1.7	1.0	12	40	20
Environment	36.0	60.9	85.3	692	701	946
Health	43.0	61.5	65.6	1,070	1,199	1,432
Education	5.9	6.7	17.3	145	151	202
Welfare	3.7	7.2	8.3	86	118	121
Community services n.e.c.	9.1	20.8	31.6	175	262	395
<i>Total community welfare</i>	98.1	158.8	209.2	2,181	2,471	3,115
<i>Advancement of knowledge—</i>						
Earth, ocean and atmosphere n.e.c.	72.7	82.2	66.9	778	865	687
General advancement of knowledge	6.2	7.2	12.1	109	153	179
<i>Total advancement of knowledge</i>	78.9	89.3	79.0	887	1,018	866
Total	955.3	1,143.8	1,315.2	17,136	18,144	19,141

Higher education sector

The estimate of expenditure on R&D carried out in Australia by higher education organisations during 1984, 1986 and 1988 are shown in the next table at *current* prices. At average 1984-85 prices, R&D expenditure is estimated to have increased by 57 per cent and 22 per cent over 1984 and 1986 respectively.

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY HIGHER EDUCATION ORGANISATIONS, AUSTRALIA R&D EXPENDITURE BY SOCIO-ECONOMIC OBJECTIVE

Socio-economic objective	Expenditure on R&D (\$m)								
	1984			1986			1988		
	Total	Univer- sities	CAEs	Total	Univer- sities	CAEs	Total	Univer- sities	CAEs
National security (Defence)	1.2	1.2	—	1.9	1.7	0.2	2.5	2.2	0.2
Economic development—									
Agriculture	58.9	57.3	1.5	74.2	72.0	2.1	85.5	81.5	4.0
Forestry and fisheries	8.2	8.0	0.2	8.9	8.6	0.4	12.0	11.2	0.8
Mining (prospecting)									
Energy sources	1.8	1.7	0.1	4.1	3.7	0.3	3.6	3.3	0.4
Other	3.4	3.2	0.1	7.2	7.0	0.2	6.2	5.5	0.7
Mining (extraction)									
Energy sources	1.0	1.0	0.1	1.3	1.2	0.1	2.8	2.5	0.3
Other	3.6	3.3	0.3	6.8	5.6	1.2	8.3	6.8	1.5
Manufacturing	18.6	16.1	2.4	28.9	24.1	4.8	46.1	39.4	6.8
Construction	7.2	6.9	0.3	9.1	8.2	0.8	12.5	11.2	1.4
Energy	25.4	23.7	1.7	27.3	25.4	1.9	29.9	27.4	2.5
Transport	3.7	3.2	0.5	4.7	4.2	0.5	4.9	4.5	0.4
Communications	6.0	5.5	0.4	8.2	7.2	1.0	10.3	8.9	1.4
Economic services n.e.c.	18.6	17.5	1.1	36.1	33.3	2.8	49.7	46.4	3.3
<i>Total economic development</i>	<i>156.4</i>	<i>147.6</i>	<i>8.8</i>	<i>216.6</i>	<i>200.6</i>	<i>16.1</i>	<i>271.9</i>	<i>248.6</i>	<i>23.4</i>
Community welfare—									
Urban and regional planning	4.3	4.1	0.2	6.0	5.6	0.4	7.0	6.2	0.8
Environment	12.6	11.5	1.0	17.2	15.7	1.4	28.4	25.8	2.6
Health	139.8	134.8	5.0	187.6	180.8	6.8	226.2	216.3	9.9
Education	26.6	23.6	3.0	36.7	32.9	3.8	41.9	35.1	6.8
Welfare	8.3	8.0	0.3	10.0	9.1	0.9	8.6	7.9	0.7
Community services n.e.c.	13.3	12.8	0.8	18.8	17.0	1.7	21.9	19.8	2.1
<i>Total community welfare</i>	<i>204.8</i>	<i>194.5</i>	<i>10.4</i>	<i>276.2</i>	<i>261.1</i>	<i>15.0</i>	<i>334.1</i>	<i>311.0</i>	<i>23.0</i>
Advancement of knowledge—									
Earth, ocean and atmosphere n.e.c.	42.3	41.8	0.6	50.4	49.9	0.6	50.7	49.5	1.2
General advancement of knowledge	281.0	278.1	2.9	336.6	331.7	4.9	417.6	410.9	6.7
<i>Total advancement of knowledge</i>	<i>323.3</i>	<i>319.9</i>	<i>3.5</i>	<i>387.0</i>	<i>381.6</i>	<i>5.4</i>	<i>468.3</i>	<i>460.4</i>	<i>7.9</i>
Total	685.7	663.1	22.7	881.7	844.9	36.7	1,076.8	1,022.3	54.5

**RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY HIGHER
EDUCATION ORGANISATIONS, AUSTRALIA
HUMAN RESOURCES DEVOTED TO R&D BY SOCIO-ECONOMIC OBJECTIVE**

<i>Socio-economic objective</i>	<i>Person years of effort on R&D</i>								
	<i>1984</i>			<i>1986r</i>			<i>1988</i>		
	<i>Total</i>	<i>Univer- sities</i>	<i>CAEs</i>	<i>Total</i>	<i>Univer- sities</i>	<i>CAEs</i>	<i>Total</i>	<i>Univer- sities</i>	<i>CAEs</i>
<i>National security (Defence)</i>	29	28	1	52	39	13	42	36	6
Economic development—									
Agriculture	1,922	1,863	59	2,012	1,949	63	2,174	2,045	129
Forestry and fisheries	282	265	17	256	237	19	260	224	35
Mining (prospecting)									
Energy sources	71	56	15	112	95	17	105	85	20
Other	108	96	12	206	194	12	163	131	32
Mining (extraction)									
Energy sources	34	33	1	40	37	2	75	63	12
Other	128	110	18	194	156	38	213	163	51
Manufacturing	625	522	103	896	682	215	1,233	949	284
Construction	225	210	15	226	201	25	269	233	36
Energy	769	706	64	719	643	76	695	602	93
Transport	129	108	22	137	109	28	116	97	19
Communications	196	175	21	258	200	58	245	196	49
Economic services n.e.c.	443	399	45	805	700	105	989	853	136
<i>Total economic development</i>	<i>4,933</i>	<i>4,542</i>	<i>391</i>	<i>5,861</i>	<i>5,202</i>	<i>659</i>	<i>6,536</i>	<i>5,640</i>	<i>896</i>
Community welfare—									
Urban and regional planning	116	107	9	150	134	16	144	119	25
Environment	422	377	45	493	427	66	646	554	92
Health	4,140	3,902	238	4,809	4,526	283	5,221	4,894	327
Education	891	767	124	984	843	140	1,062	824	239
Welfare	245	232	13	269	229	41	199	171	29
Community services n.e.c.	337	304	33	454	379	76	463	401	62
<i>Total community welfare</i>	<i>6,151</i>	<i>5,688</i>	<i>462</i>	<i>7,159</i>	<i>6,538</i>	<i>621</i>	<i>7,735</i>	<i>6,962</i>	<i>773</i>
Advancement of knowledge—									
Earth, ocean and atmosphere n.e.c.	1,135	1,097	38	1,207	1,181	26	1,076	1,036	40
General advancement of knowledge	8,597	8,458	139	8,939	8,730	210	9,514	9,265	249
<i>Total advancement of knowledge</i>	<i>9,732</i>	<i>9,556</i>	<i>176</i>	<i>10,147</i>	<i>9,911</i>	<i>236</i>	<i>10,590</i>	<i>10,301</i>	<i>289</i>
Total	20,844	19,814	1,030	23,218	21,690	1,529	24,902	22,939	1,963

Private non-profit sector

The estimate of expenditure on R&D carried out by private non-profit organisations during 1984-85, 1986-87 and 1988-89 are shown in the next table at *current* prices. At average 1984-85 prices, R&D expenditure is estimated to have increased by 8.7 per cent and dropped by 2.9 per cent over 1984-85 and 1986-87 respectively.

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY PRIVATE NON-PROFIT ORGANISATIONS, AUSTRALIA DETAILS OF RESOURCES DEVOTED TO R&D BY SOCIO-ECONOMIC OBJECTIVE

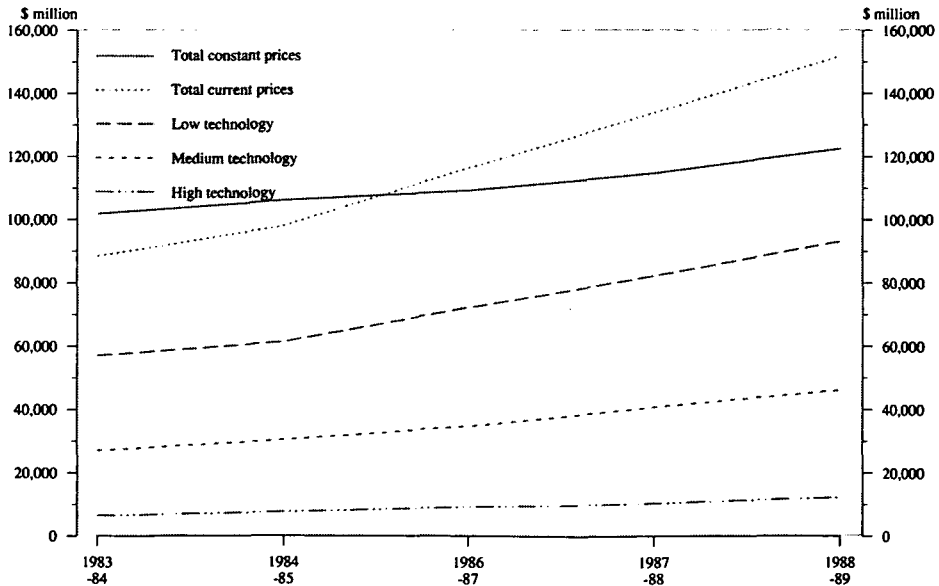
<i>Socio-economic objective</i>	<i>Expenditure (\$'000)</i>			<i>Person years of effort on R&D</i>		
	<i>1984-85r</i>	<i>1986-87r</i>	<i>1988-89</i>	<i>1984-85r</i>	<i>1986-87r</i>	<i>1988-89</i>
<i>National security (Defence)</i>	—	—	—	—	—	—
<i>Economic development—</i>						
Agriculture	55	69	179	2	3	4
Forestry and fisheries	—	35	—	—	1	—
Mining (prospecting)						
Energy sources	—	—	—	—	—	—
Other	158	—	—	1	—	—
Mining (extraction)						
Energy sources	—	—	—	—	—	—
Other	—	—	—	—	—	—
Manufacturing	—	3,767	5,053	—	49	69
Construction	159	—	—	2	—	—
Energy	535	305	288	8	4	4
Transport	427	52	—	8	1	—
Communications	3	—	16	1	—	1
Economic services n.e.c.	780	1,683	2,554	18	31	30
<i>Total economic development</i>	<i>2,116</i>	<i>5,911</i>	<i>8,090</i>	<i>41</i>	<i>90</i>	<i>106</i>
<i>Community welfare—</i>						
Urban and regional planning	397	38	38	6	—	1
Environment	4	564	411	—	16	8
Health	38,801	43,496	44,658	615	833	891
Education	1,228	1,200	1,302	24	20	22
Welfare	558	882	748	16	23	16
Community services n.e.c.	88	170	787	2	4	11
<i>Total community welfare</i>	<i>41,075</i>	<i>46,351</i>	<i>47,944</i>	<i>662</i>	<i>896</i>	<i>949</i>
<i>Advancement of knowledge—</i>						
Earth, ocean and atmosphere n.e.c.	45	48	48	1	2	2
General advancement of knowledge	251	499	607	8	9	11
<i>Total advancement of knowledge</i>	<i>296</i>	<i>547</i>	<i>655</i>	<i>9</i>	<i>11</i>	<i>13</i>
Total	43,488	52,809	56,688	712	997	1,068

Statistics on manufacturing industry technology

The level of technological development in manufacturing industry can be viewed by classifying industries to high, medium and low technology according to the intensity of their R&D effort. Using the OECD classification by this method, high technology industries are defined as those manufacturing establishments classified to aircraft (Australian Standard Industrial Classification (ASIC) Class 3244); communications and other electronic equipment (ASIC Classes 3351 and 3352); electrical appliances and machinery (ASIC Classes 3353–3357); pharmaceutical and veterinary products (ASIC Class 2763); and photographic, professional and scientific equipment (ASIC Group 334). Medium technology covers chemicals (apart from ASIC Class 2763); petroleum and coal products; non-ferrous metals and basic products; motor vehicles and parts, railway equipment and other transport equipment (ASIC Class 3245); industrial machinery; rubber and plastic products; and, other manufacturing (ASIC Group 348). Low technology covers food, beverages and tobacco; textiles, clothing and footwear; wood and wood products; paper and paper products, etc.; petroleum refining; non-metallic mineral products, basic iron and steel products; fabricated metal products; ships and boats; and, leather products.

The figure below shows that high technology industries as a group showed current price growth in turnover from 1987–88 to 1988–89 of 17 per cent. Low and medium technology groups have performed comparably with a growth of 13 per cent each. In constant prices terms, total manufacturing industry turnover has grown 20 per cent over the five year period and seven per cent between 1987–88 and 1988–89.

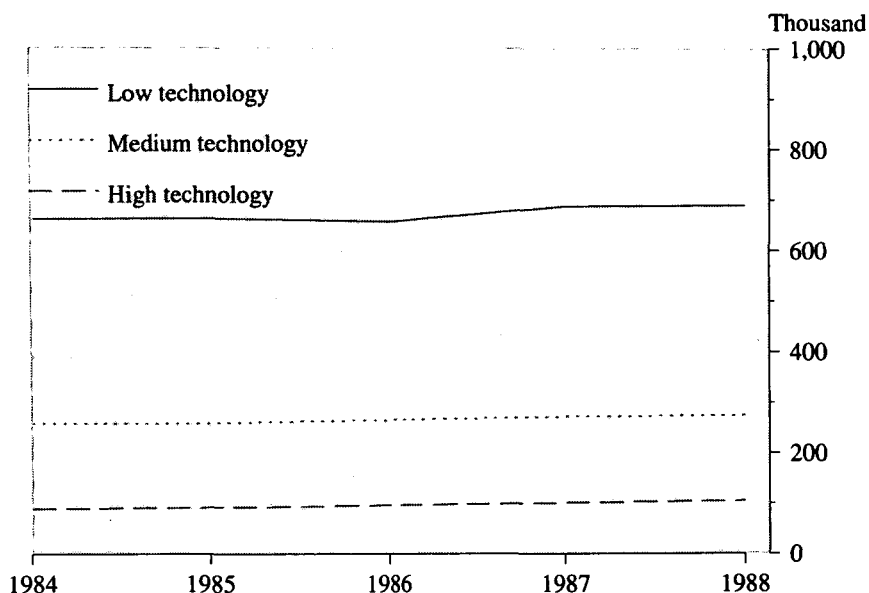
MANUFACTURING ESTABLISHMENTS, AUSTRALIA
Turnover at Current and Constant Prices



Indicates break in series. No census conducted in 1985-86.

The following figure shows manufacturing industry employment levels have grown slightly in the three categories over the five years. Data for the latest year available show rises between 30 June 1988 and 30 June 1989 for high, medium and low technology industries (1.8 per cent, 6.0 per cent and 3.4 per cent respectively).

MANUFACTURING ESTABLISHMENTS, AUSTRALIA Persons Employed at 30 June



Indicates break in series. No census conducted in 1985-86.

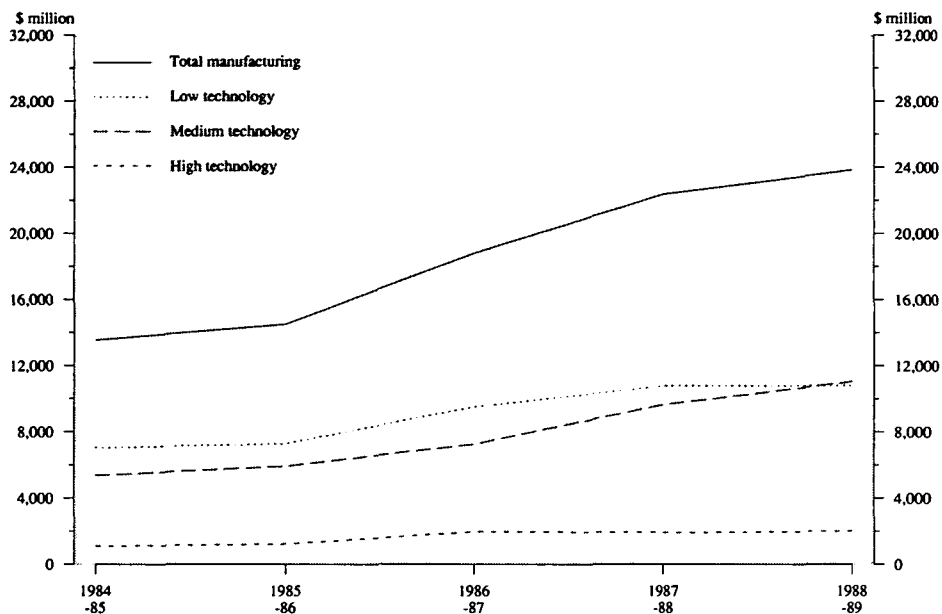
Trade statistics

Another way of viewing Australian manufacturing industry's level of technological development is to look at trade of high technology products. Products are classified initially according to commodity (Australian Import and Export Commodity Codes) but converted to an ASIC basis. Definitions of high, medium and low technology groups according to ASIC are the same as above.

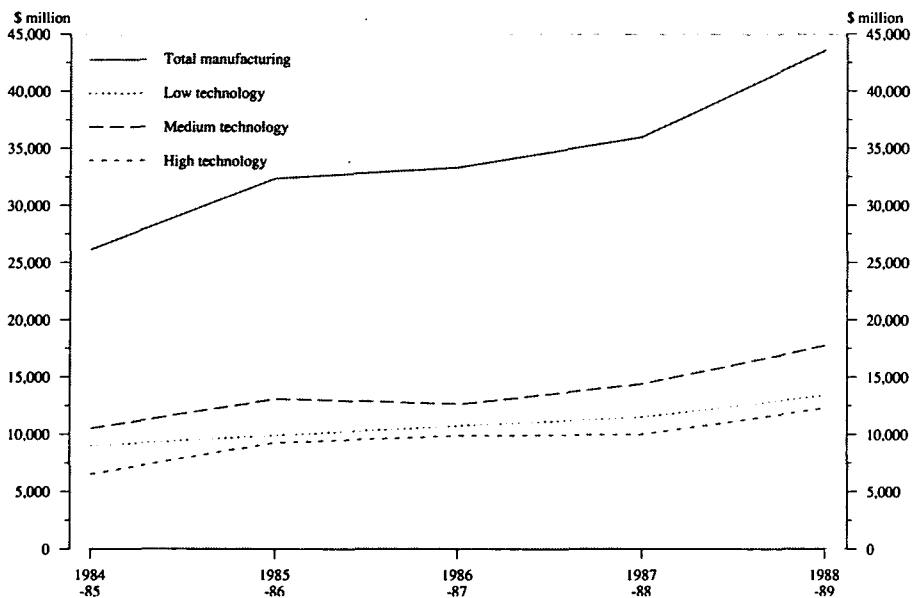
The current price value of exports of Australian manufactures has increased by six per cent for high technology products and 14 per cent for medium technology products between 1987-88 and 1988-89. Exports of low technology products remained at the same level for this period.

The current price value of imports of Australian manufactures has increased at a higher level for each of the three categories between 1987-88 and 1988-89 (23 per cent for both high and medium technology products and 17 per cent for low technology products).

EXPORTS OF MANUFACTURES, AUSTRALIA



IMPORTS OF MANUFACTURES, AUSTRALIA



Other Activities

For information on other activities related to science and technology, see *Year Book* No. 70. That edition contains information on scientific and technological information services (page 640), social science and humanities research (page 652) and international activities (page 653).

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, Technology and Commerce, the CSIRO, the Australian Nuclear Science and Technology Organisation, the Department of Defence, 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, 1984–85, 1985–86 and 1986–87 may be obtained from the Australian Bureau of Statistics (ABS). Further statistical information on higher education is obtainable from the Department of Employment, Education and Training. Trade and industry operations data are available from the ABS.

The Department of Industry, Technology and Commerce's *Australian Science and Technology Indicators Report*, published in 1988, uses S&T indicators to give a good overview and analysis of science and technology information in Australia. It presents information on R&D effort and expenditure, science and technology workforce, S&T information resources, scientific equipment and facilities, literature-based S&T measures, patent activity, technology training, financial support for technological development, industry operations and trade by level of technology, and transfer of technical knowledge.

BIBLIOGRAPHY

ABS Publications

- Research and Experimental Development, Business Enterprises, Australia, 1986–87* (8104.0)
Research and Experimental Development, General Government and Private Non-profit Organisations, Australia, 1986–87 (8109.0)
Research and Experimental Development, Higher Education Organisations, Australia, 1986 (8111.0)
Research and Experimental Development, All Sector Summary, Australia, 1986–87 (8112.0)
Research and Experimental Development, All Sector Summary (Inter Year Survey), 1987–88 (8122.0)
Manufacturing Establishments, Details of Operations by Industry Class, Australia (8203.0)

Other Publications

- DEPARTMENT OF EMPLOYMENT, EDUCATION AND TRAINING. *Selected Higher Education Statistics, Australia, 1988*
- INDUSTRY, TECHNOLOGY AND COMMERCE, DEPARTMENT OF. *Measures of Science and Innovation, Australian Science and Technology Indicators Report, 1987*. Canberra, 1987
- INDUSTRY, TECHNOLOGY AND COMMERCE, DEPARTMENT OF. *Science and Technology Statement, 1987–88*. Australia, 1988