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Preface

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As part of ongoing efforts to disseminate information on Malaysian Science and Technology (S&T), the Malaysian Science and Technology Information Centre (MASTIC) is now releasing the latest edition of the Malaysian Science and Technology Indicators 2004 Report. This is the sixth in a series of biennial reports on S&T indicators published by MASTIC since the first issue in 1992.

This report is based on survey data and studies conducted and published by MASTIC including the National Research and Development 2004 Report, Public Awareness of S&T in Malaysia 2002, National Survey of Innovation 2000 - 2001, Science and Technology Knowledge Productivity in Malaysia Bibliometric Study 2003, as well as a compilation of secondary data from other organisations and agencies.

The Malaysian S&T Indicators-2004 Report provides details of the national performance and trends in S&T including education, human resource development, research and development, innovation, scientific publications and public awareness of S&T. It also includes data spanning a series of time until 2002 and presents some international comparisons of selected S&T indicators.

MALAYSIAN SCIENCE AND TECHNOLOGY INDICATORS

2004 Report

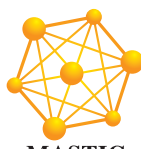


MOSTI

MALAYSIAN SCIENCE AND TECHNOLOGY INDICATORS

2004 Report

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January 2005

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ACKNOWLEDGEMENTS

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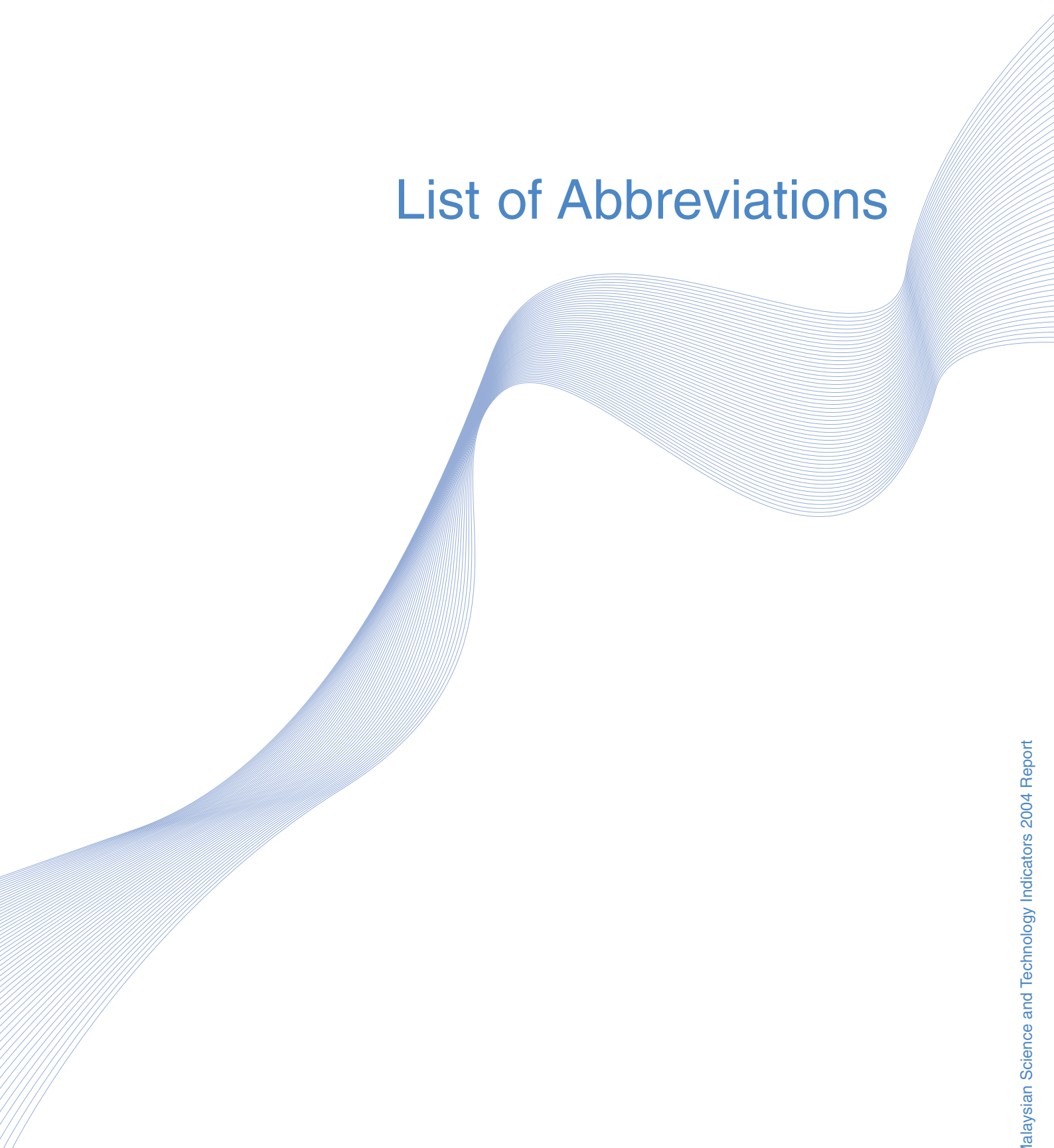
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List of Abbreviations

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ASEAN	Association of South East Asian Nations
EEA	European Economic Area
FOR	Field of Research
FOS	Field of Study
FTE	Full Time Equivalent
GDP	Gross Domestic Product
GNI	Gross National Income
GERD	Gross Domestic Expenditure on R&D
GRIs	Government Agencies and Research Institutes
ICT	Information and Communications Technology
IHLs	Institutes of Higher Learning
IMR	Institutes of Medical Research
MASTIC	Malaysian Science and Technology Information Centre
MOSTI	Ministry of Science, Technology and Innovation
NPO	Non-Profit Organisation
NSE	Natural Science and Engineering
OECD	Organisation for Economic Co-operation and Development
PECC	Pacific Economic Co-operation Council
PORIM	Palm Oil Research Institute of Malaysia
R&D	Research and Development
RM	Ringgit Malaysia
SSH	Social Science and Humanities
S&E	Science and Engineering
S&T	Science and Technology
SEO	Socio-Economic Objectives
SME	Small and Medium Enterprise
SMI	Small and Medium Industry
TBP	Technology Balance of Payments

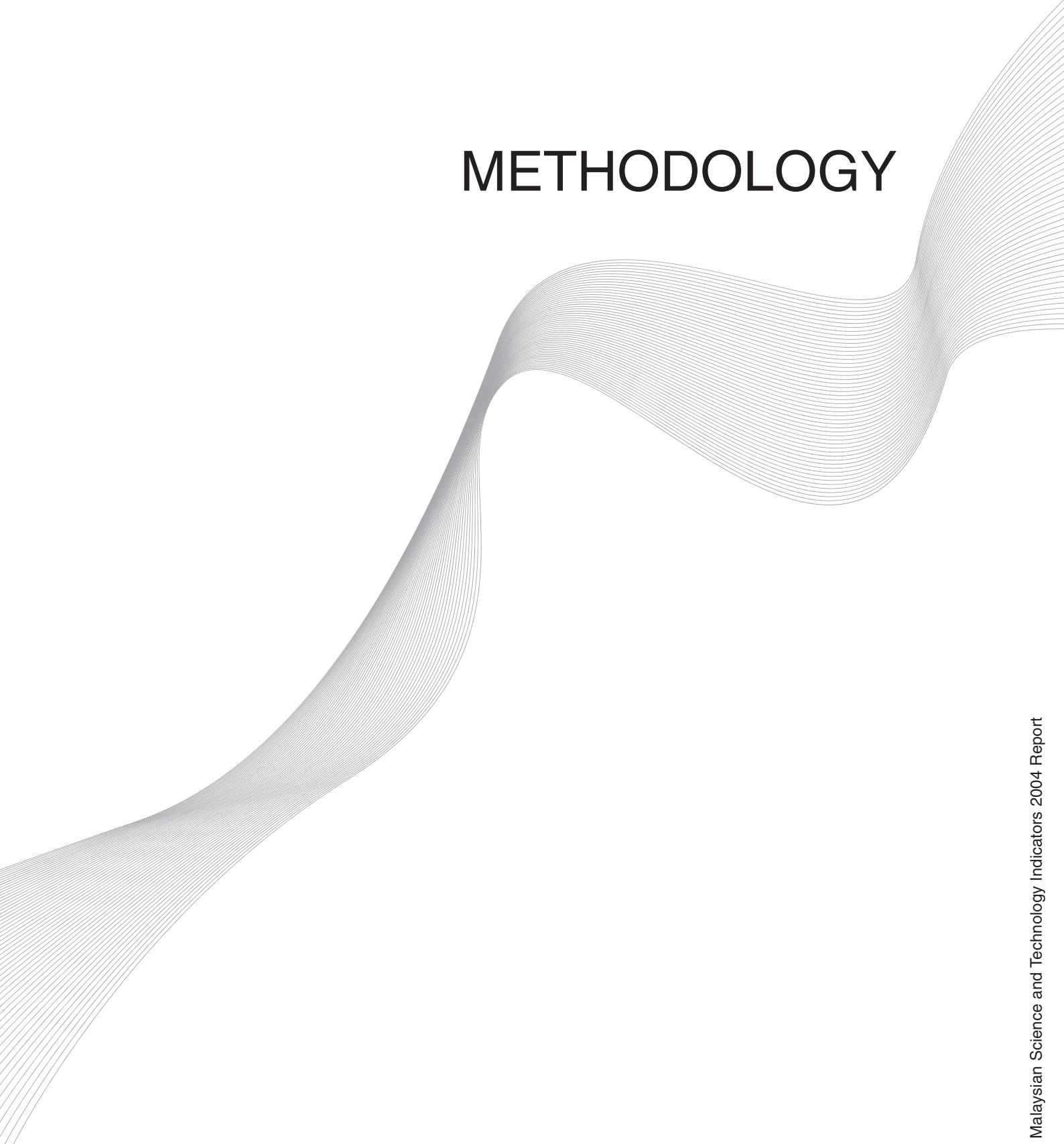
Country Abbreviations

AU	Australia
CA	Canada
DL	Germany
DK	Denmark
ES	Spain
FR	France
IN	Indonesia
IR	Ireland
JP	Japan
KR	Korea, Rep.
MY	Malaysia
NO	Norway
NZ	New Zealand
PH	Philippines
SA	South Africa
SG	Singapore
SW	Switzerland
TH	Thailand
UK	United Kingdom
US	United States

Educational Institution Abbreviations

KTAR	Kolej Tunku Abdul Rahman
KUIM	Kolej Universiti Islam Malaysia
KUITTHO	Kolej Universiti Institut Teknologi Tun Hussein Onn
KUSTEM	Kolej Universiti Sains Teknologi Malaysia
KUTKM	Kolej Universiti Teknikal Kebangsaan Malaysia
IIUM	International Islamic University of Malaysia
UiTM	Universiti Teknologi Mara
UKM	Universiti Kebangsaan Malaysia
UM	Universiti Malaya
UMS	Universiti Malaysia Sabah
UNIMAS	Universiti Malaysia Sarawak
UPM	Universiti Putra Malaysia
UPSI	Universiti Pendidikan Sultan Idris
USM	Universiti Sains Malaysia
UTM	Universiti Teknologi Malaysia
UUM	Universiti Utara Malaysia

METHODOLOGY

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This appendix provides methodological details about the type of indicators that are used in the report. It will help clarify not only definitions and sources of data but their limitations as well.

A. Education in Science and Technology

Data Sources

Data on enrolment and graduation at public and private educational institutions are obtained from the Ministry of Education, Malaysia.

Definition / Classification

In general, this report follows the OECD's classification/aggregation scheme for the field of studies. See Table A1 for more details. Due to the importance of information technology and computer science, this field of study is not included in the "natural sciences" and is reported separately. In the 1994 S&T Indicators report, information technology and computer science was classified under "information and computer technologies". "Engineering sciences & applied S&T" is now classified under the heading "engineering and technology". Two problematic categories in the previous reports are NSE nec (Natural Sciences and Engineering not elsewhere classified) and SSH nec (Social Sciences and

Humanities not elsewhere classified). Since these two categories are not very informative and were not used in the 1998 report, they have been dropped. Instead, a new category, 'Other Fields', has been added in the 2000 report. This category comprises education science, service trades, languages and other fields of education (Table A2).

It is not always possible to maintain a strict adherence to OECD's classification due to the format in which data are collected. For example, the Malaysian Ministry of Education (MOE) has its own classification scheme. In addition, data from public and private educational institutions are collected in different formats, thus making a direct comparison of these data impossible. The re-grouping of MOE's data to fit the OECD classification scheme is presented in Table A2. There are a few problems when attempts are made to re-classify data from MOE in accordance to the OECD classification scheme. The category "Art-others" includes education arts and communication – two fields that come under the social sciences (see mass communication) and humanities (art). Similarly, the category "Technical-others" includes property management that can be classified under social sciences rather than engineering and technology.

Table A1: OECD's Classification Scheme for Field of Study in Education

Aggregated Field of Study	Field of Study
Natural Sciences	Natural science Mathematics and computer science
Engineering and Technology	Engineering Architecture and town planning Trade, craft and industrial programs Transport and communications
Medical Sciences	Medical science and health related
Agricultural Sciences	Agriculture, forestry and fishery
Social Sciences	Law Social and behavioral science Commercial and business administration Mass communication and documentation Home economics (domestic science)
Humanities	Humanities Religion and Theology Fine and Applied Arts
Other Fields	General programs Education science and teacher training Service trades Other programs

Table A2: Comparison Between OECD and MOE Classification Scheme for Education

OECD SCHEME		MOE'S SCHEME	
		Public Educational Institutions	Private Educational Institutions*
Natural Sciences	Natural science Mathematics	Natural Sciences	Science and Mathematics
	IT and Computer Science	Computer Sciences and IT	Computer and Technology
Engineering and Technology	Engineering Architecture and town planning Trade, craft and industrial programs Transport and communications	Engineering and Engineering Trades Manufacturing and Processing Architecture and Planning	Engineering and Technical Skills Manufacturing and Construction Aviation and Maritime
Medical Sciences	Medical science and health related	Health Veterinary	Medicine Health and Welfare
Agricultural Sciences	griculture, forestry and fishery	Agriculture, forestry & fishery	Agriculture
Social Sciences	Law Social and behavioral science Commercial and business administration Mass communication and documentation Home economics (domestic science)	Law Social and behavioral science Business and Administration Journalism and Information	Law Social Sciences Business Administration
Humanities	Humanities Religion and Theology Fine and Applied Arts	Arts and Humanities Religion and Theology	Humanities Art, Design and Music
Other Fields	General programs Education science and teacher training Service trades Other programs	General programs Teacher training and education science Other programs	General programs Education Service trades Language

Note: (*) Based on the International Standard Classification of Education (ISCED) published by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1997

B. Human Resources for Science and Technology

Data Sources

Data on R&D personnel are obtained from the 2002 National Survey of Research and Development conducted by MASTIC.

Definitions / Classifications

Research and Development (R&D)

This report adopts OECD's definition of R&D that is stated in the Frascati Manual (1994, p.29):

"... research and experimental development (R&D) comprise 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 three types of R&D activities are defined as follows.

Basic research – as experimental or theoretical work undertaken primarily to acquire

new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.

Applied research – as also original investigation undertaken in order to acquire new knowledge, however, directed primarily towards a specific practical aim or objective.

Experimental development – in the sense of systematic work, drawing on existing knowledge gained from research and/or practical experience, that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, and in the management of the projects concerned. (OECD, 1997)

Full Time Equivalent (FTE) is a measure of the proportion of time a researcher, technician or other support staff spend on R&D work during the surveyed year. (MASTIC, 1998). FTE in year x can be calculated based on the following formula:

$$\frac{\text{Hours or days spent on R\&D in year x}}{\text{Total working hours or days in year x}} \times \frac{\text{No. of months in year x doing R\&D}}{12 \text{ months}}$$

C. Research and Development Activities

Data Sources

Data on R&D personnel are obtained from the 2002 National Survey of Research and Development conducted by MASTIC.

Definitions

Gross Domestic Expenditure on R&D (GERD) comprise of current expenditures as well as gross capital expenditures that incurred in R&D activities in a given year. Current expenditures consist of labor costs and other current costs, while capital expenditures consist of land and buildings, and instruments and equipments.

D. Innovation

Data Sources

Data on the incidence of technological innovation and innovation activities among manufacturing firms are obtained from the National Survey of Innovation (2001-2002) conducted by MASTIC.

Survey Methodology

A sample size of 4,000 respondents in the manufacturing sector was used in the survey. The survey adopted a stratified sampling method based on the size and the principal activity of the firms.

Definitions

The definitions used in the survey to identify technological innovation are based on the recommendations of the Oslo Manual, published in 1992 by the OECD and the EC and revised in 1997. The following definitions were used for the manufacturing sector:

“Technological product and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes.” (Oslo Manual, p.47)

“A technologically new product is a product whose technological characteristics or intended uses differ significantly from those of previously produced products. Such innovations can involve radically new technologies, can be based on combining existing technologies in new uses, or can be derived from the use of new knowledge.” (Oslo Manual, p.48)

“A technologically improved product is an existing product whose performance has been significantly enhanced or upgraded. A simple product may be improved (in terms of better performance or lower cost) through use of higher-performance components or materials, or a complex product which consists of a number of integrated technical subsystems may be improved by partial changes to one of the subsystems.” (Oslo Manual, p.49)

“Technological process innovation is the adoption of technologically new or significantly improved production methods, including methods of product delivery. These methods may involve changes in equipment, or production organization, or a combination of these changes, and may be derived from the use of new knowledge. The methods may be intended to produce or deliver technologically new or improved products, which cannot be produced or delivered using conventional

production methods, or essentially to increase the production or delivery efficiency of existing products.” (Oslo Manual, p.49)

E. Trade in Technology

Data Sources

Trade data for high-technology goods and medium-high technology goods are obtained from Department of Statistics. Data on royalties, contracts and professional fees, construction and engineering are obtained from Bank Negara Malaysia (BNM). These data refer to cash transactions between residents of Malaysia and the rest of the world, as reported for the Cash Balance of Payments Reporting System.

High-Technology and Medium-High-Technology Goods

The technology level of industries is determined in this report based on OECD's classification scheme. This scheme is based on R&D intensity in each industry. The products that come under some of the high technology and medium-high technology industries and their SITC codes are listed in Table F1.

Table F1: Classification of Products by Technology Intensity

High-technology industries				
Industry	ISIC Rev.3	ISIC Description	SITC Rev.3	SITC Description
Aircraft and spacecraft	353	353 - Manufacture of aircraft and spacecraft	7921, 7922, 7923, 7924, 7925, 79291, 79293, 714, 87411 - 71489 - 71499	792.1 - Helicopters 792.2 - Aeroplanes and other aircraft, mechanically-propelled (other than helicopters), of an unladen weight not exceeding 2,000 kg 792.3 - Aeroplanes and other aircraft, mechanically-propelled (other than helicopters), of an unladen weight exceeding 2,000 kg but not exceeding 15,000 kg 792.4 - Aeroplanes and other aircraft, mechanically-propelled (other than helicopters), of an unladen weight exceeding 15,000 kg 792.5 - Spacecraft (including satellites) and spacecraft launch vehicles 792.91 - Propellers and rotors, and parts thereof 792.93 - Undercarriages, and parts thereof 714 - Engines and motors, non-electric (other than those of groups 712, 713 and 718); parts, n.e.s., of these engines and motors 874.11 - Direction-finding compasses; other navigational instruments and appliances Exclude: 714.89 - Other gas turbines and 714.99 - Parts for the gas turbines of heading 714.89
Pharmaceuticals	2423	2423 - Manufacture of pharmaceuticals, medicinal chemicals and botanical products	5413, 5415, 5416, 5421, 5422	541.3 - Antibiotics, not put up as medicaments of group 542 541.5 - Hormones, natural or reproduced by synthesis; derivatives thereof, used primarily as hormones; other steroids used primarily as hormones, not put up as medicaments of group 542 541.6 - Glycosides; glands or other organs and their extracts; antisera, vaccines and similar products 542.1 - Medicaments containing antibiotics or derivatives thereof 542.2 - Medicaments containing hormones or other products of subgroup 541.5 but not containing antibiotics
Office, accounting and computing machinery	30	300 - Manufacture of office, accounting and computing machinery	75113, 75131, 75132, 75134, 7521, 7522, 7523, 7526, 7527, 7529	751.13 - Automatic typewriters; word-processing machines 751.31 - Electrostatic photocopying apparatus operating by reproducing the original image directly onto the copy (direct process) 751.32 - Electrostatic photocopying apparatus operating by reproducing the original image via an intermediate onto the copy (indirect process) 751.34 - Non-electrostatic photocopying apparatus of the contact type 752 - Automatic data-processing machines and units thereof; magnetic or optical readers, machines for transcribing data onto data media in coded form and machines for processing such data, n.e.s. 759.97 - for the machines of group 752 Exclude: 752.9 - Data-processing equipment, n.e.s.

High-technology industries				
Industry	ISIC Rev.3	ISIC Description	SITC Rev.3	SITC Description
Radio, television and communications equipment	32	321 - Manufacture of electronic valves and tubes and other electronic components 322 - Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy 323 - Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods	76381, 76383, 764 - 76493 - 76499, 7722, 77261, 77318, 77625, 77627, 7763, 7764, 7768	763.81 - Video-recording or reproducing apparatus, whether or not incorporating a video tuner 763.83 - Other sound-reproducing apparatus 764 - Telecommunications equipment, n.e.s., and parts, n.e.s., and accessories of apparatus falling within division 76 Exclude : 764.93 - with the apparatus and equipment of groups 761 and 762 and subgroups 764.3 and 764.8 and 764.99 - with the apparatus falling within group 763 772.2 - Printed circuits 772.61 - for a voltage not exceeding 1,000 V 773.18 - Optical fibre cables 776.25 - Microwave tubes (excluding grid-controlled tubes) 776.27 - Other valves and tubes 776.3 - Diodes, transistors and similar semiconductor devices; photosensitive semiconductor devices (including photovoltaic cells, whether or not assembled in modules or made up into panels); light-emitting diodes 776.4 - Electronic integrated circuits and microassemblies 776.8 - Piezoelectric crystals, mounted; parts, n.e.s., of the electronic components of group 776 898.79 - Recorded media, n.e.s.
Medical, precision and optical instruments	33	331 - Manufacture of medical appliances and instruments and appliances for measuring, checking, testing, navigating and other purposes, except optical instruments 332 - Manufacture of optical instruments and photographic equipment 333 - Manufacture of watches and clocks	774, 8711, 8713, 8714, 8719, 87211, 874, 88111, 88121, 88411, 88419, 89961, 89963, 89966, 89967	774 - Electrodagnostic apparatus for medical, surgical, dental or veterinary purposes, and radiological apparatus 871.1 - Binoculars, monoculars, other optical telescopes, and mountings therefor; other astronomical instruments and mountings therefor (excluding instruments for radio astronomy) 871.3 - Microscopes (other than optical microscopes); diffraction apparatus; parts and accessories thereof, n.e.s. 871.4 - Compound optical microscopes (including those for photomicrography, cinephotomicrography or microprojection) 871.9 - Liquid crystal devices, n.e.s.; lasers (other than laser diodes); other optical appliances and instruments, n.e.s. 872.11 - Dental drill engines, whether or not combined on a single base with other dental equipment 874 - Measuring, checking, analysing and controlling instruments and apparatus, n.e.s. Exclude : 874.11 - Direction-finding compasses; other navigational instruments and appliances and 874.2 - Drawing, marking-out or mathematical calculating instruments (e.g., drafting machines, pantographs, protractors, drawing sets, slide-rules, disc calculators); instruments for measuring length, for use in the hand (e.g., measuring rods and tapes, micromete...

Methodology

High-technology industries				
Industry	ISIC Rev.3	ISIC Description	SITC Rev.3	SITC Description
				881.11 - Photographic (other than cinematographic) cameras 881.21 - Cinematographic cameras 884.11 - Contact lenses 884.19 - Optical fibres and optical fibre bundles and cables; sheets and plates of polarizing material; unmounted optical elements, n.e.s. 899.61 - Hearing-aids (excluding parts and accessories) 899.63 - Orthopaedic or fracture appliances 899.66 - Other artificial parts of the body 899.67 - Pacemakers for stimulating heart muscles (excluding parts and accessories)

Medium-high-technology industries				
Industry	ISIC Rev.3	ISIC Description	SITC Rev.3	SITC Description
Electrical machinery and apparatus, n.e.c.	31	311 - Manufacture of electric motors, generators and transformers 312 - Manufacture of electricity distribution and control apparatus 313 - Manufacture of insulated wire and cable 314 - Manufacture of accumulators, primary cells and primary batteries 315 - Manufacture of electric lamps and	77862, 77863, 77864, 77865, 7787, 77884	778.62 - Tantalum fixed capacitors 778.63 - Aluminium electrolytic fixed capacitors 778.64 - Ceramic dielectric fixed capacitors, single layer 778.65 - Ceramic dielectric fixed capacitors, multilayer 778.7 - Electrical machines and apparatus, having individual functions, n.e.s.; parts thereof 778.84 - Electric sound or visual signalling apparatus (e.g., bells, sirens, indicator panels, burglar and fire-alarms), other than those of heading 778.34 or 778.82
Motor vehicles, trailers and semi-trailers	34	lighting equipment 319 - Manufacture of other electrical equipment n.e.c. 341 - Manufacture of motor vehicles 342 - Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers 343 - Manufacture of parts and accessories for motor vehicles and their engines	781-784, 786	781 - Motor cars and other motor vehicles principally designed for the transport of persons (other than motor vehicles for the transport of ten or more persons, including the driver), including station-wagons and racing cars 782 - Motor vehicles for the transport of goods and special-purpose motor vehicles 783 - Road motor vehicles, n.e.s. 784 - Parts and accessories of the motor vehicles of groups 722, 781, 782 and 783 786 - Trailers and semi-trailers; other vehicles, not mechanically-propelled; specially designed and equipped transport containers

Medium-high-technology industries				
Industry	ISIC Rev.3	ISIC Description	SITC Rev.3	SITC Description
Chemicals excluding pharmaceuticals	24 excl. 2423	241 - Manufacture of basic chemicals 242 - Manufacture of other chemical products 243 - Manufacture of man-made fibres 2411 - Manufacture of basic chemicals, except fertilizers and nitrogen compounds 2412 - Manufacture of fertilizers and nitrogen compounds 2413 - Manufacture of plastics in primary forms and of synthetic rubber 2421 - Manufacture of pesticides and other agro-chemical products 2422 - Manufacture of paints, varnishes and similar coatings, printing ink and mastics 2424 - Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations 2429 - Manufacture of other chemical products n.e.c. 2430 - Manufacture of man-made fibres	52222, 52223, 52229, 52269, 525, 531, 57433, 591	522.22 - Selenium, tellurium, phosphorus, arsenic and boron 522.23 - Silicon 522.29 - Calcium, strontium and barium; rare earth metals, scandium and yttrium, whether or not intermixed or interalloyed 522.69 - Other inorganic bases; other metal oxides, hydroxides and peroxides 525 - Radioactive and associated materials 531 - Synthetic organic colouring matter and colour lakes, and preparations based thereon 574.33 - Polyethylene terephthalate 591 - Insecticides, rodenticides, fungicides, herbicides, anti-sprouting products and plant-growth regulators, disinfectants and similar products, put up in forms or packings for retail sale or as preparations or articles (e.g., sulphur-treated bands, wicks and...
Railroad equipment and transport equipment, n.e.c.	352, 359	3520 - Manufacture of railway and tramway locomotives and rolling stock 3591 - Manufacture of motorcycles 3592 - Manufacture of bicycles and invalid carriages 3599 - Manufacture of other transport equipment n.e.c.	791, 785	791 - Railway vehicles (including hovertrains) and associated equipment 785 - Motor cycles (including mopeds) and cycles, motorized and non-motorized; invalid carriages

Medium-high-technology industries				
Industry	ISIC Rev.3	ISIC Description	SITC Rev.3	SITC Description
Machinery and equipment, n.e.c.	29	291 - Manufacture of general purpose machinery	71489, 71499, 71871, 71877, 71878, 72847, 7311, 73131, 73135, 73142, 73144, 73151, 73153, 73161, 73163, 73165, 73312, 73314, 73316, 7359, 73733, 73735	714.89 - Other gas turbines
		292 - Manufacture of special purpose machinery		714.99 - Parts for the gas turbines of heading 714.89
		293 - Manufacture of domestic appliances n.e.c.		718.71 - Nuclear reactors
		2911 - Manufacture of engines and turbines, except aircraft, vehicle and cycle engines		718.77 - Fuel elements (cartridges), non-irradiated
		2912 - Manufacture of pumps, compressors, taps and valves		718.78 - Parts of nuclear reactors
		2913 - Manufacture of bearings, gears, gearing and driving elements		728.47 - Machinery and apparatus for isotopic separation, and parts thereof, n.e.s.
		2914 - Manufacture of ovens, furnaces and furnace burners		731.1 - Machine tools for working any material by removal of material, by laser or other light or photon beam, ultrasonic, electrodischarge, electrochemical,
		2915 - Manufacture of lifting and handling equipment		731.31 - Horizontal lathes, numerically controlled
		2919 - Manufacture of other general purpose machinery		731.35 - Other lathes, numerically controlled
		2921 - Manufacture of agricultural and forestry machinery		731.42 - Other drilling machines, numerically controlled
		2922 - Manufacture of machine-tools		731.44 - Other boring-milling machines, numerically controlled
		2923 - Manufacture of machinery for metallurgy		731.51 - Milling machines, knee-type, numerically controlled
		2924 - Manufacture of machinery for mining, quarrying and construction		731.53 - Other milling machines, numerically controlled
		2925 - Manufacture of machinery for food, beverage and tobacco processing		731.61 - Flat-surface grinding machines, numerically controlled, in which the positioning in any one axis can be set up to an accuracy of at least 0.01 mm
		2926 - Manufacture of machinery for textile, apparel and leather production		731.63 - Other grinding machines, numerically controlled, in which the positioning in any one axis can be set up to an accuracy of at least 0.01 mm
		2927 - Manufacture of weapons and ammunition		731.65 - Sharpening (tool- or cutter-grinding) machines, numerically controlled
		2929 - Manufacture of other special purpose machinery		733.12 - Bending, folding, straightening or flattening machines (including presses), numerically controlled
		2930 - Manufacture of domestic appliances n.e.c.		733.14 - Shearing machines (including presses), numerically controlled, other than combined punching and shearing machines
				733.16 - Punching or notching machines (including presses), including combined punching and shearing machines, numerically controlled
				735.9 - Parts, n.e.s., and accessories suitable for use solely or principally with the machine tools of groups 731 and 733
				737.33 - Machines and apparatus for resistance welding of metal, fully or partly automatic
				737.35 - Machines and apparatus for arc (including plasma-arc) welding of metal, fully or partly automatic

Technology Balance of Payments

The basis for the technology balance of payments and the methodology used are laid out in the OECD document titled Proposed Standard Method of Compiling and Interpreting Technology Balance of Payments Data – TBP Manual (1990).

The OECD defines the technology balance of payments (TBP) in the following manner:

“The technological balance of payments measures the flows of funds for transactions concerning industrial property rights. It covers invisible transaction in a country’s balance of payments concerning the purchase and sale of “disembodied” technology in the form of intellectual and industrial property rights including patents, licenses, know-how and technical assistance. It is therefore an indicator of technology transfer across countries.”

In Malaysia, there are no efforts as yet to collect technology transfer data in accordance to the guidelines such as the TBP Manual. The closest proxy to TBP is the compilation of cash balance of payments data for the following three categories:

- i) royalties and license fees;
- ii) contracts and professional fees; and
- iii) construction and engineering.

These data are used as proxies for TBP in the report. Items included in each of the above categories are as follows:

- i) Royalties and license fees – comprise of fees for authorized use of patents, copyrights, trademarks, industrial processes, franchises etc. and the use through licensing agreements, of produced originals or prototypes (such as manuscripts and films).
- ii) Contracts and Professional Fees – comprise of: (a) payments to/receipts from non-resident head-offices and branches arising from sharing of administrative

and operating expenses, and (b) fees for services provided in the form of legal, accounting, management consulting, public relations, advertising, market research and all commissions, brokerage fees levied by non-financial intermediaries.

- iii) Construction and Engineering – comprise of: (a) construction (e.g. ports, dams, bridges, roads, airports, refineries and plants) and installation of electrical and mechanical systems. It also includes activities undertaken in connection with the prospecting and exploration of all types of minerals (exclude imports and exports of goods), (b) fees for provision of expertise in engineering, architectural and other technical services, including planning, project design and supervision of turnkey projects; research and development; product testing and certification.

F. Publications and Citations

Data Sources

Bibliometric data in this report is obtained from the following ISI Thompson Scientific databases available on CD-ROM from MASTIC:

- i) National Science Indicators (NSI) Especially Prepared for MASTIC, 1981-2002
- ii) National Citation Report-Malaysia (NCR) Especially Prepared for MASTIC, 1981-2002, and
- iii) The National Bibliometric Study of Science & Technology Knowledge Productivity in Malaysia: 2003, undertaken by MASTIC

The ISI databases were queried by publication and citation counts for countries, subfields, authors, institutions and collaboration.

G. Awareness, Knowledge, and Attitude Towards Science and Technology

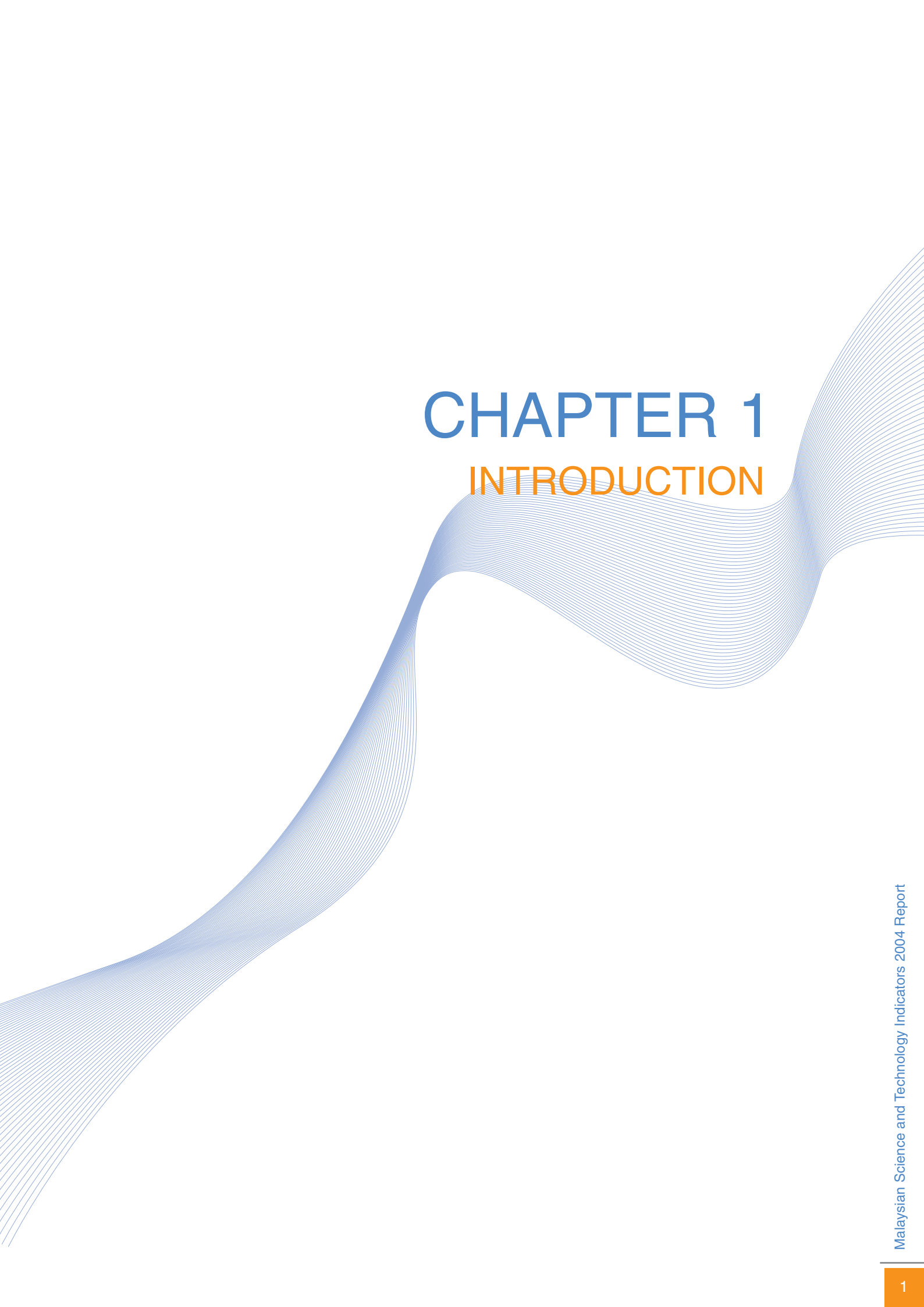
Data Sources

Data for public awareness, knowledge and attitude towards S&T issues are obtained from the 2002 Public Awareness of Science and Technology Malaysia Survey conducted by MASTIC.

A Brief Tour of the Survey Methodology

A sample size of 5,000 respondents was used for the survey. Proportional sampling was employed in terms of characteristics such as race, rural/urban, age group, and gender. In the survey, knowledge and interest in S&T issues are surveyed in 11 categories: (1) space exploration; (2) application of computer technology; (3) application of nuclear technology for electricity generation; (4) business and economy; (5) environmental pollution; (6) foreign affairs; (7) national education policy; (8) new discoveries in medicine; (9) new discoveries in the sciences; (10) new inventions in Malaysia; and (11) new technology and innovation. A scale of one to four is used in the survey.

A set of ten questions was posed to the survey respondents' to gauge their perceived S&T knowledge. These were questions requiring yes/no responses. To assess the public's perception and attitude, a set of 11 questions were asked. Respondents were required to state whether they agree, disagree or are not sure about each of these statements.

A decorative graphic consisting of multiple thin, wavy lines in blue and orange, flowing from the bottom left towards the top right, framing the chapter title.

CHAPTER 1

INTRODUCTION

Science and technology play an increasingly important role in sustaining and improving the competitiveness of Malaysia. The World Competitiveness Year Book placed Malaysia in the 16th position for 2004, ahead of more developed nations such as Germany (21), United Kingdom (22), Japan (23), South Korea (35), and New Zealand (18) (IMD, 2004). This enviable position can be attributed to, among others, impressive economic performance and business efficiency. The weakness of Malaysia lies in its scientific infrastructure and innovation system that lacks innovative capability. Therefore, addressing weaknesses in the area of S&T and building scientific capabilities are the strategic directions that Malaysia must seriously consider whilst continuing to exploit our strengths and capabilities that are already embedded in our competitive structure.

In charting the future direction of Malaysia towards greater competitiveness, science and technology development in terms of scientific infrastructure and human resource is crucial. In line with Malaysia's vision to transform our nation into a knowledge-based economy, education, training and retraining in science and technology deserve special attention. In other words, competitiveness that is driven by science and technology requires capacity building in human resource through education and scientific infrastructure development.

The world today is characterised by increasing globalisation, regionalism and bilateralism, and competition both domestic and global has become stiffer and more complex over the years. Public intervention in the form of policies with regards to investment in scientific infrastructure, education and training is seen as necessary, if not highly desired in achieving the explicit goal of increasing science and technology capability and innovativeness.

Besides the present national agenda to build scientific capabilities, regional and international cooperation is taking place in order to cooperate, collaborate and hasten the development of technologies and the dissemination of knowledge in identified areas (ASEAN Annual Report, 2002-2003, pp.62-95;

OECD, 2004). Amongst the OECD member countries, much attention has been devoted to two major issues: ensuring sustained development of human resources in science and technology and enhanced international co-operation in science and technology. Co-operation in science and technology towards sustainable development, notably by transferring knowledge and technology among member countries as well as to less developed ones, has been given due attention.

The co-operation among ASEAN Member Countries as well as ASEAN + 3 are excellent examples of a regional co-operation. One of the areas that is of interest to governments in ASEAN and ASEAN + 3 relates to Science Policy Development in which the development of technology competitiveness indicators as a policy making tool is being undertaken. A common set of benchmarks for ASEAN Member Countries to assess their science and technology capabilities and technology competitiveness is being undertaken by the ASEAN Science and Technology Community for Innovation, Competitiveness and Knowledge. Therefore, the preparation of the Science and Technology (S&T) Indicators Report should be the continuous effort of the Malaysian Government to assess its capabilities in S&T, vis-à-vis other nations. At the same time, the S&T indicators report provides feedback to public policy makers to enable them to evaluate existing policies, to design and implement new ones.

Indicators for science and technology may be defined as a set of statistics which measure quantifiable aspects of the creation, dissemination and application of science and technology, arranged to answer a specific question. The indicators that are recorded over a period of time allow us to see trends and to benchmark.

Science and Technology Indicators Report, 2004 is the sixth volume published by the Malaysian Science and Technology Information Centre (MASTIC), Ministry of Science, Technology and Innovation. This biennial report is a catalogue of the inputs of Malaysia's scientific endeavours and the outputs of these efforts.

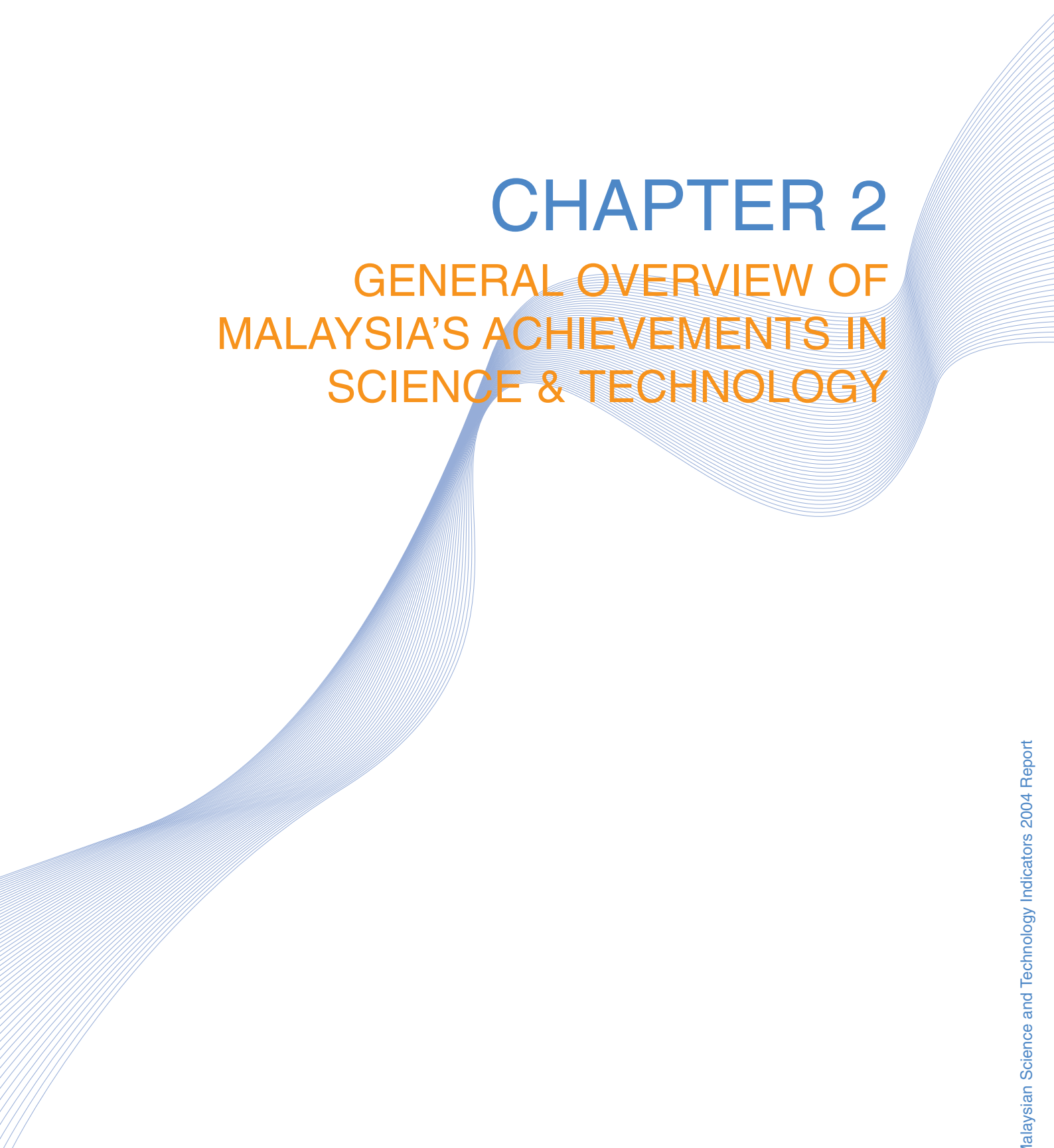
1.1 Organisation of the Report

The presentation of the chapters closely adheres to the input-output model, i.e., the inputs to scientific efforts are presented followed by outputs. In this report, data are organised and categorised into groups: individuals and institutions. Findings that are individual-based are those from the Survey of Public Awareness toward Science and Technology, 2002; while data that are institution-based are from R&D Survey, 2002, The National Survey of Innovation, 2000-2001, as well as institutional reports from relevant agencies. The sectors that are covered are government, business, and institutions of higher education. The chapters in this report are :

- Chapter 1 – Introduction
- Chapter 2 – General Overview of Malaysia's Achievements in S&T
- Chapter 3 – Education in S&T
- Chapter 4 – Human Resource for S&T
- Chapter 5 – Research and Development Activities
- Chapter 6 – Innovation in the Malaysian Manufacturing Sector
- Chapter 7 – Trade in Technology
- Chapter 8 – Publications and Citations
- Chapter 9 – Awareness, Knowledge and Attitude Towards S&T
- Chapter 10 – Public Support for S&T
- Chapter 11 – International Comparisons

A new chapter "Publications and Citations" has been added to this report. Publications and citations are in a way, a measurement of output in R&D activities. One major usage of this indicator is for international comparison. It also helps to identify high impact papers and journals and the authors, leading universities and corporations as well as to understand the latest development in the scientific fields. Although this is a direct measure for the university sector, works of scientists and inventors in other sectors are not necessarily disseminated through publications and citations unless they choose to disseminate their findings through publications. In reality, private companies that are R&D-driven and are innovative often keep their work confidential. Hence publications and citation reports are in a way an inadequate measure of scientific knowledge and achievement. Reference could be made to Chapter 8 for more discussions relating to publications and citations as indicators.

In addition to this new chapter, S&T Indicators Report 2004 gives readers a deeper understanding on the innovative activities in Malaysia. The chapter on innovation which is derived from the findings obtained in the second national survey of innovation provides information on the status of innovation among companies in Malaysia as well as the trends in innovative activities.

A decorative graphic consisting of numerous thin, parallel blue lines that form a wavy, ribbon-like shape. It starts from the bottom left, curves upwards and to the right, then loops back and curves downwards and to the right, ending near the top right corner. The lines are closely spaced, creating a sense of motion and depth.

CHAPTER 2

GENERAL OVERVIEW OF MALAYSIA'S ACHIEVEMENTS IN SCIENCE & TECHNOLOGY

Malaysia's economy continued its recovery path from the Asian financial crisis that took place in 1998. Domestic output, as measured by the real GDP figures, grew from RM209.9 billion in 2000 to RM219.3 billion in 2002, representing a growth of 4.4% over the period of two years. On an annual basis, the real GDP registered a slower growth of 4.1% in 2002 as compared to 8.5% in 2000 due to a combination of weak demand in the electronics sector and the adverse knock-on the effects on the tourism-related industry as a result of the threat of international terrorism.

In terms of individual's wealth, Malaysia's income per capita improved slightly from RM13,333 in 2000 to RM13,683 in 2002 due to an almost stagnant real GNP growth of 0.3% in 2001. When adjusted for purchasing power, the income per capita for Malaysia stood at US\$9,300, which was more than double the income per capita for China (US\$4,400) and half of that for Taiwan (US\$18,000), in line with our nation's middle - income status relative to other countries.

The share of the Malaysian government's expenditure relative to domestic

output has increased during the period 2000 to 2002. The federal government's expenditure as a percentage of GDP increased from 24.7% in the year 2000 to 29.0% in 2002, financed primarily through budget deficits (-5.8% and -5.6% in the year 2000 and 2002 respectively). However, budget deficit above 5% will typically raise an alarm as it will not be sustainable over the long term. Consequently, the future expenditures in all sectors in Malaysia's economy, including those that are related to science and technology (S&T), must be driven by the private sector.

Table 2.1 provides a comparison of Malaysia's economy relative to selected countries in OECD, ASEAN and the Far East. It is apparent that a country's achievement in S&T correlates strongly with its wealth, as measured using GDP per capita. However, the monetary wealth of a country provides only one perspective to the analysis of its S&T development. This report combines all factors that contribute to the development of S&T in Malaysia, ranging from education and research activities to employment and trade in technology-related goods and services.

Country	Real GDP Growth	GDP at Current Price GDP	Population (million)	Per Capita GDP (nominal)	Per Capita GDP (PPP)
Malaysia	4.1%	94,910	24,531	3,869	9,300
Singapore	2.2%	88,274	4,171	21,162	24,000
Thailand	5.4%	126,473	63,430	2,034	6,900
Taiwan	3.6%	281,921	22,510	12,524	18,000
South Korea	6.3%	476,700	47,640	10,000	17,000
Australia	2.8%	409,200	19,663	20,700	28,100
US	2.4%	10,383,100	288,600	36,100	36,100
UK	1.6%	1,563,700	59,008	26,400	28,000
France	1.2%	1,431,300	61,082	23,400	27,200
Japan	-0.4%	3,972,500	127,435	31,200	26,900
Canada	3.3%	724,800	31,414	23,100	30,300

Note: All figures are in US\$

Source: World Bank

Table 2.1: Economic Data for Selected Countries (2002)

2.1 Education in S&T

Overall, student enrolment in the science and mathematics subjects at the secondary school has increased between 2000 and 2002, despite the overall reduction in the number of students registered for SPM (-8.6%) and marginal increase (1.9%) in the overall students registered for STPM.

At the university level, both social sciences and humanities continued to be more popular than S&T related fields such as natural sciences, engineering, IT and medical sciences. More students were enrolled at public educational institutions than private educational institutions for both undergraduate and postgraduate courses. The ratio of enrolment in first degree courses was 73:27 in favour of public educational institutions. For both types of institutions, social science recorded the highest enrolment, followed by engineering and technology at public institutions, and IT and computer science at private institutions.

Enrolment in masters and doctoral degrees were heavily skewed towards public institutions. In 2002, 84.4% of the total 29,464 enrolment in masters degrees and 95.1% of the total 4,053 enrolment in doctoral degrees were at public universities. Of the enrolment at masters level, 43.4% were for natural science equivalent subjects while for doctoral degrees, the percentage was 48.4%.

A total of 51,261 students graduated at first-degree level in 2002, with 60.5% of the total coming from public universities. Again, the graduation in masters and doctorate degrees were dominated by public universities, which contributed 90.8% of the total 6,226 masters graduates and 99.2% of the total 490 doctoral graduates in 2002. A higher percentage (58.6%) of natural science equivalent graduates were recorded at doctoral level as compared to master level (32.5%), indicating a doctoral degree is still very much associated with intense research-oriented activities as emphasised by most natural science subjects.

2.2 Human Resource in S&T

The period between 2000 and 2002 recorded an increase in the number of researchers per 10,000 labour force from 15.6 to 18.0. Similarly, researchers per 10,000 population also increased from 6.4 to 7.3. In terms of R&D personnel, there has been an improvement from 23,262 in 2000 to 24,937 in 2002. Although the manpower in R&D is still low when measured by international standards, there is a marked improvement over the last ten years.

Examining the trends in R&D personnel in different sectors, the private sector registered a significant increase in researchers in terms of headcount (45.4%) during the period of 2000-2002. There were more male researchers, technicians and other support personnel involved in R&D compared to females in all sectors for the two years of 2000 and 2002. For the private sector, in terms of headcount, males made up 70.9% of the total R&D personnel in the sector in 2002. In the public sector, 65% males were involved in R&D in Government Research Institutes (GRIs) whereas in Institutes of Higher Learning (IHLs), the involvement was 70.5%.

The overall concentration of activities was in the order of applied research (6,981), basic research (4,508) and experimental development (2,497). For the private sector, the focus was on applied research (44.2%) and experimental development (27.8%), clearly indicating the emphasis on market driven research to satisfy market needs. For the GRIs, 37.3% of the researchers were engaged in applied research, followed by 22.6% in basic research in 2002. For the IHLs, more emphasis was given to applied research (38.4%) and basic research (33.4%).

Of the three major sectors in the economy, the field of research that received tremendous attention in 2002 in terms of the number of researchers was engineering sciences, followed by information, computer & communication technologies, and applied sciences & technologies. The two fields of research that had the least number of researchers in 2002 were marine sciences and physical sciences.

The majority of researchers in the private sector in 2002 had a bachelor's degree (68.5%), followed by masters degree (10.1%) and PhD degrees (2.4%). The field of research that attracted a large number of researchers was information, computer & communication technologies, engineering sciences and applied sciences & technologies. Earth sciences and environmental sciences had the least number of researchers. In the case of government sectors, IHLs had the highest percentage of PhD holders (41.9%), whereas GRIs had 27.6% of researchers with similar qualification.

For IHLs the distribution of researchers in the various fields in 2002 was more or less quite well distributed compared to the private sector as 9 out of the 18 fields of research had more than 500 researchers. The field with the highest number of researchers was engineering sciences, followed by social sciences and information, computer & communication technologies. For GRIs, the concentration of researchers was in agriculture and engineering sciences. The distribution suggested that private sector R&D is market-driven and customer-focused, whereas GRIs and IHLs undertake research in areas that the private sector does not emphasise.

Analysis on Malaysian-born scientists and engineers currently working abroad is limited due to data unavailability. In the case of US for 1999, most of the Malaysian-born scientists and engineers were still holding Malaysian citizenship (67.5%), despite working in the U.S. Of these, 42.5% held a permanent visa and another 26.3% had a temporary visa. Almost one-third (32.5%) were already U.S. citizens. The largest proportion of these R&D workers was in engineering, followed by computer and mathematical sciences, and life sciences. In terms of sector of employment, more than three-quarters worked in the business and industry sector (77.6%). Slightly more than 10% worked in the education sector, presumably in universities or colleges throughout the U.S. About 9.2% worked in the government sector.

In the case of Australia for 2001, 1,578 Malaysian-born scientists and engineers worked in the country, with slightly more than

half (56.7%) becoming Australian citizens. In terms of gender, more than three-quarters were males. Almost three-quarters were working in the private sector, while the rest worked with the state/territory government. 71.3% of these R&D workers were working as building and engineering professionals, while the rest were engaged as natural and physical science professionals.

2.3 Research and Development (R&D) Activities

Overall, the R&D expenditure increased steadily from RM1,671.5 million in 2000 to RM2,500.6 million (an increase of 49.6%) in 2002. About two-thirds of the R&D expenditure (65.3%) came from the private sector, 20.3% from Government Research Institutes (GRIs), and the remaining 14.4% derived from Institutes of Higher Learning (IHLs). The R&D expenditure for the private sector increased both in real terms and in terms of percentage contribution towards total R&D expenditure for the whole economy, from 57.9% in 2000 to 65.3% in 2002. Corresponding to the overall increase in R&D expenditure for the 2000-2002 period, all sectors within the economy recorded an increase in R&D expenditure. For the private sector, the amount of expenditure increased by RM665.2 million or 40.7%, while GRIs and IHLs also experienced an increase in spending on R&D amounting to RM89.6 million (an increase of 21.5%) and RM74.3 million (an increase of 26.0%), respectively. This indicates that the overall increase in total R&D expenditure during the reference period was mainly by the private sector. In terms of the GERD/GDP ratio, the increase was from 0.50 in 2000 to 0.69 in 2002.

The total R&D expenditure in year 2002 was RM2.5 billion, an increase of RM829.1 million or 49.6% from year 2000. In 2000, capital expenditure was 51.7% of total expenditure and current expenditure made up 48.3%. The structure of expenditure had changed significantly together with the increase in total expenditure. Compared to 2000, the percentage had increased by 7.4%. The increase was relative to GRIs and IHLs which had proportionally less expenditure in 2002 compared to 2000.

The manufacturing sector is the engine of growth for Malaysia. Building capacity for R&D in the private sector will enhance the competitiveness of the sector in terms of new product development and process innovation. Although companies with revenues of less than RM10 million made up 37.9% of the respondent companies, the amount of R&D spent made up only 11.5% of total private sector R&D expenditure, indicating the limited resources of small companies for R&D.

GRIIs that are involved in agricultural research and IT, such as FRIM, MPOB, and MIMOS, experienced a significant increase in expenditure. MIMOS alone accounted for 61.6% of the total R&D expenditure in 2002. For current expenditure, in general, most of the agencies experienced a decline in expenditure in 2002. For capital expenditure, the opposite was found, i.e., most agencies saw an increase in expenditure in 2002. Total expenditure increased by 21.5%, in which capital expenditure experienced a significant increase of 121.6%, whilst the current expenditure declined by 48.9%.

Universiti Sains Malaysia (USM) experienced the highest growth of total expenditure with a 161.2% increase. The bulk of this increase was for current expenditure. For Universiti Malaya (UM), the increase was mainly due to an increase in capital expenditure. In 2002, UPM, previously the highest spender of R&D expenditure amongst the IHLs, experienced a decline in expenditure by 34.2% when compared to the 2000 figure. The amount of expenditure by other universities was still small.

In terms of R&D output, the total number of patent applications has declined over the years. The total number of patents applied for the period 2001-2002 has dropped compared to the number of applications for the period 1999-2000. On the whole, the total number of patents granted for residents and non-residents has increased from 1,126 to 2,962 for the period 1999-2000 and 2001-2002, respectively. The increase is largely due to the increase in the number of patents approved for non-residents. While the number of

applications by residents for the period 2001-2002 has increased by about 60% compared to the 1997-1998 period, there was no corresponding increase in the number of approvals. The number of approved patents was 50 for the period 2001-2002 compared to 73 for the period 1997-1998. The field of chemistry and metallurgy has the highest number (4,115 or 27.91%) of patents granted since 1988. The total number granted was 2,962 for 2001-2002 compared to 1,125 and 1,352 for 1999-2000 and 1997-1998, respectively.

2.4 Innovation

About 35% of the manufacturing firms that responded to the MASTIC survey indicated that they carried out innovating activities during the period 2000-2001. The number of innovators varied across industries in the manufacturing sector. The highest number of innovators were found in industries such as electrical machinery and apparatus (67%), textile products (73%), scientific instruments (75%), motor vehicles (80%), and radio, television and communications equipment (82%).

In terms of firm size, innovating activities tended to be carried out in larger firms. While majority of innovating and non-innovating firms tend to be locally-owned firms, foreign ownership presence is greater amongst innovating firms than non-innovating firms. Most of the innovating firms (71%) were limited companies (Sendirian Berhad) while a smaller proportion of non-innovating firms (44%) were limited companies. Some 50% of non-innovating firms were sole-proprietorship and partnership firms.

Most of the innovating companies were established within the period 1980-1999. Some 39% of the innovating firms were established in the period 1990-1999 while 25% of the innovating firms were established during 1980-1989.

The survey also indicated that innovation was carried out by firms of all sizes. Some 46% of innovating firms were small firms (< 50 employees) while medium-sized (50-249

employees) and large-sized firms (>249 employees) account for 27% and 25% of total innovating firms, respectively. In terms of firm size measured by turnover, about 45% of innovating firms had annual turnover exceeding RM10 million.

Most of the innovating companies (73%) were involved in both product and process innovation. Some 58% of innovating companies were reported to have on-going projects with product and process innovations.

From the survey, the most important objective for innovation was the improvement of product quality. Some 81% of all innovating firms cited this as an important objective of innovation. Other important objectives included the opening up of new markets or increase in market share (47%) and the extension of product range (46%).

Only 32% of the innovating firms indicated government support as a highly important reason for undertaking innovation activities. Around 95% of the innovating companies (or 245 firms) reported that they did not receive any government support or incentives. For those receiving government support, the most popular avenues were duty free importation of machinery or equipment (55 firms), tax incentives (21 firms) and technical support services (16 firms).

There are significant variations in the impact of innovation on an industry's turnover. They range from as low as 15% (in the machinery and equipment industry) to as high as 70% (in leather goods industry). For most industries, the impact of innovation on turnover was within the range of 20-50%.

2.5 Trade in Technology

Malaysia continued to register a trade surplus in high technology goods, although the trend indicated a decreasing surplus from the peak of RM 51.5 billion in 1999 to RM 34.9 billion in 2002. However, the country posted an improvement in the trade deficit of medium-high technology goods, where the figure has improved from the highest deficit of RM 22.2 billion in 2000 to a deficit of RM 17.3 billion in

2002. Overall, exports in medium and high technology goods were still higher than imports, which ran parallel to the overall trade surplus that the country was enjoying in all categories.

The picture was not so rosy for technology-related services. The country registered a net outflow of money, amounting to RM 6.8 billion in 2002 for the payment of royalties, contracts and professional charges, and construction and engineering. Although this was an improvement from the highest deficit experienced in 2000 (RM 7.9 billion), coverage ratio (51.3%) in 2002 was far lower than the highest achieved in 1998 (72.7%). Data showed that the problem lies with royalties, which registered a meagre growth of 0.1% in receipts but high growth in payments (17.4%) over the last 10 years.

2.6 Publications and Citations

Publications and citations are important measures or indicators of scientific knowledge creation and diffusion. Most large scale macro-level bibliometrics studies are based on the analysis of research papers and citation links of databases from the ISI databases. The advantages of the ISI databases are that the journals and scientific publications are selected based on some quality criteria (e.g. peer reviewed journals) and is currently the only source that allows for a complex analysis of publications by countries, institutions, authors and scientific disciplines.

In terms of publication output by country, the United States has the highest output of papers (37.64%) followed by the United Kingdom (9.06%) and Japan (8.13%). Malaysia's share or output of papers stands at 0.08% of the world output. Malaysia was ranked at the 55th position among 178 nations as at 2002.

For Malaysia the most productive field output in scientific disciplines was Physical Chemistry/Chemical Physics at 7.95% of total Malaysian output for the period of 1981-2002. This is followed by Materials Science and Engineering, Organic Chemistry/Polymer Science and Environment/ Ecology.

Using standard fields or combining fields, the four fields with the highest productivity in Malaysia are Clinical Medicine, Chemistry, Plant and Animal Sciences and Agricultural Sciences. International comparison of fields shows Malaysia's share of papers in Agricultural Chemistry is the highest at 0.51% of world output. Although Physical Chemistry/Chemical Physics is the most productive field in Malaysia, in international terms, Malaysia's share in this field amounts to a mere 0.08% of the world output.

In Malaysia, the higher productivity in the medical and life sciences publications which include outputs in the fields of agriculture science, ecology and environment, can be linked to the greater investment and funding geared toward national policies which may be related to political will (e.g. war against cancer), scientific developments (e.g. revolutionary findings in molecular biology) and socio-economic needs (e.g. aging society, spread of diseases such as SARs, JE etc.). Malaysia's contribution in these fields is however insignificant when compared to the rest of the world, as the USA, UK and Japan, contribute the most to the world output. Malaysia's contribution to the world is more significant in the field of agricultural sciences, particularly agricultural chemistry, although the amount of her contribution is still a very modest 0.51% of the world output. Malaysia has still a long way to go in the S&T fields in terms of publication output.

2.7 Public Awareness in S&T

The chapter on public awareness of science and technology is based on the report of the survey on "Public Awareness of Science and Technology in Malaysia, 2002". Overall, there has been an improvement in the level of perceived knowledge about S&T-related and general issues for year 2002 compared to year 1998 and 2000. For the 11 issues examined, eight enjoyed an improvement in the score while the remaining three showed a decline in the knowledge score. The level of perceived knowledge reported range from 2.04 to 2.78. Males were generally more aware and had a higher level of perceived knowledge in S&T-related and general issues compared to women.

Findings show that youths were consistently the group with the highest level of perceived knowledge compared to children and adults.

In terms of stated interest in S&T-related and general issues, overall the level of interest shown was low. Based on the scale of 1 to 4, the highest level of interest reported was 2.66 in the area of environmental pollution while the lowest level of interest was for the issue of "international and foreign policies" (mean = 2.10). In addition to the general lack of interest in the issues examined, the level of interest had deteriorated for five of the 11 issues examined compared to findings of year 2000. These five areas were: "environmental pollution", "new inventions from Malaysia", "economy and business", "new technology and inventions", and "national education policy". Comparing between males and females, males had a higher level of expressed interest in S&T-related and general issues. Unlike findings of the 2000 survey where females showed a higher level of interest in three fields out of the 11 examined, the survey results of 2002 show that females scored lower in all areas in terms of interest expressed.

Comparing the interest among the three age groups, it is obvious that the youths had the highest level of interest compared to children and adults. The only two areas that children showed greater interest than adults were "aerospace exploration" and "application of computer technology". Within group comparisons in the level of interest among youths show that there was a decline in four of the 11 issues examined. They were "environmental pollution", "new inventions from Malaysia", "economy and business", and "new technology and inventions".

In examining the attitude of the Malaysian public toward science and technology, the decline in the percentage of respondents agreeing with statements that relate to the role of science and technology does not augur well for the development of S&T, especially in an era that is S&T-driven. The statement "S&T make our life healthier, easier and more comfortable" continued to enjoy a high percentage of agreement at 80.6% even though the percentage agreeing with this

statement has dropped by 6.5% from 2000. The percentage of respondents agreeing with the statement "Daily chores are more interesting with the application of S&T" has dropped drastically from 86.2% in 2000 to 67.8% in 2002. Similarly, for statements "Most scientists work toward improving life" and "I need to know about science in my daily life" had suffered substantial drop in percentage of respondents agreeing with them.

The attitude of all the three age groups toward science and technology had grown less favourably, with the percentage decline being most drastic among children. Youths remained the group with the most favourable attitude even though the decline cut across all age groups. For children, they were the least positive about S&T-related benefits.

A rural-urban comparison shows that urban respondents in general had a more positive attitude toward science and technology as compared to those in the rural areas. Both males and females shared similar attitudes about science making life healthier, easier and more comfortable. Almost an equal percentage of males and females agreed that the government should support S&T research, the quality of science and mathematics education is not satisfactory, new inventions will counteract harmful consequences of technological advancement, and that S&T is very important for societal advancement. The only statement that males and females differed in the percentage of respondents in agreement was "Scientists should research about health even if it causes pain to animals" in which 37.5% of males agreed compared to 34.0% of females.

2.8 Public Support for S&T

Chapter 10 provides details on the schemes and incentives by the government to further promote R&D activities. Several new schemes were introduced in 2002: Technology Acquisition Fund for Women, E-Manufacturing Grant, Grant for RosettaNet Standard Implementation for SMEs and Grant for Upgrading Engineering Design Capabilities.

For the existing schemes, the pattern of utilisation is different for the different types of

schemes. The applications and approvals for Commercialisation of R&D Fund (CRDF) suffered a phenomenal decrease in the number of applications in the 2001-2002 period as compared to the 1999-2000 period, i.e., from 99 to 17, respectively. As a consequence of the small number of applications, the number of projects approved for the grants correspondingly decreased from 26 for the period 1999-2000 to only 10 for the time frame of 2001-2002. While Electrical and Electronics (E&E) was the sector with the highest number of applications in 1999-2000, it had only one application in 2002. Biotechnology which enjoyed as many as 5 applications in 1999 did not have any applications for the entire period of 2001-2002.

Tax incentives in the form of double deductions for revenue expenditure on R&D remain attractive amongst industries. A marked increase in the application for double deduction for expenses related to R & D can be seen in the 2001-2002 period as compared to the corresponding period of 1999-2000. The number of applications in the current period increased to 582 and 684 for 2001 and 2002, respectively from 162 in the previous year. This is attributable to the huge surge in applications from the automotive parts industry that had experienced an increase of about 10 times the number of projects applied.

For year 2001, the industry that had the largest amount of deductions approved was the semiconductor industry with a total deduction of RM24.6 million followed by the agriculture-palm oil, rubber, cocoa, and fruit sector with deductions amounting to RM12.5 million. For year 2002, the industry with the largest amount approved was the automotive parts industry followed by the agriculture industry. The strong surge in the amount of double deductions granted to the automotive parts industry (from about RM0.8 million in 2000 and 2001 to RM87.8 million in 2002) signifies the intensity of competition within the industry.

Analysing ITAF by industry in 2001 and 2002 shows that in 2001, about RM1.6 million was provided to successful applicants under the ITAF 2 scheme, and about RM9 million was disbursed under ITAF 3. In 2002, the

amount for ITAF 2 increased to about RM3.5 million while the amount approved for ITAF 3 reached about RM13.7 million.

DAGS, which was introduced to develop the information and communication technology industry in Malaysia, shows that in 2001, a total of 51 applications were received versus 14 in 2002, representing a decrease of 37 applications. Corresponding to the decrease in the number of applications, the amount applied dropped from about RM100.4 million in 2001 to RM33.3 million in 2002. The private sector had been the most active sector in utilising this scheme.

In 2000, under the MGS scheme, 10 out of the 24 applications were approved, totaling close to RM22 million against the amount applied of RM138.9 million. In 2001, the number of applications dropped to 13 resulting in the decline in the number of approvals to 6 with the total amount approved decreasing to around RM12.5 million (Amount applied was RM50.5 million). Total applications and approvals rose slightly in 2002 to 16 and 8 respectively with the total funds disbursed reaching to about RM16.1 million. The industries that were active in the application for funding were the business application software and the engineering application software industries for both 2001 and 2002.

Intensification of Research in Priority Areas (IRPA) was introduced by the government to boost R&D activities especially in national R&D priority areas for knowledge enhancement and commercialisation. Among public institutions of higher learning, Universiti Putra Malaysia was the leading university in terms of the number of projects and amount of allocation approved. For public institutions, MARDI was the most active with a total of 63 projects approved. Allocation by industry shows that the most active industries were manufacturing and construction, followed by agro-industry.

2.9 International Comparisons

Any comparison between Malaysia and other countries should take into account the different levels of economic development.

Malaysia's gross national income per capita is currently about one tenth to one fifth that of developed countries. There are also considerable differences in the economic structure of the Malaysian economy and those of developed economies. In developed economies, the services sector plays a larger role in the national economy while the agriculture sector's role is fairly insignificant.

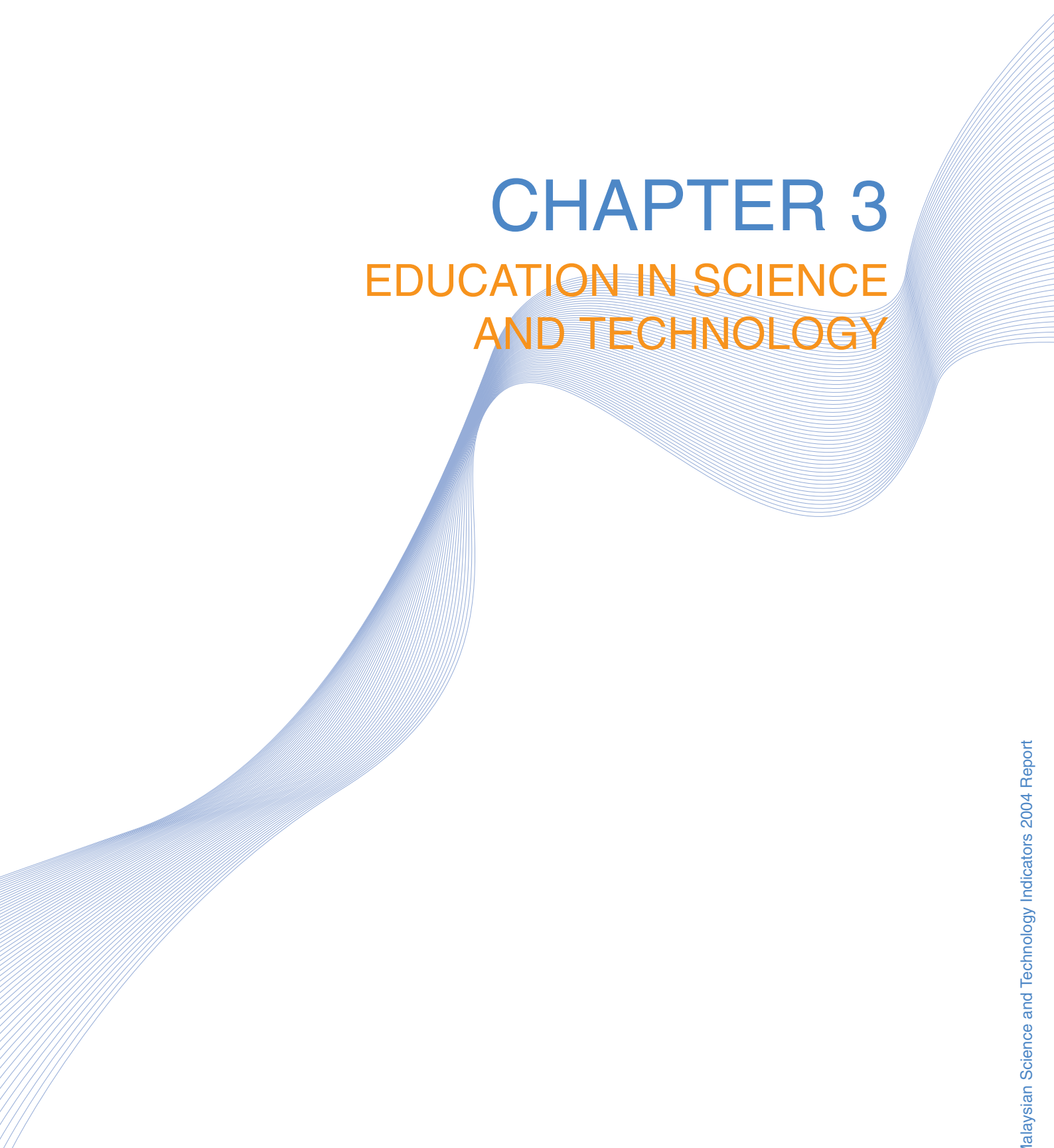
The percentage share of degrees granted in the area of science and engineering in public universities at 37% is fairly high compared to similar figures for public and private universities in more developed countries.

The overall level of innovation in Malaysia's manufacturing sector at 35% is below that achieved in most of the developed countries in Europe. European countries with comparable levels of innovation include Finland (36%) and Belgium (34%). As in other countries, larger firms tend to be more innovative than smaller firms.

In the area of trade in technology, the combined manufacturing export shares of high technology and medium-high technology manufacturing industries at 42% is lower than the 50-80% levels observed in developed countries.

The gap between Malaysia and developed countries is even larger in the area of S&E publications. Malaysia's S&E articles per capita are currently around 22, well below the 400–1100 levels observed in developed countries.

The general level of public awareness and understanding of knowledge in science and technology is also lower in Malaysia compared to that observed in developed countries. However, there are some areas of knowledge in S&T in which the Malaysian public shows a comparable level of understanding.

A decorative graphic consisting of numerous thin, parallel blue lines that form a wavy, ribbon-like shape. It starts from the bottom left, curves upwards and to the right, then loops back and curves downwards and to the right, ending near the top right corner. The lines are closely spaced, creating a sense of motion and depth.

CHAPTER 3

EDUCATION IN SCIENCE AND TECHNOLOGY

Public sector education has always been the pillar of the education system in Malaysia. In recent years however, private colleges and universities have expanded rapidly to provide alternatives for students to pursue tertiary level education. As private education is commercial-driven, business and information technology are the most popular courses offered at these institutions. The lack of interest by private colleges to offer pure science and engineering courses is understandable, as it would cost more to construct science laboratories and equip them with scientific apparatus. Consequently, this poses a challenge for policymakers to ensure continuing emphasis on S&T subjects like natural sciences, engineering, medical and agricultural sciences.

This chapter examines student enrolment by field of study at pre-university and university levels, both at public and private institutions. Data were sourced from the Ministry of Higher Education, although some data are inconsistent in terms of their availability and comparison across degree levels. Where possible, the data are reclassified in accordance to OECD guidelines for the purpose of analysis.

3.1 Education in S&T at the Secondary School and Pre-University Level

Public sector education forms the backbone of the education system in Malaysia. Children are required to attend schools at the age of seven until they complete the lower secondary exam known as Penilaian Menengah Rendah (Lower Secondary Assessment) or PMR. With exception of those required to attend Remove Classes (applicable to students attending national-type schools, i.e. those with Chinese or Tamil language as medium of instruction), students typically complete PMR at the age of fifteen.

After the completion of PMR, students are streamed into arts and science at their own choice for the O-level equivalent Malaysian exams called Sijil Pelajaran Malaysia (SPM). This exam requires two years of classes, which most students sit at the age of seventeen. Subsequently, students proceed to the A-level equivalent of Malaysian exams called Sijil Tinggi Pelajaran Malaysia (STPM), where they typically remain with the stream that they took at SPM level. However, due to the fact that students are required to pass an exam before being allowed to proceed to the next one, the number of students enrolled for the three exams are expected to decrease in the order of PMR, SPM and STPM.

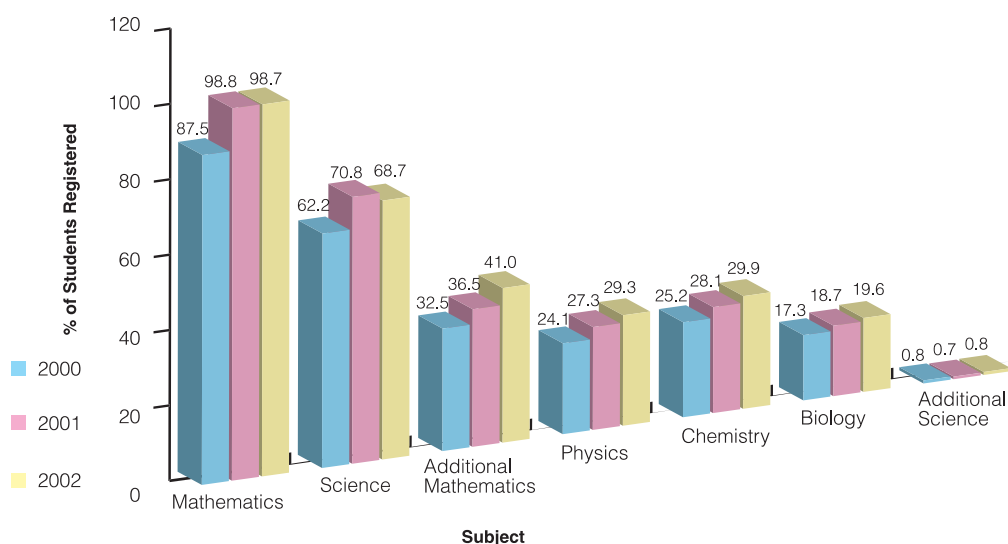


Figure 3.1: Registration for Sijil Pelajaran Malaysia by Subject, 2000 - 2002

In the case of SPM, out of the total 356,141 students who registered for SPM examinations in 2002, about 20-41% of the students took science subjects such as Physics, Biology, Chemistry and Advanced Mathematics (Figure 3.1). This is an increase in terms of percentages of the students registered for the science subjects in year 2000, which were between 17-33%. Advanced Mathematics was the most popular science subject, which saw an increase of 21% in the number of students

registered for the exam between 2000 and 2002.

In the case of STPM, the percentages of students registered for science subjects were even lower. Out of the total 42,560 students registered for the STPM examination in 2002, 1-30% took science subjects, as compared to 1-20% for 2000 (Figure 3.2). The most popular science subject among students was Chemistry, which saw an increased 49% in the number of registration between 2000 and 2002.

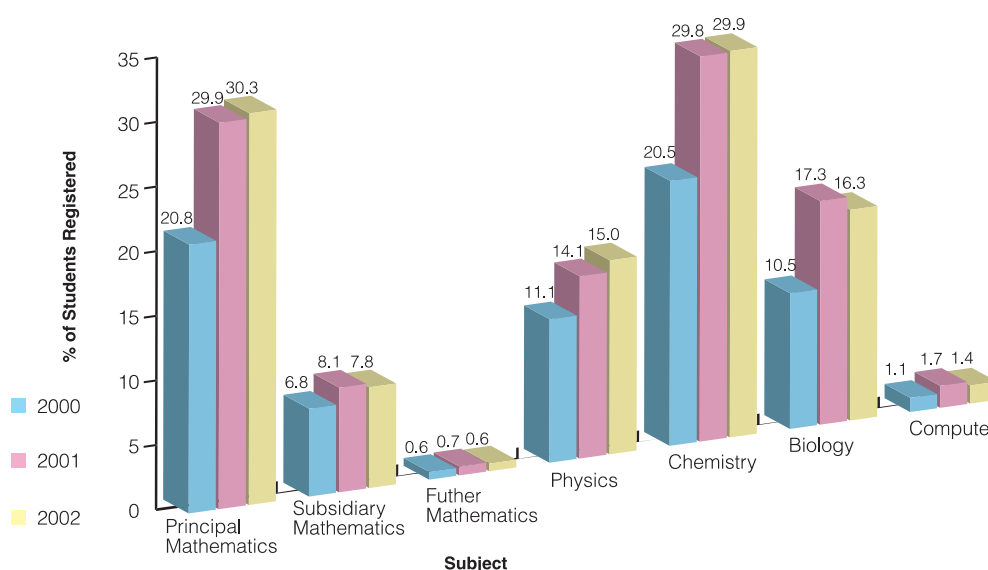


Figure 3.2: Registration for Sijil Tinggi Pelajaran Malaysia by Subject, 2000 - 2002

3.2 Tertiary Education in S&T

In the year 2002, the number of students enrolled in first degree courses in public tertiary institutions was 182,569 while those at private colleges totaled 67,044, giving a ratio of 73:27 between public and private institutions. This represents a 29% and 32% increase from the year 2000 for both types of institutions respectively. 52,001 students completed their first degree studies in 2002, representing an increase of 43% from the year 2000. The big increase in the number of completion in first degree courses was attributed to the 367% of increase in the number of students completing their studies at private institutions in 2002 as compared to the year 2000.

For masters degree courses, enrolment was concentrated in the public tertiary institution, totaling 24,884 intakes (84.5%) as compared to private colleges with 4,580 intakes (15.5%). The

total number of students registered for masters degree courses in 2002 increased by 63.1% when compared to 2000. This pattern was repeated for graduation, with 5,655 (90.7%) students completing their courses at public institutions as compared to 580 (9.3%) at private colleges. These numbers represent an increase of 93% and 266% from the year 2000, respectively.

In the case of doctoral programs, there was a sharp increase in the number of enrolment at private institutions, rising from 18 students in the year 2000 to 197 students in the year 2002 (10.9 times). To a lesser extent, the increase in enrolment at the public institutions was also high, rising from 2,701 to 3,856 students (1.4 times). However, graduation at PhD level was dominated by public tertiary institutions, producing 486 PhD graduates as compared to 4 graduates for private institutions.

3.2.1 Public Educational Institutions

In general, enrolment in science and technology-related courses at public tertiary institutions has increased from 1992 to 2002, registering an average growth rate of 14.7% per annum. For the period of 2000 and 2002, there has been a growth of 38.5% in the enrolment in natural science courses and a growth of 36.3% in social science courses. Enrolment in engineering and technology had an increase of 6,542 (or 21.4%) from 30,596 for the academic year 2001/2002 to 37,138 for 2001/2002 (Figure 3.3). However, enrolment in agricultural science experienced a drop of 3,793 students over the same period.

Enrolment in social science courses continued to enjoy the largest share in terms of the total number of students registered for first degree courses at the public institutions, which was 47.9% (Figure 3.4).

Enrolment in 'other fields', consisting of teacher training, education and other subjects has dropped from 21,375 in 2000 to

17,874 in 2002. Within natural science equivalent subjects, engineering and technology constitute the largest segment, representing 48.0% of the total registration, followed by IT and computer science (22.3%).

3.2.2 Enrolment in First Degree Courses

Enrolment in first-degree courses at public universities recorded a 29.2% increase between 2000 and 2002, with a total number of 182,569 students enrolled in 2002, representing 73% of the total first degree enrolment of higher learning institutions. UPM recorded the biggest total intake (22,924 students), followed by UM (22,761 students) and UiTM (21,831 students) (Figure 3.5). For natural science subjects, UTM recorded the highest intake (16,730 students, with 89.5% enrolled for engineering courses) followed by UM (9,886 students) and USM (8,912 students). UKM recorded the highest intake for medical sciences (2,303 students), UPM for agriculture sciences (1,870 students) and UUM for IT and computer sciences (2,273 students).

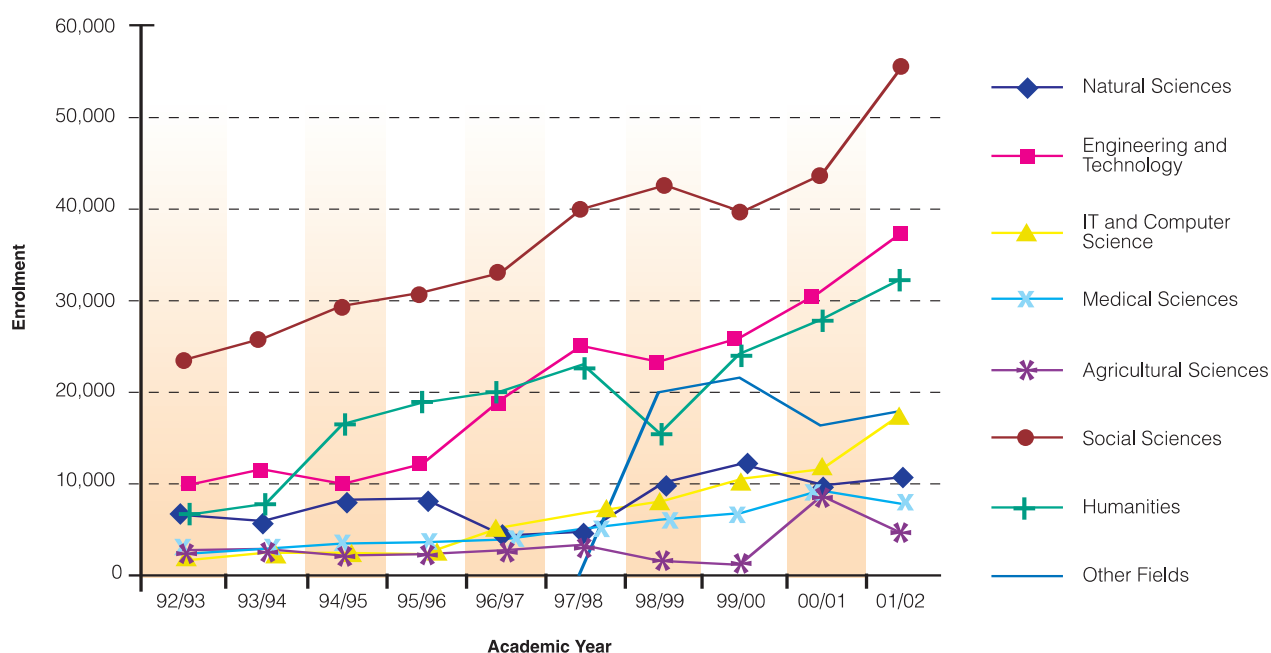


Figure 3.3: Total Enrolment in First Degree Courses at Public Educational Institutions, 1992-2002

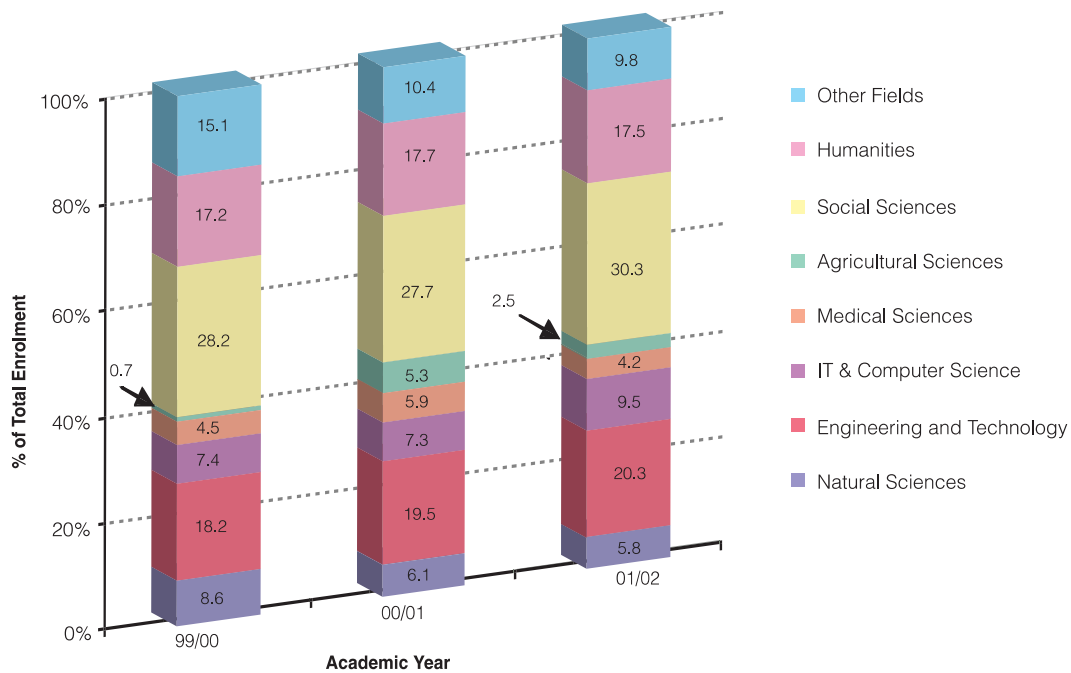


Figure 3.4: Composition of First Degree Enrolment in Public Educational Institutions , 1999-2002

3.2.3 Graduations in First Degree Courses

Graduation in social science and humanities dominated the first-degree courses, constituting 57.1% of the total number of first-degree graduates of 31,033 in 2002 (Figure 3.6 and Figure 3.7). Both natural science equivalent and social science & humanities subjects saw an increase in their percentages of the total graduation due to the reduction in the percentage of graduation in 'other fields' by 61.6% when compared against the year 2000. Natural science equivalent students constituted 37.1% of the total number of first degree graduates in 2002, which was higher than the 32.4% registered in 2000.

The number of students graduating in first degree courses for natural science equivalent subjects had increased by an average of 9.4% per annum since 1994. Out of 11,522 students who graduated in this field in 2002, 39.9% was from engineering, 23.2% was from natural science and 18.8% was from computer science. Graduation in agriculture science registered the highest growth (206.9%) followed by IT and computer science (34.6%) when compared against year 2000. Looking at a longer term trend, there is clearly a strong

shift towards graduation in applied science as compared to pure science subjects.

Figure 3.8 shows the number of graduating students in the various fields of study by institution for 2001/2002 academic year. UiTM had the largest number of first-degree graduates, constituting 17.3% of the total graduation at public institutions. At subject level, USM had the largest number of graduates in engineering and technology, UUM had the largest number of graduates in IT and computer science, UM and USM for medical sciences, and UKM for agriculture science. However, for overall natural science subjects, UPM produced the largest number of graduates, amounting to 1,440, which was equivalent to 12.7% of the total natural science graduates leaving public tertiary institutions in 2002.

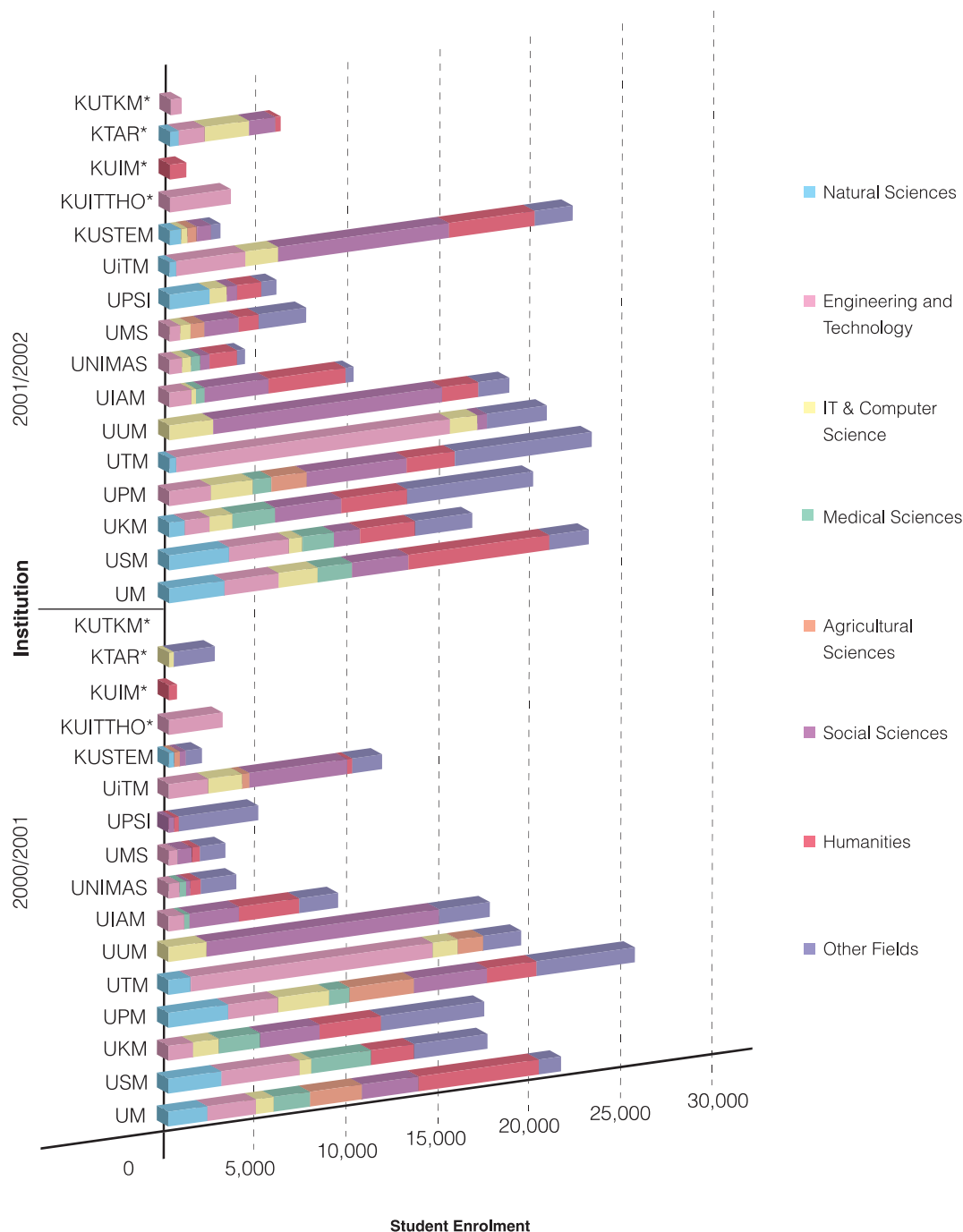


Figure 3.5: Enrolment in First Degree Courses at Public Educational Institutions, 2000/2001-2001/2002

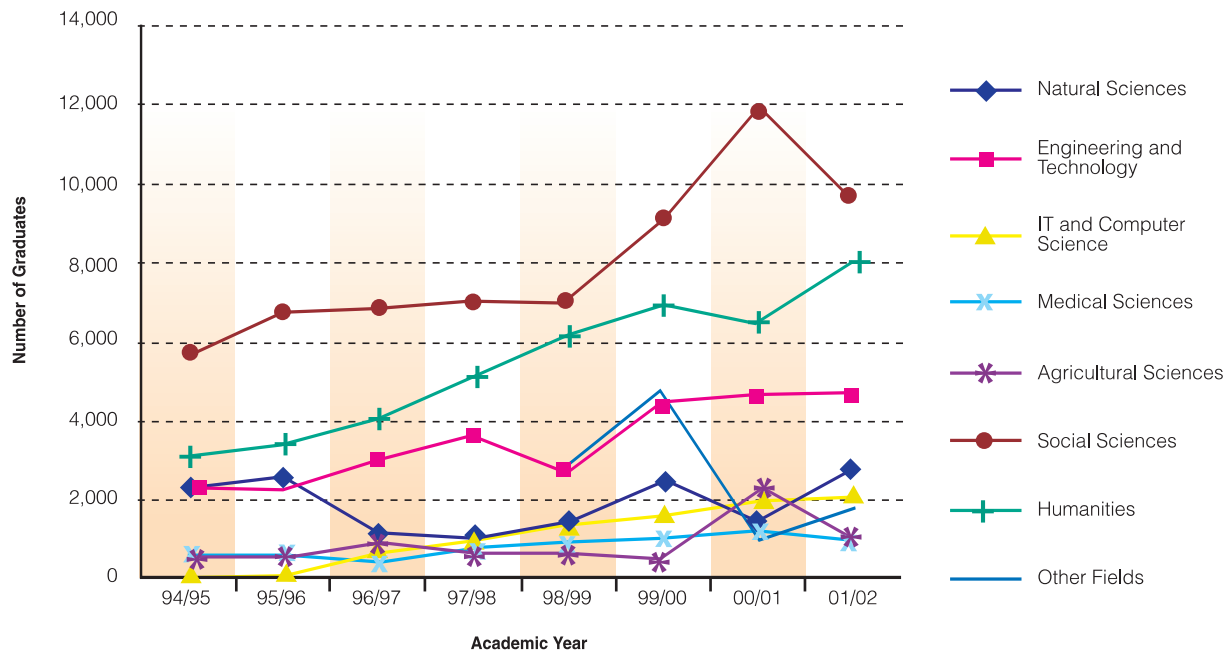


Figure 3.6: Graduating Students in First Degree Courses at Public Educational Institutions, 1994-2002

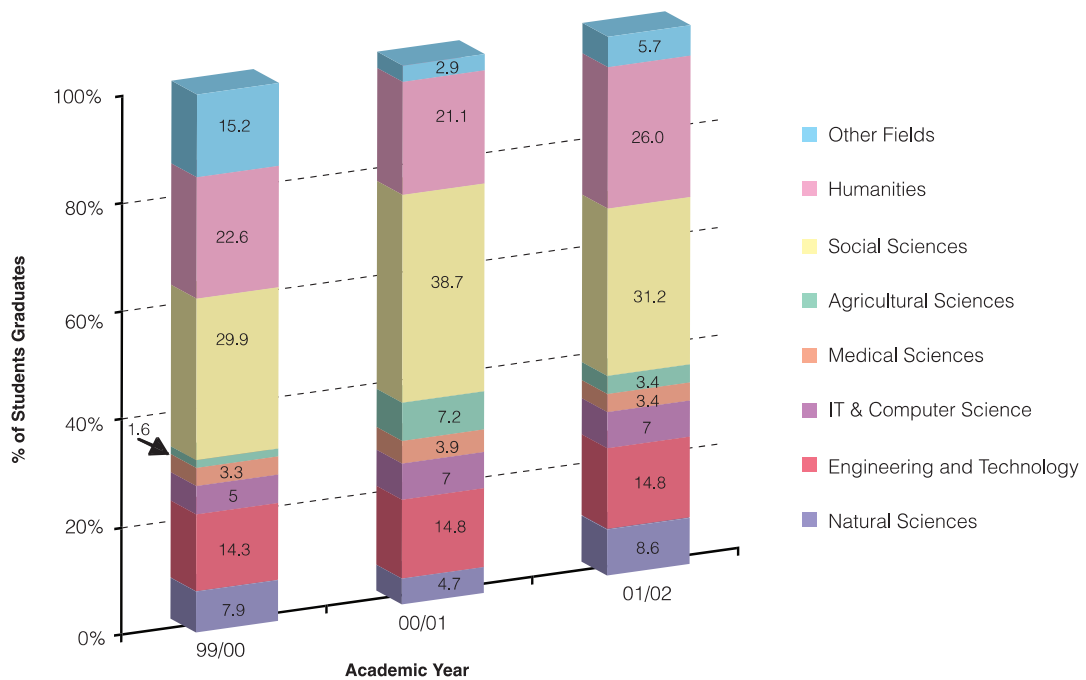


Figure 3.7: Composition of First Degree Graduates in Public Educational Institutions, 1999-2002

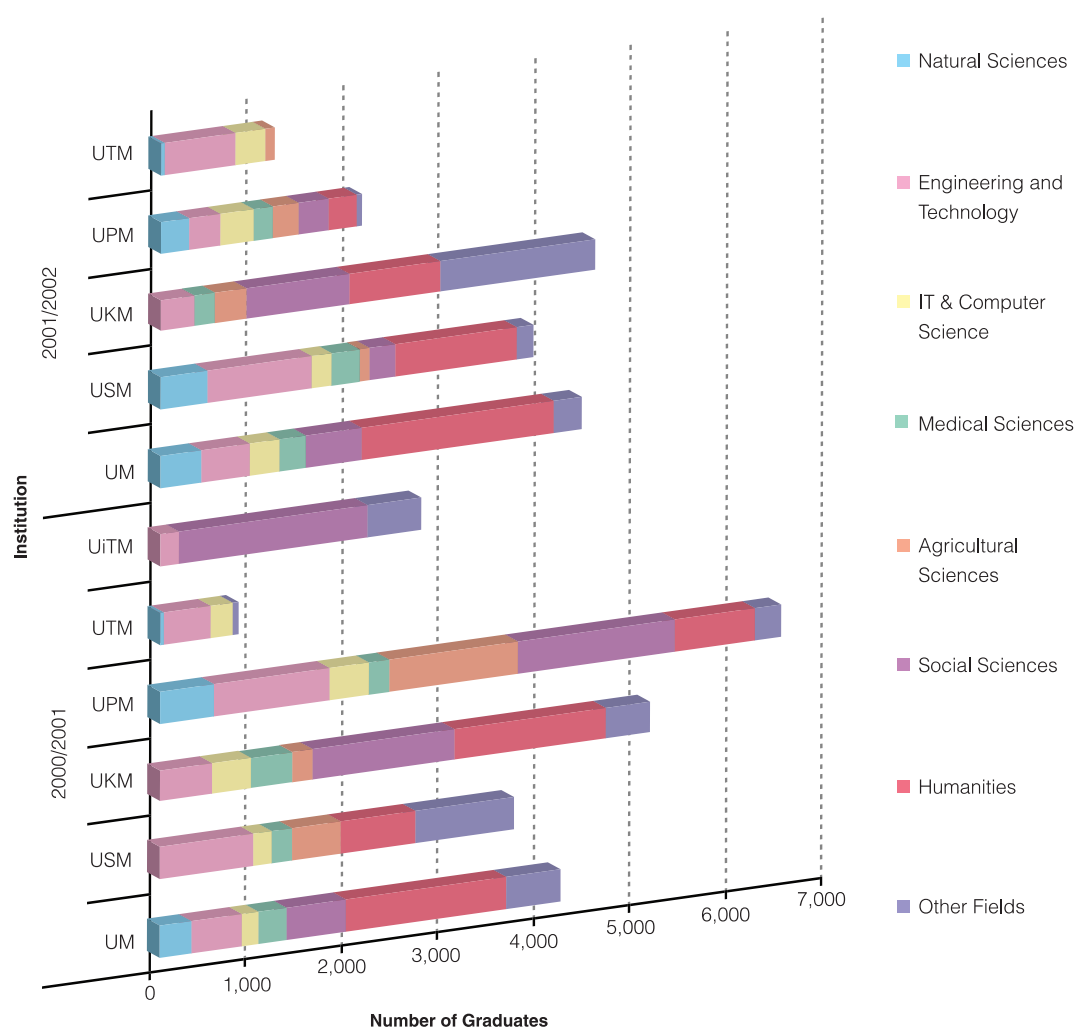


Figure 3.8: Graduates in First Degree Courses at Selected Public Educational Institutions, 2000/2001 -2001/2002

3.2.4 Enrolment in Graduate Degree Courses

Enrolment in Masters level courses at public institutions had grown rapidly over the last 10 years, registering an average increase of 23.4% per annum since 1992. The largest increase was over the last 2 years, where total enrolment increased from 15,497 in 2000 to 24,844 in 2002, representing an increase of 60.6% (Figure 3.9). Enrolment in arts subjects recorded the highest increase in the last two years (140.7%) whereas enrolment in science and technical subjects increased by 12.4%. In the year 2002, the arts subjects dominated the enrolment at Masters level, constituting 56.3% of the total enrolment (Figure 3.10).

Enrolment in Doctoral degree courses at public institutions has also grown rapidly over the last 10 years, registering an average increase of 21.2% per annum since 1992. Between 2002 and 2000, the number of enrolment in doctoral degree courses increased by 42.8% (Figure 3.11), with science and technical subjects constituting 50.8% of the total enrolment in 2002 (Figure 3.12).

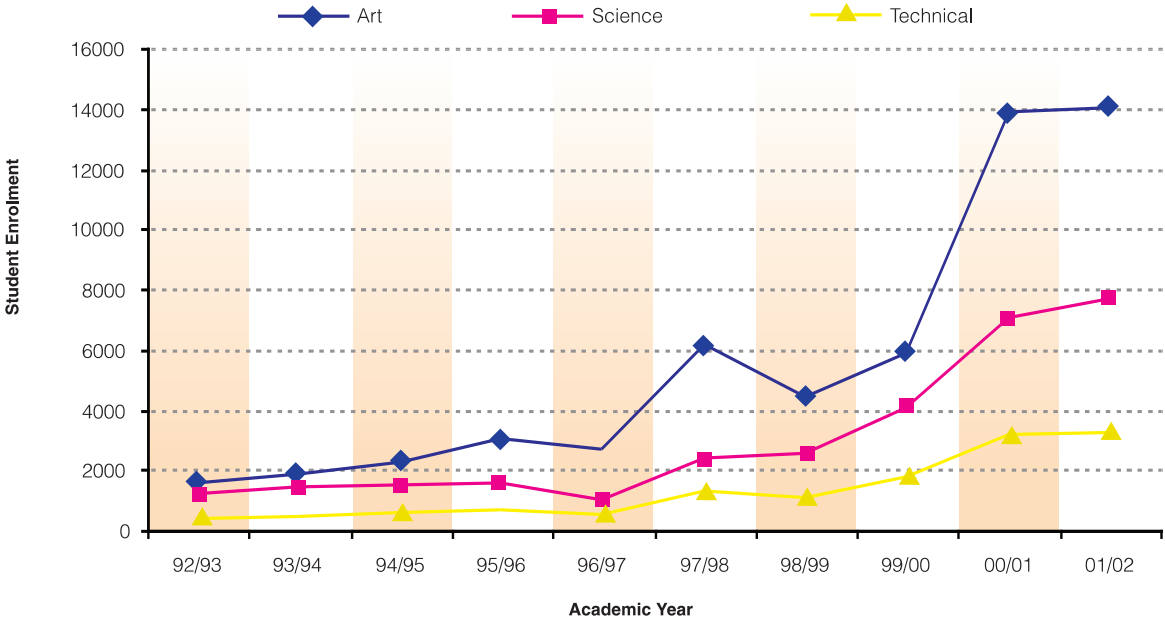


Figure 3.9: Enrolment in Master's Degree Courses at Public Educational Institutions, 1992-2002

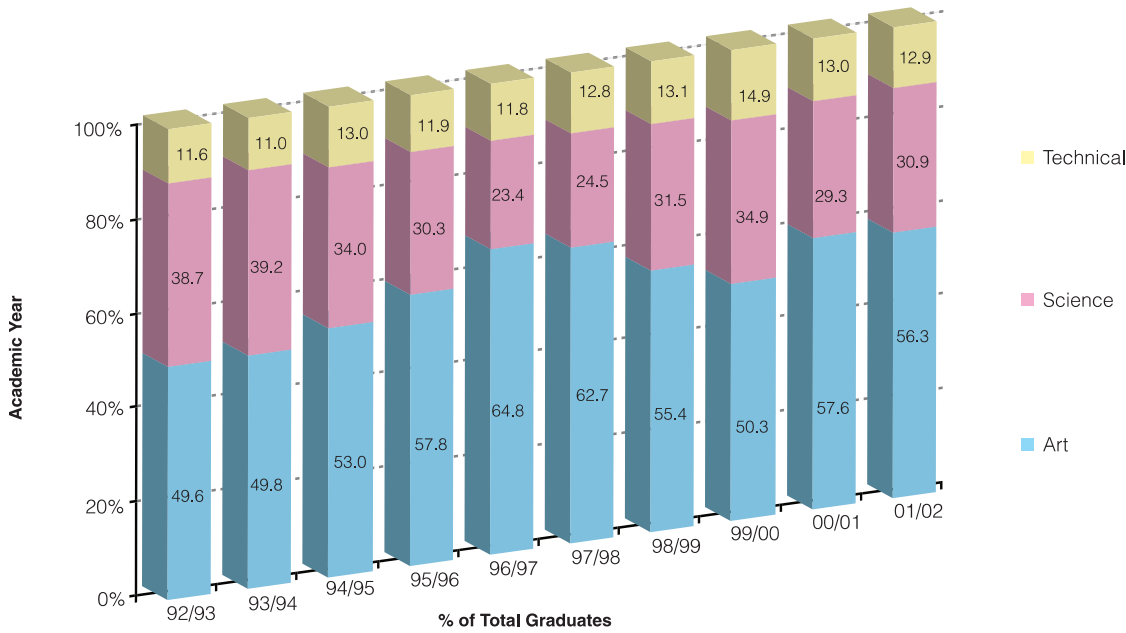


Figure 3.10: Composition of Master's Degree Enrolment in Public Educational Institutions, 1992-2002

Chapter 3 Education in Science and Technology

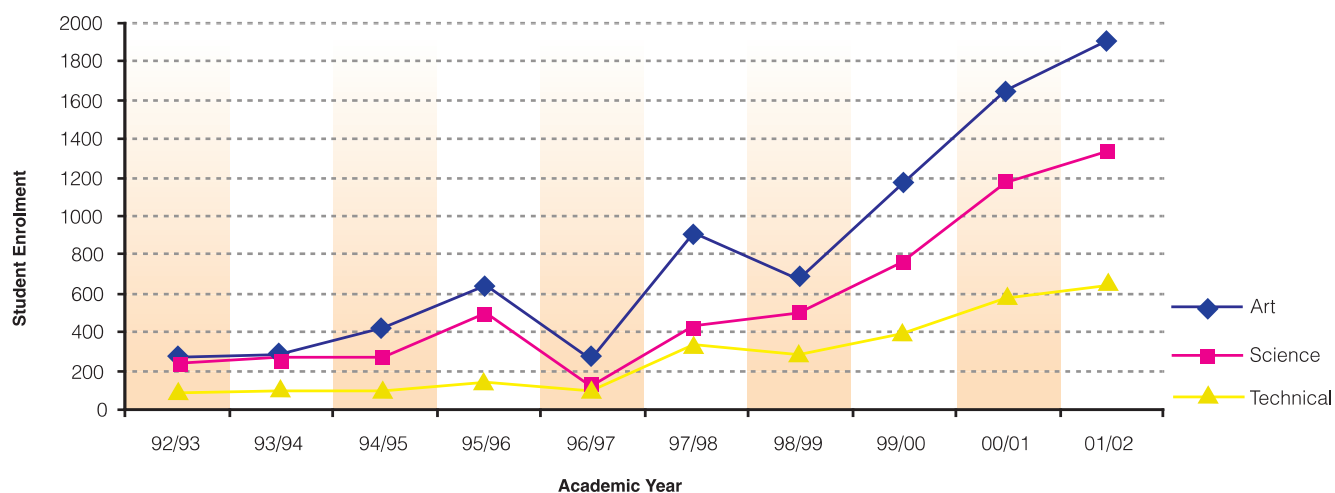


Figure 3.11: Enrolment in Doctoral Degree Courses at Public Educational Institutions, 1992-2002

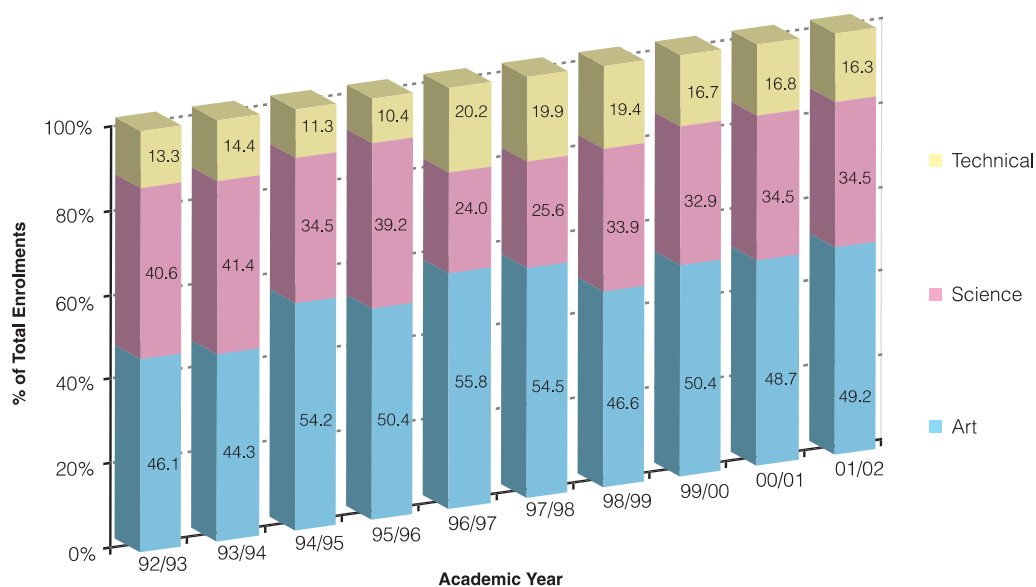


Figure 3.12: Composition of Doctoral Degree Enrolment in Public Educational Institutions, 1992-2002

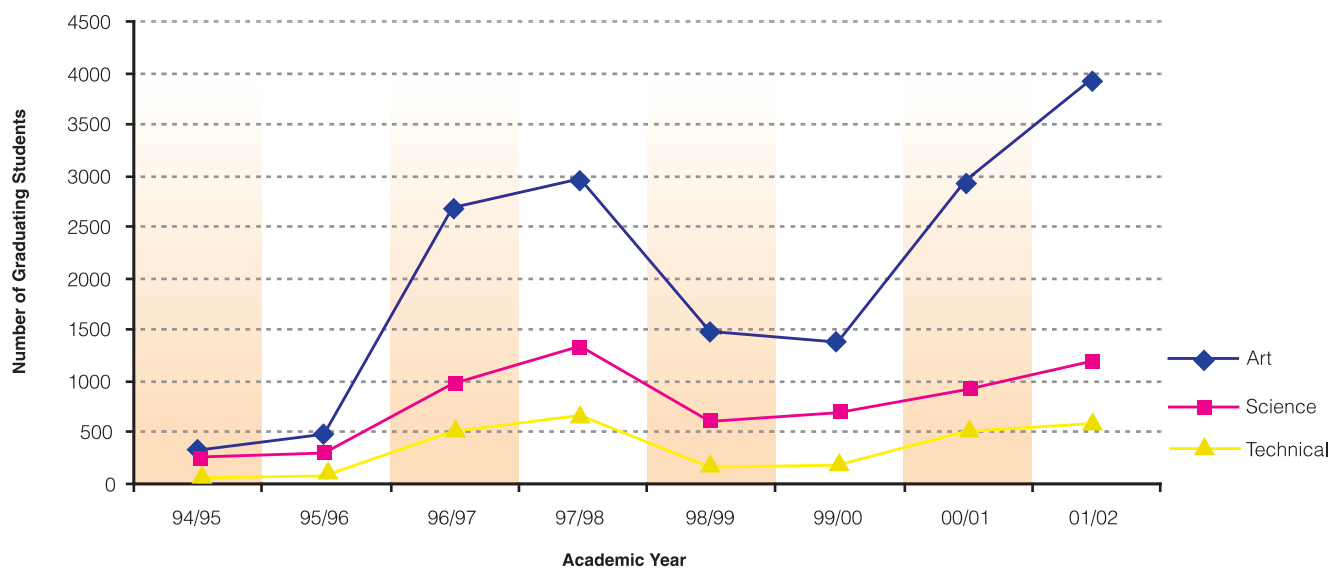


Figure 3.13: Graduating Students in Masters Degree Courses at Public Educational Institutions, 1994-2002

3.2.5 Graduations in Masters and Doctoral Degree Courses

Figure 3.13 shows the number of graduating students at the Masters level. The number of graduates at Masters level increased by 93.1% between 2000 and 2002. The reason for this huge increase was due to the 40.6% drop in Masters level graduation recorded earlier between 1998 and 2000. Graduation in arts subjects recorded a higher growth (188.1%) when compared to science and technical subjects (10.6%), meaning the total Master graduates in science and technical subjects in 2002 (1,734) were lower than 1998 (1,984).

The increase in the number of graduates at the Doctoral level was impressive. From 1999/2000 to 2001/2002, there was a 124% increase in the number of students (Figure 3.14). A total of 287 Science and Technical graduates obtained their doctoral degree in 2001/2002, compared to 227 in 2000/2001. For Arts, the number of increase in graduating students was marginal.

3.3 Tertiary Education in S&T – Private Educational Institutions

Private higher educational institutions are classified into 3 categories, namely, private colleges, private universities and campus branches. Private colleges are those institutions offering a variety of programs ranging from pre-university courses to degree courses conducted in cooperation with foreign higher educational institutions as well as professional bodies. Private universities are privately held institutions that have been awarded the charter to issue their own degrees, whose status could be either university or college university. Campus branches are institutions set up by foreign universities to expand their educational offerings to local students with minimal or zero need for residence at the overseas main campus. However, statistical data available from the Ministry of Education combines private universities and campus branches into one category, which we will now refer to as private universities.

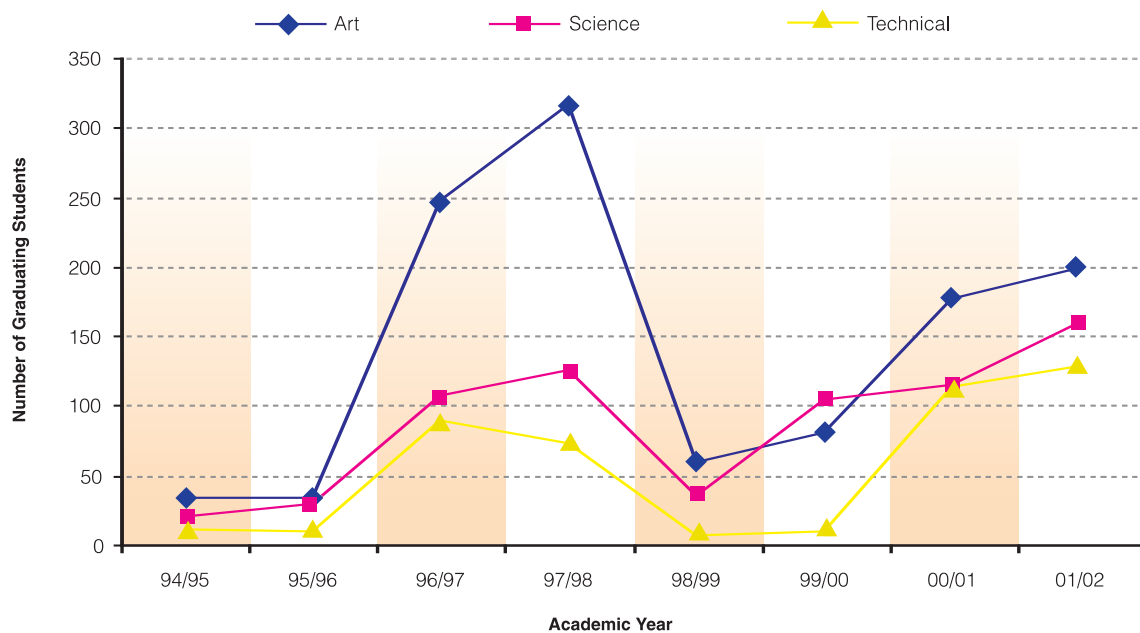


Figure 3.14: Graduating Students in Doctoral Degree Courses at Public Educational Institutions, 1994-2002

3.3.1 Enrolment in First Degree Courses

In 2002, 67,044 students enrolled in first degree courses at private educational institutions, representing 32.0% increase from the year 2000. The split between private colleges and private universities was almost equal in 2002 (50.3%:49.7%), as compared to higher proportion for private colleges in the year 2000 (55.5%:45.5%). This was due to higher enrolment growth in private universities, at 47.3% from 2002, as compared to growth of 19.8% for private colleges.

S&T related fields represented 92.5% of total enrolment at private educational institutions in the year 2002. However, private colleges showed higher enrolment percentage in social science subjects, in contrast to private universities, which had higher proportion of enrolment in natural science subjects.

Within the natural science category, IT & Computer Science subjects registered the highest number of enrolment with 18,617 students in 2002 (Figure 3.15). However, the highest growth was registered by enrolment in core natural science subjects (such as Chemistry, Biology, Physics, Mathematics and Computer Sciences), which registered an increase of 674.4% from the year 2000.

However, the enrolment in this category at 1,320 students was still small when compared against total enrolment of 67,044 students, especially when compared in the light of other non-S&T subjects of 5,024 students in 2002.

In general, there was an improvement in the ratio of genders for enrolment in private educational institutions, from 48:52 male: female ratio in the year 2000 to 50:50 in the year 2002. However, there were more males than females in natural science courses (58.5% males) as opposed to social science courses (61.1% females).

3.3.2 Graduations in First Degree Courses

A total of 20,228 students graduated in first-degree courses at private institutions in 2002, which was a huge increase as compared to 5,708 students in 2000. Of this, 72.0% were from private colleges 28.0% were from private universities. Social science and humanities recorded the highest graduation, representing 53.8% of the total. Figure 3.16 shows that within natural science equivalent subjects, IT and computer science constitute the largest percentage (56.7%) of the 8,890 graduates in 2002, followed by engineering and technology (32.2%).

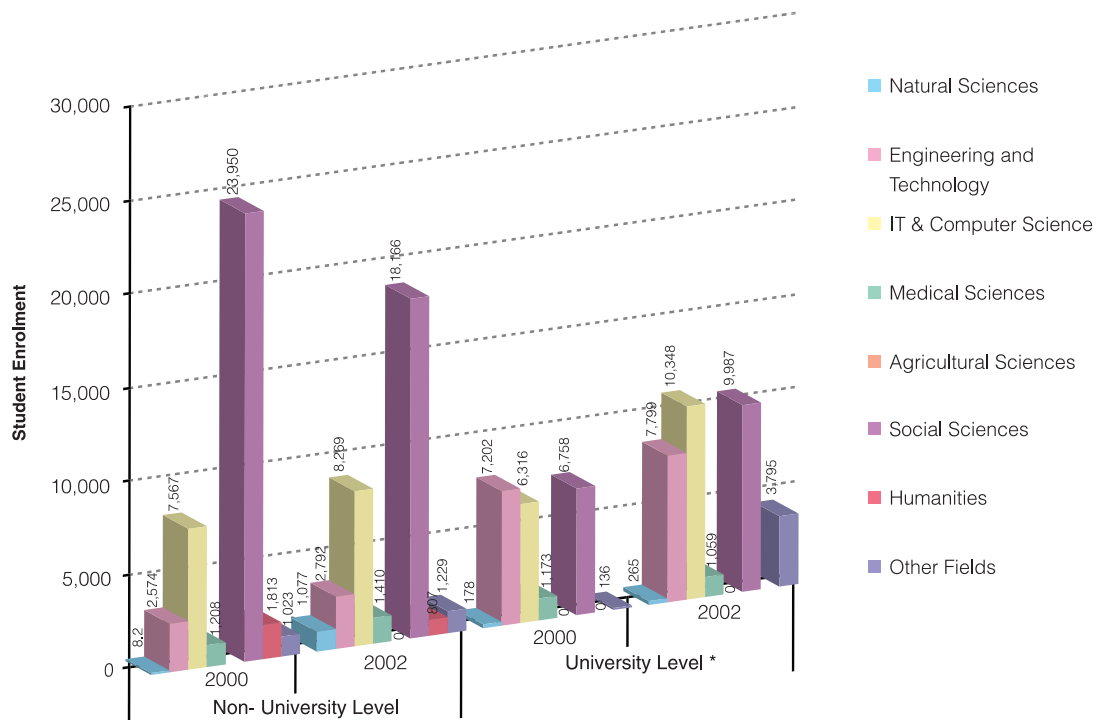


Figure 3.15: Enrolment in First Degree Courses at Private Educational Institutions by Field of Study, 2000-2002

Note: (*) Includes data from campus branches

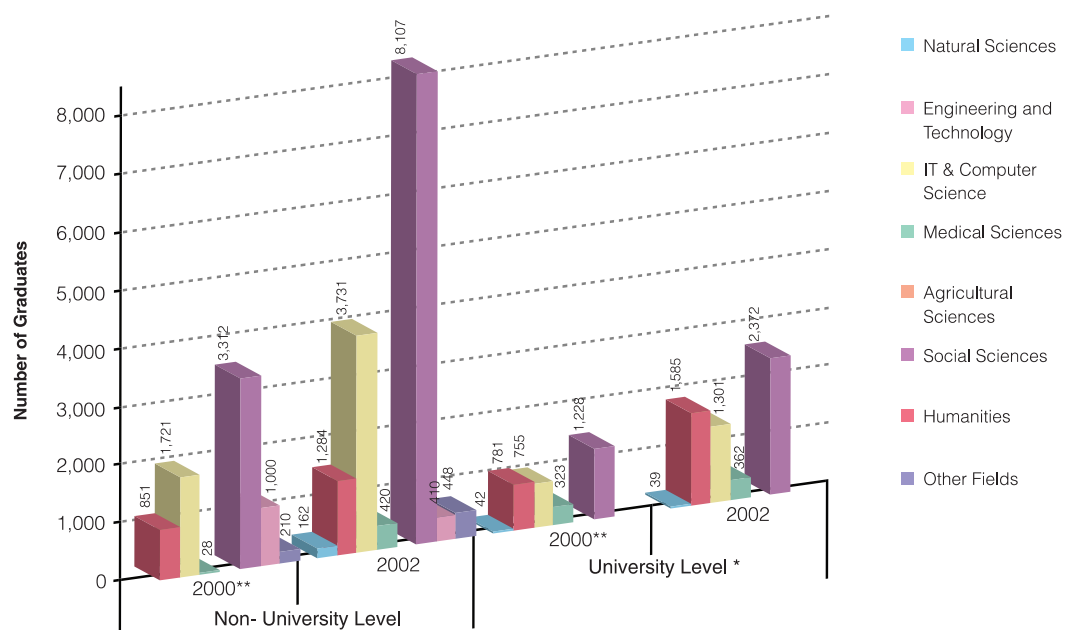


Figure 3.16: Graduating Students in First Degree Courses at Private Educational Institutions by Field of Study, 2000-2002

Note: (*) Includes data from campus branches
(**) Data not available for campus branches

3.3.3 Enrolment in Graduate Degree Courses

Enrolment in Masters Degree courses at private institutions was 4,580 in 2002, an increase of 78.1% from 2000. The ratio split of the enrolment was in higher for private colleges, which represented 54.9% of the total. Again, social science and humanities dominated the intake with 57.0% of the total enrolment. Within natural science equivalent subjects, the largest intake was for medical sciences (899 places) followed by IT and computer sciences at 748 places (Figure 3.17). The intake of medical science students by private universities is

expected to reduce significant burden to the government as there was no intake for this subject prior to the year 2002.

Enrolment in doctoral degree at private institutions registered a huge increase between 2000 and 2002. Total enrolment stood at 197 in 2002 as compared to only 18 in 2000. However, almost all (195) of the enrolment was for social science and humanities, and only 1 each was registered for engineering and computer science. Since doctoral degrees are higher level educational programs, all of the enrolments were recorded for private universities.

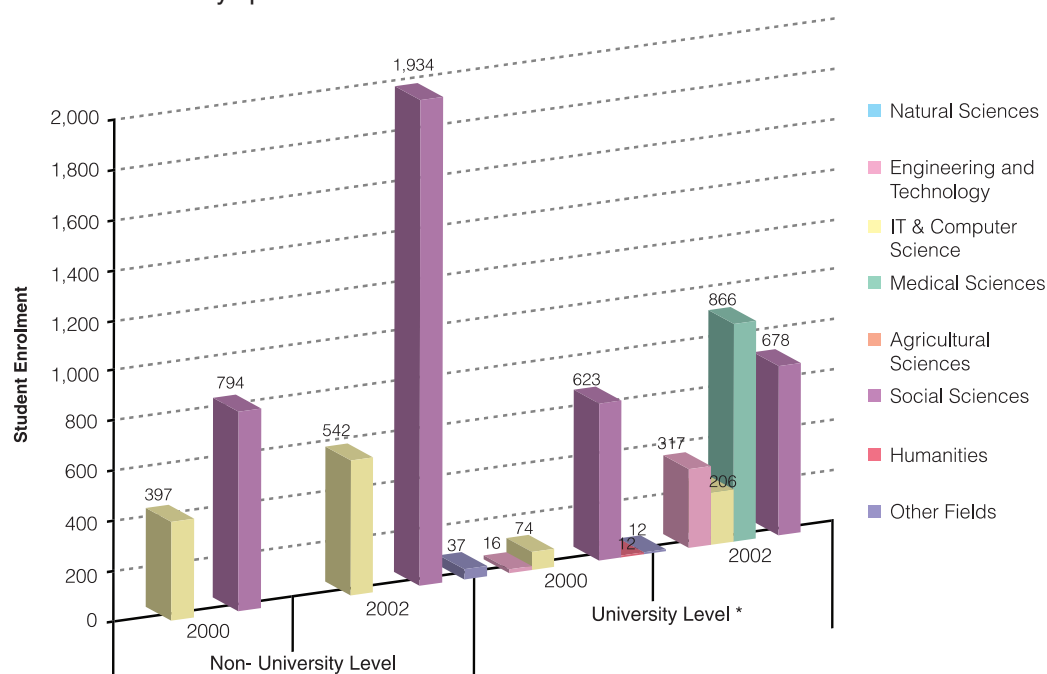


Figure 3.17: Enrolment in Masters Degree Courses at Private Educational Institutions by Field of Study, 2000-2002

Note: (*) Includes data from campus branches

3.3.4 Graduations in Masters and Doctoral Degree Courses

In 2002, a total of 571 students graduated with Master Degrees from private institutions, with 57.1% of the students from private universities. A Slightly higher percentage (50.9%) of the total graduation came from natural science equivalent subjects, of which IT and computer science constitutes the biggest percentage (60.5%).

Only 4 students graduated with doctoral degree in 2002, unchanged from 2000. All of the students graduated in social science subjects.

3.3.5 Enrolment in Other Programmes

Figures 3.18 and 3.19 show the student enrolment in certificate and diploma programmes in private institutions. In 2002, a total of 93,393 students were enrolled in certificate programmes at private institutions, with 95.9% of them enrolled at private colleges. The total enrolment at private institutions in 2002 was 88.8% higher than 2000. Out of the total 93,393 registered for the certificate programmes, 34.8% was for IT and computer science, followed by humanities with 12.2%. Social science was next, with 11.1% of total enrolment, followed by engineering and technology (10.4%).

In the case of diploma programmes, a total of 131,178 students were registered in the year 2002, representing an increase of 34.7% from 2000. The enrolment was dominated by private colleges, constituting 97.7% of the total intake. Social science and computer science

recorded the highest intakes, each having 34% of the total enrolment at private institutions. The biggest growth was recorded for medical sciences, registering an increase of 139.3% between 2000 and 2002.

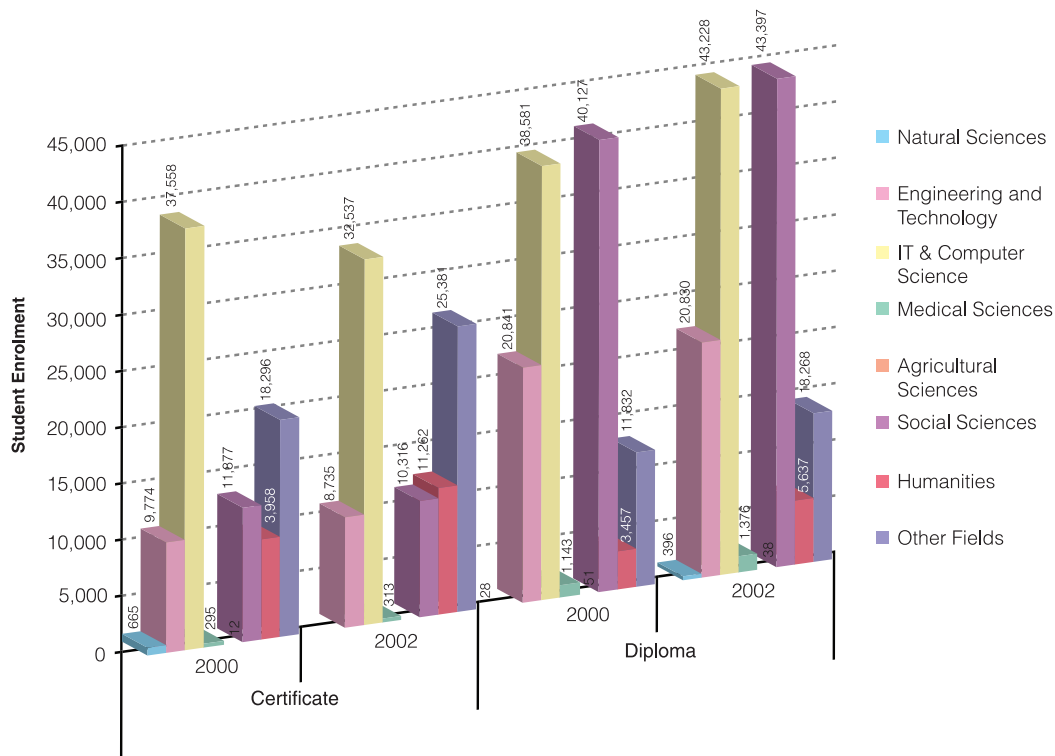


Figure 3.18: Enrolment in Other Programmes at Private Institutions (Non-University Level), 2000-2002

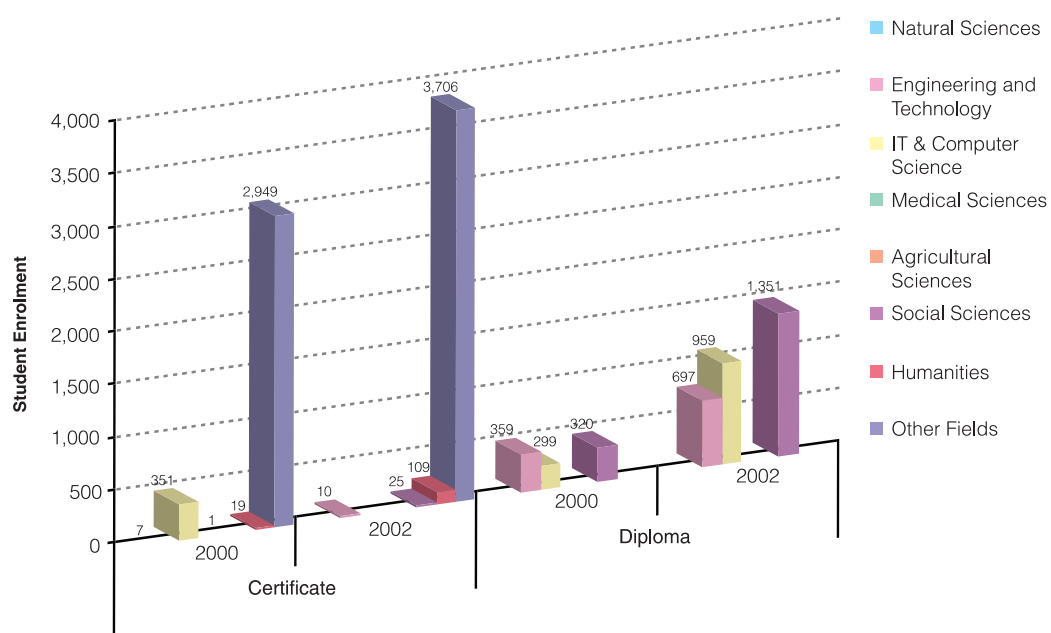


Figure 3.19: Enrolment in Other Programmes at Private Institutions (University Level*), 2000-2002

Note: (*) Includes data from campus branches

3.3.6 Graduation in Other Programmes

Figure 3.20 and Figure 3.21 show the number of graduating students in other programmes at the private educational institutions. Graduation in certificate programmes recorded a huge increase between 2000 and 2002. A total of 60,819 students graduated in 2002 as compared to 24,000 in 2000, representing an increase of 153.4%. All of the graduations were from private colleges. IT and computer science recorded the

highest graduation (39.9%), followed by social science (18.1%).

Graduation in diploma programmes also recorded a huge increase between 2000 and 2002, registering a growth of 86.4%. Total graduation stood at 55,988 in 2002, with computer science and social science each constituted 34% of the total graduation. Almost all of the graduations came from private colleges (99.4%).

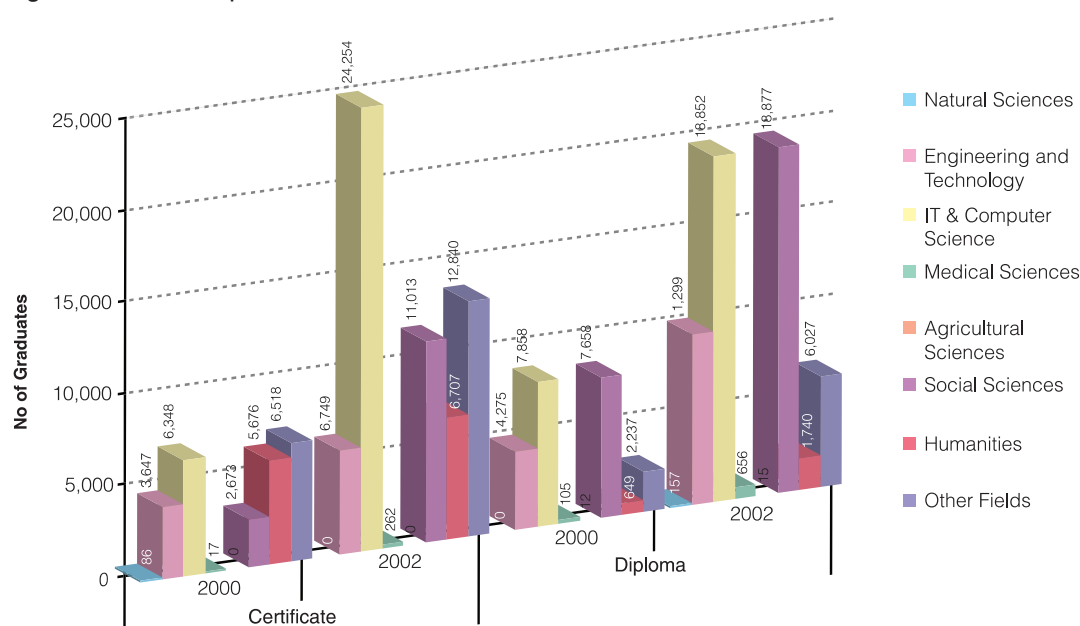


Figure 3.20: Graduations in Other Programmes at Private Non-University Level Institutions, 2000-2002

A comparison of student enrolment in public and private institutions shows that there were more students enrolled at public institutions than private institutions for both undergraduate and postgraduate courses (Figure 3.22 and Figure 3.23). Total enrolment in first-degree courses at public institutions was 182,569 as compared to 67,044 at private institutions, representing a ratio of 73:27. For both types of institutions, social science recorded the highest enrolment, followed by engineering and technology at public institutions and IT and computer science at private institutions.

Enrolment in masters and doctoral degrees were heavily skewed towards public institutions. In 2002, 84.4% of the total 29,464 enrolment in masters degree and 95.1% of the total 4,053 enrolment in doctoral degree were at public universities. Of the enrolment at masters level, 43.4% were for natural science equivalent

subjects while for doctoral degrees, the percentage was 48.4%.

A total of 51,261 students graduated at first-degree level in 2002, with 60.5% of the total coming from public universities. Out of this, the percentage of natural science students was 36.6% for public tertiary institutions, while for private tertiary institutions, the percentage was 42.4% due to higher number of graduates in IT and computer science. At the post-graduate level, graduations at masters and doctorate levels were dominated by public universities, which contributed 90.8% of the total 6,226 masters graduates and 99.2% of the total 490 doctoral graduates in 2002. A higher percentage (58.6%) of natural science equivalent graduates were recorded at doctoral level as compared to masters level (32.5%), indicating doctoral degree is still very much associated with intense research-oriented subjects as emphasized by most natural science subjects.

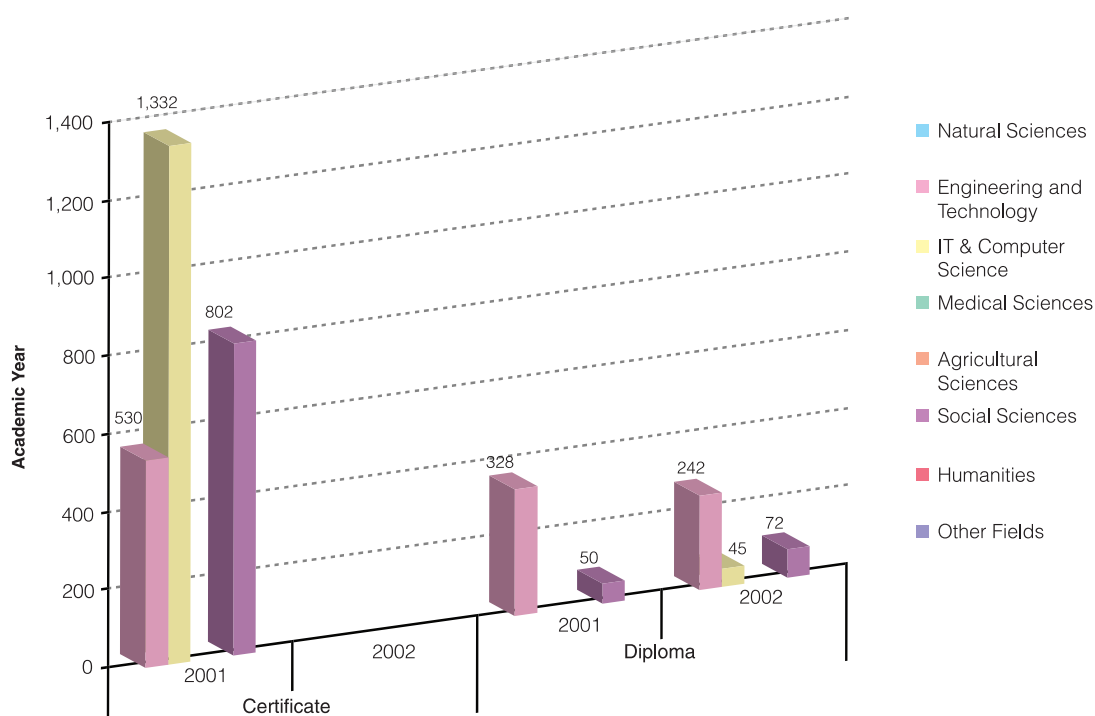


Figure 3.21: Graduations in Other Programmes at Private University Level Institutions

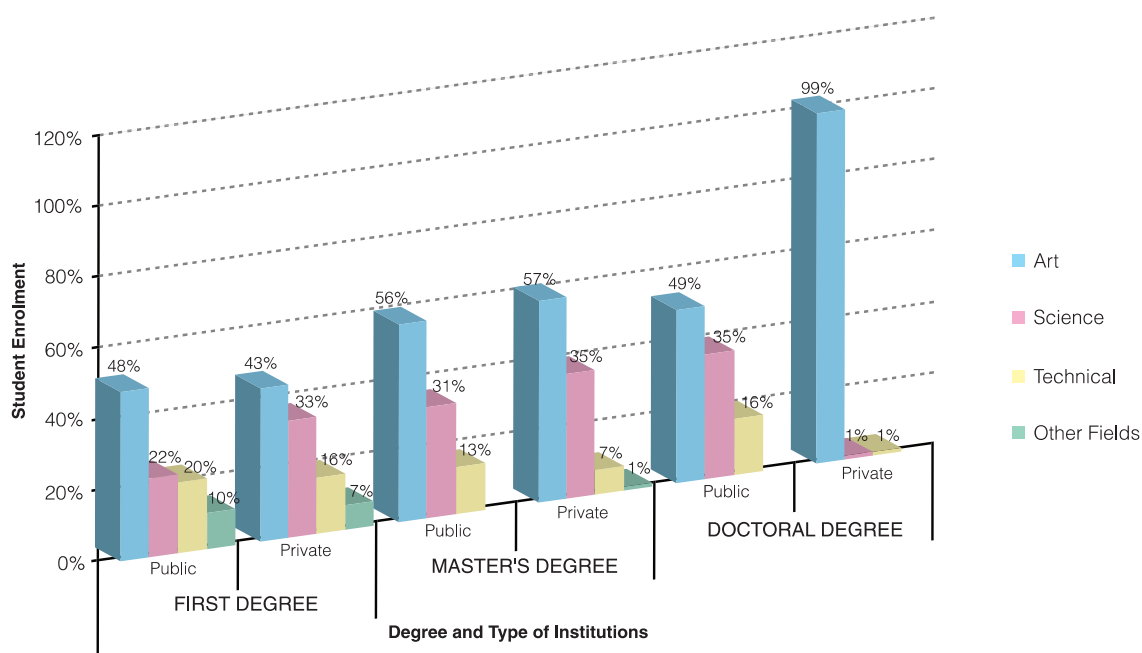


Figure 3.22: Comparison of Student Enrolment in Public and Private Educational Institutions, 2002

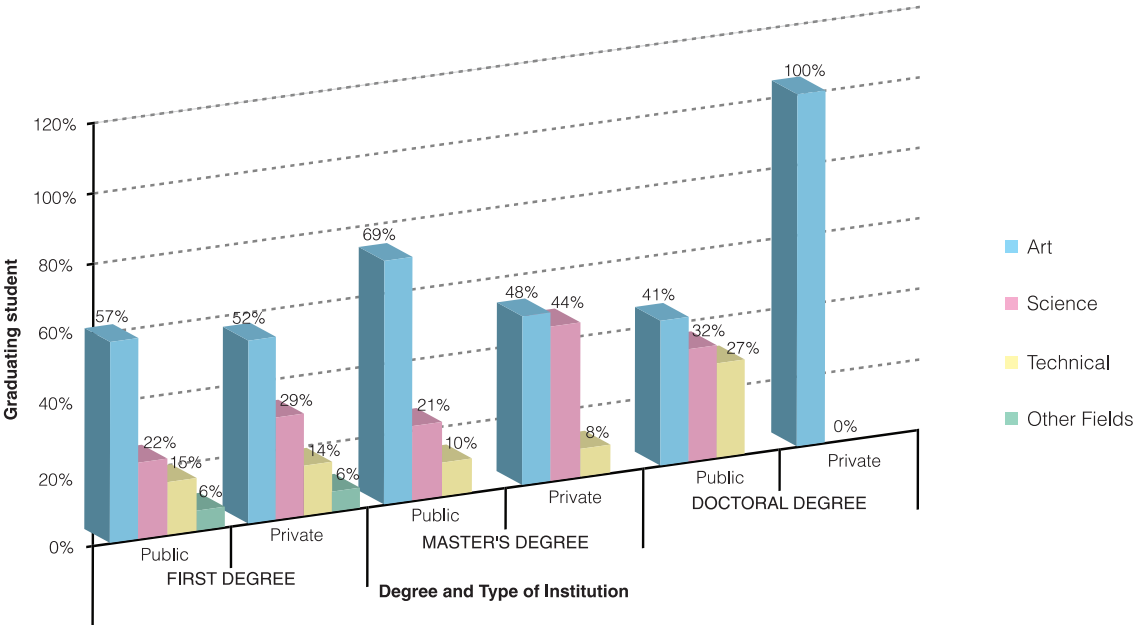
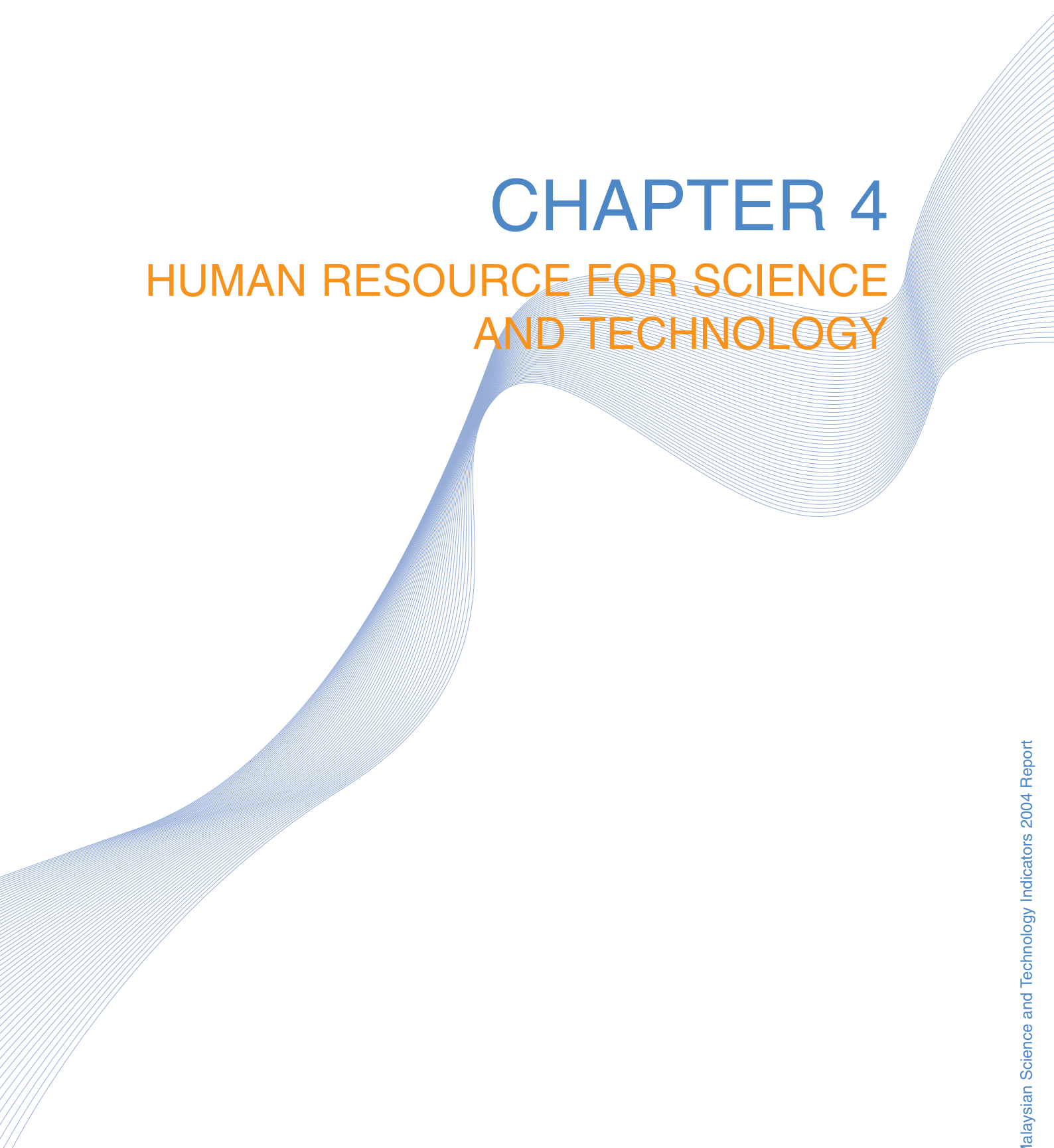


Figure 3.23: Comparison of Graduations in Public and Private Educational Institutions, 2002



CHAPTER 4

HUMAN RESOURCE FOR SCIENCE AND TECHNOLOGY

From the broadest perspective, human resource is important for the economic development of any nation. The formation of human capital has gained increasing importance in the face of rapid technological development as well as the fast technology cycle that renders technological obsolescence. Human resource is important in all areas of a nation's development, in particular, for a country like Malaysia that strives to achieve a developed nation status by year 2020. This chapter looks into the human resource for science and technology over the years. It seeks to provide a trend study on the distribution of human resource in the public and private sectors. The characteristics of research personnel, size, and gender composition will be highlighted.

4.1 Workforce in Research and Development (R&D)

The same classification of workforce in research and development as appeared in previous reports is adopted here: they are researchers and R&D personnel comprising technicians and other support staff. Headcount as well as full time equivalent (FTE) are used to measure the labour input into R&D.

Researchers per 10,000 labour force

increased from 15.6 in 2000 to 18.0 in 2002 (Figure 4.1). Corresponding to this, researchers per 10,000 population also increased from 6.4 to 7.3. In terms of total R&D personnel (headcount), there has been an improvement from 23,262 in 2000 to 24,937 in 2002. Measured in terms of FTE, the number of R&D personnel has improved from 10,060 in 2000 to 10,731 in 2002. Although the manpower in R&D is still low when measured by international standard, there is a marked improvement over the last ten years.

There was a slight increase in researchers and R&D personnel in terms of headcount and FTE from 2000 to 2002 when compared to the period 1998 to 2000 (Figure 4.2). The percentage increase in headcount for researchers during the period 2000 to 2002 was 18.4%. In terms of FTE, the number of researchers increased by 11.45%. Although the number of researchers increased by 18.4% the increase was not proportionate in terms of FTE.

For R&D personnel, the percentage increase was 7.2% and 6.7% for headcount and FTE, respectively. Compared to the 1998-2000 period, the performance in the 2000-2002 period was less encouraging, indicating that the steep increase in the number of R&D personnel since 1996 has slowed down.

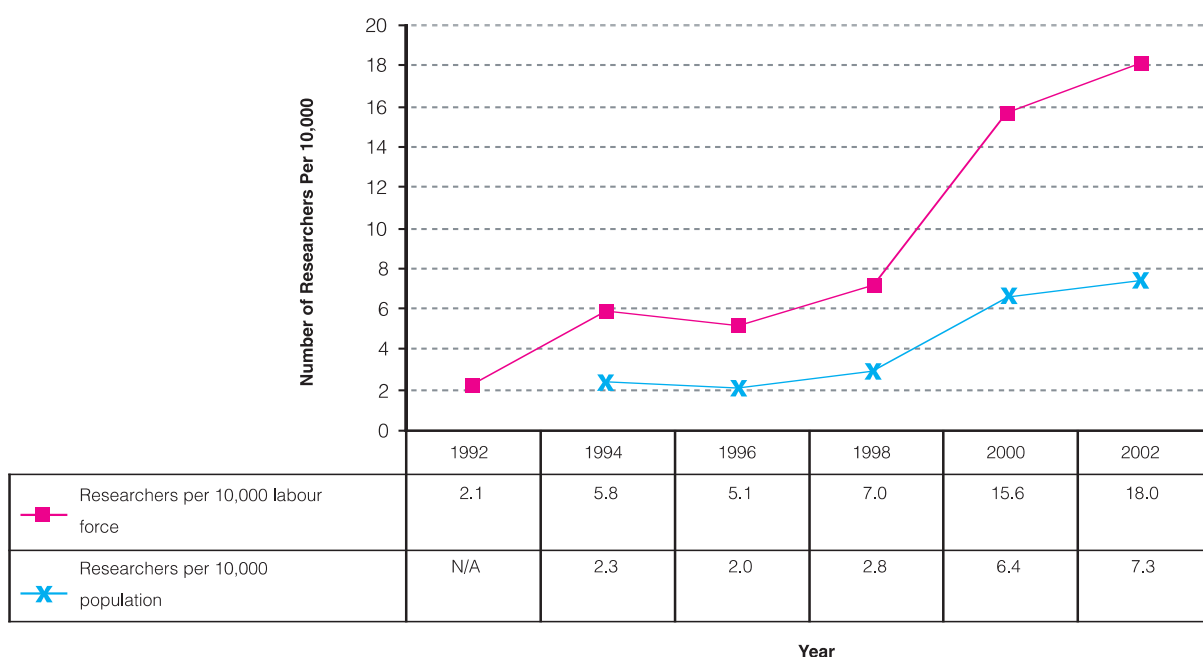


Figure 4.1: Number of Researchers Per 10,000 Labour Force and Population, 1992-2002

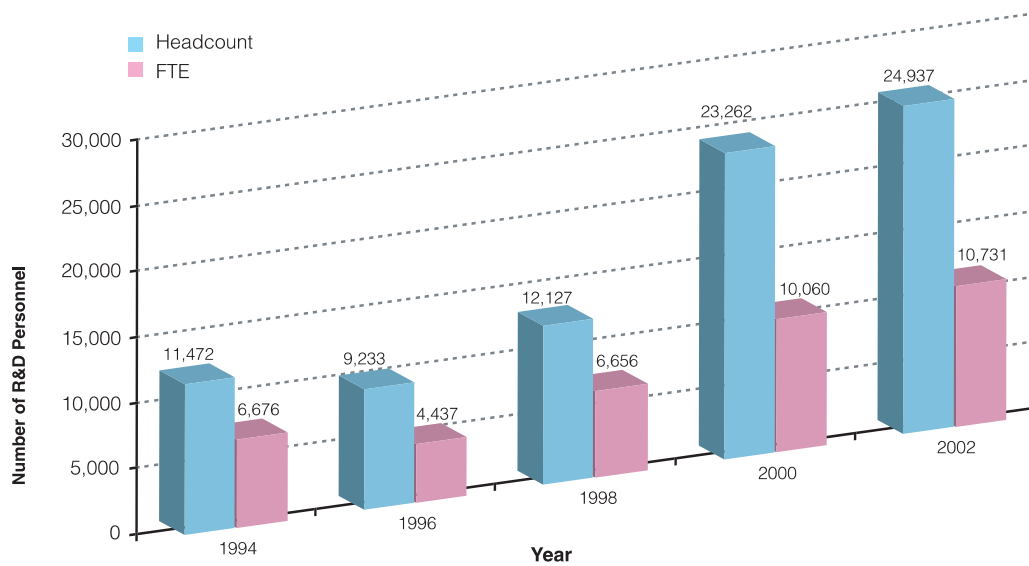


Figure 4.2: R&D Personnel (FTE and Headcount), 1994-2002

Examining the trends in R&D personnel in different sectors, the private sector registered a significant increase in researchers in terms of headcount (45.4%) during the period of 2000-2002. However, in terms of number of researchers (FTE), there was a significant decline in the number of researchers. For R&D personnel, the private sector leads the way by experiencing the highest increase, i.e., 27.1% and 21.9% respectively for FTE and headcount. This clearly indicates the increased involvement and commitment of the private sector in R&D. The

performance of the institutes of higher learning (IHLs) sector was rather poor when compared to the 1998-2000 period.

For government research institutes (GRIs), the trend was not encouraging. In general, the number of R&D personnel in GRIs had declined during the 2000-2002 period, both in terms of FTE and headcount. In terms of percentage contribution of each sector towards total R&D personnel, the contribution of IHLs was clearly increasing for the period 2000-2002 (Figure 4.3).

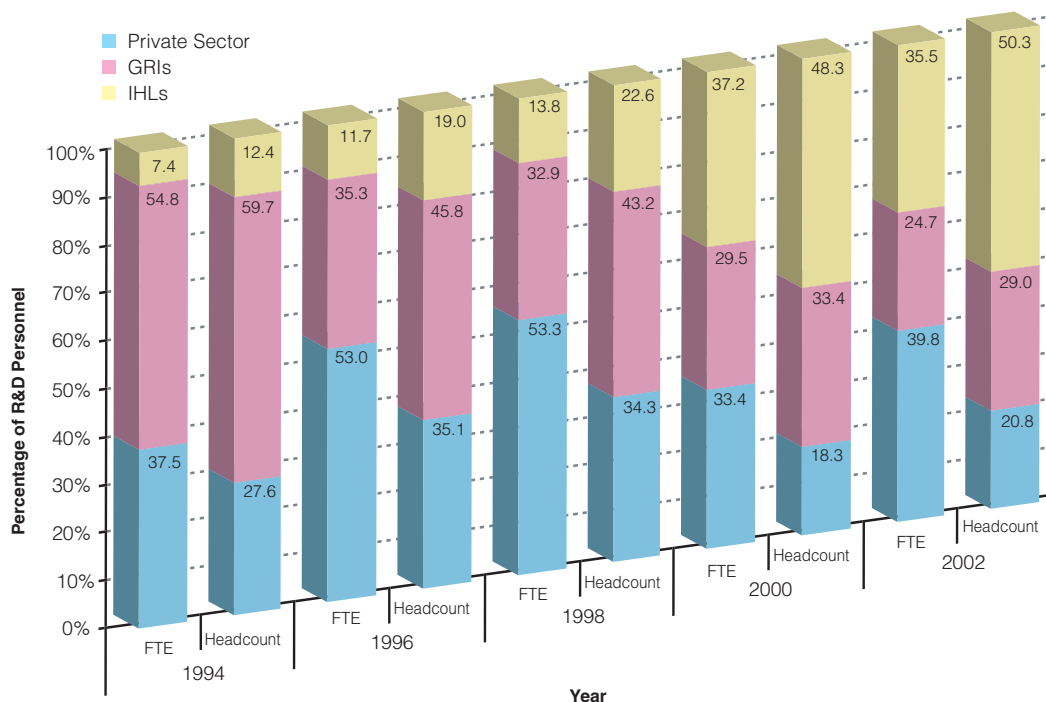


Figure 4.3: R&D Personnel (FTE and Headcount) by Sector, 1994-2002

Examining the ratio of researchers to R&D personnel in the private sector, the 2002 figure saw a drastic decline in the ratio of FTE when compared to the ratio in 2000, from 0.6 to 0.2, indicating that many of the researchers involved in R&D did not devote their time fully on R&D activities during this period. However, the ratio for researchers by headcount saw a slight increase to 0.6 from 0.5, indicating that more and more personnel were being employed as researchers during the period. For GRIs, the ratio increased from 0.4 to 0.5 for FTE. However for headcount the ratio remained the same at 0.5. For IHLs, the ratio for both FTE and headcount remained unchanged at 0.8.

Looking at the ratio of FTE to headcount for researchers, a drastic decline in the ratio was observed for the private sector, i.e., from 0.9 in year 2000 to 0.3 in year 2002. For GRIs, no change in ratio was recorded, whilst the IHLs saw a slight decrease in the ratio, i.e., from 0.4 to 0.3. For R&D personnel, the ratio of FTE to headcount remained the

same over the two years of 2000 and 2002 at 0.8 for the private sector, 0.4 for GRIs and 0.3 for IHLs.

4.1.1 Gender Composition of Research Personnel (Headcount and FTE) by Sector

There were more male researchers, technicians and other support personnel involved in R&D as compared to females in all sectors for the two years, 2000 and 2002 (Figures 4.4 and 4.5). For the private sector, in terms of headcount, males made up 70.9% of the total R&D personnel in the sector in 2002. In the public sector (GRIs) and IHLs, in terms of headcount, there were 70.5% and 65.1% males involved in R&D respectively in 2002.

In terms of FTE, a similar situation was observed. For the private sector, the FTE for males made up 70.2% of total input into R&D in 2002. For IHLs, the percentage of male researchers measured in terms of FTE was 60.7%, whereas it was 70.1% for GRIs in 2002.

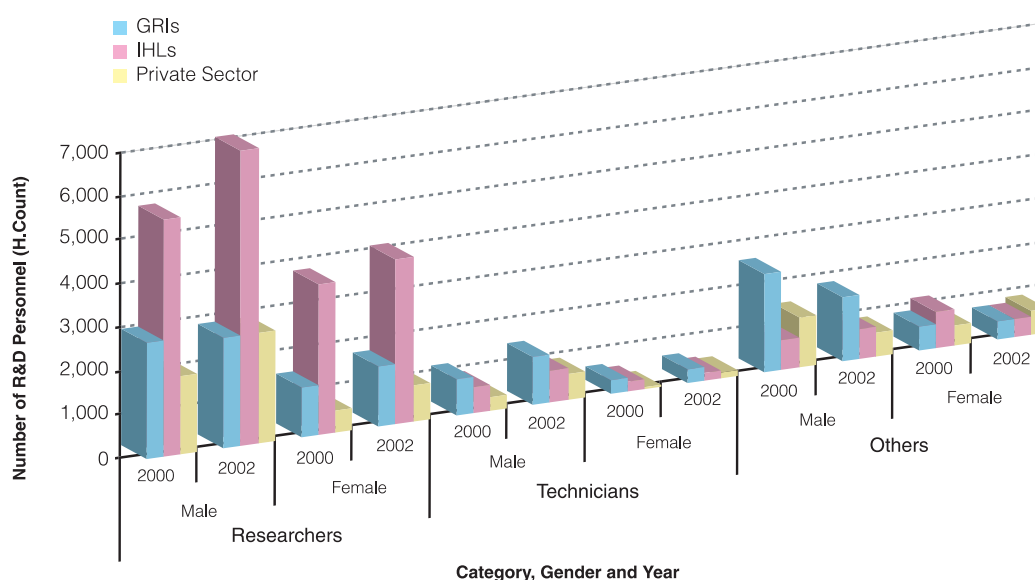


Figure 4.4: R&D Personnel (Headcount) by Sector, Category and Gender, 2000-2002

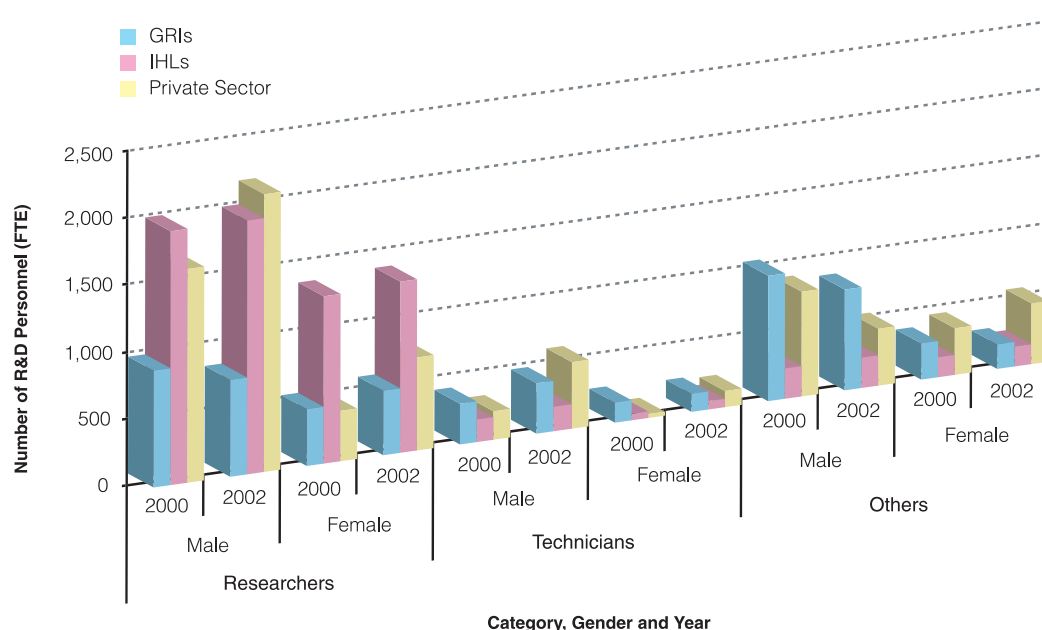


Figure 4.5: R&D Personnel (FTE) by Sector, Category and Gender, 2000-2002

4.1.2 Researchers (Headcount and FTE) by Sector, Qualification and Gender

In terms of headcount (with the sectors and qualification levels collapsed), females made up 35.8% of total researchers, while males made up 64.2% in 2002. Aggregating the sectors, researchers with PhD made up 37.4% (5,375) of total researchers in the same year. Those with master's degree made up 31.6% (4,537). Bachelors degree holders constituted 42.0% (6,041) and the remaining 6.3% (905) were non-degree holders.

For all levels of qualification, in terms of headcount, male researchers outnumbered females in R&D activities in 2002. Comparing participation in R&D in terms of gender, the percentage of female researchers with PhD was 27.5% (1,503). For other qualifications, such as masters and bachelors degree holders and non-degree holders, slightly more than 30% of researchers were females. This shows that females were not adequately represented in the field of R&D, in particular, at the PhD level. Reasons for the low level of female participation are well documented in gender studies and it is not within the purview of this report to analyse them. However, it is important to note here that female

representation in R&D activities in 2002 had improved slightly when compared to 2000.

For the private sector, in terms of headcount, the proportion of researchers having a bachelors degree was higher in 2002 (Figure 4.6). Female researchers' representation in all categories of qualifications was from 15% to 27%. There were very few female researchers with PhD (12 persons) and they constituted only 14.8% of total researchers with PhD in the private sector in 2002. This number represented less than 1% of the total number of researchers with PhD in all sectors.

For GRIs and IHLs, the female participation, in terms of headcount, was much higher compared to the private sector in 2002. On the whole, females made up more than 30% of researchers with qualification at the masters and bachelors degrees level. By far, GRIs had the highest percentage of female researchers with PhD among the three sectors, i.e., 29.0% of total researchers with the same qualification. In terms of FTE in 2002, overall, total female contribution was 2,452 or 34.3%, whereas the males contributed the balance of 65.7%.

Looking at the FTE in R&D by qualification, female researchers with PhD

contributed 28.6%, whereas for the master level, it was 36.7%. Those with bachelors degree contributed 35.9% towards FTE for the category in 2002. Measured in FTE, the situation of male/female participation was similar to the situation under headcount. The distribution of female researchers by sector

shows that females were less involved in the private sector R&D across qualification categories. Consistent with the higher female participation in R&D at GRIs and IHLs, the contribution of women in terms of FTE was higher in these two sectors than in the private sector.

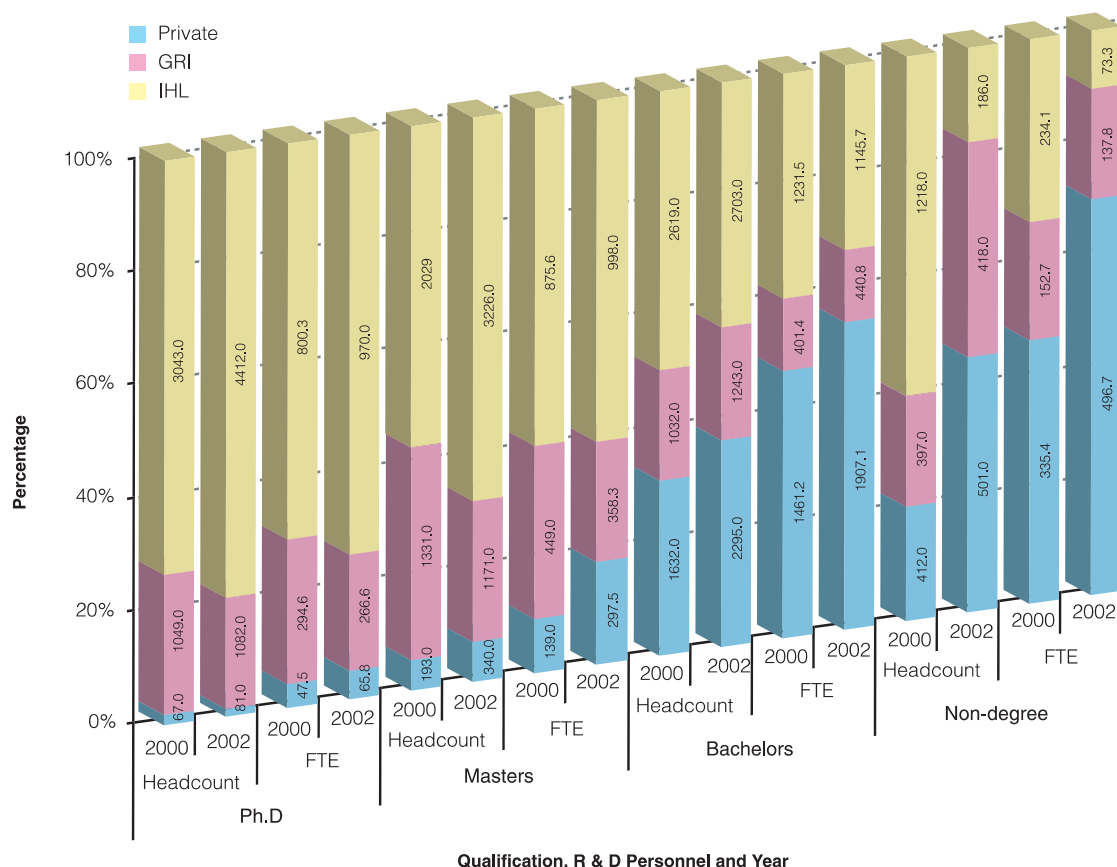


Figure 4.6: Researchers (Headcount and FTE) by Sector and Qualification, 2000-2002

4.1.3 Types of Research by Sector

The distribution of researchers by sector and types of research provides a better understanding of the emphasis in research and development in Malaysia (Figure 4.7). Overall, in terms of headcount, the concentration was on applied research as indicated by the number of researchers (6,981) involved in this type of research in 2002. This is followed by basic research (4,508) and experimental development (2,497).

For the private sector, in terms of headcount, the largest number of researchers were involved in applied research (44.2%), followed by experimental development (27.8%)

and "all types" (11.9%). The types of research conducted by the private sector are a clear indication of the emphasis on market driven research to satisfy market needs. When compared to 2000, less emphasis have been given by the private sector to basic research in year 2002 (i.e., 17.5% in 2000 compared to 3.2% in 2002).

For the government research institutes (GRIs), in terms of headcount, 37.3% of the researchers were engaged in applied research, followed by 22.6% in basic research in 2002. The allocation of researchers to the various types of research indicated the importance of applied research as well as basic research in GRIs.

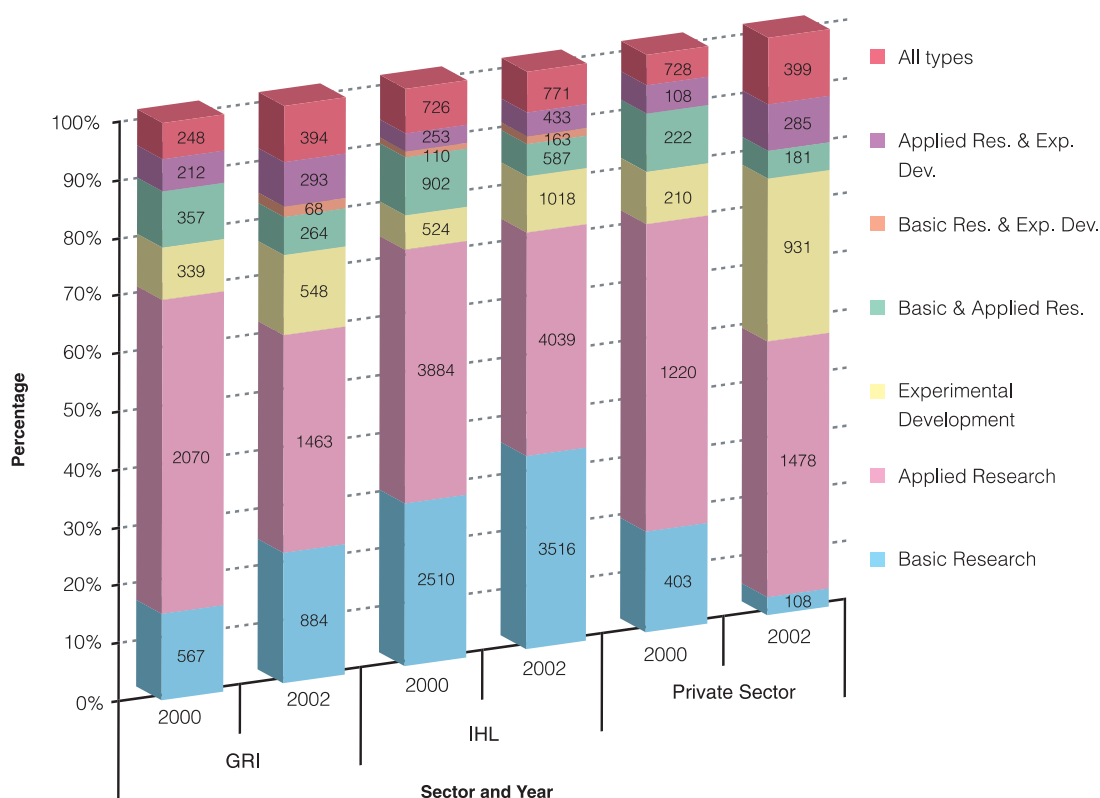


Figure 4.7: Researchers (Headcount) by Type of Research, 2000-2002

The role of government agencies in basic research becomes apparent in the case of the types of research undertaken by IHLs. More emphasis was given to applied research (38.4%) and basic research (33.4%).

The government's strategy of assuming more responsibilities in basic research is appropriate for the development of technological capabilities of the country. In this respect, the government has taken positive steps in providing the necessary infrastructure and implementing programmes such as providing scholarship for tertiary education in science and attracting scientists from abroad.

Attracting Malaysian scientists working abroad and foreign scientists to Malaysia is a short-term measure to overcome the shortage of scientists. However, this programme was not very successful. To date, only a total of 93 (23 locals and 70 foreigners) have responded. One possible explanation for this less than satisfactory response could be the difficulty in matching compensation and benefits enjoyed by scientists working abroad.

Another programme known as the 'Young German Professionals for Employment in Malaysia' has been formulated. It is still in the initial stages of planning. As a long-term measure to develop an internal pool of scientists, a fellowship programme known as the National Science Fellowship has been established for post-graduate studies in priority areas of science and technology in local universities. So far, there are 77 successful candidates.

4.1.4 Field of Research (FOR) and Qualification by Sector

Figure 4.8 shows the number of researchers for selected fields of research of the three major sectors in the economy, the field of research that received tremendous attention in 2002 in terms of the number of researchers was engineering sciences (3,124). This is followed by information, computer and communication technologies (2,917) and applied sciences and technologies (1,844). The two fields of research that had the least number of researchers in 2002 were marine sciences and physical sciences.

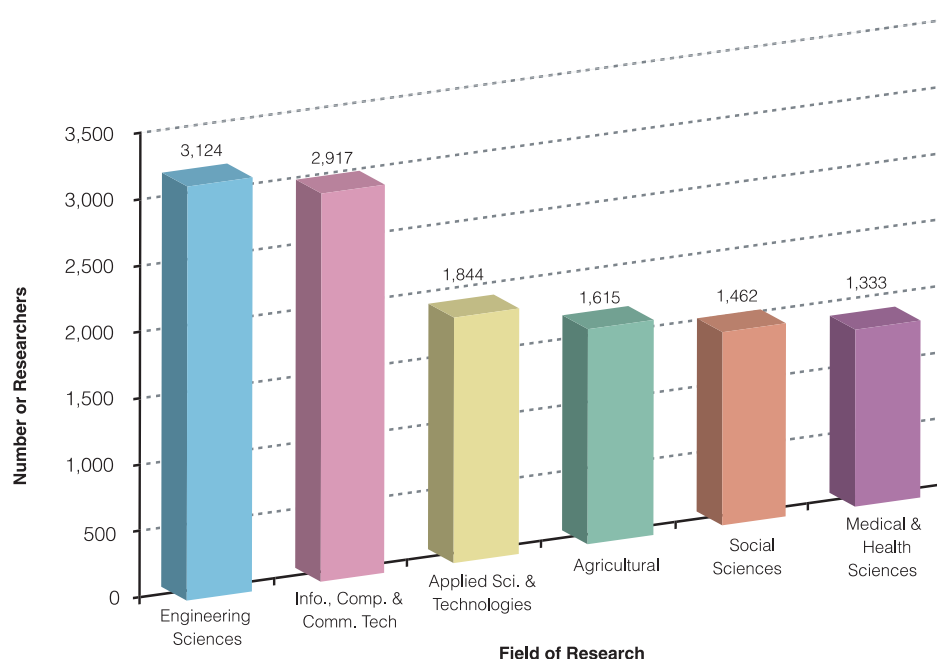


Figure 4.8: Researchers (Headcount) by Selected Field of Research, 2002

The majority of researchers in the private sector in 2002 are equipped with bachelors degrees (68.5%), followed by masters degree (10.1%) and PhD degrees (2.4%). About 18.9% of researchers in this sector did not have any degree.

In the private sector in 2002, the field of research that had a large number of researchers was: information, computer and communication technologies (1,347), engineering sciences (1,182) and applied sciences and technologies which employed 382 researchers (Figure 4.9). Earth sciences and environmental sciences had the least number of researchers (2 and 4 each, respectively).

For GRIs and IHLs, the percentage of researchers with PhD and master qualifications in 2002 was higher. IHLs had the highest percentage of PhD holders (41.9%), whereas GRIs had 27.6% of researchers with similar qualification. Those with master degree made up 30.6% and 29.9% of researchers in IHLs and GRIs respectively.

For IHLs the distribution of researchers in the various fields in 2002 was more or less quite well distributed compared to the private sector as nine out of the 18 fields of research had more than 500 researchers. The field with the highest number of researchers

was engineering sciences (1,522), followed by social sciences (1,206) and information, computer and communication technologies (1,184). For GRIs, the concentration of researchers was in agriculture (895) and engineering sciences (420).

The distribution suggested that private sector R&D is market-driven and customer-focused, whereas government research institutes and IHLs undertake research in areas that the private sector does not emphasise.

4.1.5 Socio-Economic Objectives (SEO) and Qualification by Sector

Examining the socio-economic objectives of R&D provides details about the purpose for which R&D was conducted. For the private sector, in terms of headcount, in 2002, it is obvious that R&D was conducted mainly for the purpose of manufacturing (1,648 researchers), followed by information and communication services (722 researchers), and natural science technology and engineering (455 researchers). For IHLs, in 2002 the natural science technology and engineering had the most number of researchers (2,461), followed by manufacturing (1,330), health (1,019) and information and communication services (698). For GRIs, in 2002 researchers were engaged in plant

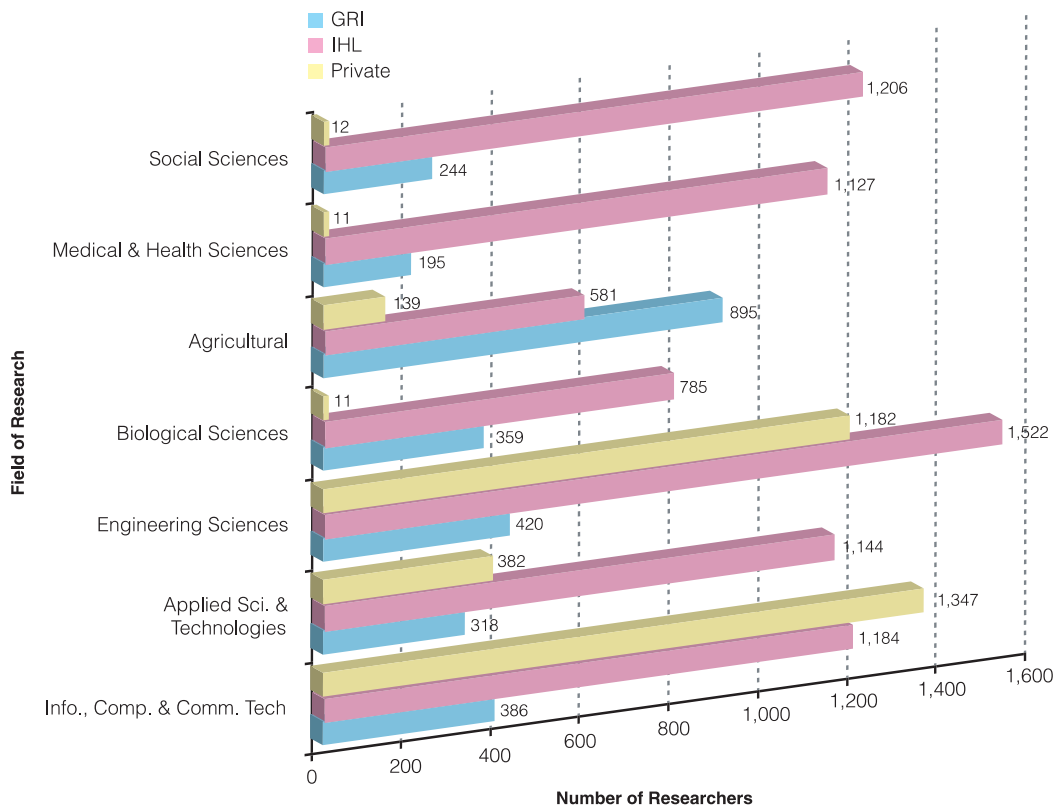


Figure 4.9: Researchers (Headcount) by Sector and Selected Field of Research, 2002

production and primary products (1,184), followed by natural science technology and engineering (553) (Figure 4.10).

When one compares some of the statistics of year 2002 with that of 2000,

almost similar results were obtained. The top five main socio-economic objectives of 2002 were the same as those of 2000. The only difference was that the ranking of the socio-economic objectives for 2000 was slightly different from 2002.

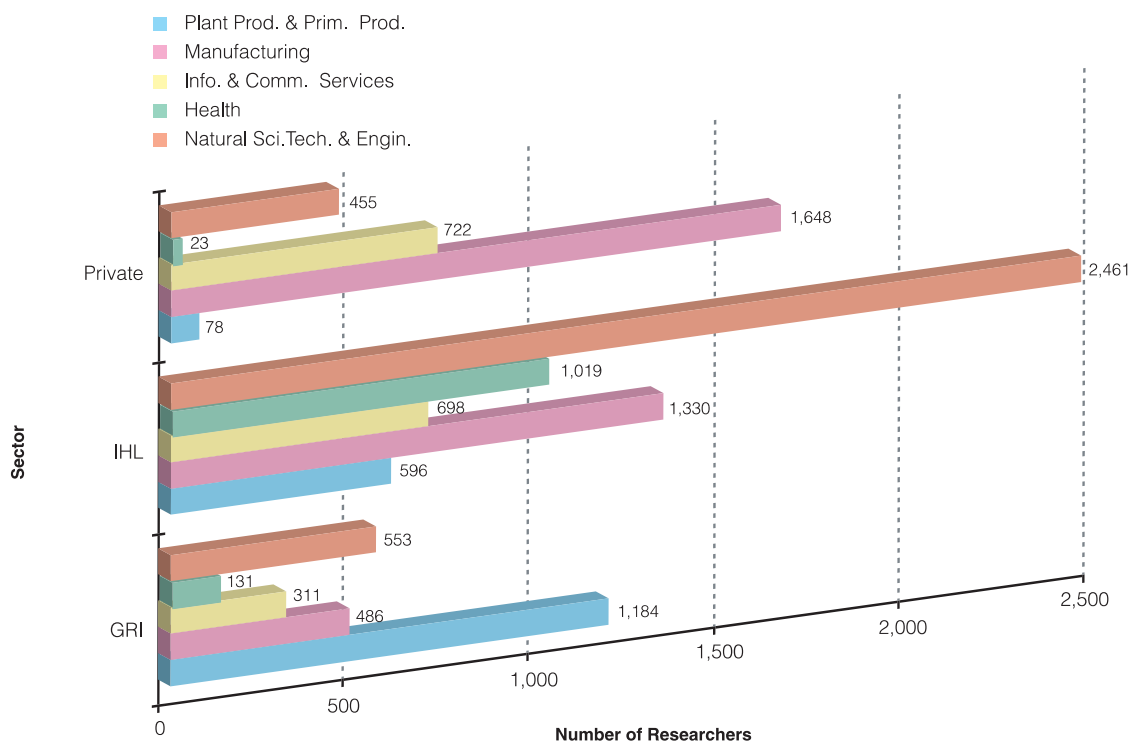


Figure 4.10: Researchers (Headcount) by Sector and Selected Socio-Economic Objectives (SEO), 2002

Chapter 4 Human Resource For Science and Technology

4.2 Private Sector R&D Personnel (Headcount and FTE)

Total private sector R&D personnel, in terms of headcount, in 2002 stood at 5,177 representing a significant increase of 21.9% from 2000. For all categories of R&D personnel, the locals outnumbered foreigners (Figure 4.11). The ratio of local researchers to foreign national in 2002 was 13.0, a marginal increase from 12.7 in

2000. The ratio of local to foreign research personnel was much higher, consistent with the government policy of utilising local human resources.

From the perspective of FTE, the ratio of local researchers to foreign national in 2002 was 12.9. The ratio of local R&D personnel to foreign national was 18.4, almost the same ratio when using headcounts.

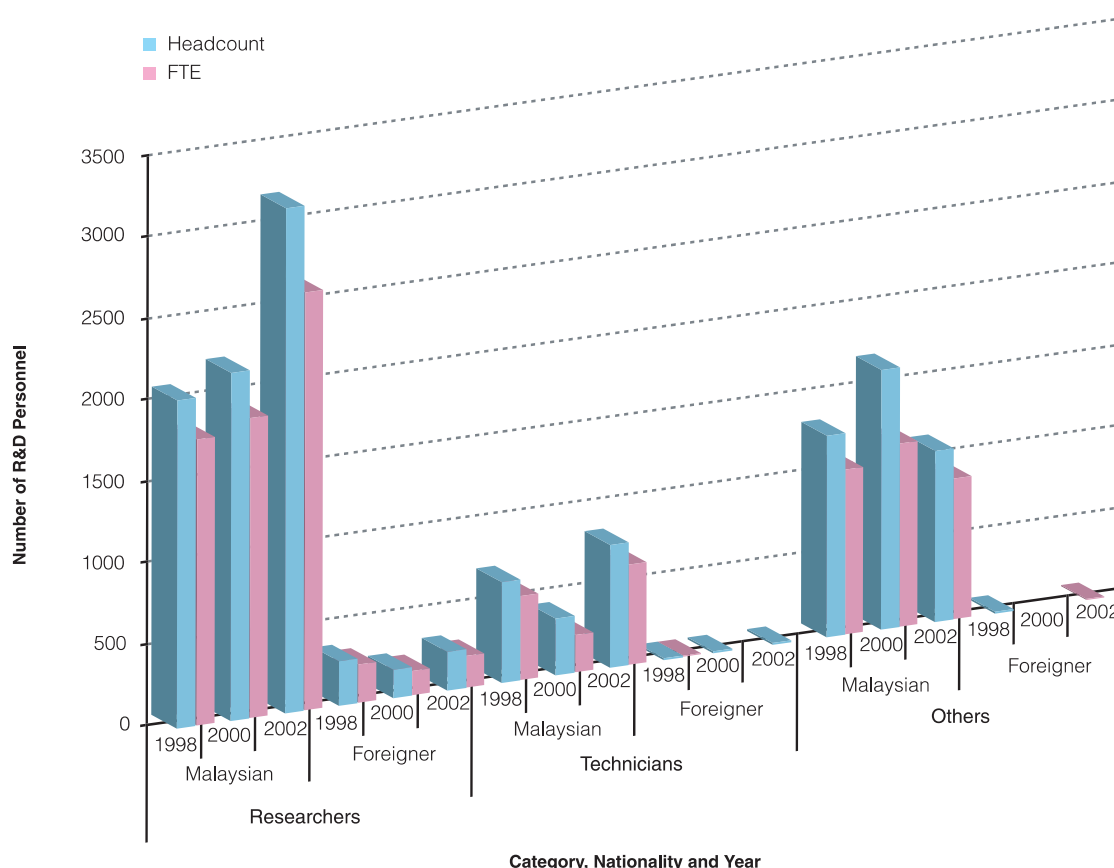


Figure 4.11: R&D Personnel (Headcount and FTE) in Private Sector by Nationality, 1998-2002

4.2.1 Private Sector R&D Personnel by Industry, Nationality and Gender

As mentioned earlier in the chapter, private sector R&D personnel were mainly utilised for manufacturing (Figure 4.12). In 2002, they were mainly found in electrical machinery and appliances industry (980), followed by agriculture, livestock and fishery industry (922) and transport equipment (587). Services (telecommunication services, computer and related services and other services) employed 249 people in R&D,

whilst the primary industry had 922 employees in R&D.

The trend is similar when using FTE as a basis for measurement. In 2002, the industry with the highest FTE in R&D (69.1% of the total) was manufacturing, followed by real estate, renting and business activities (24.4%). This was a major shift from the year 2000, where the former was more dominant, accounting for 80.5% of the total FTE as compared to 7.4% for the latter (Figure 4.13).

In terms of nationality, local citizens still dominated the R&D headcount in the private sector, with a slight decrease in the ratio of foreigners to locals from 96% in 2000 to 95% in 2002. In terms of FTE, the ratio remained at 95% for both 2000 and 2002.

In terms of gender, there were more males than females across all industries. However, it is worthy to note that the ratio of male to female, on headcount basis, has reduced from 3.3 in 2000 to 2.4 in 2002, indicating more women have entered into the field during the period. The improvement was also demonstrated in terms of FTE, where the ratio of male to female has reduced significantly from 4.2 in 2000 to 3.0 in 2002.

4.2.2 Private Sector R&D Researchers (FTE) by Industry, Qualification and Gender

Total FTE spent on R&D in year 2002 was 2,767.1 representing a significant increase of 39.5% from 2000 (1,983.0). As mentioned earlier, in terms of headcount there was a 21.9% increase in private sector R&D personnel. This might indicate that a significant proportion of R&D employees were part-timers. The industry spending the most effort on R&D in 2002 was the radio, television and communications equipments and apparatus industry, followed by the electrical machinery and appliances industry and the research and development (under the Real Estate, Renting and Business Activities category) industry. In 2000, the electrical machinery and appliances had the highest R&D effort. This was followed by the motor vehicles, trailers and semi-trailers industry and the radio, television and communications equipments and apparatus industry. Consistent with the government's policy of promoting the Multimedia Super Corridor and the thrust given to the IT industry to spearhead economic growth, computer and related services industry has seen an increase in private sector R&D effort by almost 3 times, from 156 in 2000 to 465 in 2002.

In terms of qualification, in the private sector, researchers with bachelor degree contributed a total R&D effort (FTE) of 1907.1

(68.9% of total FTE) in year 2002. Those with PhD contributed only 2.4% of total FTE and they were mainly found in the research and development industry (under the Real Estate, Renting, and Business Activities sector). Those with masters degrees were also mainly employed in the Real Estate, Renting, and Business Activities sector and electrical machinery and appliances industry.

In terms of gender, there were more male than female researchers in almost all industries and for all categories of qualification except for a few industries. Overall, the ratio was skewed towards male, as demonstrated by the male to female ratio of 3.0 in 2002.

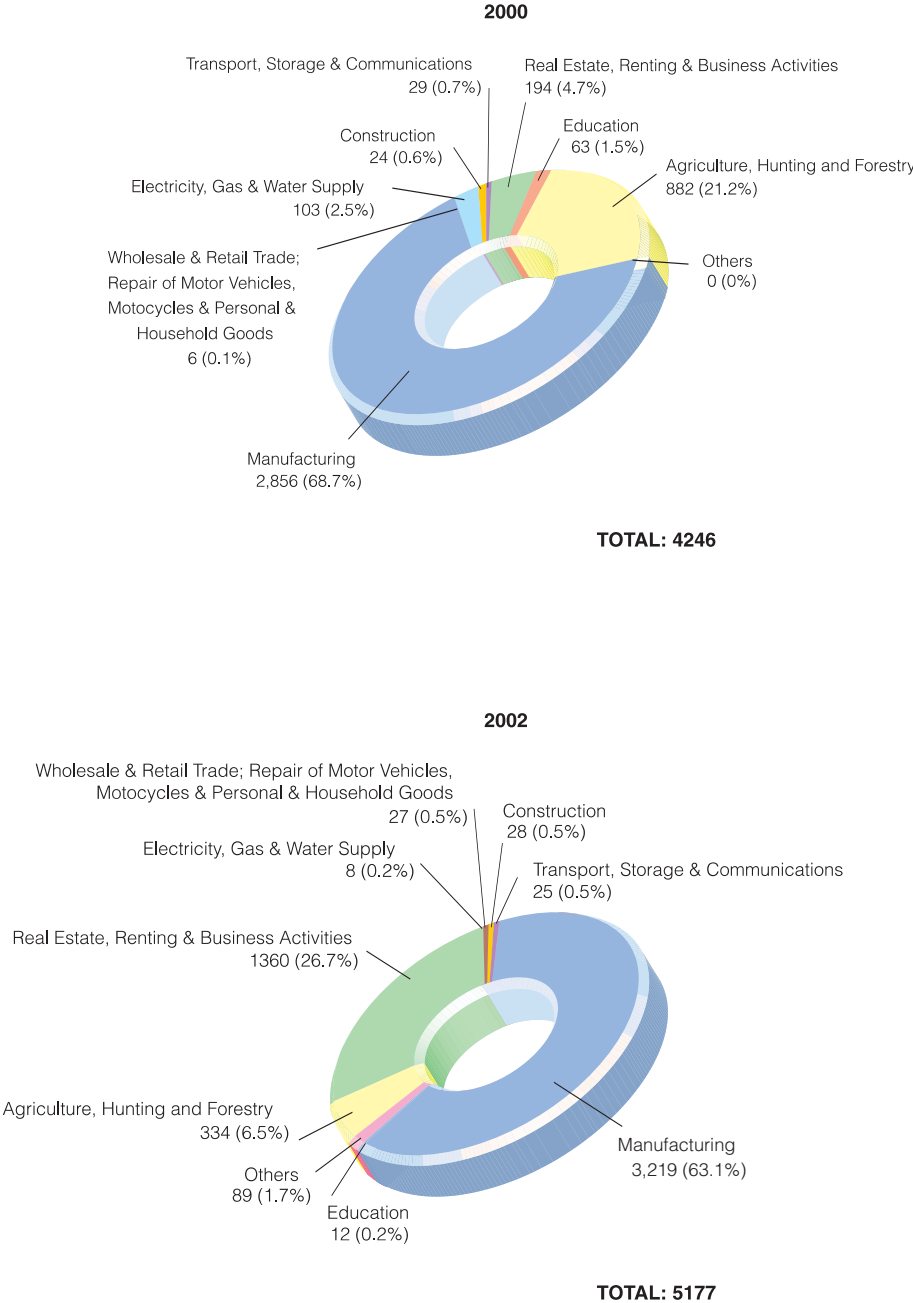


Figure 4.12: Private Sector R&D Personnel (Headcount) by Industry, 2000-2002

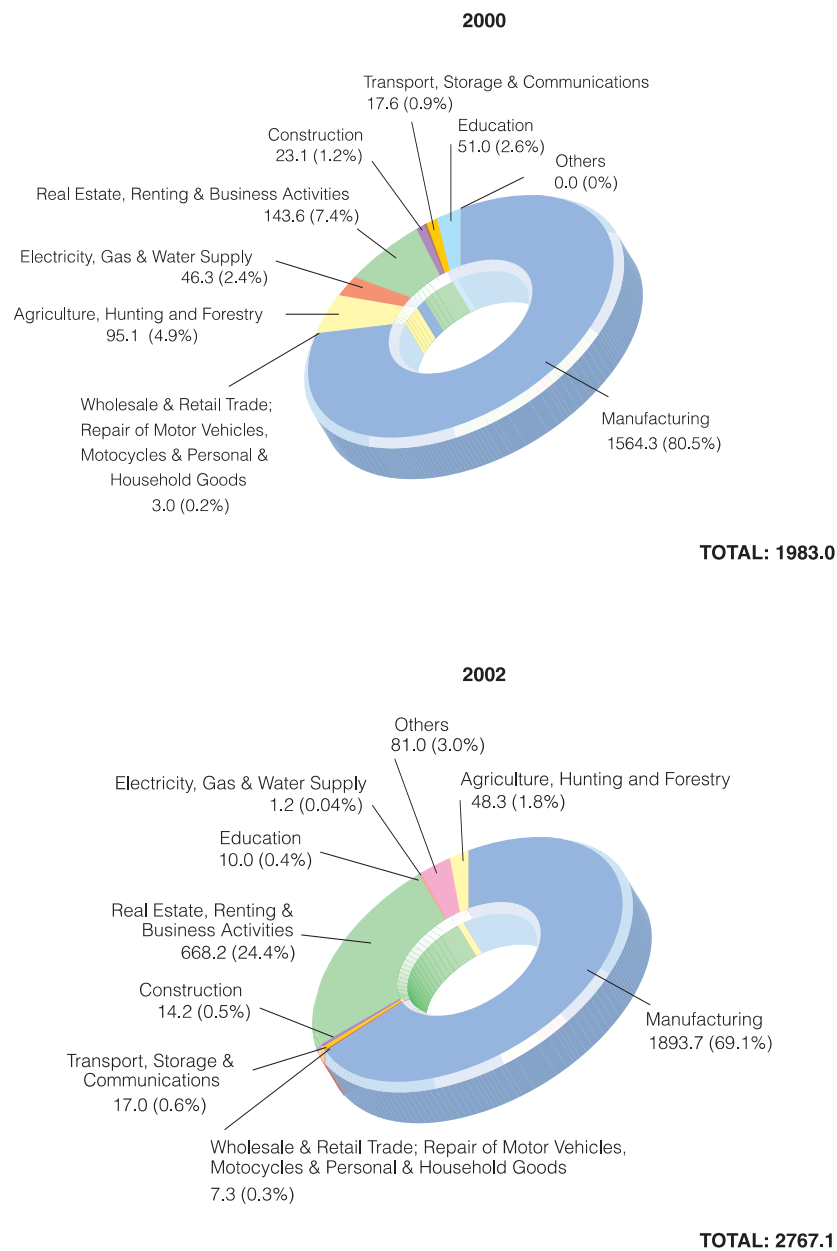


Figure 4.13: Private Sector Researchers (FTE) by Industry, 2000-2002

4.2.3 Private Sector R&D Personnel (FTE) by Field of Research (FOR)

Figure 4.14 shows that in 2002, the field of research that received the highest level of attention was information, computer and communication technologies with FTE of 1,134.2. This is followed by engineering sciences (774.3), and applied science and technologies (314.6). In 2000, the field of research that received the most attention was the same, i.e., information, computer and

communication technologies (578.3 in FTE of researchers). The fields of research that received substantial FTE in 2000 were engineering sciences (774.3 in FTE of researchers) and applied science and technologies (314.6). The top three fields of research that contributed towards private sector R&D personnel for 2000 and 2002 were the same except that the total FTE input by researchers was slightly different, 2,567.5 and 1,840.5 for 2002 and 2000, respectively, representing a significant increase of 39.5% for 2002.

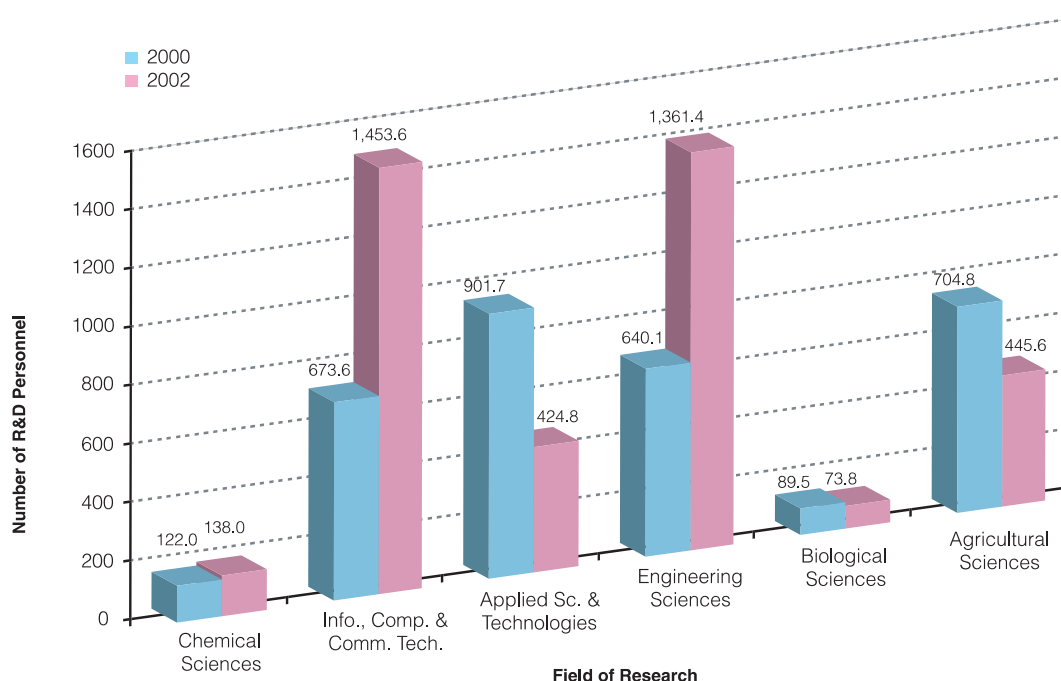


Figure 4.14: Private Sector R&D Personnel (FTE) by Selected Field of Research, 2000-2002

4.3 R&D Personnel (Headcount and FTE) in GRIs by Institution

R&D efforts in GRIs were mainly for research in the agricultural field. In 2002, the majority of R&D personnel were found in agriculture (in terms of headcount): Malaysian Agricultural Research Development Institute (1,189), Malaysian Palm Oil Board (983), Forest Research Institute of Malaysia (870), SIRIM (467), and JTSB (441) (Figure 4.15). In terms of FTE in 2002, the situation was similar. A large proportion of R&D personnel in terms of FTE in GRIs were for the agricultural sector. For example, FTE contributed by MARDI was 407.1, while the MPOB and JTSB contributed 357.8 and 337.2 of total FTE respectively.

4.3.1 GRI Research Personnel (Headcount) by Nationality and Qualification

In terms of headcount, the majority of GRIs research personnel in 2002 were Malaysians. Foreigners made up a negligible number (5.6%). In terms of qualification, most of the researchers with PhD were employed by FRIM (241), followed by MARDI (209), Malaysian Palm Oil Board (207), and SIRIM (106). MARDI also ranked first in terms of researchers with masters degree (285), followed by FRIM (184), MOE (120), MPOB (114), and SIRIM (112). This is shown in Figure 4.16.

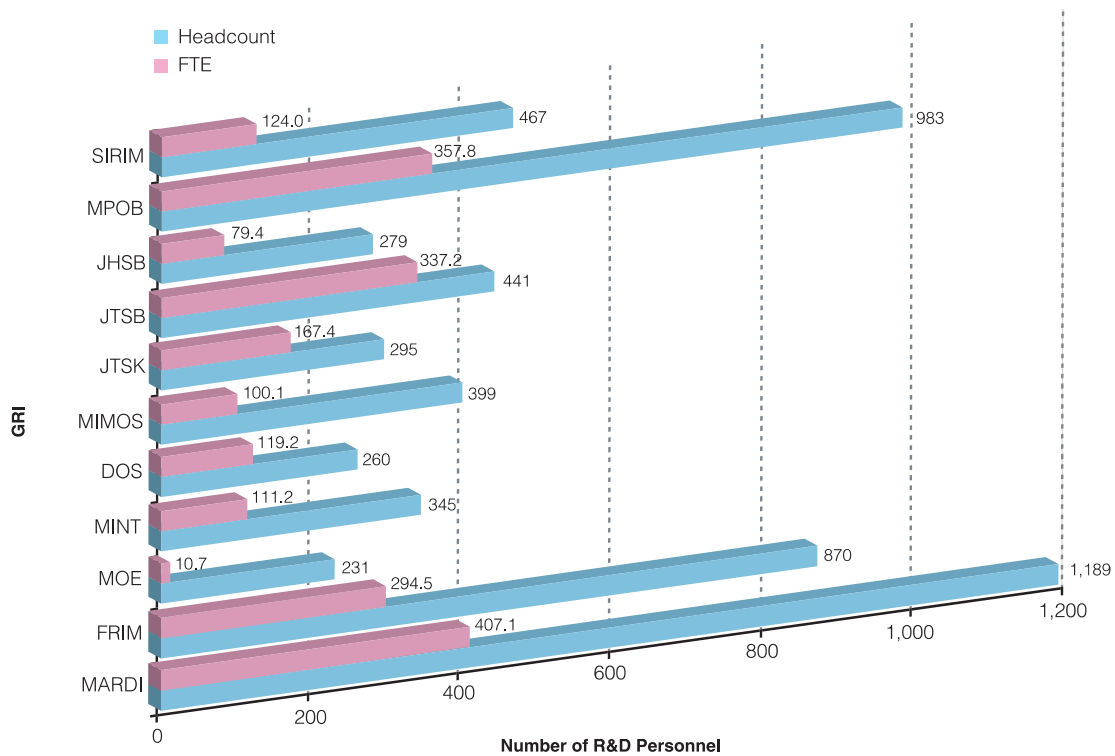


Figure 4.15: R&D Personnel (Headcount and FTE) in Selected GRIs, 2002

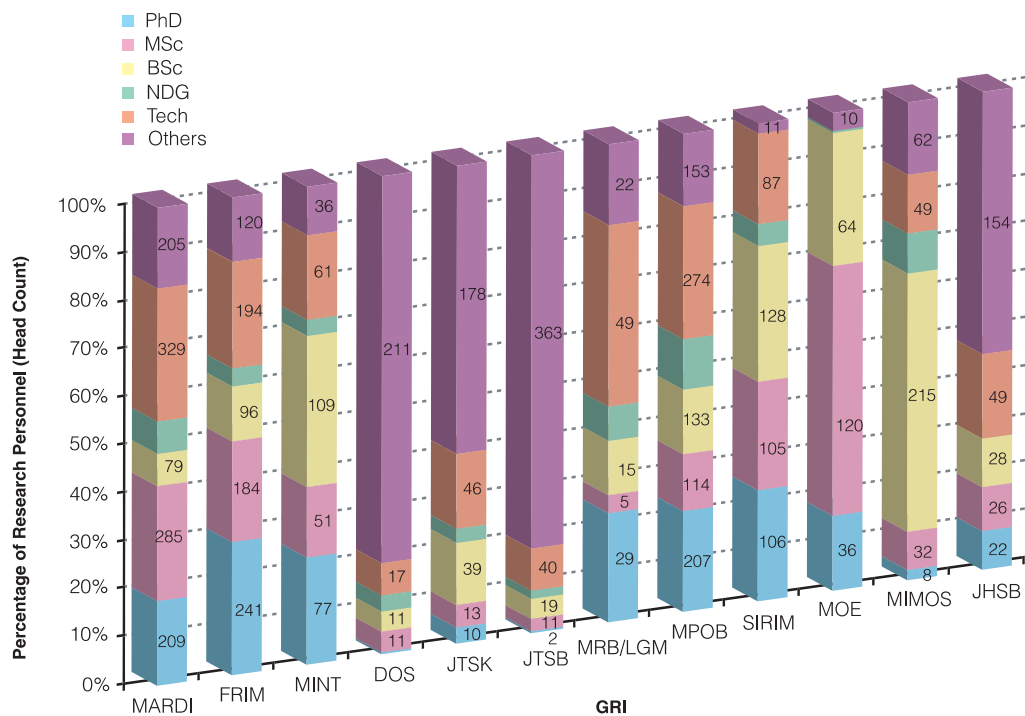


Figure 4.16: Composition of Research Personnel (Headcount) in Selected GRIs by Qualification, 2002

4.3.2 GRI R&D Personnel (FTE) by Field of Research (FOR)

In terms of field of research, agricultural sciences ranked first with FTE of 271.1 or 22.5% of total FTE for 2002 (Figure 4.17). Although this indicates the importance of agriculture as seen by the emphasis given by government research institutions, the importance of agricultural sciences had declined over the years. The next most important field of research was biotechnology,

154.1. This was followed by engineering sciences, 133.9. Comparing FTE for GRIs for 2000 and 2002 by field of research, similar trend could be observed with agricultural sciences having the highest amount of FTE at 1,538.1 or 51.9% of total FTE for 2000. This was followed by biological sciences (14.9% of total FTE). The third most important field of research was applied sciences and technologies, having R&D personnel in terms of FTE of 215.8 in 2000.

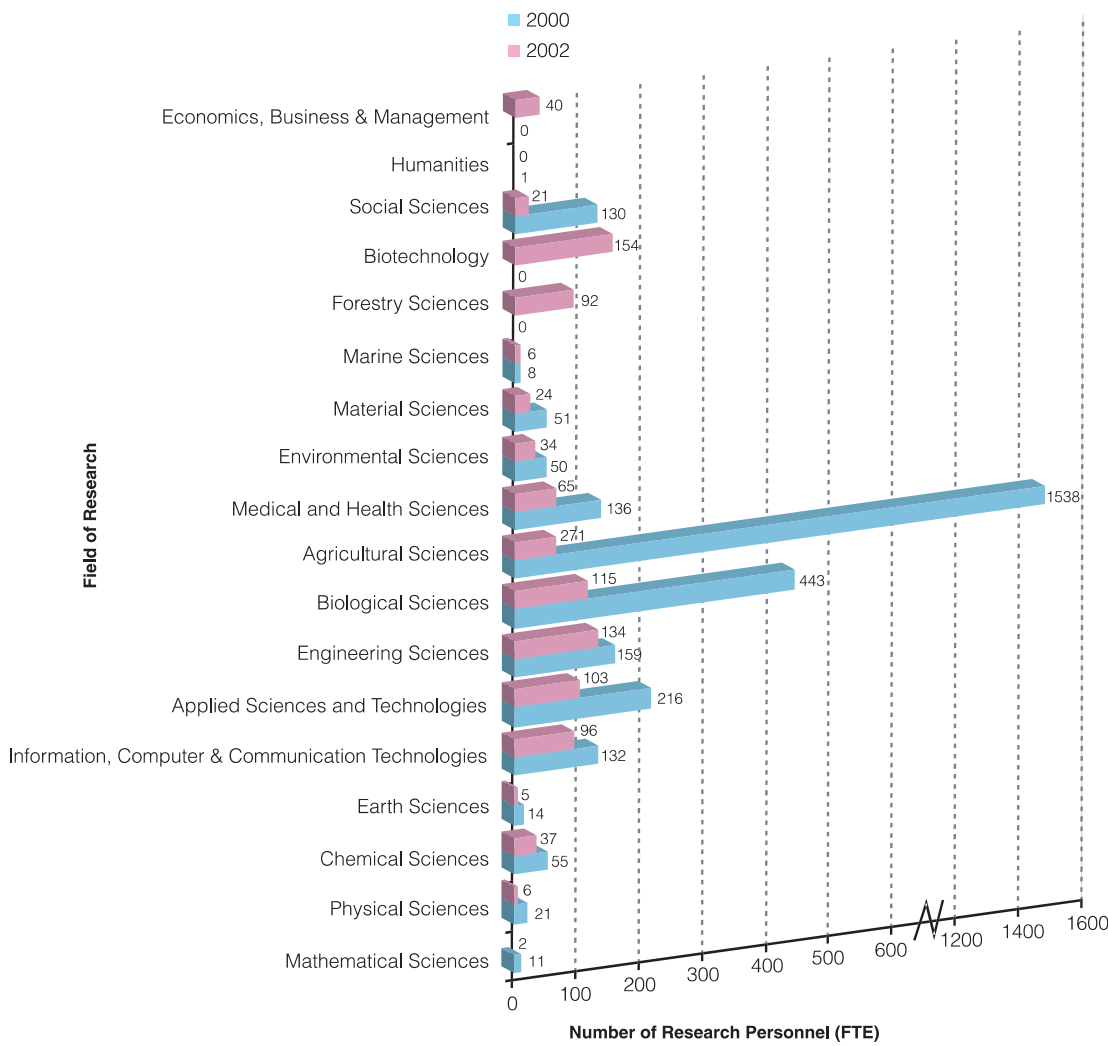


Figure 4.17: R&D Personnel (FTE) in GRI by Field of Research (FOR), 2000-2002

4.4 R&D Personnel (Headcount and FTE) in IHLs by Institution and Nationality

In terms of headcount, Universiti Teknologi Malaysia (UTM) had the largest number of researchers (2,515), followed by Universiti Pertanian Malaysia (UPM) (2,012) and Universiti Sains Malaysia (USM) (2,001) (Figure 4.18). In terms of foreign researchers, UPM had the largest number (214), followed by USM (180) and Universiti Kebangsaan Malaysia (UKM) (66). The ratio of foreign to local researchers was low at 0.07 (Figure 4.19).

In terms of research personnel, locals made up 93.8% of total research personnel,

while the balance was foreign research personnel. Compared with 2000, the ratio of foreign to local researcher was the same as in 2002, i.e., at 0.07. In terms of percentage of research personnel, locals made up 93.4% in 2000, while foreigners made up the balance 6.6%. Therefore, in terms of nationality, not much change had taken place between 2000 and 2002.

In terms of FTE, foreign to local ratio for researchers in year 2002 was 0.10. For Malaysians, the lower FTE indicated that besides research and development activities, Malaysian researchers probably had to perform managerial and administrative functions as well, thus diminishing in their contribution to FTE.

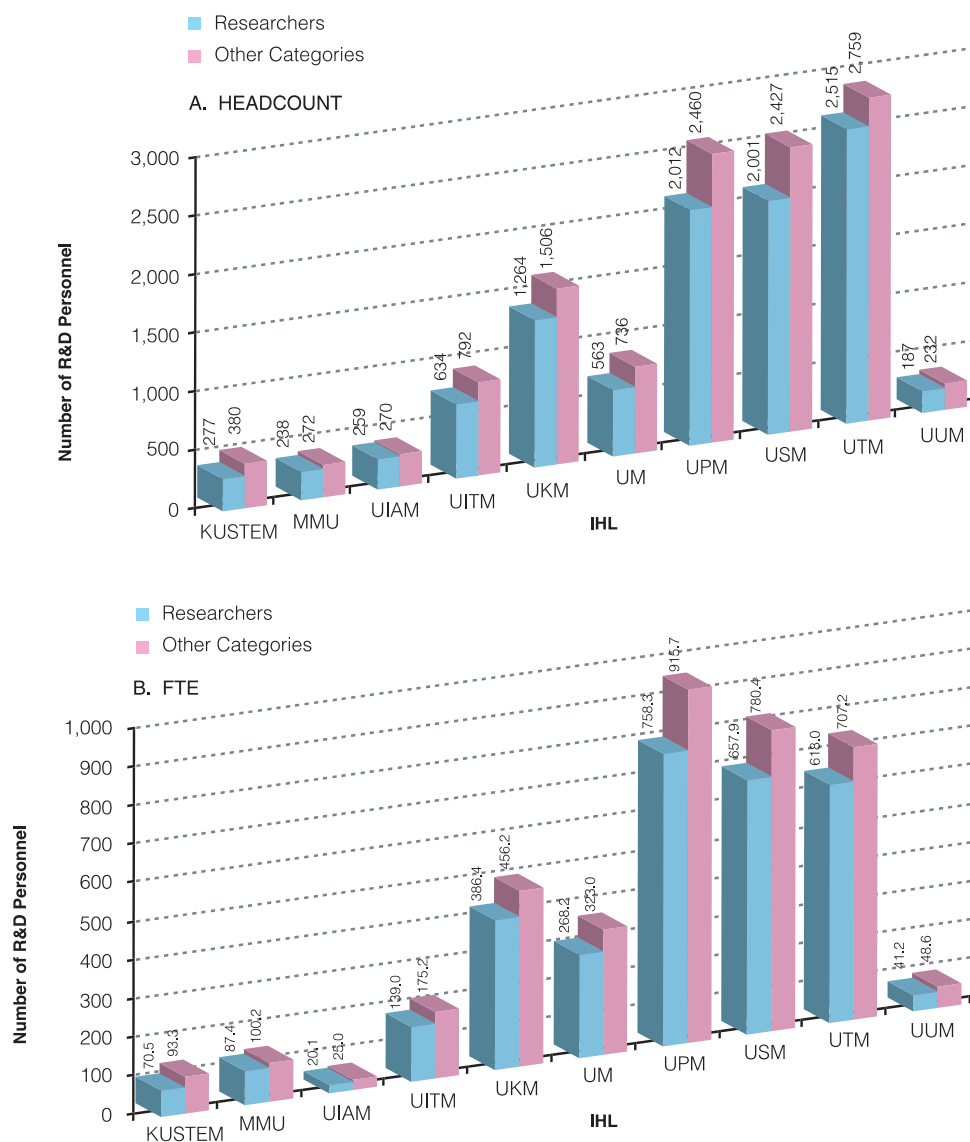


Figure 4.18: R&D Personnel (Headcount and FTE) in Selected Institutes of Higher Learning, 2002

4.4.1 IHL Researchers by Nationality, Gender and Qualification

In terms of qualification, researchers (local and foreign combined) with PhD in year 2002 made up 41.9% of total researchers. Those with master degree constituted 30.6% of the total, while 25.7% were those with bachelor degree. The remaining 1.7% did not have any degree. There were more male researchers compared to female researchers for all categories of qualifications, with male to female

ratios ranged from 2.7 for PhD, 2.6 for Masters and 1.1 for Bachelors degrees. Local researchers dominated at IHLs, making up 93.3% of the total headcount, as compared to 6.6% for the foreigners.

In terms of FTE, 61.8% of the researchers at IHL hold higher degree qualifications in 2002, of which half of these were doctorates. This was an improvement when compared to 2000, where the figure was 53.4% for higher degrees.

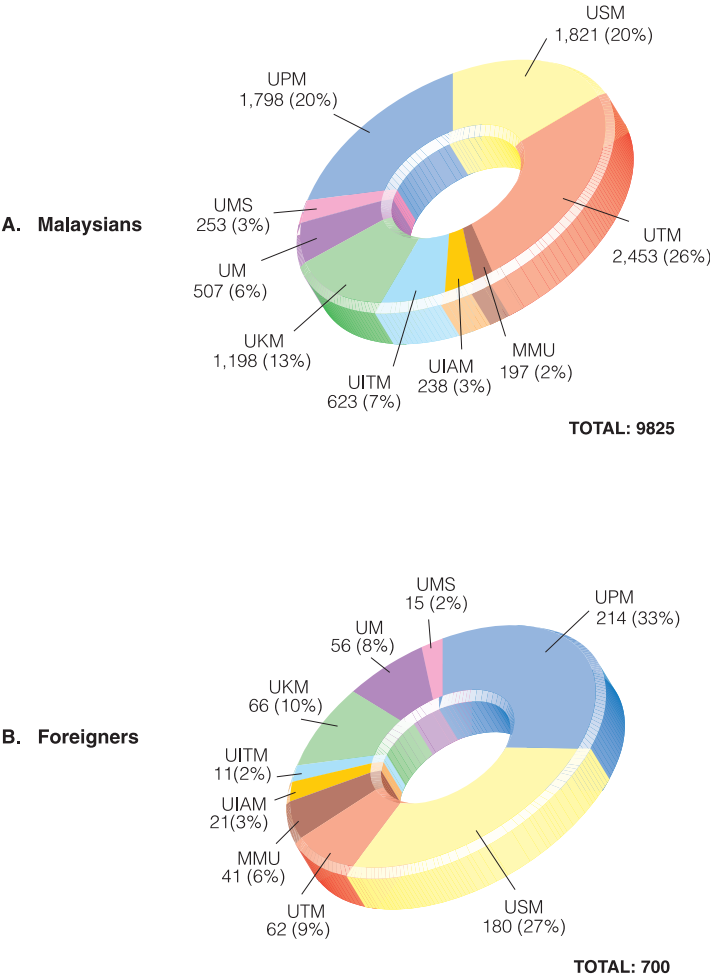


Figure 4.19: Researchers (Headcount) in IHL by Selected Institutions and Nationality, 2002

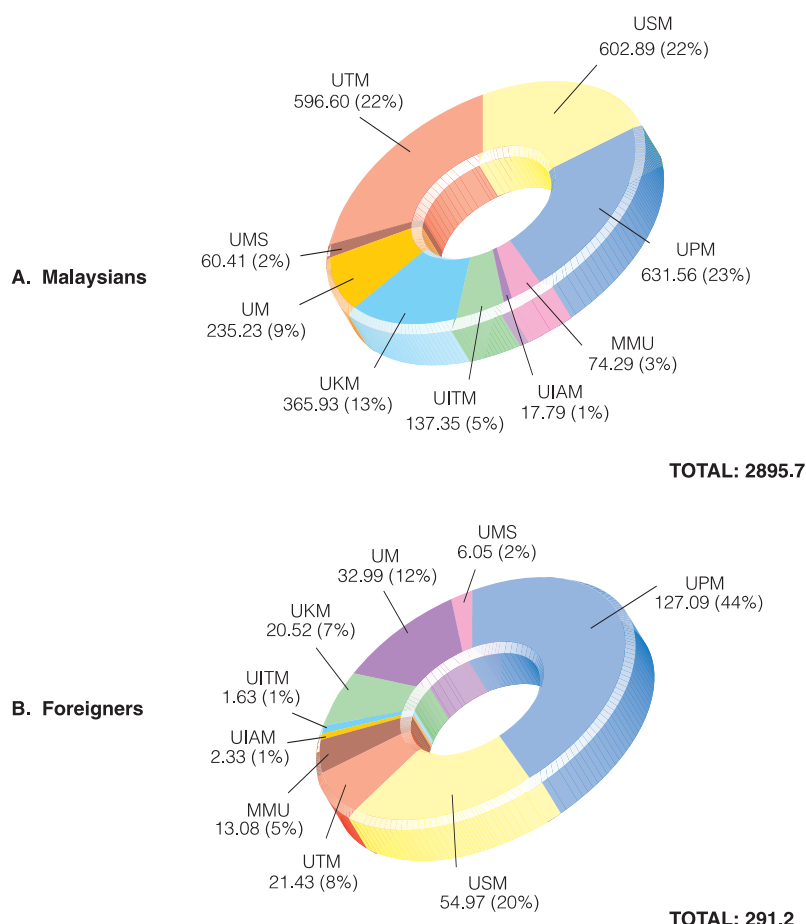


Figure 4.20: Researchers (FTE) in IHL by Selected Institutions and Nationality, 2002

4.4.2 IHL R&D Personnel (Headcount and FTE) by Field of Research

In 2002, in terms of headcount, a total of 12,538 researchers were attached to institutes of higher learning (IHLs), representing a significant 49.0% increase over 2000 (Figure 4.21). In terms of field of research, there were 1,808 research personnel working in the engineering sciences, 1,500 in the social sciences, 1,369 in medical and health sciences, and 1,356 in information, computer, and communication technology. Compared to the 2000 figures, 2002 saw a significant increase in R&D personnel in 14 out of the 18 field of research listed.

USM had the largest number of research personnel in the medical and health

sciences in 2002. UKM was next, followed by UPM. For social sciences, UPM had the largest number of researchers, UiTM was second and UTM third. UPM led in agricultural research in terms of the number of research personnel, followed by USM and KUSTEM.

Measuring the human resource input in terms of FTE, the total FTE for 2002 represented an increase of almost double (96.1%) over 2000 (Figure 4.22). The fields of research that attracted attention in 2002 were engineering sciences, medical and health sciences, information, computer, and communication technology, and applied science and technology. The usage of research input in terms of FTE was about the same as the allocation of researchers measured by headcount.

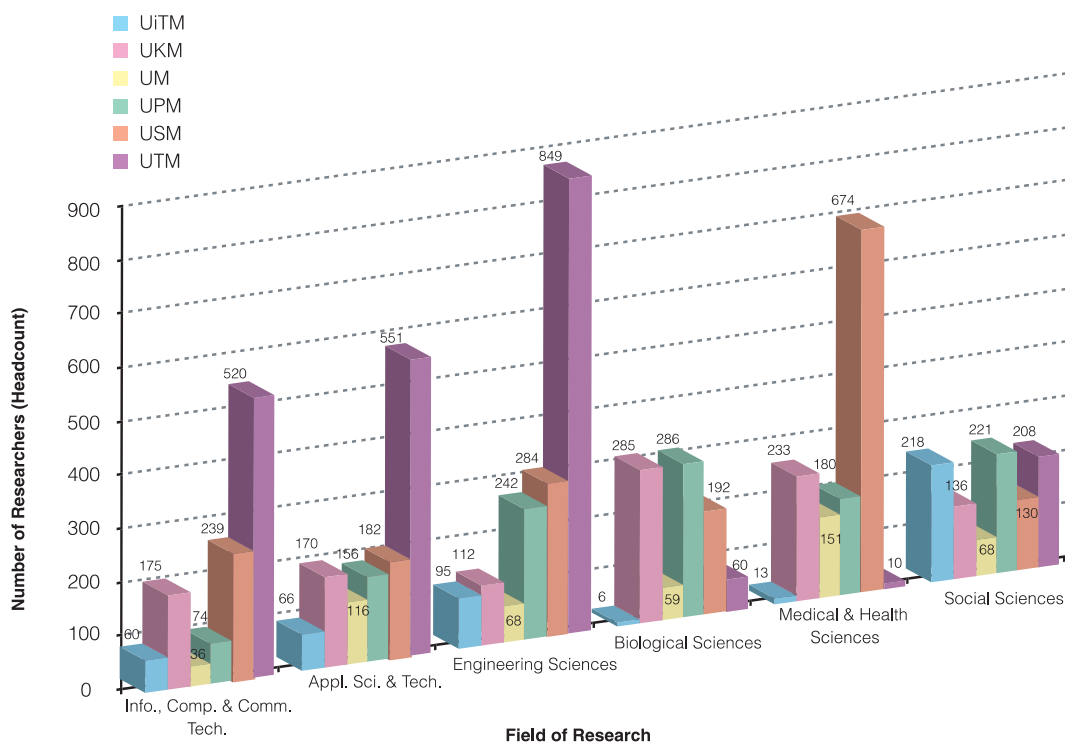


Figure 4.21: Researchers (Headcount) for Selected IHL by Selected Field of Research (FOR), 2002

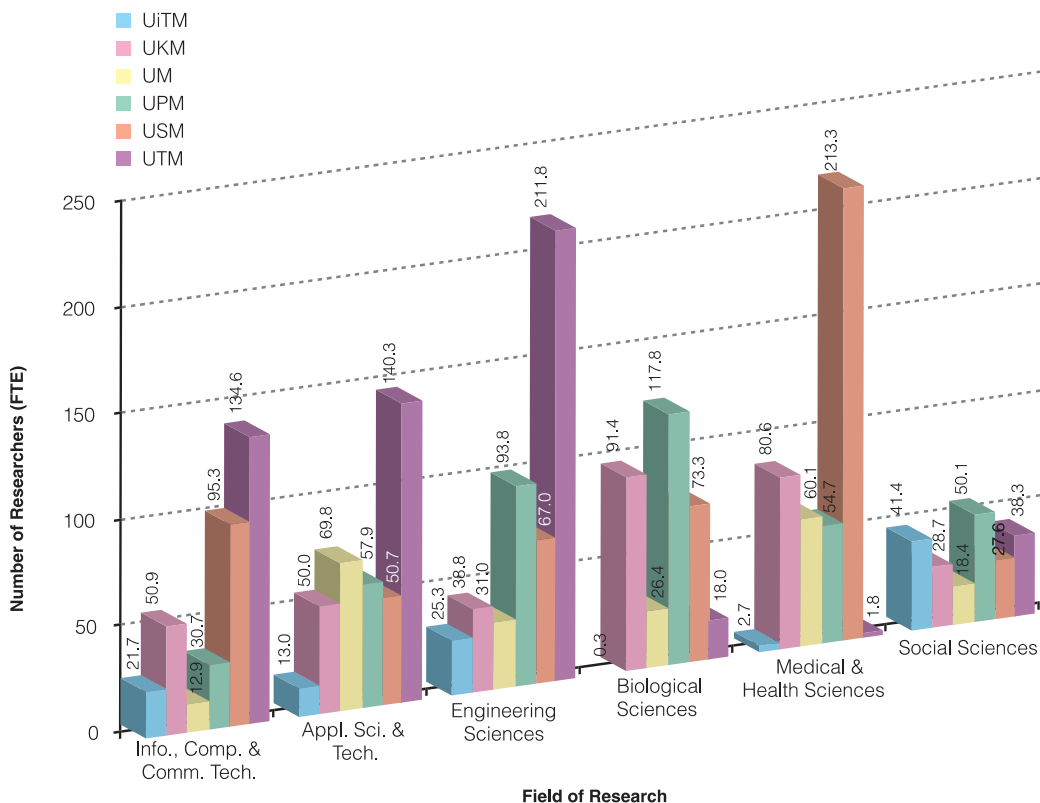


Figure 4.22: Researchers (FTE) for Selected IHL by Selected Field of Research (FOR), 2002

4.5 Malaysian-Born Scientists and Engineers Working Abroad

It is a well-known fact that thousands of Malaysian-born scientists and engineers (MBSE) are currently working abroad. These countries include the United States, United Kingdom, Australia and Singapore. However, this section will only discuss Malaysian-born scientists and engineers in the U.S. and Australia. The data for other countries are not available.

Figure 4.23 presents the Malaysian-born scientists and engineers working in the U.S. by citizenship status, type of degree, occupation group, sector of employment and educational level in 1999. As shown in panel A, there were about 8100 Malaysian-born scientists and engineers working in the U.S. In terms of citizenship status, most of the Malaysian-born scientists and engineers were still holding Malaysian citizenship (67.9 per cent), despite working in the U.S. Of these, 42.0% held a permanent visa and another 25.9% had a temporary visa. Almost one-third (32.1%) were already U.S. citizens.

In terms of type of expertise/ qualification, the largest proportion of them were in engineering (38.8%), followed by computer and mathematical sciences (16.3%), and life sciences (12.5%). About 17.5% of the Malaysian born working in the U.S. was non-scientists and engineers.

In terms of occupation group, most of them worked in the engineering area (28.9%). About 23.7% worked in the mathematical and computer sciences area and 7.9% worked in the life sciences area.

In terms of sector of employment, more than three-quarters worked in the business and industry sector (77.6%). Slightly more than 10% worked in the education sector, presumably in universities or colleges throughout the U.S. About 9.2% worked in the government sector.

Figure 4.24 shows that there were 1,578 MBSE working in Australia in 2001. Slightly more than half (56.7%) had already become Australian citizens. The balance 43.3% was still Malaysians. In terms of gender, more than three-quarters (77.6%) were males. Only 22.4% were

females. When the variable industry sector was examined, almost three-quarters (72.9%) were working in the private sector. About 14.8% were working with the state/territory government.

Figure 4.25 shows that in terms of types of occupation, an overwhelming proportion of MBSE working in Australia were working as building and engineering professionals (71.3%). The balance was engaged as natural and physical science professionals (28.7%).

A large proportion of MBSE working in Australia were involved in the property and business services industry (40%). This was followed by the manufacturing industry 16.0%, health and community services industry 9.2%, and government administration and defense industry 6.7% (Figure 4.26).

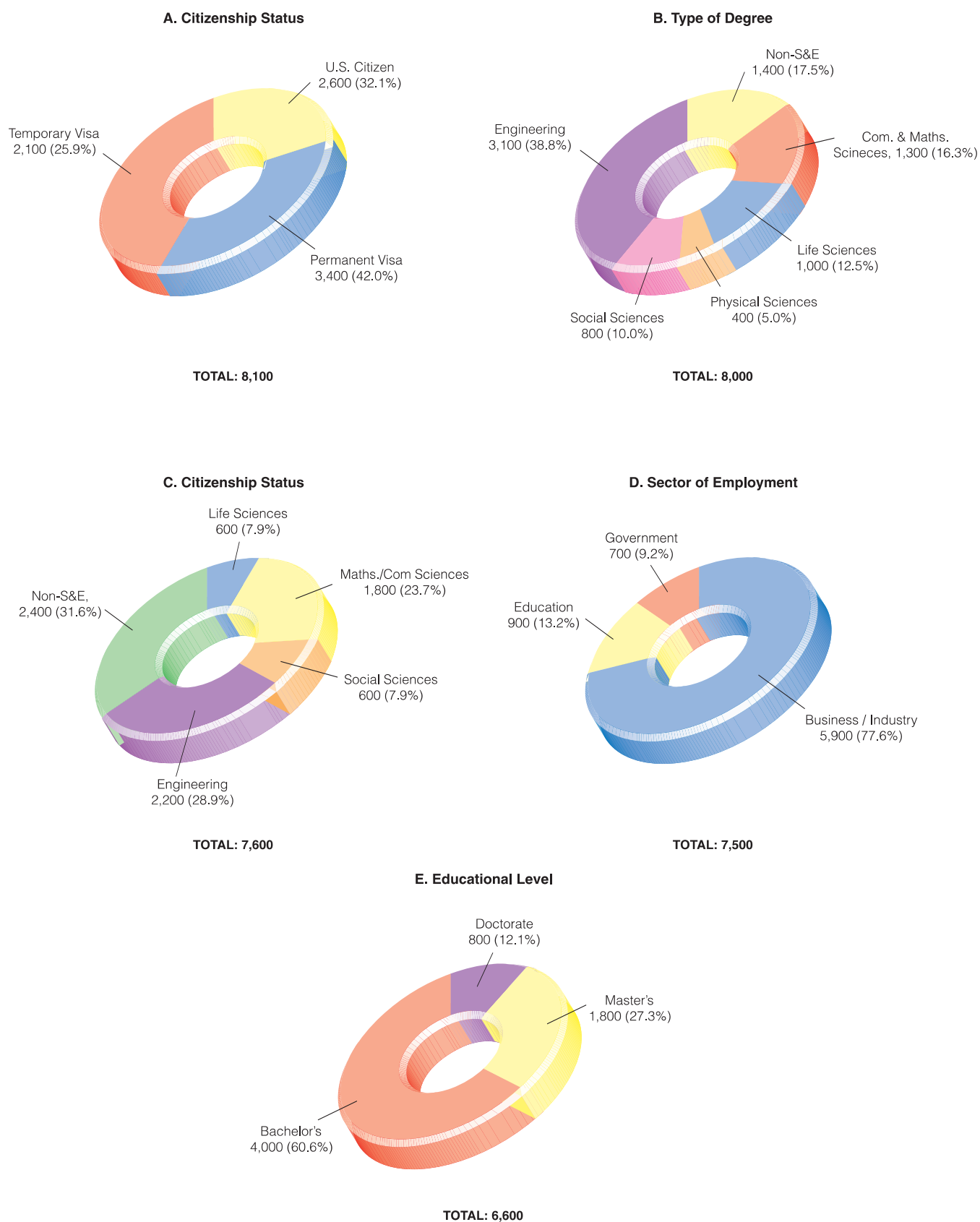


Figure 4.23: Malaysian-Born Scientists and Engineers Working in United States by Citizenship, Type of Degree, Occupation Group, Sector of Employment and Educational Level, 1999

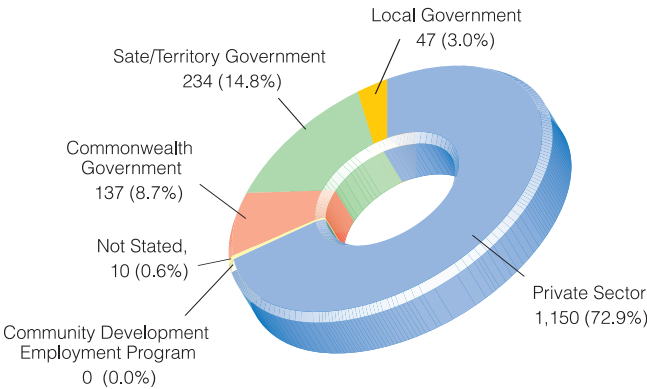


Figure 4.24: Malaysian-Born Scientists and Engineers Working in Australia by Industry Sector, 2001

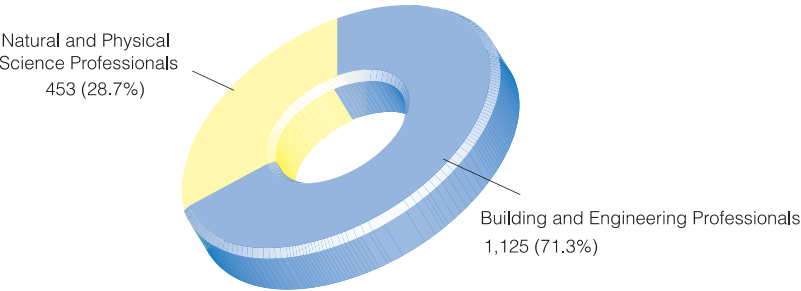


Figure 4.25: Malaysian-Born Scientists and Engineers Working in Australia by Type of Occupation, 2001

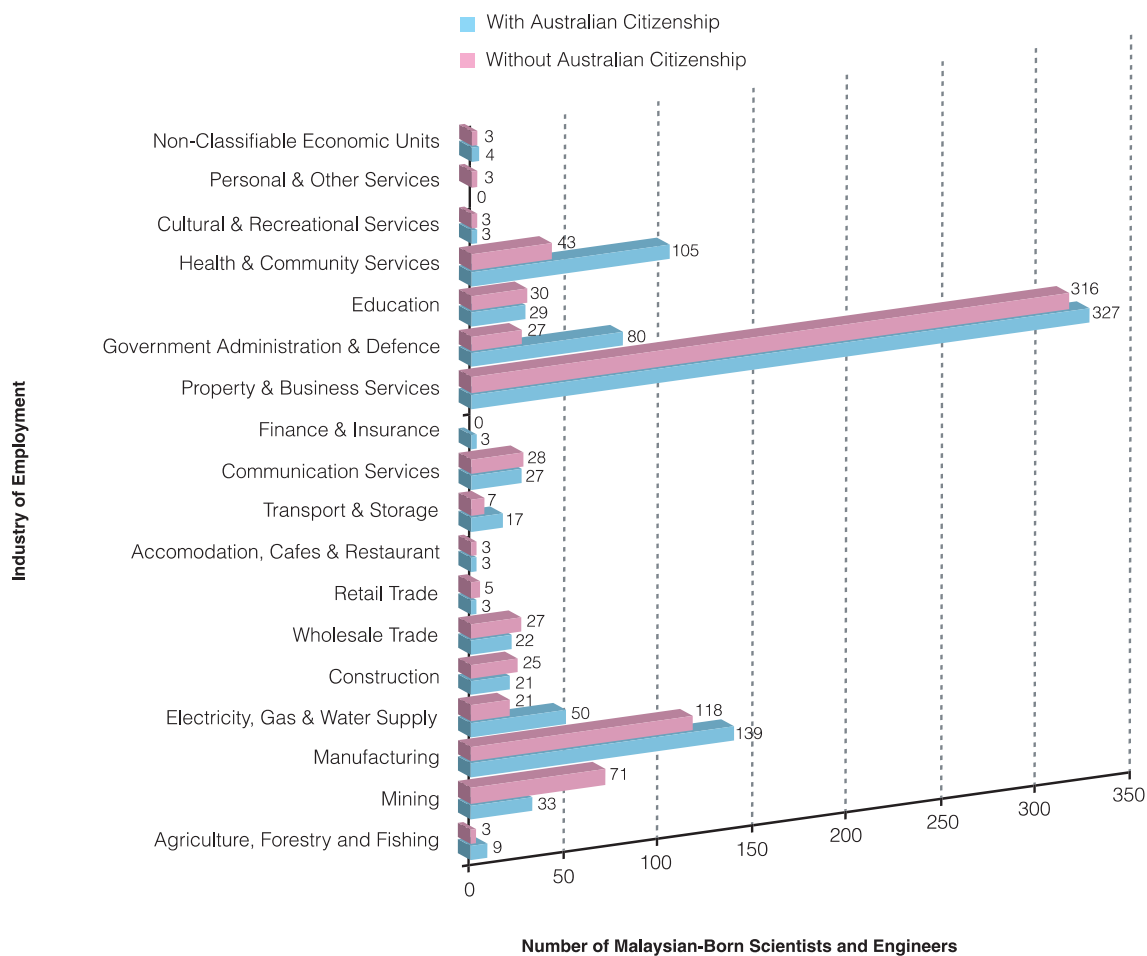


Figure 4.26: Malaysian-Born Scientists and Engineers Working in Australia by Industry of Employment and Citizenship, 2001

The Returnees Programme

Malaysia has been experiencing tremendous achievement in its industrialisation programmes beginning with import substitution in the sixties to the present export-oriented and globalised economy. Malaysia is now moving towards the knowledge-based economy. In order to implement this strategic shift, Malaysia needs highly skilled workforce in all sectors of its economy. As it has been widely acknowledged, Malaysia could benefit from an increase in human resource in the fields of science and technology. The ratio of R&D scientists and technologists is 15 per 10,000 labour force in year 2000, which pales in comparison to Singapore (83:10,000) and South Korea (60:10,000). Malaysia intends to increase this ratio to 60 per 10,000 labour force by 2010. Realising the importance of human resource in ICT for the knowledge-based economy, the government has plans to increase the number of personnel employed in the field of information technology from 108,000 to 306,610 by year 2010, representing an increase of 11% in annual employment.

Efforts to expand the pool of highly skilled personnel included the brain gain programme started in 1995, which encouraged foreign scientists and Malaysian scientists residing overseas to work in Malaysia. The incentives are mostly in the form of allowances, which is quite similar to those received by employees in the public sector. Some examples of incentives include allowance for excess baggage, food and accommodation for 10 days upon arrival in Malaysia, housing allowance of RM1,000-RM2,500 per month and payment of gratuity upon completion of service contract. Added incentives are full coverage of primary school tuition fees and two-thirds coverage of secondary school tuition fees for school-going children. The programme was successful in recruiting 94 (24 Malaysians and 70 foreigners) scientists. However, by 2004 they have all returned to their home/host countries.

In 2001, the government introduced another programme known as the Returnees

Programme to attract highly skilled Malaysians residing overseas to return and serve in the country. The programme targeted not only scientists but also individuals with expertise in various fields such as science and technology, information and communications technology (ICT), medical and health, and finance and accounting. Returnees would receive the following incentives under the programme:

- Tax exemption for all personal effects brought into Malaysia.
- Import duty and sales tax exemption for two motorcars registered in the country of residence of the applicant for at least six months in the name of the husband/ wife/ child.
- Permanent resident status for non-Malaysian spouse and children of the applicant.

Terms and conditions for applicants differ by field of expertise and academic qualifications. For example, the requirements for applicants in the field of ICT:

- Minimum two years after obtaining PhD; or
- Minimum four years after obtaining Masters degree; or
- Minimum six years after obtaining Bachelor degree; or
- Minimum ten years after obtaining Diploma

Response to this programme has not been encouraging so far. While there is an estimated number of 30,000 Malaysians working abroad, only 665 had applied from 2001 to August 2004. Of this, 279 applications were approved and 165 had taken up the offer and returned. Table 1 and Table 2 show the status of the programme.

Table 1: Number of Approvals by Field of Expertise 2001-2004

Area of Expertise	Number	%
Medical and Health	94	33.69
Information and Communications Technology (ICT)	59	21.15
Finance and Accounting	50	17.92
Industry	39	13.98
Science and Technology	12	4.30
Arts and Culture	2	0.72
Aerospace	2	0.72
Others	21	7.53
TOTAL	279	100.0

Source: Ministry of Human Resource, Malaysia

Table 2: Number of Approvals by Country, 2001 - August 2004

Country	Number	%
United Kingdom	101	36.20
United States	34	12.19
Singapore	31	11.11
Brunei	25	8.96
Australia	17	6.09
Japan	17	6.09
Taiwan	11	3.94
Hong Kong	9	3.23
Canada	5	1.79
China	4	1.43
Others	25	8.96
TOTAL	279	100.0

Source: Ministry of Human Resource, Malaysia

The lack of enthusiasm among Malaysians working abroad to respond to this programme could probably be explained. The first major reason concerns the package of incentives. The incentives offered may not be substantial enough to persuade our highly skilled (and highly paid) Malaysians based overseas to leave their current career. Besides having to undertake a huge pay cut, returnees are also required to work for five years in Malaysia or the incentives would be forfeited. In addition, exemption for bringing two cars into the country will only benefit Malaysians returning from places where cars are much cheaper than in Malaysia, but not for returnees from Singapore and Taiwan where cars are more expensive.

Secondly, the stringent qualifying criteria not only failed to facilitate but had acted as further obstacles. Since applicants need to have minimum years of working experience to qualify, they would have by then established their career and build their families overseas, which make it more difficult to relocate. Spouse and children might not be able to adapt to life in Malaysia. Education for their children is another major consideration.

Thirdly, further career advancement prospect is another major consideration. The infrastructure and funding for R&D in Malaysia is lagging behind research institutions and universities in developed countries. The disadvantaged environment for R&D might limit the potential for future career development.

In order to develop the pool of expertise to address the shortage of human resource for S&T, a multi-prong strategy should be considered. While the Returnees Programme is a stop-gap measure to increase the number of scientists and researchers, it is a short-term or at best medium-term measure. In the long-term, the Malaysian government needs to address the more fundamental issues such as developing infrastructure for S&T and encouraging education in S&T at school and university levels. For now, the success of this programmes hinges on more innovative package of incentives that are valued by scientists working abroad in order to attract them to return.



CHAPTER 5

RESEARCH AND DEVELOPMENT ACTIVITIES

This chapter traces the research and development (R&D) activities conducted by the public and the private sectors in Malaysia. The R&D Survey is a biennial effort to measure the changes that have taken place in R&D in Malaysia over the years. The scope of the R&D Survey include: R&D by type of research, field of research, socio-economic objectives, investment in R&D in terms of monetary measure and time, sources of funding and the detailed activities by sector. R&D is crucial for the technological growth and economic development of a nation. Hence, this report will give numerous inputs to policy makers. The data for this chapter are from the R&D Survey 2002.

5.1 R&D Expenditure: An Overview

Overall, the R&D expenditure increased steadily from RM1,671.5 million in 2000 to RM2,500.6 million (an increase of 49.6%) in 2002 (Figure 5.1). This indicates the commitment of various sectors, i.e. the government and the private sectors, to R&D. About two-thirds of the R&D expenditure (65.3%) came from the private sector, 20.3% from government research institutes (GRIs), and the remaining 14.4% derived from institutes of higher learning (IHLs). The R&D expenditure for the private sector increased

both in real terms and in terms of percentage contribution towards total R&D expenditure for the whole economy, from 57.9% in 2000 to 65.3% in 2002. Correspondingly, the contribution of both the GRIs and IHLs to the R&D expenditure in 2002 has declined, from 25.0% to 20.3% for GRIs and from 17.1% to 14.4% for IHLs. However, in absolute terms, both sectors, GRIs and IHLs, registered an increase in R&D expenditure during the period under study, i.e. 2000-2002.

Corresponding to the overall increase in R&D expenditure for the 2000-2002 period, all sectors within the economy recorded an increase in R&D expenditure. For the private sector, the amount of expenditure increased by RM665.2 million or 40.7%, while GRIs and IHLs also experienced an increase in spending on R&D amounting to RM89.6 million (an increase of 21.5%) and RM74.3 million (an increase of 26.0%), respectively. This indicates that the overall increase in total R&D expenditure during the 2000-2002 period was mainly contributed by the private sector.

In terms of the GERD/GDP ratio, the increase was from 0.50 in 2000 to 0.69 in 2002. The expenditure per research personnel had also increased from RM71,855 in 2000 to RM100,277 in 2002, representing an increase by 39.6%.

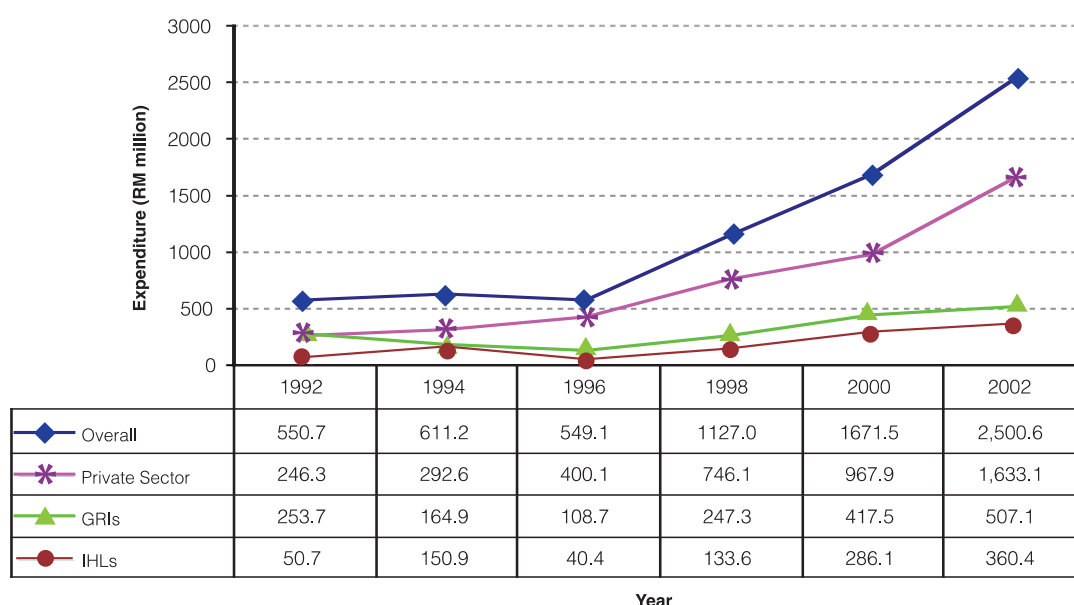


Figure 5.1: Total Expenditure on R&D by Sector, 1992-2002

5.1.1 R&D Activities by Type, Field of Research and Socio-Economic Objectives (SEO)

Examining the profile of R&D expenditure in terms of types of research, it can be seen that two of the three types of research, i.e., applied and experimental work, received substantial increase in R&D spending (Figure 5.2). There was a marked decline in expenditure for basic research. It is obvious that a large portion of the expenditure was used for applied research, followed by experimental work and basic research. In 2000, applied and basic research made up 51.0% and 27.0% of total R&D expenditure respectively. But in 2002, applied research made up 68.6% of the total expenditure and basic research made up 8.4% (i.e., representing a decline of 53.6% from 2000). Expenditure on experimental work increased substantially by RM 208.9 million. In terms of percentage increase from 2000 to 2002, applied research had increased tremendously by 101.2%. The shift towards more applied research and experimental work and less on basic research was probably due to the prudential attitude taken by the private sector in order to minimise risks. However, there must

be a balance between the different types of research. Greater emphasis on basic research is necessary to develop cutting edge technology that will generate products that are "new to the world".

In terms of the priority area of research in year 2002, engineering sciences was the focus for the private sector, whereas GRIs emphasized research in information, computers and communication technology. IHLs, on the other hand, focused their research mainly on environmental sciences. For the GRIs, the area was the same as in 2000. For IHLs, environmental sciences had become the priority area. This is the first time environmental sciences had become a priority area in research by a particular sector since 1992.

For socio-economic objectives, manufacturing had remained the objective for the private sector, whereas GRIs had changed from natural sciences, technologies and engineering to information and communication services. The IHLs had changed their socio-economic objectives from natural resources to manufacturing for year 2002.

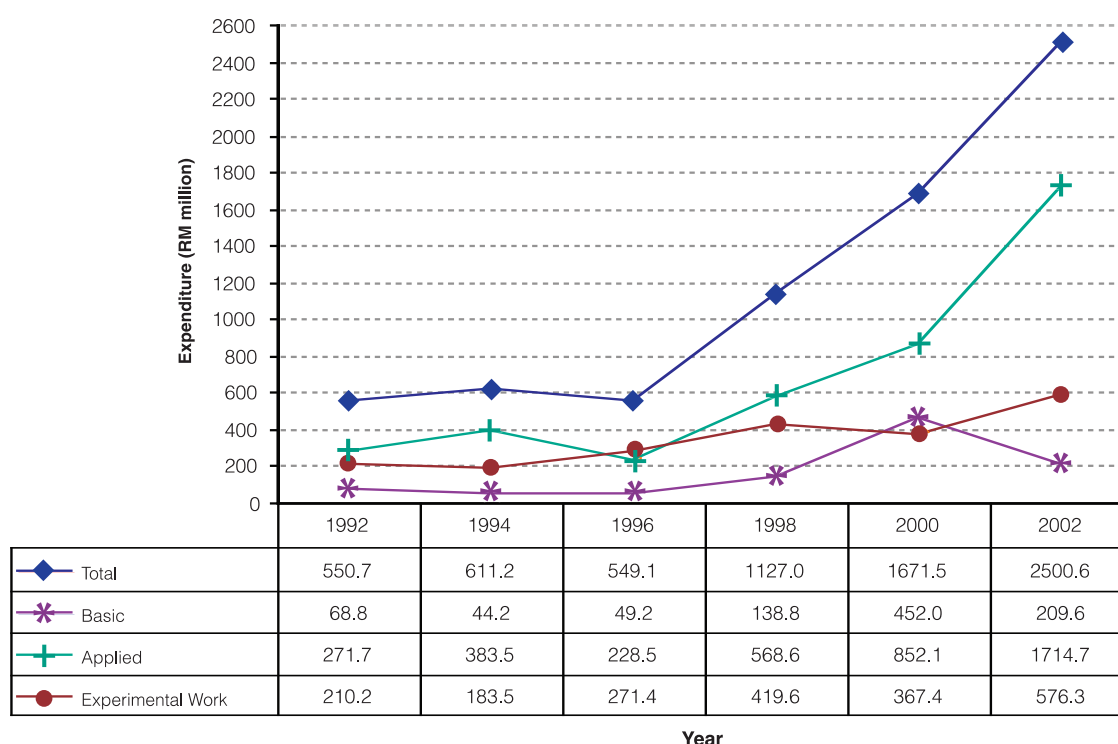


Figure 5.2: R&D Expenditure by Type of Research, 1992-2002

5.2 Industry R&D Expenditure

The total R&D expenditure in year 2002 was RM2.5 billion, an increase of RM829.1 million or 49.6% from year 2000. Of this amount, capital expenditure (land, building and machinery) made up 45.0% and current expenditure (labour and operating costs) took up 55.0%. In 2000, capital expenditure was 51.7% of total expenditure and current expenditure made up 48.3%. The structure of expenditure had changed significantly together with the increase in total expenditure.

Examining the amount of contribution by the various sectors, it is obvious that the private sector played the leading role in investment with its contribution of 65.3% of the total R&D expenditure (Figure 5.3). Compared to 2000, the percentage had increased by 7.4%. The increase was relative to the expenditures of GRIs and IHLs which had proportionally decreased in 2002 compared to 2000. IHL contributed 14.4% (17.1% in 2000), while the balance 20.3% (25.0% in 2000) came from GRIs.

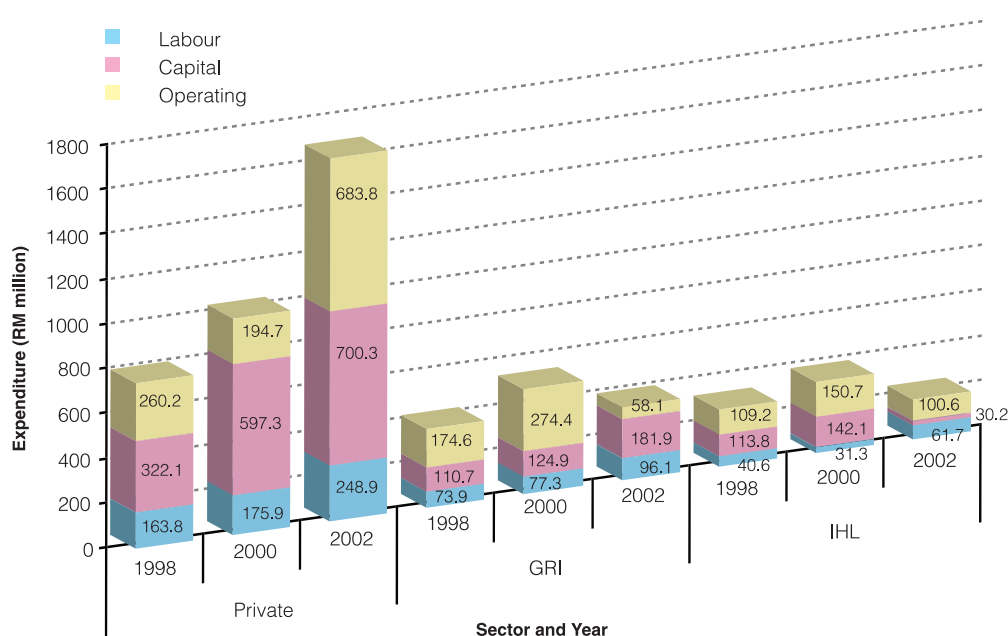


Figure 5.3: R&D Expenditure by Sector, 1998-2002

5.2.1 R&D Expenditure by Sector and Field of Research (FOR)

Figure 5.4 presents R&D expenditure for the various sectors and the allocation of resources for the various fields of research. The three areas receiving the bulk of R&D expenditure in 2002 were: engineering sciences (39.1%), information, computer and communication technology (24.4%) and applied science and technologies (12.6%).

Comparing the three sectors, the private sector spent heavily on the engineering sciences, followed by information, computer and communication technology, and applied

science and technologies. GRIs spent heavily on information, computer and communication technology, followed by economics, business and management, and agricultural sciences. The IHLs spends more on environmental sciences, followed by applied science and technologies, and engineering sciences. This information is useful for identifying opportunities for collaborative linkages among the various sectors and research groups.

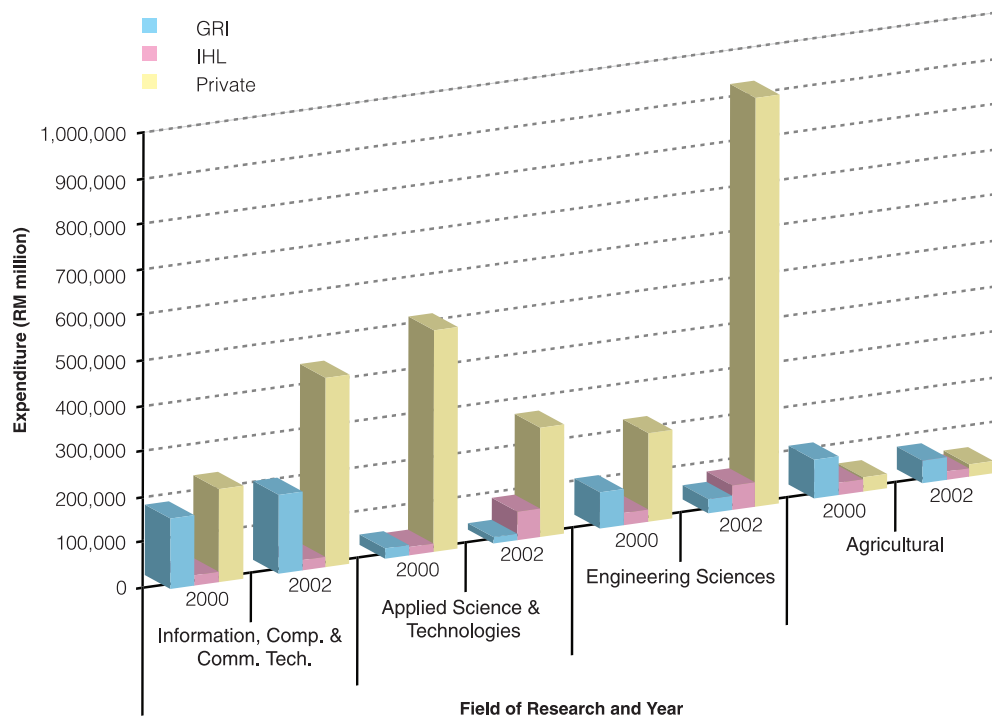


Figure 5.4: R & D Expenditure by Sector and Selected Field of Research, 2000-2002

5.2.2 Socio-Economic Objectives of R&D Expenditure by Sector

In 2002 economic development remained the main objective of R&D with 82.0% of total R&D expenditure spent for this purpose (Figure 5.5). This is followed by advancement of knowledge (RM 245.7 million), society (RM 197.7 million) and defense (RM 8.0 million). In year 2002, expenditure for economic development increased compared to year 2000, while expenditure for advancement of knowledge decreased substantially. Figure 5.6 presents the sub-sector that showed the largest amount of spending was manufacturing, followed by information and communication services. This is consistent with the national economic structure where manufacturing is the major contributor towards GDP. This spending pattern is similar to the amount spent in year 2000. As the world moves very quickly into the age of information technology, substantial investment had been allocated towards R&D in information, computer and communication technology as indicated in the R&D expenditure for 2002.

In terms of FTE, economic development continued to be the top priority of R&D for 2002 with 64.59% of FTE spent. This category experienced a decrease of 5.87% (Figure 5.7). For the private sector, although economic development remained the most important objective for R&D, it declined as much as the percentage points from 92.1% in 2000 to 81.7% in 2002. While economic development experienced a decline, advancement of knowledge had a significant increase in full time equivalent from 3.9% in 2000 to 16.8% in 2002. Overall defense had a slight increase in FTE, while society suffered a decline. For GRIs and IHLs, economic development received the most attention in terms of FTE. Apart from economic development, the next objective for IHLs was the advancement of knowledge. Similar pattern can be seen for GRIs when the next important objective of R&D after economic development was also advancement of knowledge.

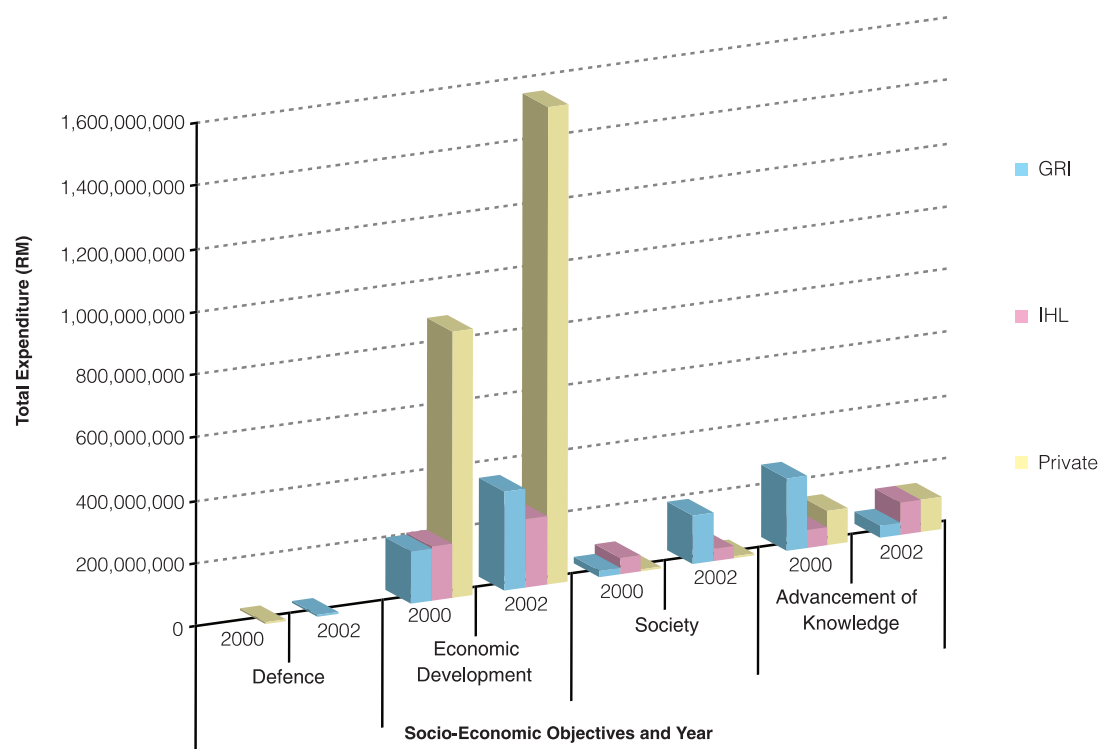


Figure 5.5: Socio-Economic Objectives of R & D Expenditure by Sector, 2000-2002

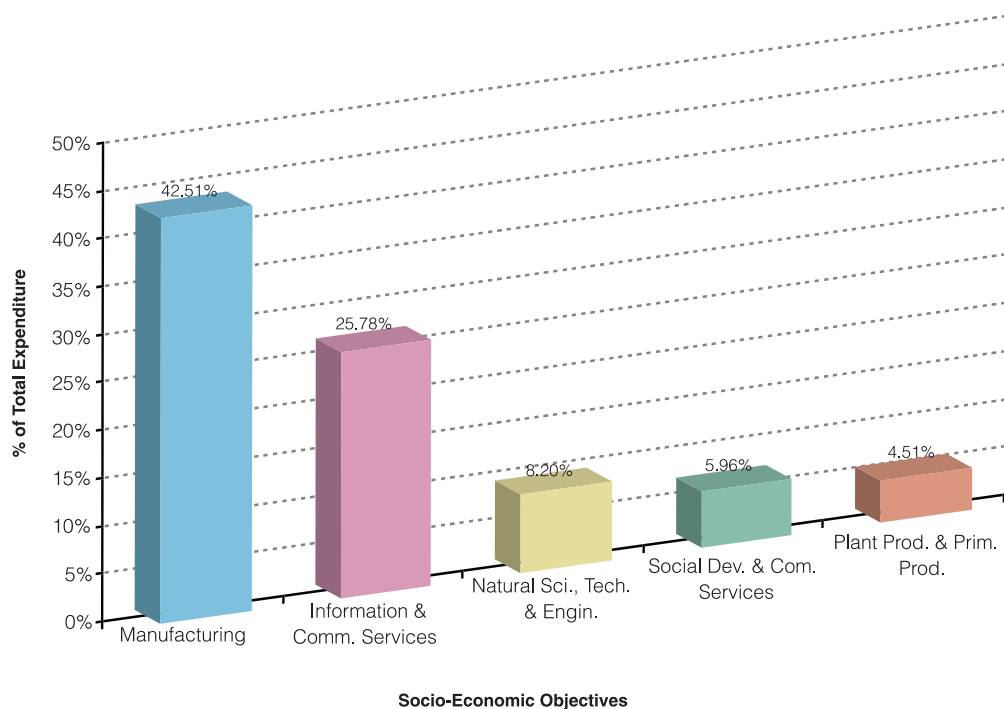


Figure 5.6: Top 5 Socio-Economic Objectives Expenditure by Sub Sector, 2002

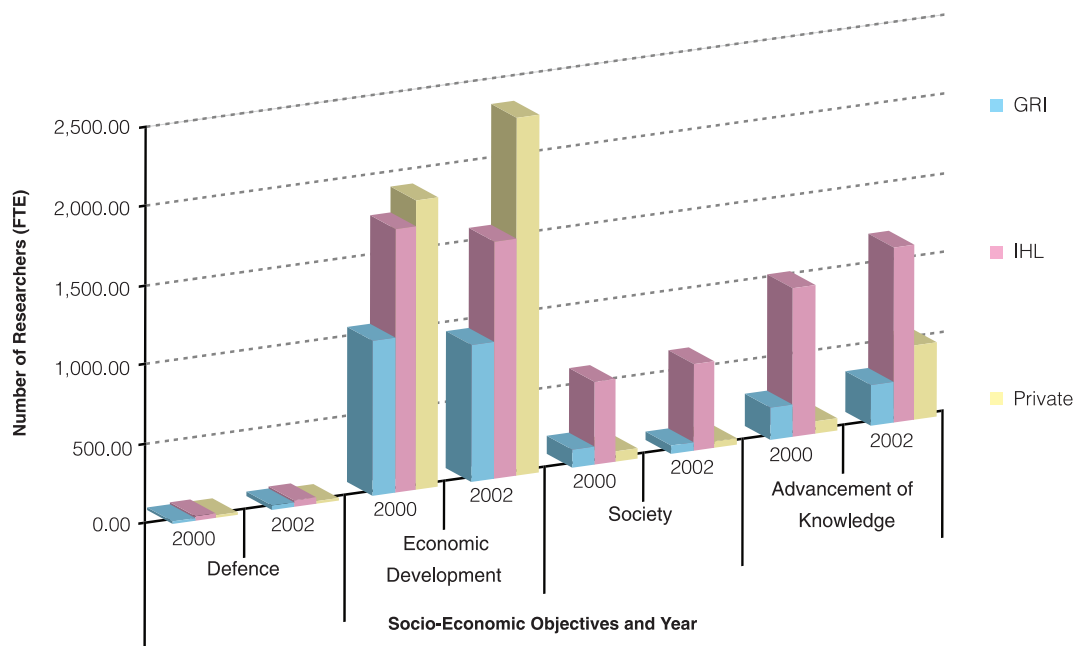


Figure 5.7: Socio-Economic Objectives of R&D (Full Time Equivalent) by Sector, 2000-2002

5.2.3 Sources of Funds and Extramural R&D Expenditure

Figure 5.8 shows the sources of funds for R&D expenditure for the three sectors, namely GRIs, IHLs and the private sector. Sources of funds point to the financial strength of local R&D capacity as well as the role played by the financial community in promoting R&D. Contrary to the situation in 2000, in 2002 the internal source of funds was the major source of funding for R&D. Own funds totaling RM1.59 billion (58.1%) were used for R&D. In 2000, own funds made up of only 20.6% of total funding. In terms of external funds, federal government provided 14.0% (12.8% in 2000), while state and local government contributed another 0.85% (1.4% in 2000).

The majority of the funds for R&D concentrated in the private sector (59.6%). This is significantly higher than the contribution of the private sector in 2000 (42.2%). GRIs contributed 19.6% (24.1% in 2000) in funds. As in 2000, in 2002 IHLs remained second after the private sector in terms of R&D expenditures.

For the private sector, it is clear that most of the funds (75.8%) came from internal sources. The bulk of the external funding for the private sector came from foreign "other

funds" (17.2%). For GRIs, most of the expenditure was internally funded (43.2%). IHLs received most of their funding from the federal government (39.2%), IRPA (37.1%), and internal sources (21.4%).

5.2.4 R&D Expenditure Outsourced

In terms of the trend of R&D expenditure outsourced from 1992-2002, recent years saw a tremendous increase in outsourcing, especially in year 2000 at RM568.3. In 2002, this figure dropped significantly by 46.2% to RM305.95. The private sector was the most active in terms of R&D outsourcing work, especially outsourcing overseas. In 2002, 93.4% of the outsourcing activities involved the private sector. More than three-quarter (78.7%) of the private sector R&D expenditure were outsourced to overseas partners. In 2000, 95.1% of GRIs R&D expenditure outsourcing involved the IHLs. Other than the aforementioned examples, R&D expenditure outsourcing between domestic sectors and overseas was rather minimal (Figure 5.9).

For 2002, the amount outsourced to foreign countries was rather large at RM230.0 million, representing 75.3% of the total amount outsourced (with the majority from the private sector) compared to the amount outsourced

locally, i.e., RM75.4 million or 24.7% (Figure 5.10). The total amount of expenditure outsourced abroad increased substantially by 73.3% in 2002. The country receiving the largest amount of R&D expenditure outsourced was India, followed by the U.S.A. In 2000, U.K. was the top recipient of R&D expenditure outsourced (Figure 5.11).

For the private sector, the amount outsourced overseas represented 78.7%, whereas for GRIs and IHLs the amount of expenditure outsourced overseas in absolute terms was very marginal, i.e., less than RM5 million. This indicates that the private sector is very dependent on foreign capacity and skills for R&D.

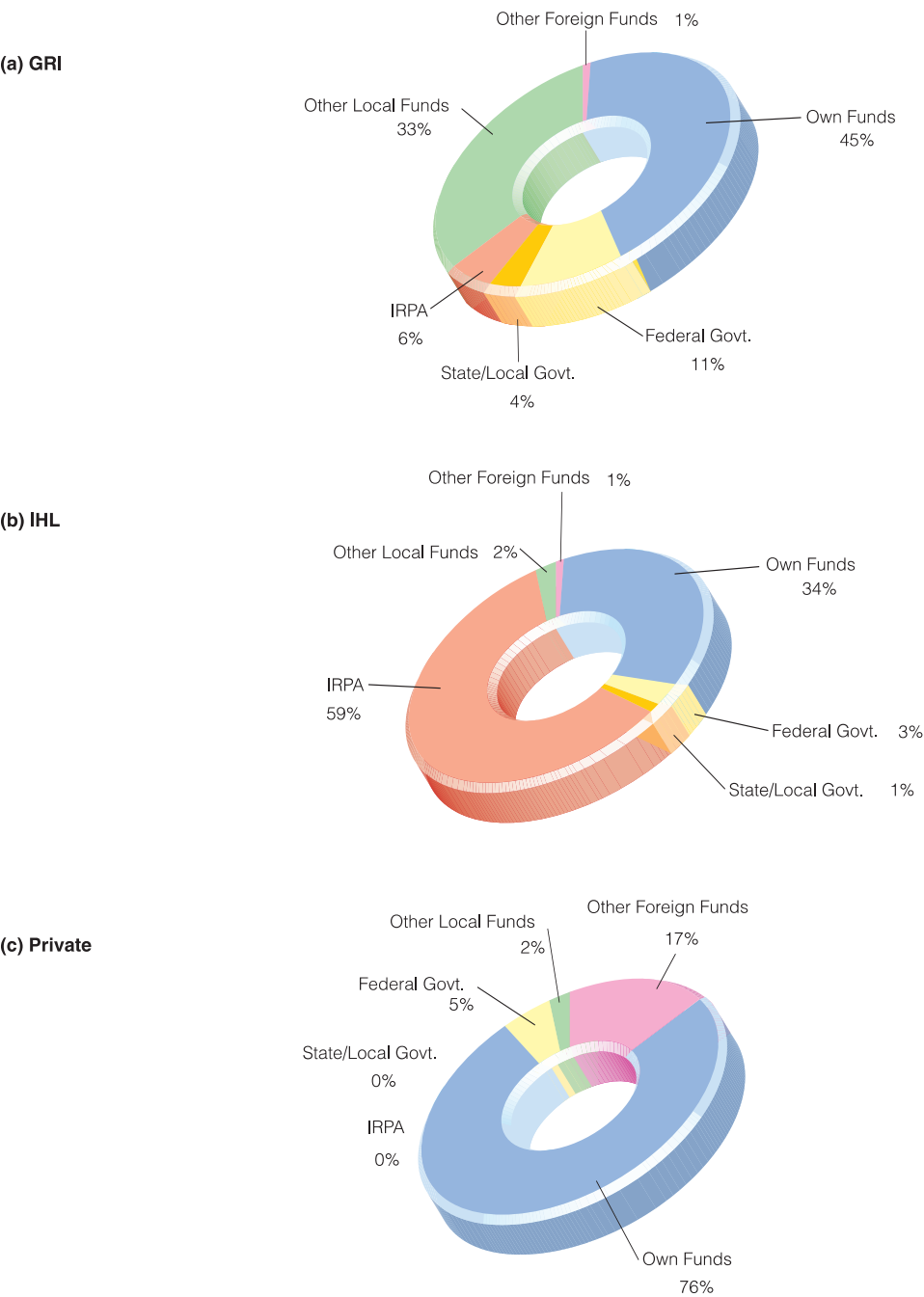


Figure 5.8: Sources of Funds for R&D Expenditure, 2002

The pattern of amount outsourced R&D indicated that there was a low level of cooperation between sectors, for example from private sector to GRIs, or from GRIs to IHLs. As an example, the absolute amount of local outsource from GRIs to IHLs was only RM1.5 million. On the other hand, the amount of R&D

expenditure outsourced by IHLs to IHLs was RM7.1 million only. However, for the private sector, the percentage outsourced to the public sector locally was 92.4%, though quite a significant figure, however, the absolute value was low since the amount outsourced abroad was more than 78.7%.

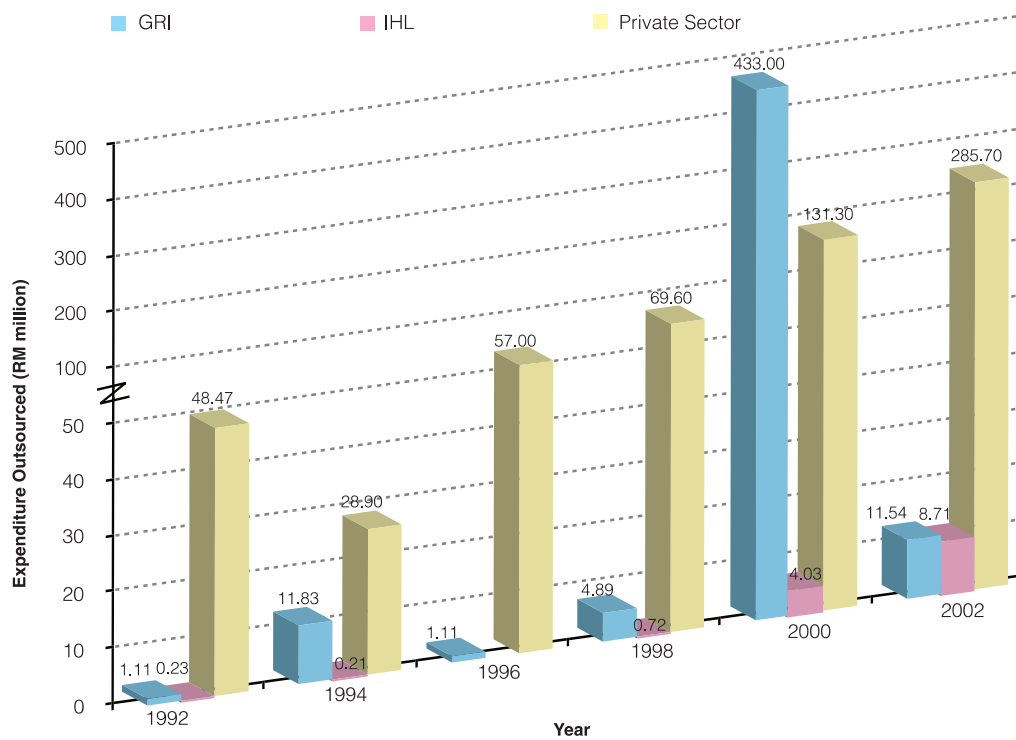


Figure 5.9: R&D Expenditure Outsourced Overseas and Local, 1992-2002

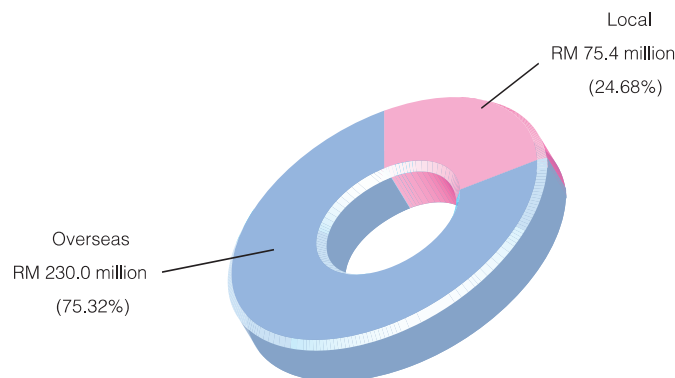


Figure 5.10: R&D Expenditure Outsourced Overseas and to Local Research Institutions, 2002

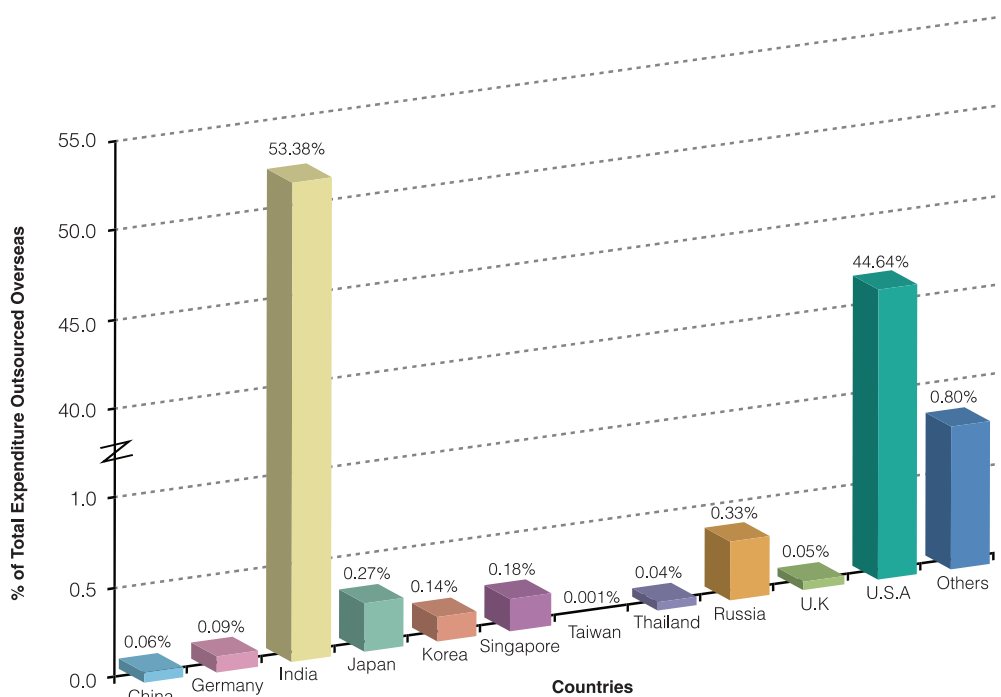


Figure 5.11: R&D Expenditure Outsourced Overseas by Country, 2002

5.3 Private Sector R&D

The manufacturing sector is the engine of growth for Malaysia. Building capacity for R&D in the private sector will enhance the competitiveness of the sector in terms of new product development and process innovation. In order to achieve growth, Malaysia in general, and private sector companies, in particular, must increase its own internal capabilities for R&D and at the same time reduce its dependence on foreign

countries for materials and parts, technology and management expertise.

5.3.1 R&D Expenditure by Size

Figure 5.12 shows private sector R&D expenditure by revenue. In year 2002, 35.9% of the respondent companies had revenue of between RM10 million to RM100 million, whereas those with revenue of more than RM100 million made up 20.7% of the companies surveyed. Another 37.9% had

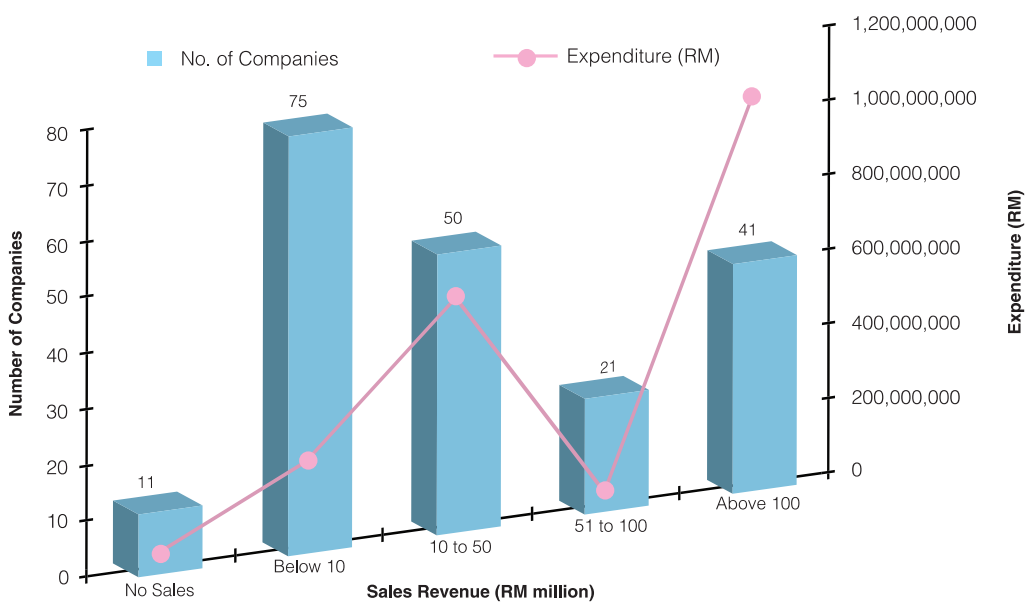


Figure 5.12: Private Sector R&D Expenditure by Sales Revenue, 2002

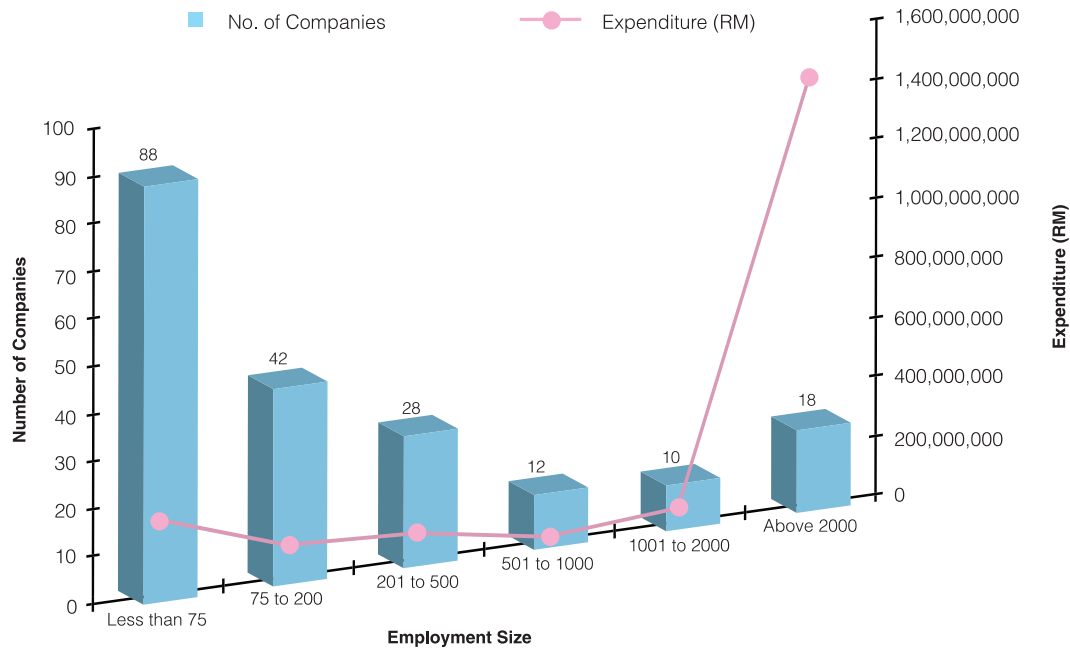


Figure 5.13: Private Sector R&D Expenditure by Employment Size, 2002

revenue of RM10 million or less. As indicated, the large companies were the ones that had the capacity to spend on R&D. About 53.8% of total R&D spending came from companies that received revenue of more than RM100 million. Although companies with revenue of less than RM10 million made up 37.9% of the respondent companies, the amount of R&D spent made up only 11.5% of total private sector R&D expenditure, indicating the limited resources of small companies for R&D.

In terms of employment size, 88 (or 44.4%) of the companies had less than 75 employees, 70 (or 35.4%) had 75-500 employees, 22 (or 11.1%) had 501-2000 employees and 18 (or 9.1%) had more than 2000 employees (Figure 5.13). A large proportion of the companies surveyed could be classified as small and medium enterprises while a small number were large companies. Examining R&D expenditure by employment size, large companies (with employment size of more than 2,000) spent about 74.6% of the total R&D expenditure. A total of 88 companies with employment size of less than 75 spent only 13.2% of total R&D expenditure. This clearly shows the resource constraints of small companies for R&D.

5.3.2 R&D Expenditure by Ownership

Figure 5.14 shows private sector R&D expenditure by industry and ownership. Companies that were owned or controlled were grouped together for easy comparisons. For local companies, R&D expenditure for 2002 was RM929.9 million representing a significant increase of 180.9% compared to 2000. Foreign companies, on the other hand, with expenditure of RM689.4 million experienced a marginal increase of 8.1%. In 2002, expenditure by local companies made up 56.8% of total R&D, whereas it was 34.1% in 2000. This is an encouraging trend.

For local companies, manufacturing industry was the sector with the largest R&D expenditures for 2002 (RM742.8 million or 80.0% of total expenditures). "Real estate, renting, and business activities" sector had the second largest expenditures in R&D, RM127.1 million, which is 13.7% of total expenditures. This is followed by the others sector ("others") with expenditures of RM45.6 million (4.9%). The "others" category is made of Extra-territorial Organisations and Bodies, Private Household with Employed Persons and Other Service Activities. R&D expenditures for 2002 by manufacturing sector experienced a substantial increase in spending when

compared to 2000. The “real estate, renting and business activities” sector had really increased its R&D expenditures from RM8.9 million in 2000 to a massive RM 129.1 million in 2002 (an increase of more than 1,300%).

For foreign companies, a similar pattern was observed with 94.5% of total

expenditures coming from manufacturing. The second most important sector is the “real estate, renting, and business activities” with expenditures amounting to RM23.3 million (3.4%). Compared to 2000, the increase in total R&D expenditures in 2002 was marginal (8.1%).

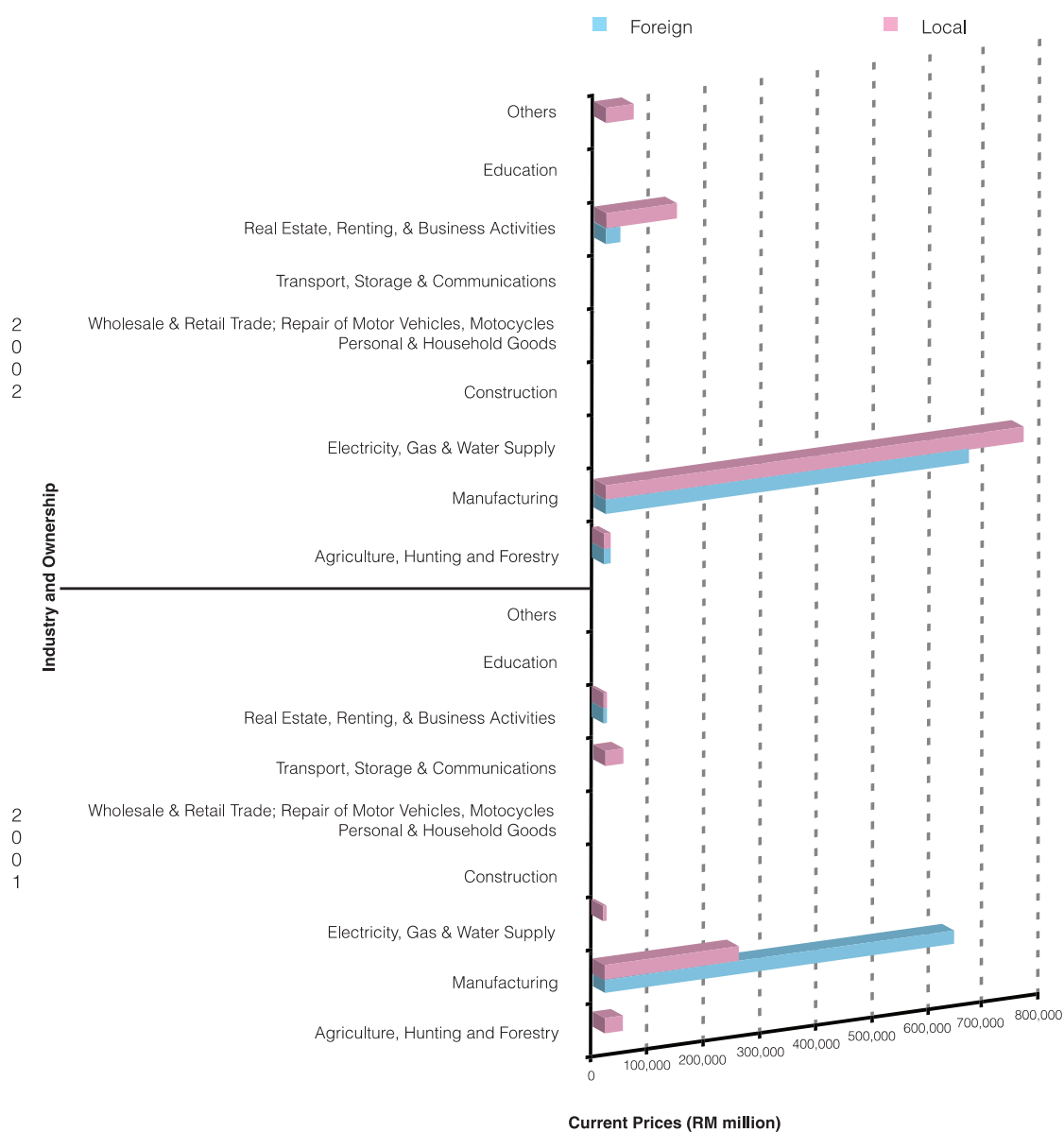


Figure 5.14: Private Sector R & D by Selected Industry and Ownership (Foreign & Local), 2001-2002

5.3.3 Type of R&D Expenditure

Figure 5.15 presents the types of R&D expenditure by the private sector. In 2002, the share of current expenditure on R&D comprising of labour and operating costs amounted to 57.1%, whilst the balance was capital expenditure consisting of land and building and machinery and equipment. The structure of expenditure was almost the opposite of the 2000 figures. Analysing expenditure of sub-sectors, it can be seen that the motor vehicles, trailers, and semi-trailers sub-sector was the largest spender of R&D in the private sector. Compared to 2000, capital expenditure for 2002 had increased by 14.7%, whilst the current expenditure had increased significantly by 60.3%. The sub-sector of electrical machinery and apparatus had the second highest spending in R&D for 2002.

5.4 R&D Expenditure in Government Research Institutes (GRIs)

In terms of overall total expenditure, there was an increase of 21.5% in 2002. It is clear that the government strives to achieve growth through greater spending on R&D in some targeted industries. For example, agencies involved in agricultural research such as FRIM, MPOB, and IT namely MIMOS,

experienced a significant increase in expenditure. This is in line with the government's strategy of adopting biotechnology and IT as the strategic sector for future economic development. Institutions such as Malaysian Institute of Microelectronic System (MIMOS), FRIM and MPOB had substantial increase in total expenditure in real terms in year 2002. MIMOS alone accounted for 61.6% of the total R&D expenditure by GRIs in 2002.

For 2002, agricultural agencies still received substantial attention in R&D. Agriculture-related research institutes, such as Malaysian Agriculture Research Development Institute (MARDI), FRIM, MPOB and Malaysia Rubber Board (MRB) spent a total of 24.5% of all GRI's R&D spending.

Figures 5.16 and 5.17 present the current and capital expenditure incurred by selected GRIs. For current expenditure, in general, most of the agencies experienced a decline in expenditure in 2002. For capital expenditure, the opposite was found, i.e., most agencies saw an increase in expenditure in 2002. Total expenditure increased by 21.5%, in which capital expenditure experienced a significant increase of 121.6%, whilst the current expenditure declined by 48.9%.

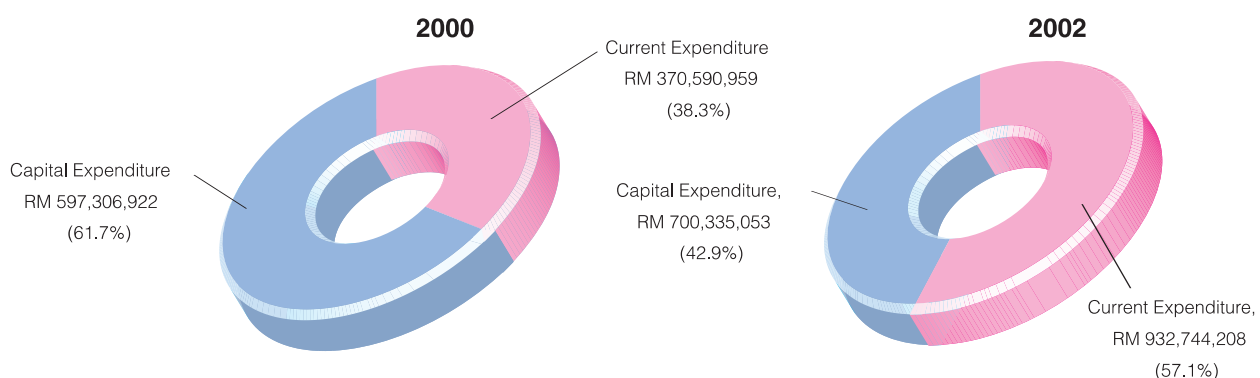


Figure 5.15: Private Sector R&D Expenditure by Types of Expenditure, 2000-2002

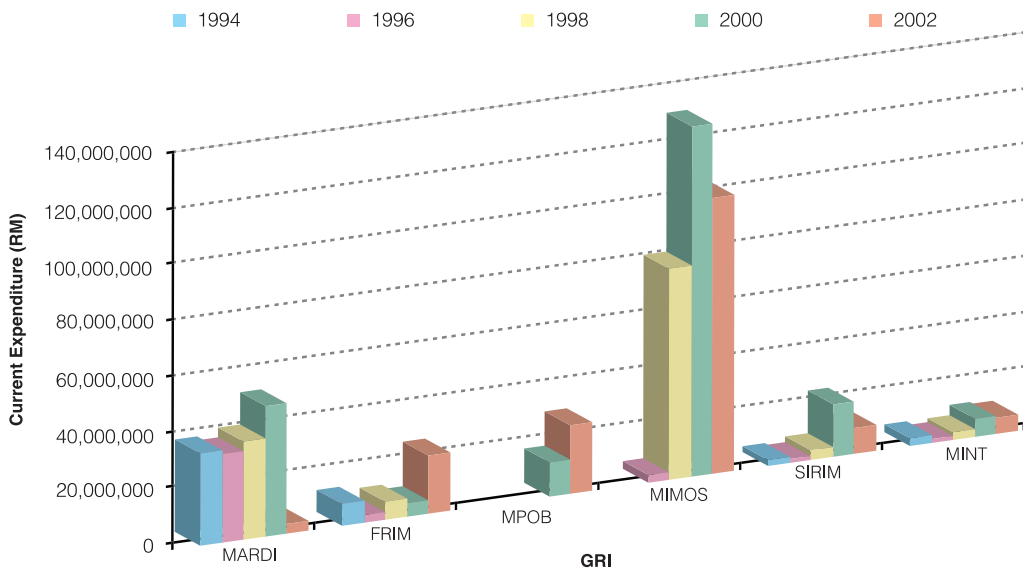


Figure 5.16: R&D Expenditure (Current Expenditure) in Selected GRIs, 1994-2002

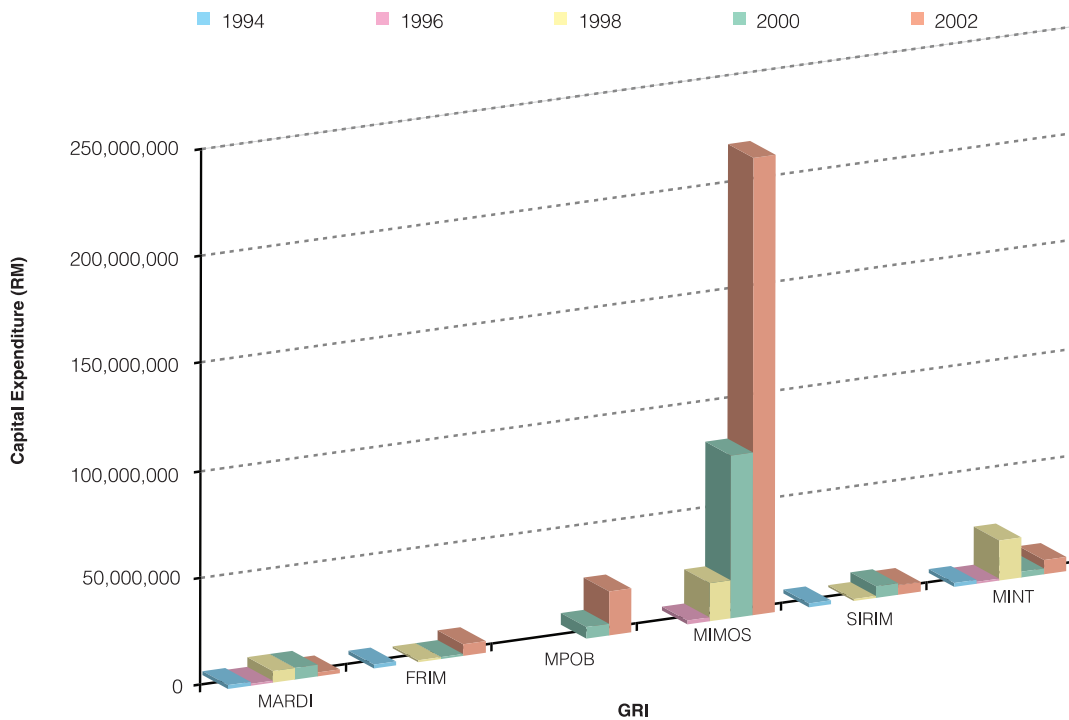


Figure 5.17: R&D Expenditure (Capital Expenditure) in Selected GRIs, 1994-2002

5.5 R&D Expenditure in Institutes of Higher Learning (IHLs)

Figure 5.18 shows R&D expenditure in IHLs. In terms of total expenditure (comprising current and capital expenditure), Universiti Sains Malaysia (USM) experienced the highest growth with a 161.2% increase. The bulk of this increase

was for current expenditure. Universiti Malaya (UM) also saw a significant increase of 88.0%. UM's increase was mainly due to an increase in capital expenditure.

In 2002, UPM, previously the highest spender of R&D expenditure amongst the IHLs, experienced a decline in expenditure by 34.2% when compared to the 2000 figure.

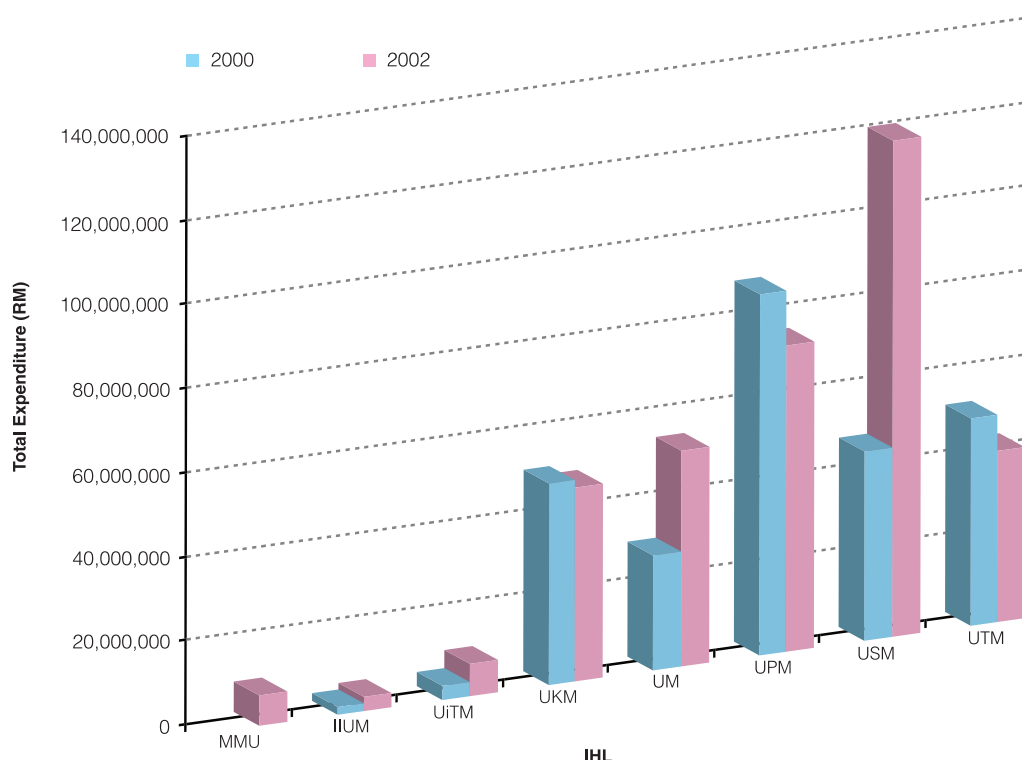


Figure 5.18: R&D Expenditure in Institutes of Higher Learning (IHLs), 2000-2002

The amount of expenditure of other universities was still small. However, significant improvements have been made by most of these universities. For example, IIUM saw an increase in expenditure by 86.1% over the reference period of 2001-2002, UiTM by 124.5%, and UMS by 49.2%. However, in terms of absolute value, the R&D expenditure of these universities was still small. R&D expenditure for some universities declined. These include UNIMAS, UPM, UTM, and UUM.

5.6 R&D Output

The technological development and advancement of any country is determined in part by the number of patent applications filed and approvals granted. This section describes the trend in patent applications and approvals based on those filed in Malaysia (Ministry of Domestic Trade and Consumer Affairs) and the United States (US Patent and Trademark Office).

Figure 5.19 shows the number of patents applied for and granted to resident and non-residents for patent filed in Malaysia. Over the years, the total number of patent applications has declined. The total number of patents applied for the period 2001-2002 has dropped compared to the number of applications for the period

1999-2000. A total of 10,871 applications were received for the period 2001-2002 compared to 12,036 and 12,416 for 1999-2000 and 1997-1998, respectively. This decline is largely due to the decrease in the number of applications by non-residents. The number of applications by residents has increased while that of non-residents has decreased by about 15% from 1997-1998 to 2001-2002. As a result of this, the auto-sufficiency ratio has improved from 0.03 in 1998 to 0.07 in 2002. Similarly, the inventiveness coefficient has also improved from 8.7 in 1998 to 13.1 in 2002. Corresponding to this improvement, the dependency ratio has dropped from 29.9 in 1998 to 14.3 in 2002.

On the whole, the total number of patents granted for residents and non-residents has increased from 1,126 to 2,962 for the period 1999-2000 and 2001-2002, respectively. The increase is largely due to the increase in the number of patents approved for non-residents. While the number of applications by residents for the period 2001-2002 has increased by about 60% compared to 1997-1998 period, there was no corresponding increase in the number of approvals. The number of approved patents was 50 for the period 2001-2002 compared to 73 for the period 1997-1998. The drop in the number of patents granted is reflected in the auto-sufficiency ratio as it dropped from 0.04 in 1998 to 0.02 in 2002.

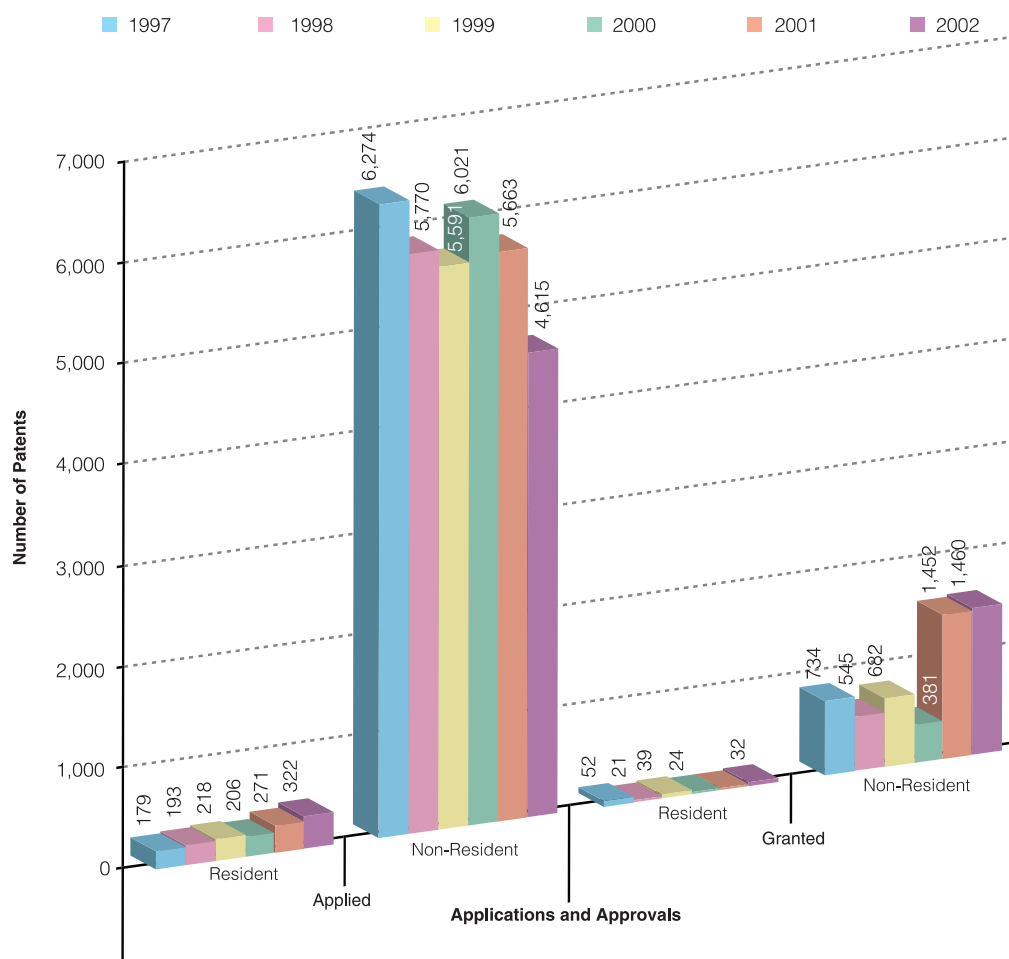


Figure 5.19: Patent and Utility Innovation Filed in Malaysia: Applications and Approvals, 1997-2002

Figure 5.20 shows the number of patents granted by field of technology. The field of chemistry and metallurgy has the highest number (4,115 or 27.91%) of patents granted since 1988. Human necessity had the second highest number (2,643 or 17.86%) of patents granted, followed by performing operations and transporting (2,450 or 16.61%). The field with the least number of patents granted was textiles and paper (197 or 1.34%).

For patents filed in Malaysia, United States had the highest number of applications as well as the number of patents granted in 2001 (1931 patents applied; 530 patents

granted) and 2002 (1538 patent applied; 437 patent granted), followed by Japan (Figure 5.21). Japan had a total of 834 patents granted for the period 2001-2002. Germany ranked third in terms of the number of applications for patents and utility innovations. In the case of Germany, the number of applications was 588 and 439 for 2001 and 2002, respectively. For patents granted, Germany ranked fourth with only 156 patents granted for both years. Although UK ranked sixth with a total number of applications of 469, the number of patents granted was 159, which placed it as the third highest.

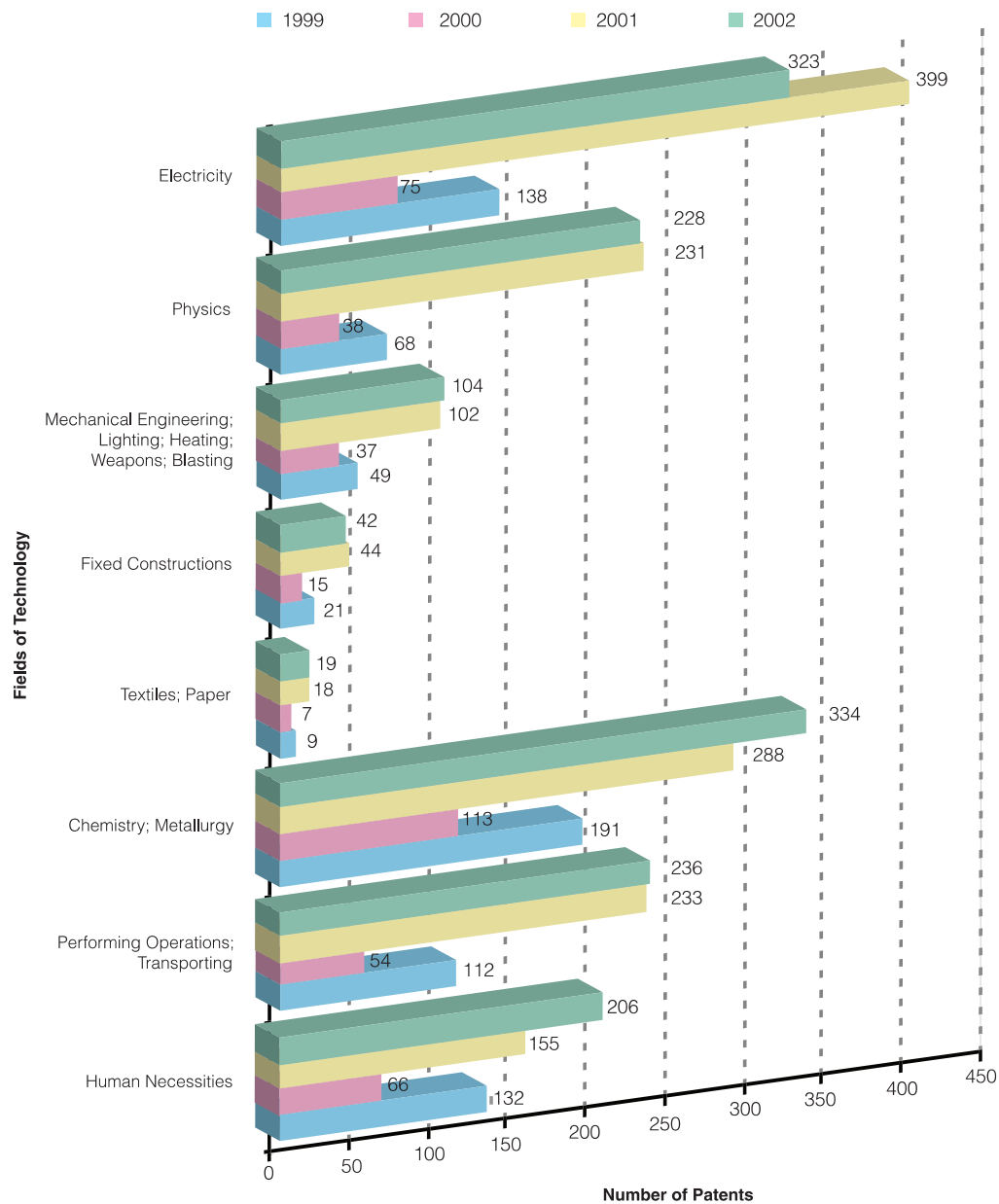


Figure 5.20: Number of Patents Granted in Malaysia by Field of Technology, 1999-2002

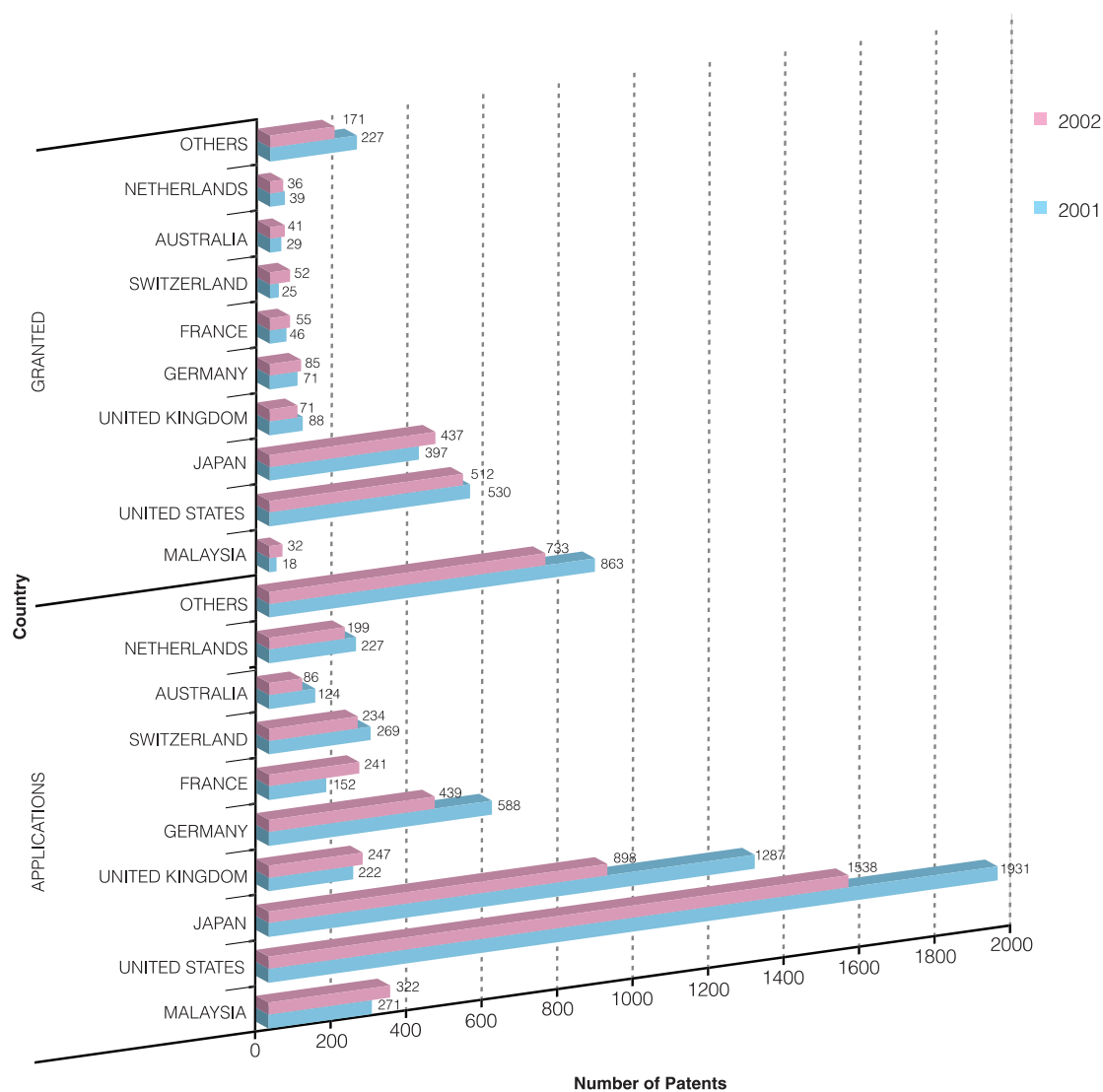


Figure 5.21: Applications and Approvals of Patent and Utility Innovations (Patent Filed in Malaysia) by Country, 2001-2002

Malaysia has 593 patent applications for the period 2001-2002 with only 50 patents approved. The overall number of patent applications and patents granted has increased over the period 2001-2002 compared to previous years. This is impressive especially when compared to Australia, a country that have about the same population size. For Australia, the number of applications was 210 and the number of patents granted stood at 70.

Examining the status of patent applications among some of the ASEAN countries, Taiwan, and Republic of Korea shows that Malaysia ranked ahead of these countries followed by Taiwan (320) and Korea (197). Brunei and Philippines had the least number of applications (Figure 5.22).

While the foregoing data about the status of patent applications and approvals

were obtained the Intellectual Property Division, Ministry of Domestic Trade and Consumer Affairs, Malaysia, Figure 5.23 shows patent applications for various countries, beginning from year 1993 to 2001, based on the data obtained from the Technology Assessment and Forecast (TAF) Database, United States Patent and Trademark Office (US, PTO). US had the largest number of patent filed over the years as well as for the relevant reference periods. This is followed by Japan, Germany and Taiwan. Malaysia had only 268 applications for the period of 1993-2001. This is to be expected since these patents referred to patents filed in the US. Compared to Australia, Malaysia has far less patents filed than Australia (5846 patent applications). According to this data source, Singapore has 1195 patents filed, about 4-5 times more than the patents filed by Malaysians.



Figure 5.22: Applications of Patent and Utility Innovations (Patent Filed in Malaysia) for Selected Asean Countries, Taiwan and Korea, 2001-2002

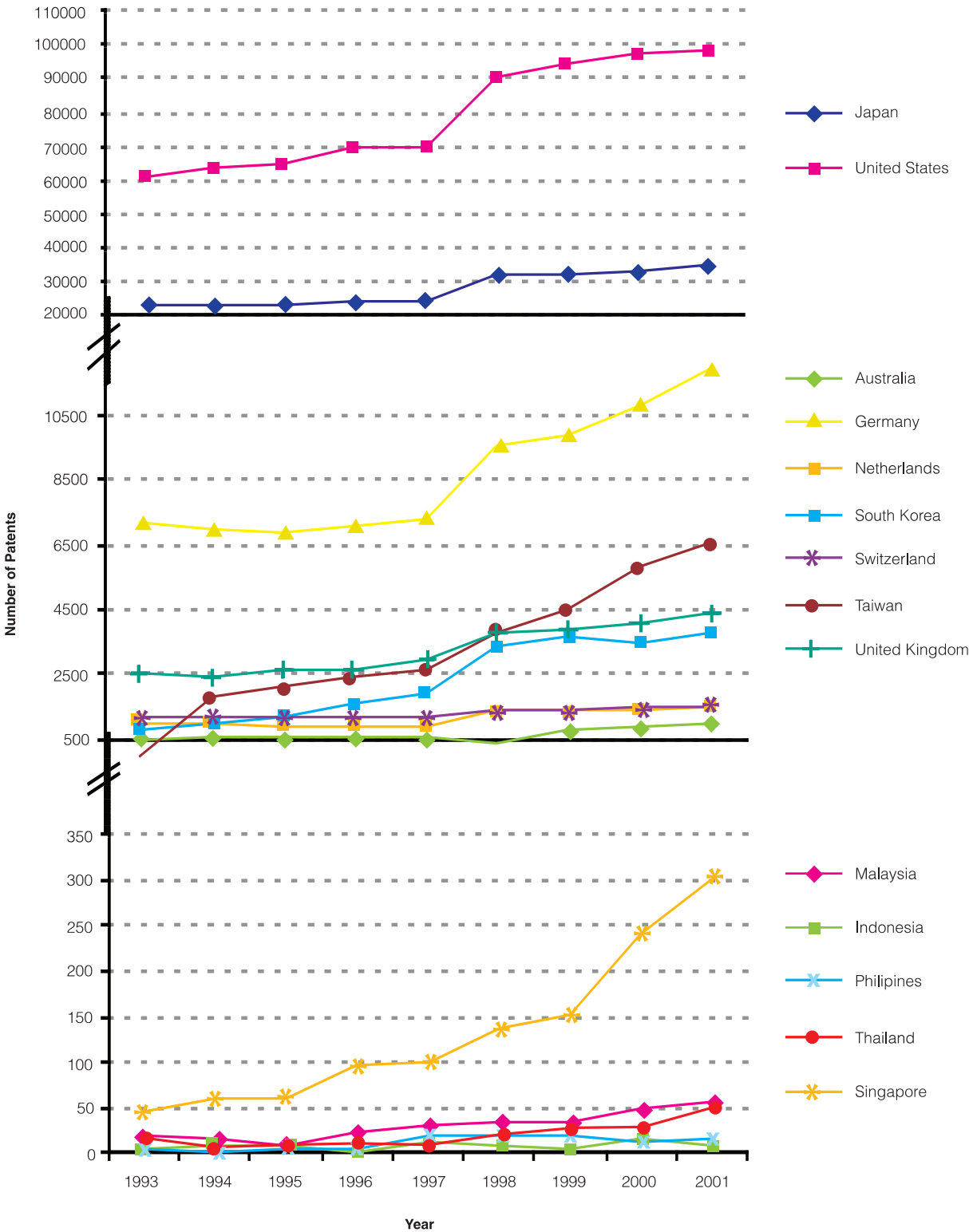


Figure 5.23: Patent Count by Selected Countries (Patent Filed in United States;USTPO), 1993-2001

5.6.1 Patent Count by Country and Type

The US Patent and Trademark Office (PTO) issues several different types of patent documents offering different types of protection and covering different types of subject matter. For a detailed description of the types of patents, please refer Appendix V. Utility patent is the most common, followed by design and plant. It can be said that the most common types of patent are utility and design patents. Again, US ranked as the country with the most number of patents in all types of patents. This is followed by Japan and Germany. Malaysia ranked rather low with only 56 patents comprising 39 utility and 17 design patents. Malaysia did not have other types of patents such as plant, reissue and Statutory Invention Registrations (SIRs) (Figure 5.24). Although Malaysia is far behind Singapore in term of patents granted for 2000 (242) and 2001 (304), it is still ahead of Thailand (2000: 30, 2001: 47) and Philippines (2000: 12, 2001: 15).

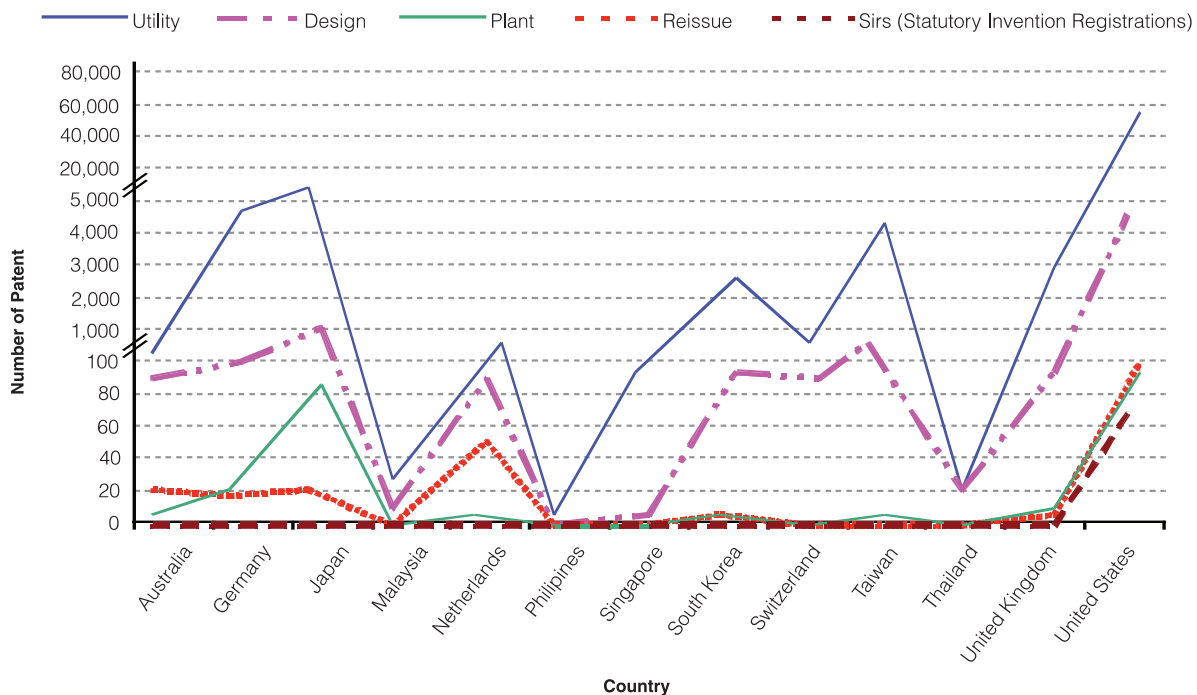


Figure 5.24: Patent Count by Country and Type of Patent (Filed in United States; USPTO), 2001

5.6.2 Inventor Awards

Awards won by Malaysian inventors have been increasing over the years, reflecting a positive growth in the inventiveness capacity. In 2001-2002, a total of 72 awards were won compared to 35 in 1999-2000. Especially in Gold Awards, Malaysians won 16 Gold in 2002 representing an improvement of more than 100% over 2001. 20 Silvers and 9 Bronze were won in 2002 (Figure 5.25).

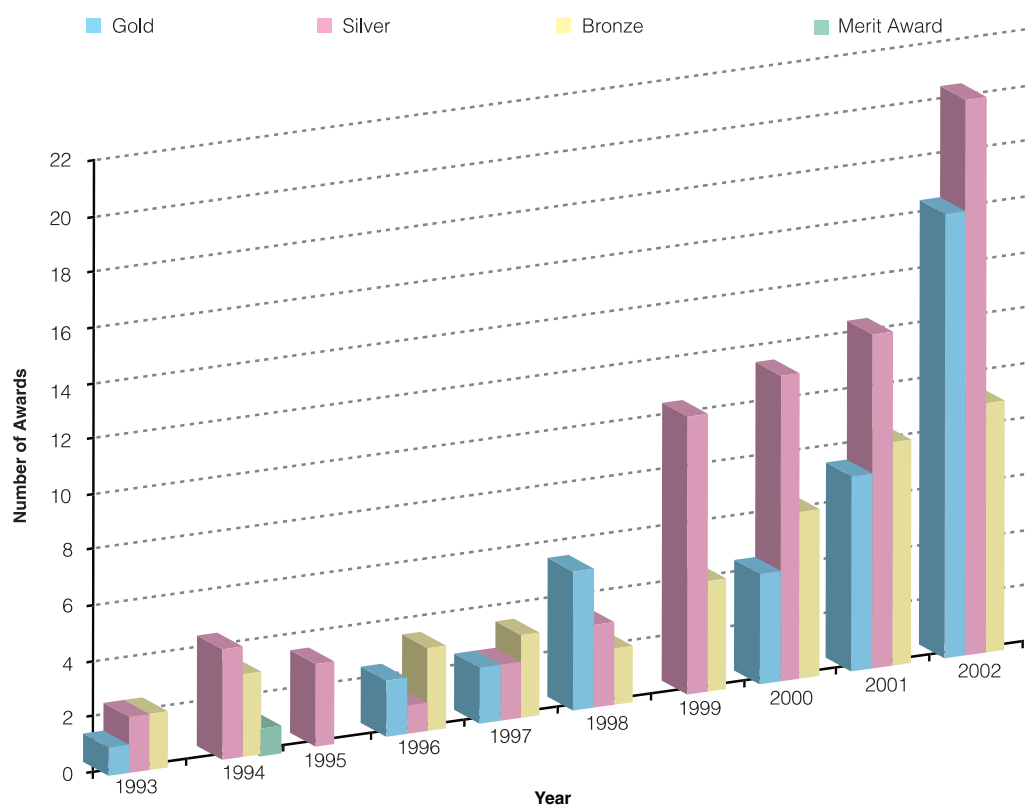


Figure 5.25: Awards Received by Malaysian Inventors at the International Inventors' Exhibition, Geneva, 1993-2002



CHAPTER 6

INNOVATION IN THE MANUFACTURING SECTOR

One of key indicators of the status of science and technology (S&T) in any country is the extent of technological innovation taking place in the country. Innovation statistics are also important indicators of the technological vibrancy of a country's economic sector. For firms in any economic sector, the long-term survival of these firms depends on their ability to generate technological innovations. This has become increasingly true in a globalised market environment.

In Malaysia, the Malaysian Science and Technology Information Centre (MASTIC) at the Ministry of Science, Technology and Innovation has been carrying out national surveys of innovation since 1995 in an effort to assess the extent of technological innovation in the country's manufacturing sector. The latest of such surveys is the National Survey of Innovation 2000-2001 which was undertaken in year 2002. The survey covered the manufacturing sector during the reference period of 2000-2001. In the survey, a total of

4,000 questionnaires were sent out to business establishments in the manufacturing sector. Some 745 firms responded to the survey giving a response rate of 19%. This chapter summarises the key findings of the National Survey of Innovation 2000-2001. It also compares these findings with that of the previous survey of innovation, namely, the National Survey of Innovation 1997-1999.

6.1 Innovation in the Manufacturing Sector

6.1.1 Overall Level of Innovation

In the National Survey of Innovation 2000-2001, 35% (or 259 firms) of the 745 firms surveyed indicated that they carried out innovation. In other words, about 35% of the firms that responded to the survey indicated that they carried out innovation (Figure 6.1). This is higher than the corresponding figure of 21% in the previous survey covering the period 1997-1999.

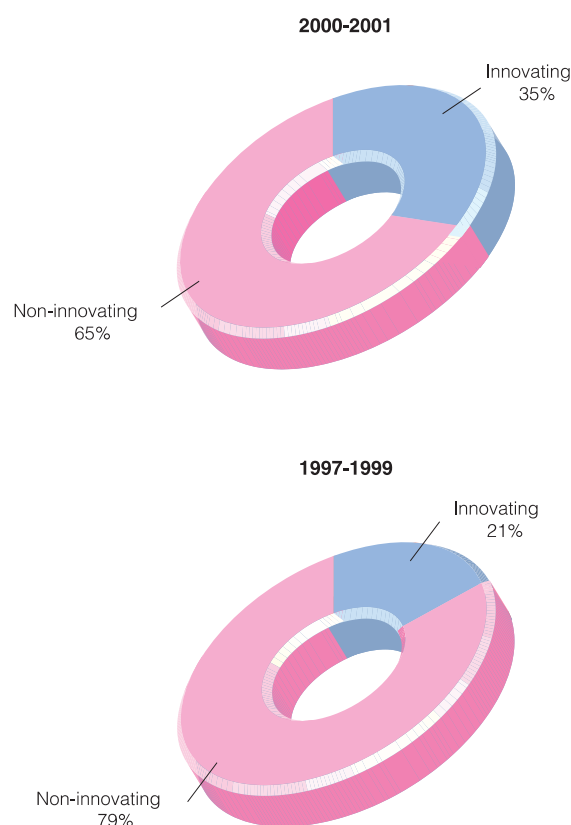


Figure 6.1: Innovating and Non-Innovating Firms in the Manufacturing Sector, 1997-1999 and 2000-2001

6.1.2 Innovation Across Industries

There are significant variations in the level of innovation across the different industries in the manufacturing sector in Malaysia (Figure 6.2). Sectors with the lowest level of innovation include the machinery and equipment industry (10%) and the wood products industry (16%). High levels of

innovation are observed in industries such as electrical machinery and apparatus (67%), textile products (73%), scientific instruments (75%), motor vehicles (80%), radio, television and communications equipment (82%). Furthermore, the levels of innovation across the different industries were higher during the 2000-2001 period compared to the 1997-1999 period (Figure 6.3).

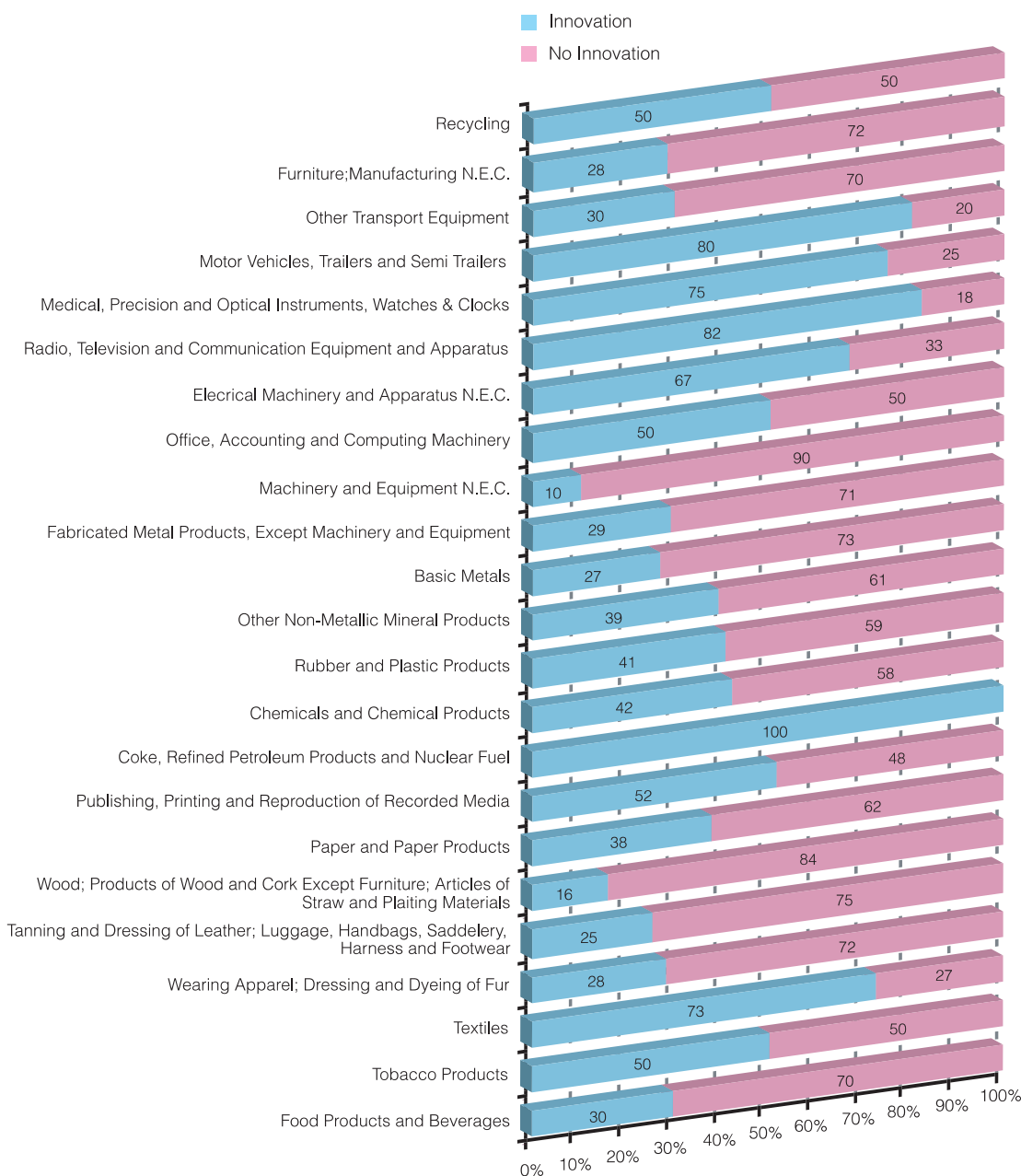


Figure 6.2: Innovation Profile in the Manufacturing Sector, 2000-2001

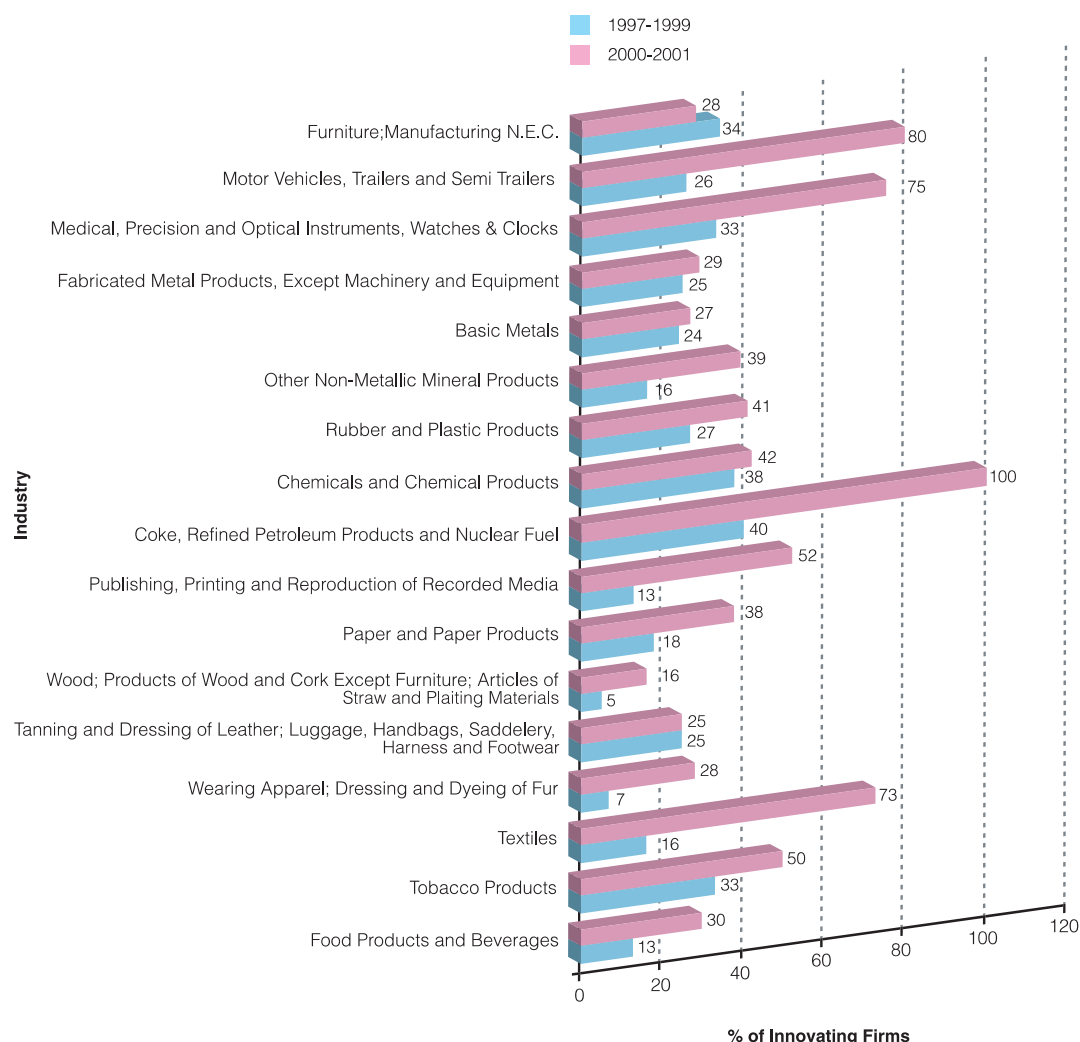


Figure 6.3: Innovation Profile of Manufacturing Sector, 1997-1999 and 2000-2001

6.2 Innovation and Firm Size

The Survey also indicated that innovation tend to be undertaken by larger firms (Figure 6.4). Large firms (with employment size exceeding 250 workers) account for 25% of the total number of innovating firms. On the other hand, only seven percent of the total number of non-innovating firms was large firms. About 55% of non-innovating firms were small firms with less than

20 workers. The results from the 1997-1999 innovation survey were slightly different – about 45.6% of the innovating firms are medium-sized firms with employment size between 50 – 249 employees (Figure 6.5). About 32.8% of the innovating firms in the 2000-2001 period was smaller firms with less than 20 employees. This is considerably higher than the corresponding figure of 1.8 % for the 1997-1999 period.

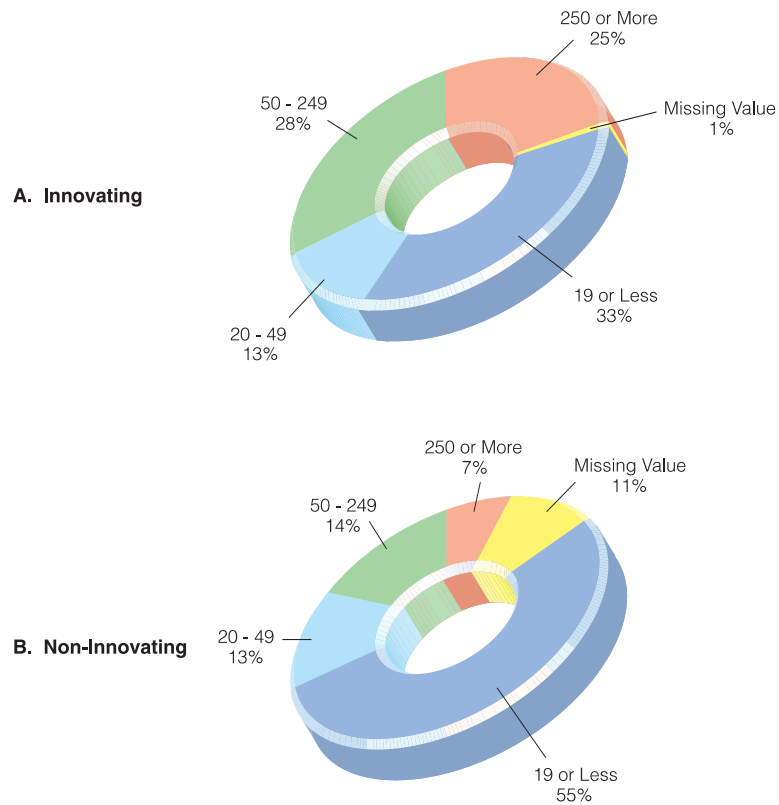


Figure 6.4: Firm Size of Innovating and Non-Innovating Firms, 2000/2001

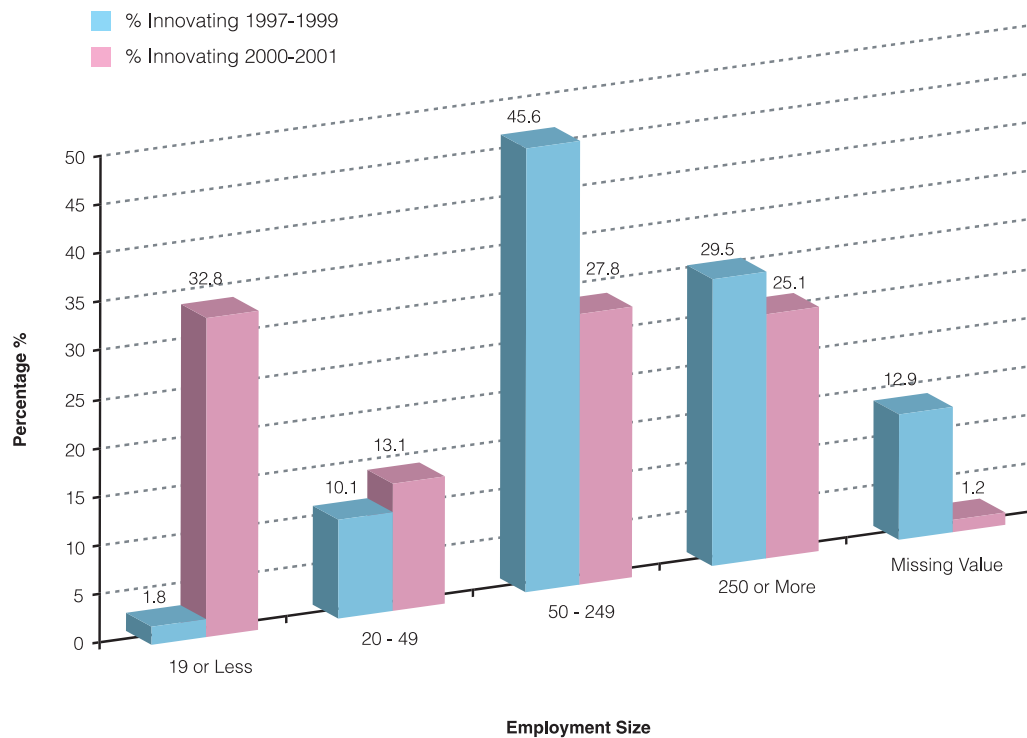


Figure 6.5: Innovating Firm Size Distribution, 1997-1999 and 2000-2001

6.3 Innovation and Foreign / Local Ownership

The Survey also found that the majority of innovating and non-innovating firms were locally-owned firms (Figure 6.6). Some 10% of innovating firms were foreign-owned

firms while only 5% of non-innovating firms were foreign-owned firms. Compared to the previous survey (1997-1999), the percentage of innovating firms that were locally wholly-owned was higher in the 2000-2001 survey (Figure 6.7).

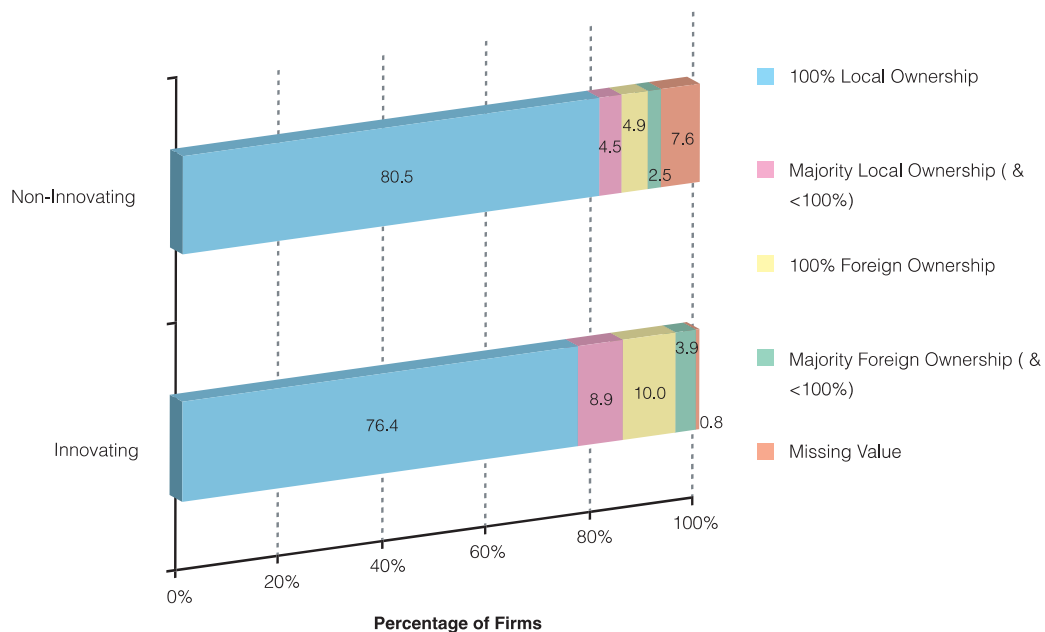


Figure 6.6: Local Ownership vs. Foreign Ownership in Innovating and Non-Innovating Firms in the Manufacturing Sector, 2000/2001

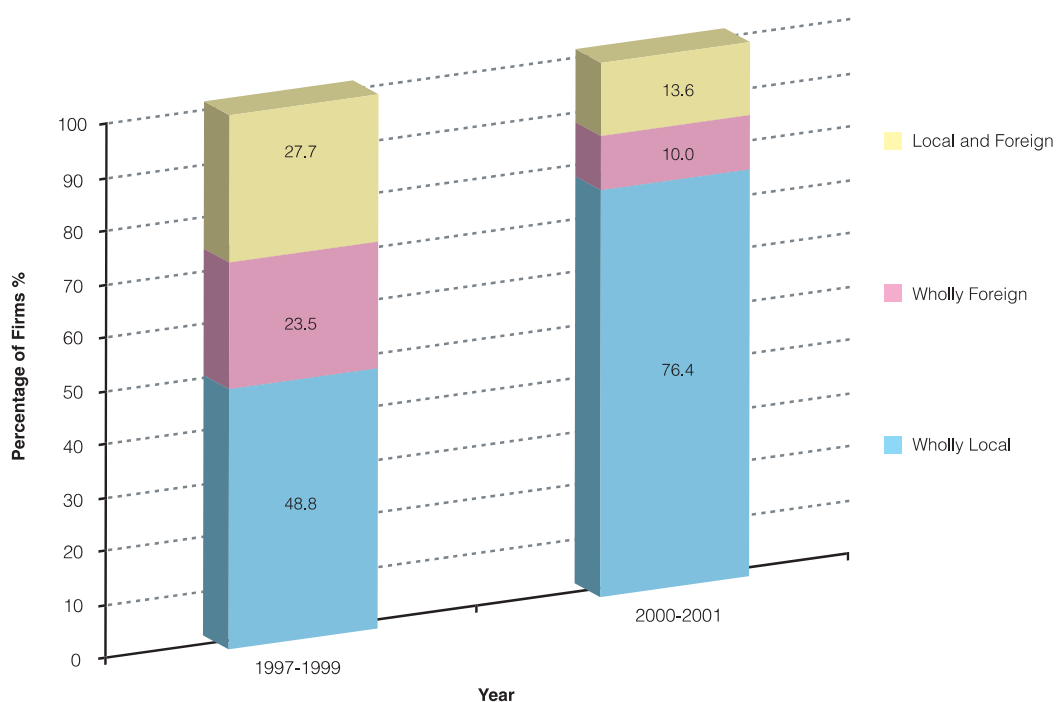


Figure 6.7: Local and Foreign Ownership of Innovating Firms, 1997-1999 and 2000-2001

6.3.1 Innovation and Ownership Structure

In terms of ownership structure, a large percentage of the innovating firms (71%) in the 2000-2001 period were limited companies (Sdn.Bhd.) (Figure 6.8). In contrast, a smaller

percentage of non-innovating firms (44%) were limited companies. About 50% of non-innovating firms were sole-proprietorship and partnership firms. In the 1997-1999 survey, limited companies continued to be the dominant ownership type amongst innovating firms (Figure 6.9).

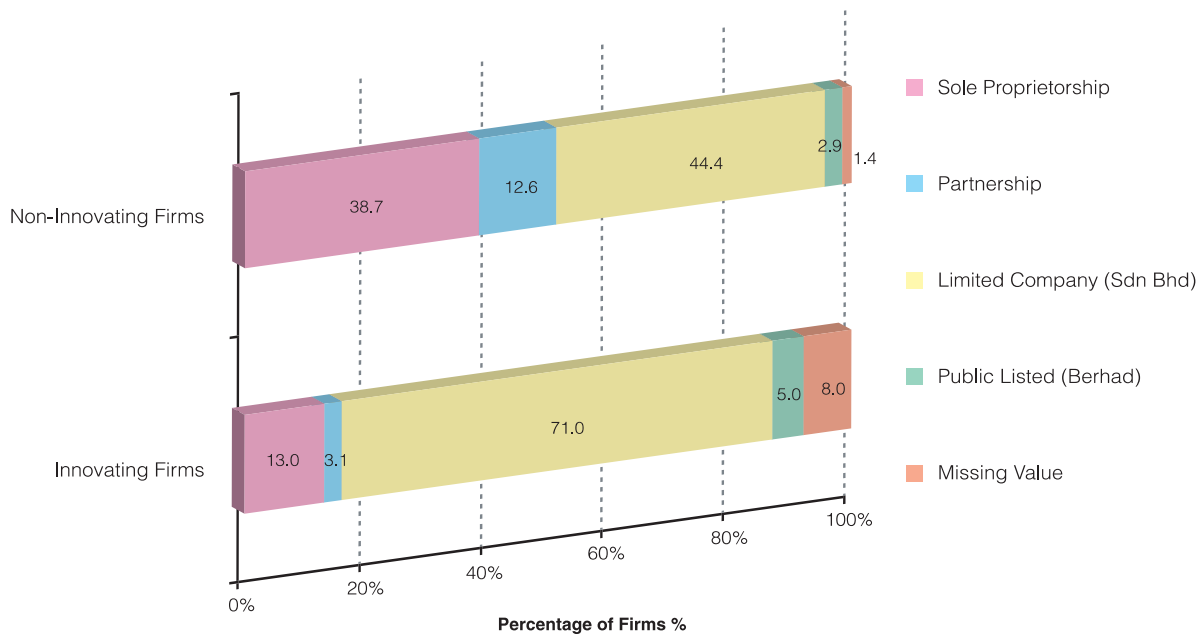


Figure 6.8: Type of Ownership of Innovating and Non-Innovating Firms in the Manufacturing Sector, 2000/2001

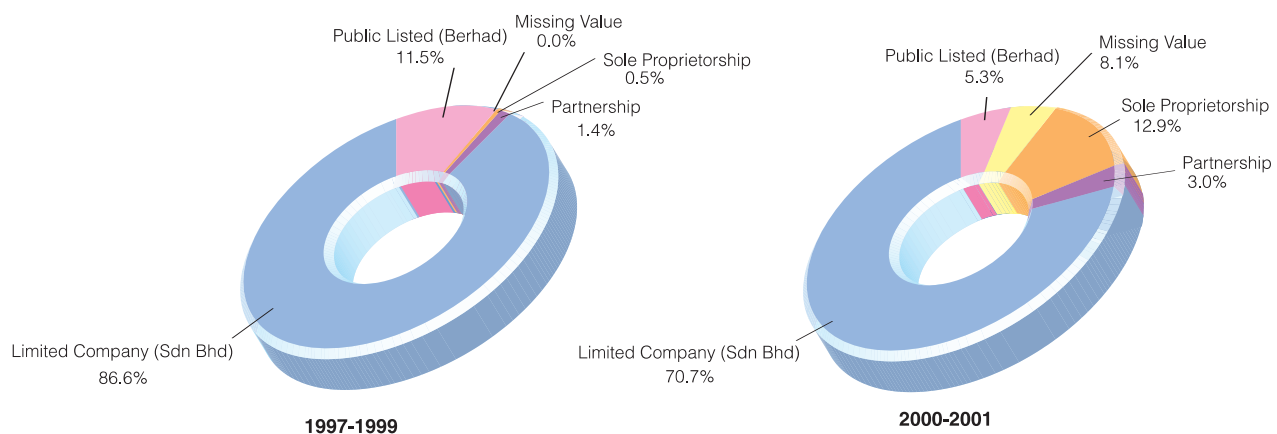


Figure 6.9: Ownership Structure of Innovating Firms, 1997-1999 and 2000-2001

6.4 Geographic Distribution of Innovating Firms

The geographical distribution of innovating firms is extremely skewed (Figure 6.10). During the period of 2000-2001, four states in Peninsular Malaysia accounted for 87% of the total number of innovating firms in

Malaysia. The states are: Selangor (129 firms or 49.2%), Kuala Lumpur (68 firms or 26.0%), Penang (20 firms or 7.6%) and Johor (11 firms or 4%). In the previous survey covering the period 1997-1999, there were fewer innovating firms from Kuala Lumpur whereas a higher number of innovating firms were from Penang, Johor and Perak (Figure 6.10).

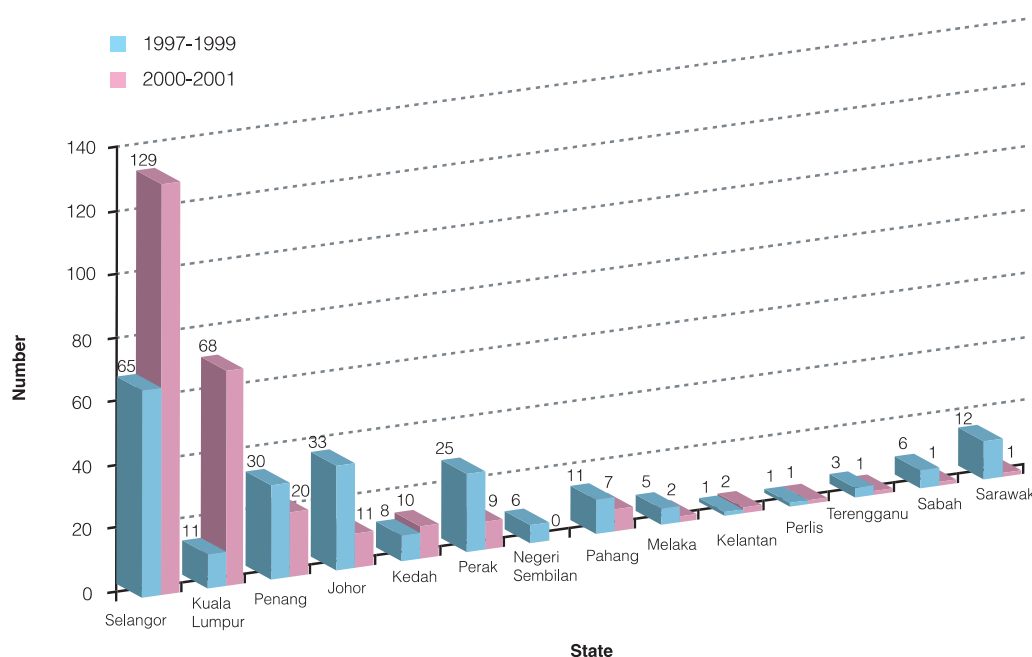


Figure 6.10: Geographical Distribution of Innovating Firms, 1997-1999 and 2000-2001

6.5 Age Profile of Innovating Firms

Most of the innovating firms in the manufacturing sector were established within the period 1980-1999 (Figure 6.11). In the 2000-2001 survey, around 39% of the innovating firms were established in the period 1990-1999 while 25% of the innovating firms were established during 1980-1989. The age profiles of innovating firms in the 1997-1999 period and the 2000-2001 period are very similar.

6.6 Product and Process Innovations

Both the 1997-1999 innovation survey and the 2000-2001 survey indicate that a majority of the innovating firms in the manufacturing sector carry out both product and process innovation (Figure 6.12)¹. A fairly large proportion of innovating firms also conducted product and process innovations as well as having on-going projects. This is more significant (67.3%) in the 1997-1999 survey compared to the 2000-2001 survey (37.7%).

¹ Product Innovation occurs when a good or service is either new or significantly improved with respect to its fundamental characteristics, technical specifications, incorporated software or other immaterial components, intended uses, or user friendliness. Process Innovation includes new and significantly improved production technology, new and significantly improved methods of delivering products.

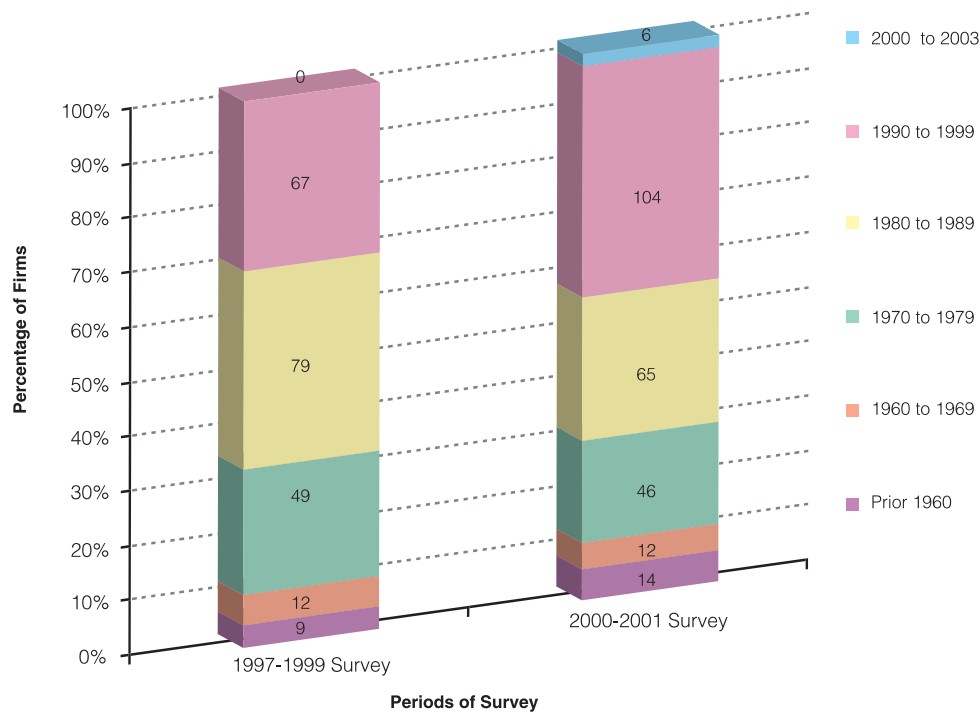


Figure 6.11: Age Profile of Innovating Firms, 1997-1999 and 2000-2001

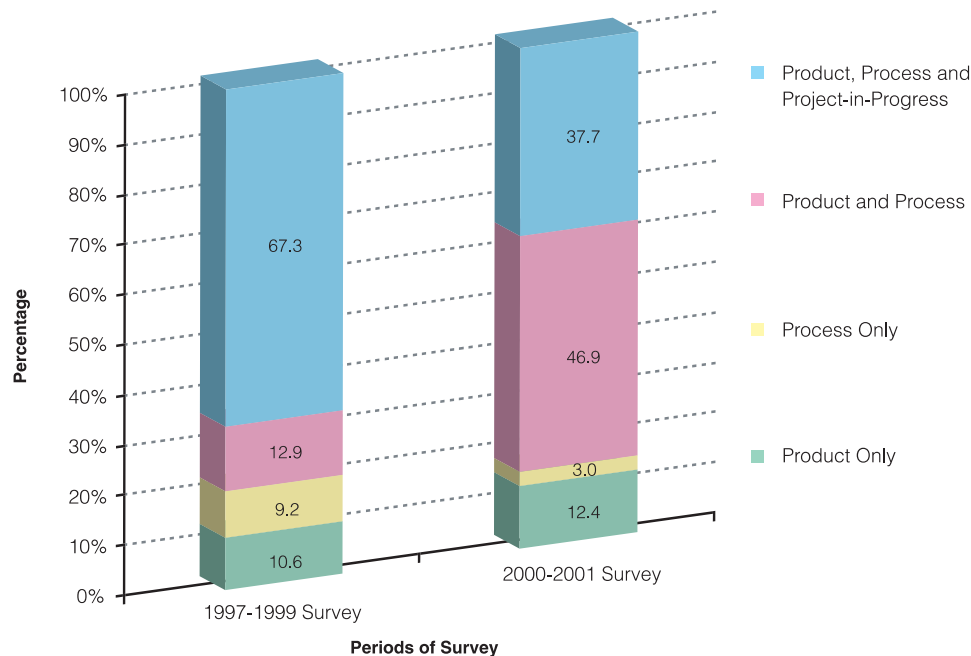


Figure 6.12: Product and Process Innovation, 1997-1999 and 2000-2001

6.7 Objectives for Innovation

Innovations are carried out for a number of reasons. In both the 1997-1999 innovation survey as well as the 2000-2001 innovation survey, the most important objective for innovation was to improve product quality

(Figure 6.13). The other important objectives of innovation included the opening up of new markets or increase in market share and the extension of product range. Slightly less than half of the innovating firms indicated government support as a highly important reason for undertaking innovation activities.

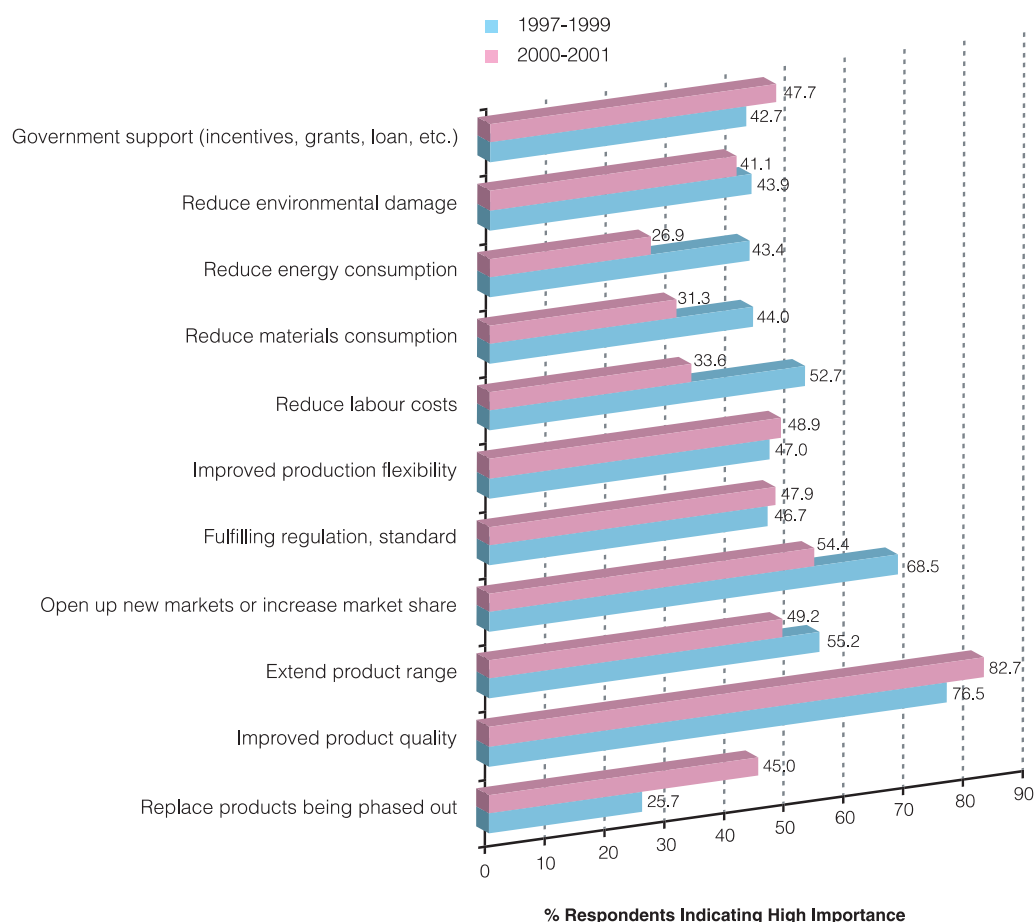


Figure 6.13: Objectives for Innovation, 1997-1999 and 2000-2001

6.8 Sources of Information for Innovation

From both the 1997-1999 and 2000-2001 innovation surveys, innovating firms indicated that their clients or customers were the most important sources of information for innovation (Figure 6.14). Other important sources of information for innovation were from within the firms, from the suppliers of equipment, materials, components or software and from competitors and other companies from the same industry.

6.9 R&D Expenditure for Innovation

Most of the innovating firms surveyed reported that they spent less than RM100,000 per annum on R&D activities (Figure 6.15). Comparing the 1997-1999 survey and the 2000-2001 surveys, the proportion of firms spending less than RM100,000 has increased. There has been a corresponding significant decline in the proportion of innovating firms spending more than RM400,000 during the same period.

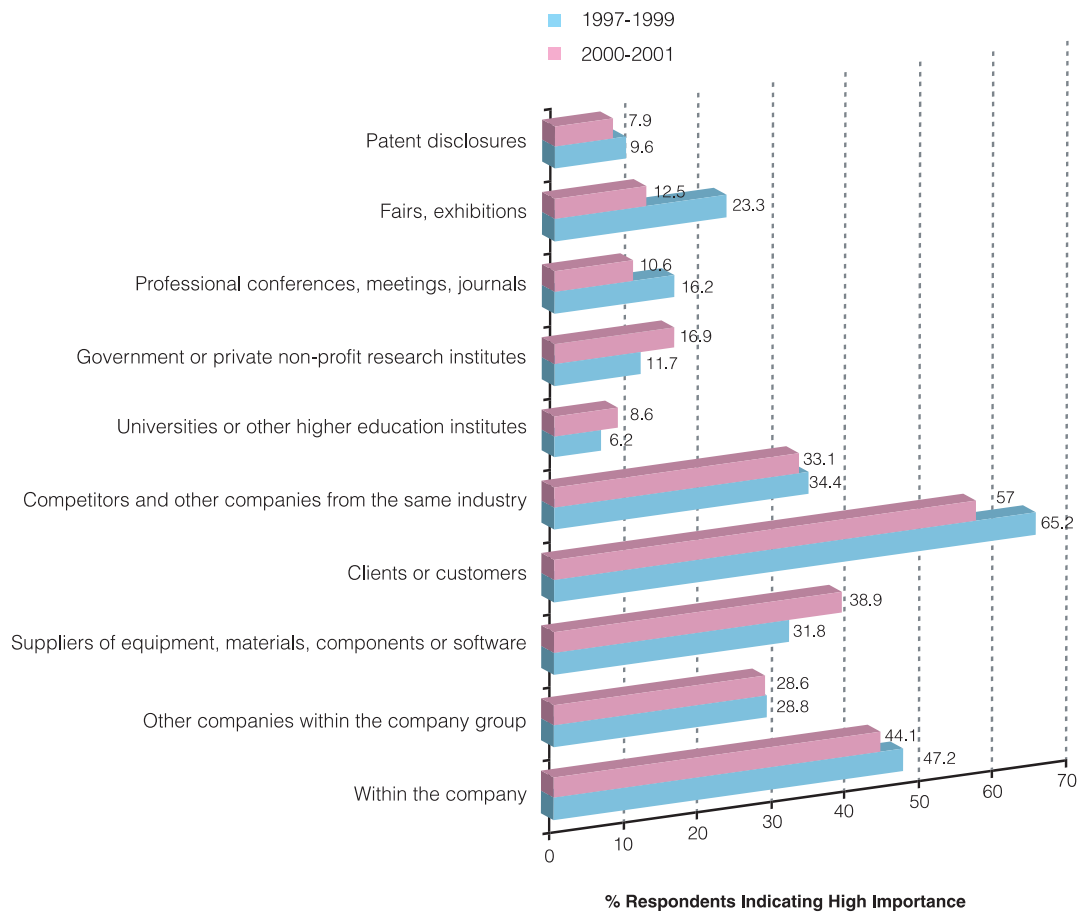


Figure 6.14: Sources of Information for Innovation, 1997-1999 and 2000-2001

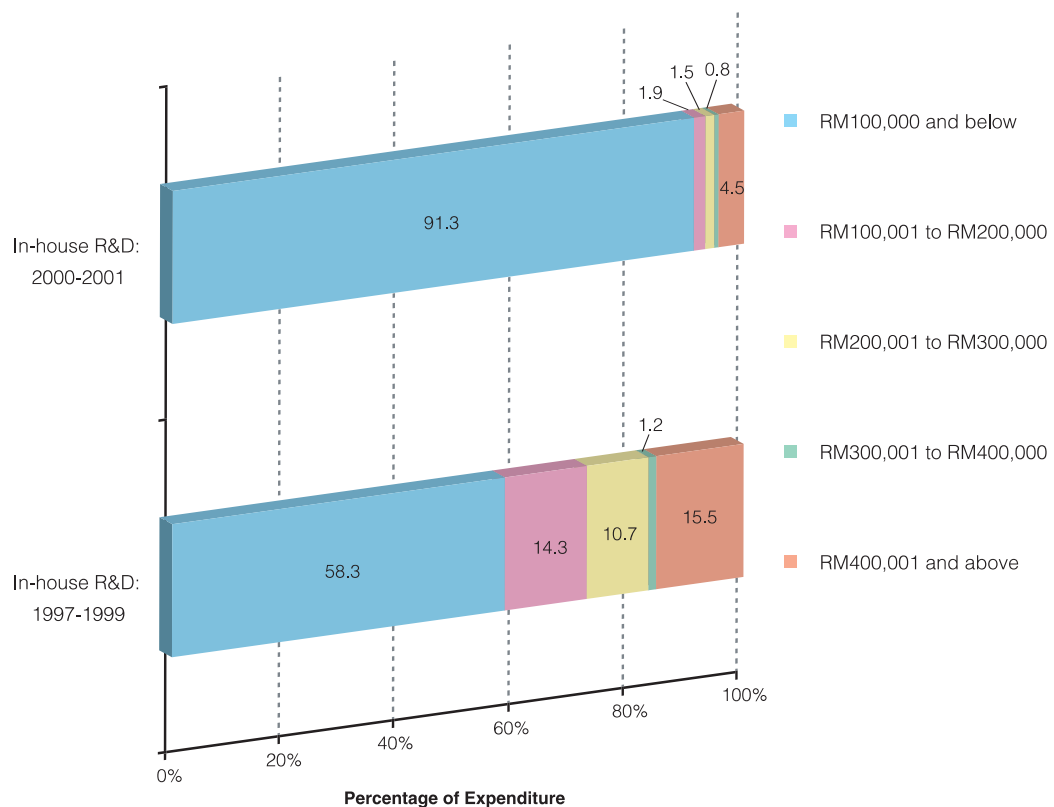


Figure 6.15: In-house Expenditure on R&D, 1997-1999 and 2000-2001

6.10 Impact of Innovation

There are significant variations in the impacts of innovation on firms' turnover in terms of percentage share of turnover attributed to new products (Figure 6.16). In the 2000-2001 innovation survey, they ranged from

3.5% (in the chemicals and chemical product industry) to 33.2% (in the fabricated metal product industry). The impact of innovation on turnover on some industry such as the fabricated metal industry was significantly higher in the 1997-1999 period compared to the 2000-2001 period.

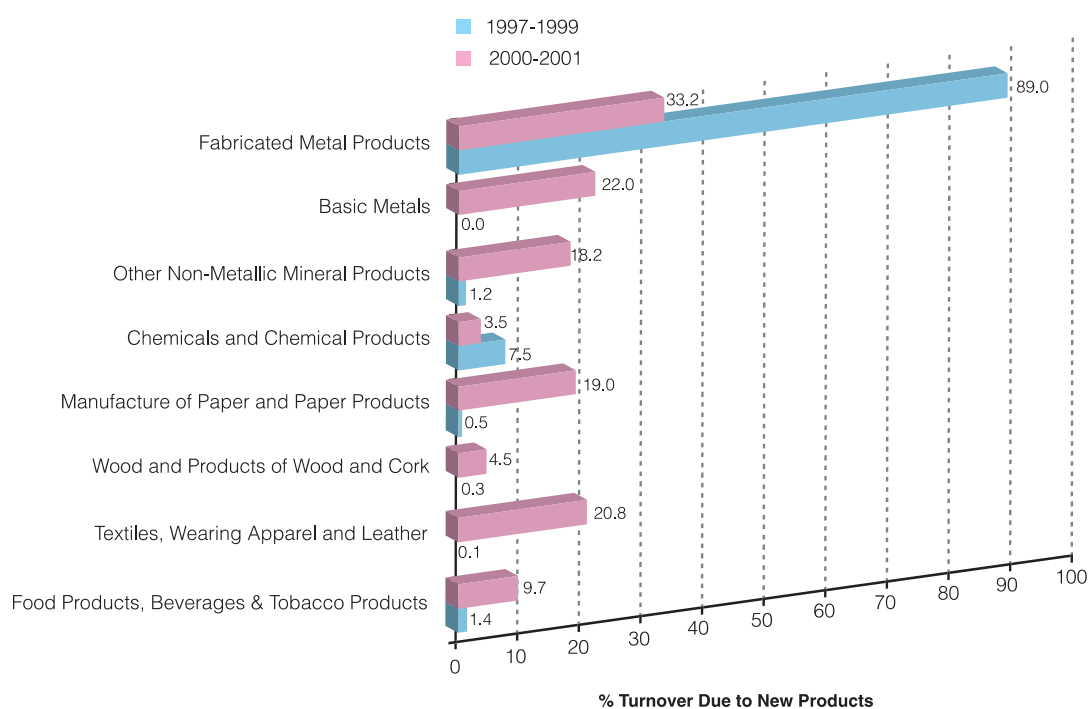


Figure 6.16: Impact of Innovation, 1997-1999 and 2000-2001

6.11 Factors Hampering Innovation

Both the 1997-1999 innovation survey and the 2000-2001 innovation survey indicate that the most important factor hampering innovation was the high cost of carrying out innovation-related activities (Figure 6.17). Other factors that were cited as important factors hampering innovation were the lack of

skilled personnel, lack of customer responsiveness to new products, lack of information in markets, the lack of information on technology and lack of excessively perceived economic risks. Regulatory factors and organisational rigidities were considered by innovating firms to be less important factors that would hamper innovation.

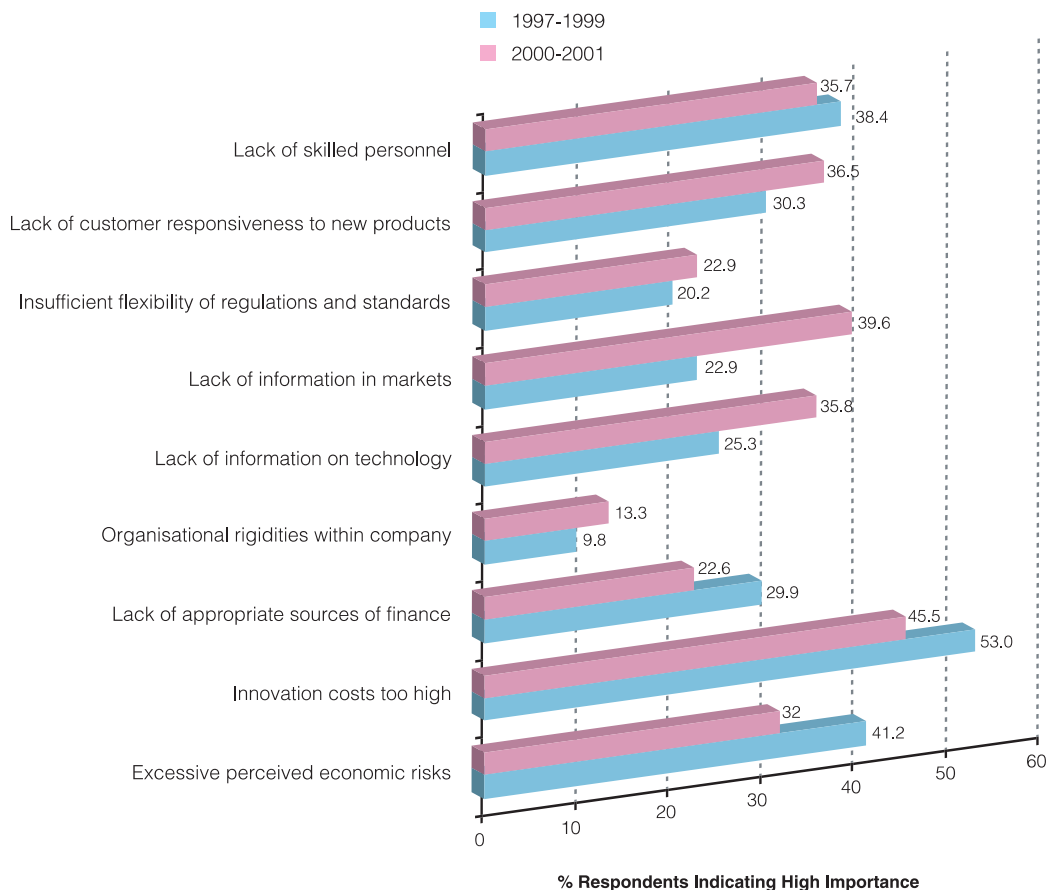


Figure 6.17: Factors Hampering Innovation, 1997-1999 and 2000-2001

Innovation Across Time: Logitudinal Evidence from Two National Surveys of Innovation

The generation and diffusion of innovation are dynamic processes best studied over a period of time. Data from the National Survey of Innovation provides a profile of innovation at a given point in time. The tracking of innovating firms participating in two or more such surveys provide an invaluable source of information on the process of innovation over time. Of the 262 innovating firms in the 2000-2001 National Survey of Innovation (NIS-3), 43 were also innovators in the previous 1997-1999 National Survey of Innovation (NIS-2).

Of these 43 firms, 35% (or 15) grew in size (in terms of number of employees) between 1999 and 2001 (Figure B1). A similar number of firms (15) declined in size during this period. Another nine firms (or 21%) remained the same in size. Slightly more than half (24 firms or 56%) of the 43 innovating firms in both surveys did not increase their innovation expenditure during the 1999-2001 period (Figure B2). During the same period, four firms reported increased their innovation expenditure while three firms decreased their innovation expenditure. In terms of changes in the number of new products, about 88% (or 38) of the 43 firms did not increase the number of new products they produce between 1999 and 2001 (Figure B3). During this period, only three firms had increase the number of new products. Two innovating firms experienced a decline in the number of new products during the same period.

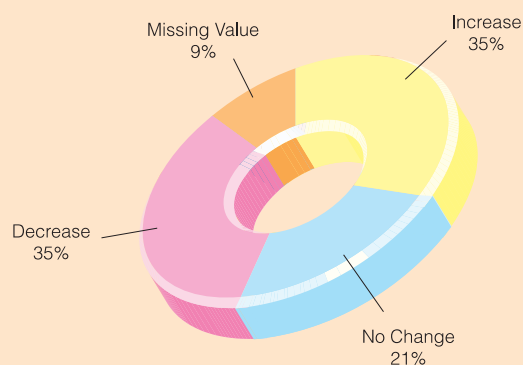


Figure B1: Changes in the Size of Innovating Firms, 1999-2001

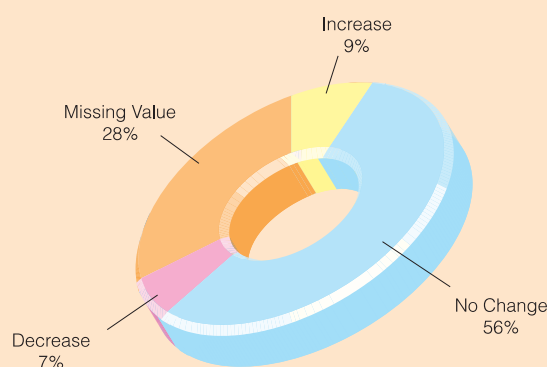


Figure B2: Changes in Innovation Expenditure by Innovating Firms, 1999-2001

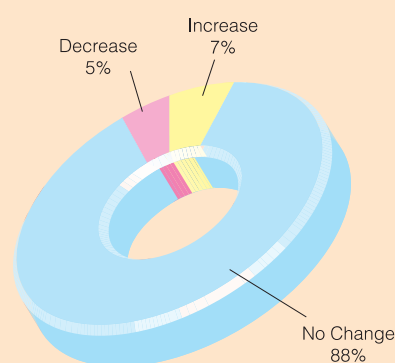


Figure B3: Changes in the Number of New Products by Innovating Firms, 1999-2001

A decorative graphic consisting of numerous thin, parallel blue lines that flow from the bottom left towards the top right, creating a sense of movement and depth. The lines are more densely packed in some areas, creating a wavy, ribbon-like effect.

CHAPTER 7

TRADE IN TECHNOLOGY

To fulfill Malaysia's ambition to become a developed nation by 2020, further structural changes in its trade patterns will need to take place. Malaysia's total exports stood at RM 373.3 billion and 357.4 billion for 2000 and 2002 respectively, and imports were RM 311.5 billion and 302.6 billion for the same periods. Although trade figures declined, nominal GDP grew from RM 342.6 billion in 2000 to RM 360.7 billion in 2002. Manufactured goods comprised the bulk of exports, constituting 81.3% and 80.2% of total exports in the year 2000 and 2002 respectively.

It is important that Malaysia charts its path for higher exports of goods with greater technology content. The country should also aspire to derive more revenues from export of technology-related services through ownership of patents, licenses and technical know-how.

This chapter attempts to highlight Malaysia's current achievement in trade in technology embodied and disembodied goods and services.

7.1 Overview of Trade in Technology

The growing emphasis on the need to transform Malaysia into a knowledge-based economy requires close attention to analysis of technology-related external trade of the country. Import of technological know-how provides a platform for greater efficiency in the production of goods and services; and export of high technology products indicates the use of technical expertise and innovation, patents and licenses in generating revenue for the country.

Based on the methodology developed by OECD, trade in technology takes two distinct forms – trade in manufactured goods, and trade in services that are related to the flow of industrial property and know-how. For manufactured goods, analysis on technology trade is based on the classification of industrial sectors and manufacturers by virtue of their technology intensity as suggested by Hatzichronoglou (1997), while technology trade in services uses the guidelines stipulated in OECD's Technology Balance of Payments Manual (TBP Manual). Trade in technology

comprises four main categories:

1. Transfer of techniques through patents and licenses, and disclosure of know-how,
2. Transfer of designs, trademarks and patterns through sale, licensing and franchising,
3. Delivery of services with technical contents, including technical and engineering knowledge, and
4. Industrial R&D

Trade data were based on up to the first five digits of Global Customs Harmonised System Codes (HS Codes), which in turn were based on Standard International Trade Classification (SITC) Codes.

7.2 Technology Trade in Manufactured Goods

The types of manufactured goods traded by a country, both for imports and exports, provide an indication on the level of S&T employed by a country and its ability to 'monetise' its technical know-how in trade with other countries. Countries with higher S&T development are expected to have exports of manufactured goods with more of medium-high and high technology contents as compared to the ones with lower technology development.

At the highest level, trade figures are classified into ten categories (numbered 0 – 9), known as SITC Commodity Sections. The products that are classified as high technology and medium-high technology products come from categories 5 to 8, namely:

- Category 5: Chemicals
- Category 6: Manufactured Goods
- Category 7: Machinery and Transport Equipment
- Category 8: Miscellaneous Manufactured Articles

Using OECD's products' classification, 40.4% of Malaysia's total export in 2002 (RM 357.4 billion) is categorised as high-technology goods, while 1.1% is categorised as medium high-technology goods (Figure 7.1).

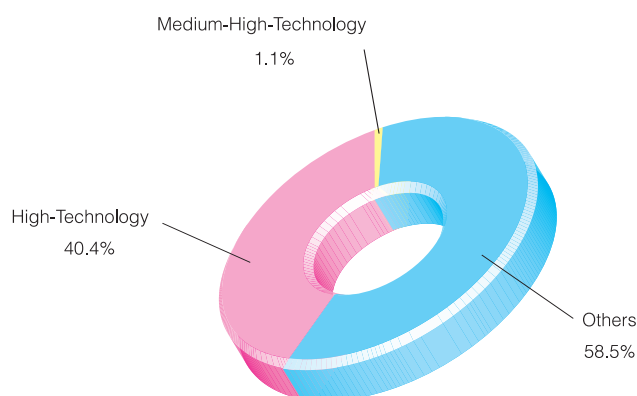


Figure 7.1: Composition of Exports by Technology Intensity, 2002

7.2.1 Trade in High-Technology Manufactured Goods

OECD considers the following categories of products as high-technology goods:

1. Aircraft and spacecraft
2. Pharmaceuticals
3. Office, accounting and computing machinery
4. Radio, television and communications equipment
5. Medical, precision and optical instruments

Using the above classifications, 50.3% of the total manufactured exports in 2002 were high technology goods, dominated by two product groups – radio, television and communications equipment (37.3%) and office, accounting and computing machinery (10.6%). This trend is similar to manufactured exports in 2000, where high technology goods constituted 57.9% of the total manufactured exports.

Although the balance of trade in high-technology goods was in favour to Malaysia, the trade surplus has decreased from RM 48.6 billion in 2000 to RM 34.9 billion in 2002. This is in parallel with the reduction of high-technology exports from RM 200.4 billion in 2000 to RM 184.6 billion in 2002.

In the case of imports, 58.3% of the total manufactured imports in 2002 were high technology goods, a slight increase from 56.6% in 2000. However, the absolute import in high-technology goods had reduced from RM 151.8 billion in 2000 to RM 149.6 billion in 2002.

7.2.2 Trade in Medium-High Technology Manufactured Goods

The following products are classified as medium-high technology manufactured goods:

1. Electrical machinery and apparatus (not elsewhere classified or n.e.c.)
2. Motor vehicles, trailers and semi-trailers
3. Chemicals (excluding pharmaceuticals)
4. Railroad equipment and transport (n.e.c.)
5. Machinery and equipment (n.e.c.)

The above products accounted for 1.1% of total manufactured exports in 2002, a slight reduction from 1.5% in 2000. The product groups that dominate this category were electrical machinery and apparatus (0.6%) and motor vehicles, trailers and semi-trailers (0.4%). Malaysia posted a trade deficit in medium-high technology goods, although the deficit has improved from RM 22.2 billion in 2000 to RM 17.3 billion in 2002.

7.3 Technology Trade in Services

OECD provides the guidelines on how to measure the technology trade in services via Technology Balance of Payments Manual (TBP Manual). Malaysia however, does not compile data using this format. A good proxy for measuring balance of payments in technology-related services can be found by using the data on cash transactions between Malaysian residents and the rest of the world. Three groups of transactions can be used to estimate the balance of payment in technology-related services:

1. Royalties
2. Contracts and professional charges
3. Construction and engineering

Of the three groups of transactions, contracts and professional charges provide the largest trade flow, both in terms of receipt and payments. Over the last ten years, the balance of payments for all three categories continue to deteriorate with deficit widening from RM 2.13 billion in 1992 to RM 6.76 billion in 2002,

representing an average growth rate of 12.2% per annum. However, the amount of deficit posted in 2002 was less than the peak experienced in 2000 at RM 7.88 billion.

The deficit in royalties, which are associated with patents and licenses, deteriorates at the highest rate. Payment of royalties increased at an average rate of 17.4% whereas the receipt of royalties posted a meager increase of 0.1% between 1992 and 2002. The result was a widening increase in deficit of royalty income, from RM 413.2 million in 1992 to RM 2.32 billion in 2002 (Figure 7.2).

Coverage ratio measures the extent to which receipts are financing payments. When receipts are balanced by payments, the coverage ratio takes a value of 100%. In the case of contracts and professional charges, the coverage ratio worsened from 79% to 65% in 2000 and 2002 respectively. For royalties, the dismal coverage ratio did not show any improvement, languishing at around 3% since 1998. However, there was a marked improvement in the coverage ratio for construction and engineering, where the figure jumped from 35% in 2000 to 56% in 2002 (Figure 7.3).

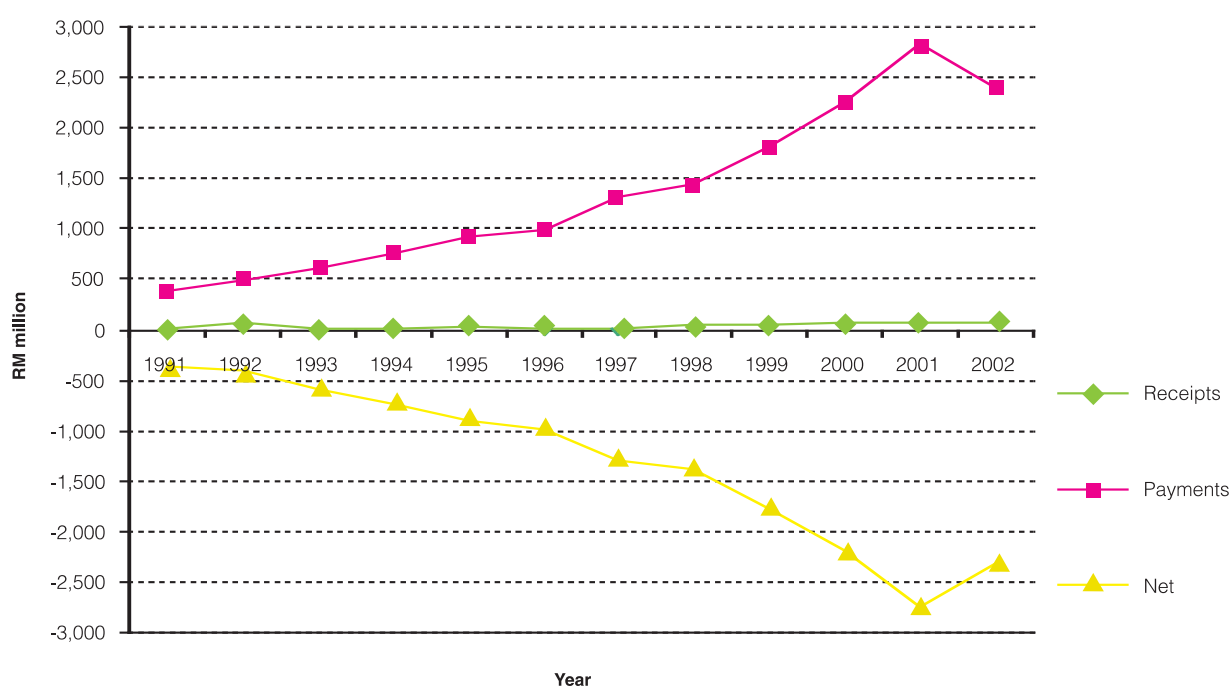


Figure 7.2: Payments and Receipts for Royalties, 1991-2002

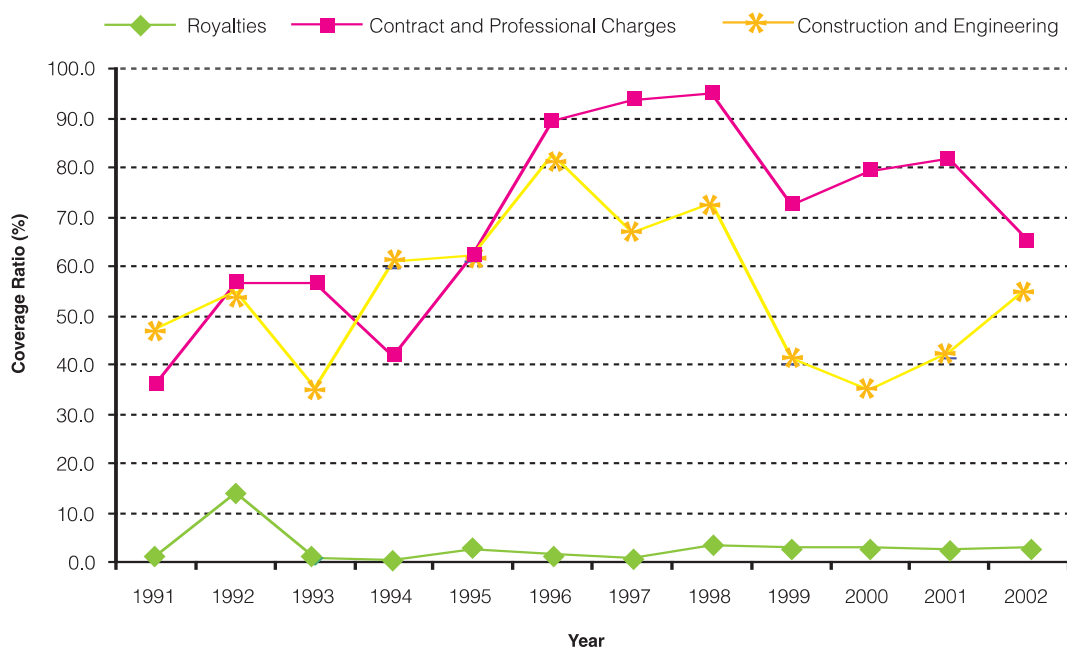


Figure 7.3: Coverage Ratios for Royalties, Contract and Professional Charges, and Construction and Engineering, 1991-2002

For contracts and professional charges, the payments for these services increased at a slower pace than the receipts for the period between 1992 and 2002, with average growth rates of 10.8% per annum for payments and 12.5% for receipts. The result was a smaller increase in the deficit for this transaction (8.6% per annum), which was the lowest among the three groups of transactions. In terms of absolute figures, the deficit in contract and professional charges has widened

from RM 1.1 billion in 1992 to RM 2.4 billion in 2002 (Figure 7.4).

The deficit in construction and engineering payment flows grew at an average rate of 11.8% per annum between 1992 and 2002. Receipts peaked at RM 5.21 billion in 1998, while payments peaked at RM 7.65 billion in 1999. However, the deficit had improved from RM 4.50 billion in 2000 to RM 2.00 billion in 2002 (Figure 7.5).

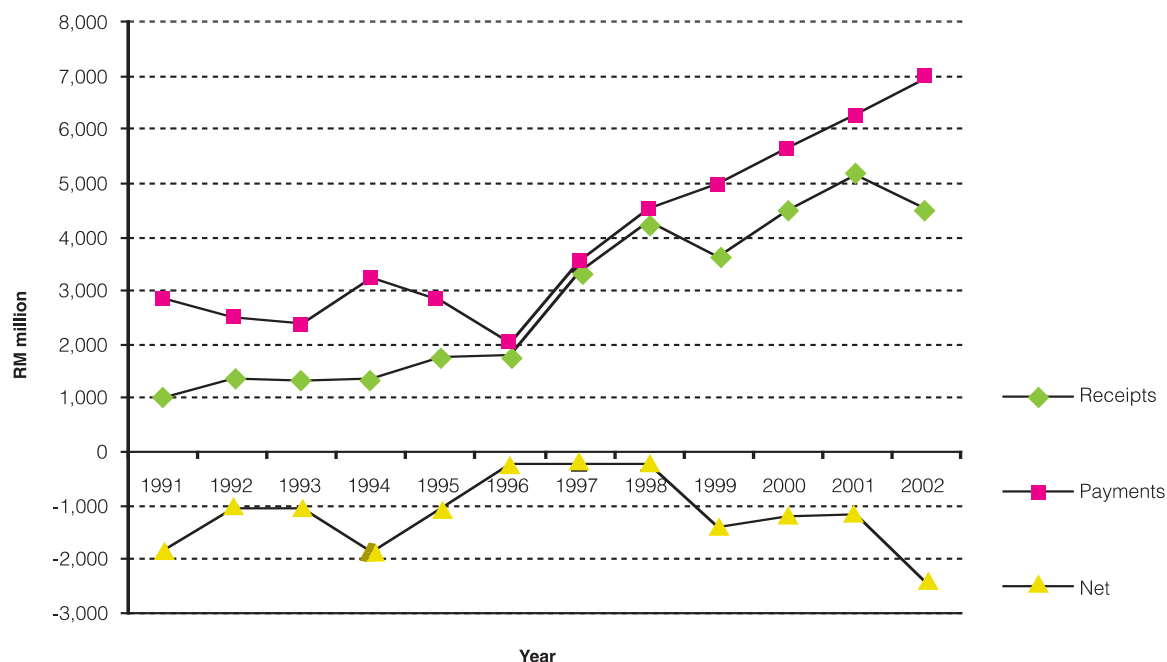


Figure 7.4: Payments and Receipts for Contracts and Professional Charges, 1991-2002

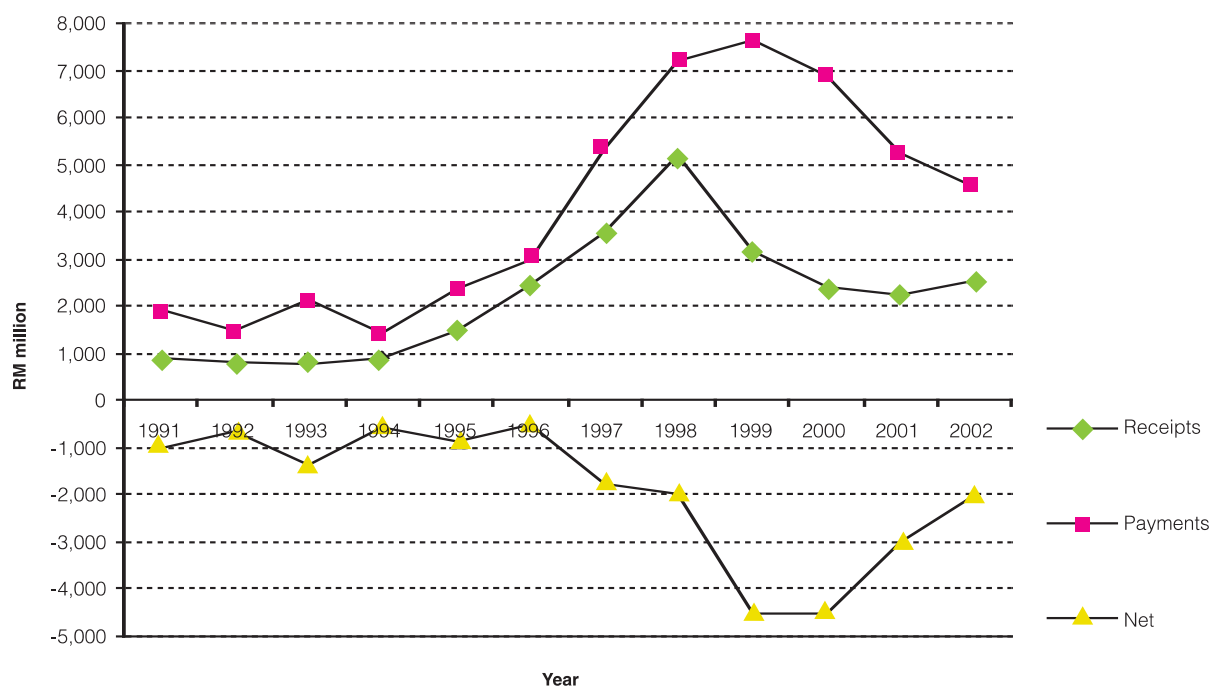


Figure 7.5: Payments and Receipts for Construction and Engineering, 1991-2002

7.4 Destinations of Payment and Sources of Receipt Flows

7.4.1 Royalties

The United States continued to be the largest source of the receipt of royalties for Malaysia, although the income had reduced slightly to RM 29.2 million in 2002 from RM 30.0 million in 2000. United Kingdom was the second most important source of royalty receipts at RM 11.6 million, followed by Singapore at RM 6.4 million. Japan, which ranked as the second highest recipient in 2000, fell to the fourth position, with amount of receipts falling from RM 14.3 million in 2000 to RM 4.9 million in 2002 (Figure 7.6).

In the case of destinations of payment of royalties, United States remained at the top position, where payments increasing from RM 928.3 million in 2000 to RM 1.03 billion in 2002. This constituted 41.1% and 43.0% of the total royalty payments for each of the years, respectively. Japan ranked second, at RM 601.5 million in 2002, followed by United Kingdom, Singapore and Switzerland, each with RM 212.6 million, RM 125.8 million and RM 105.2 million respectively. The ranking of the top five destinations for royalty payments in 2002 did not change from the year 2000 (Figure 7.7).

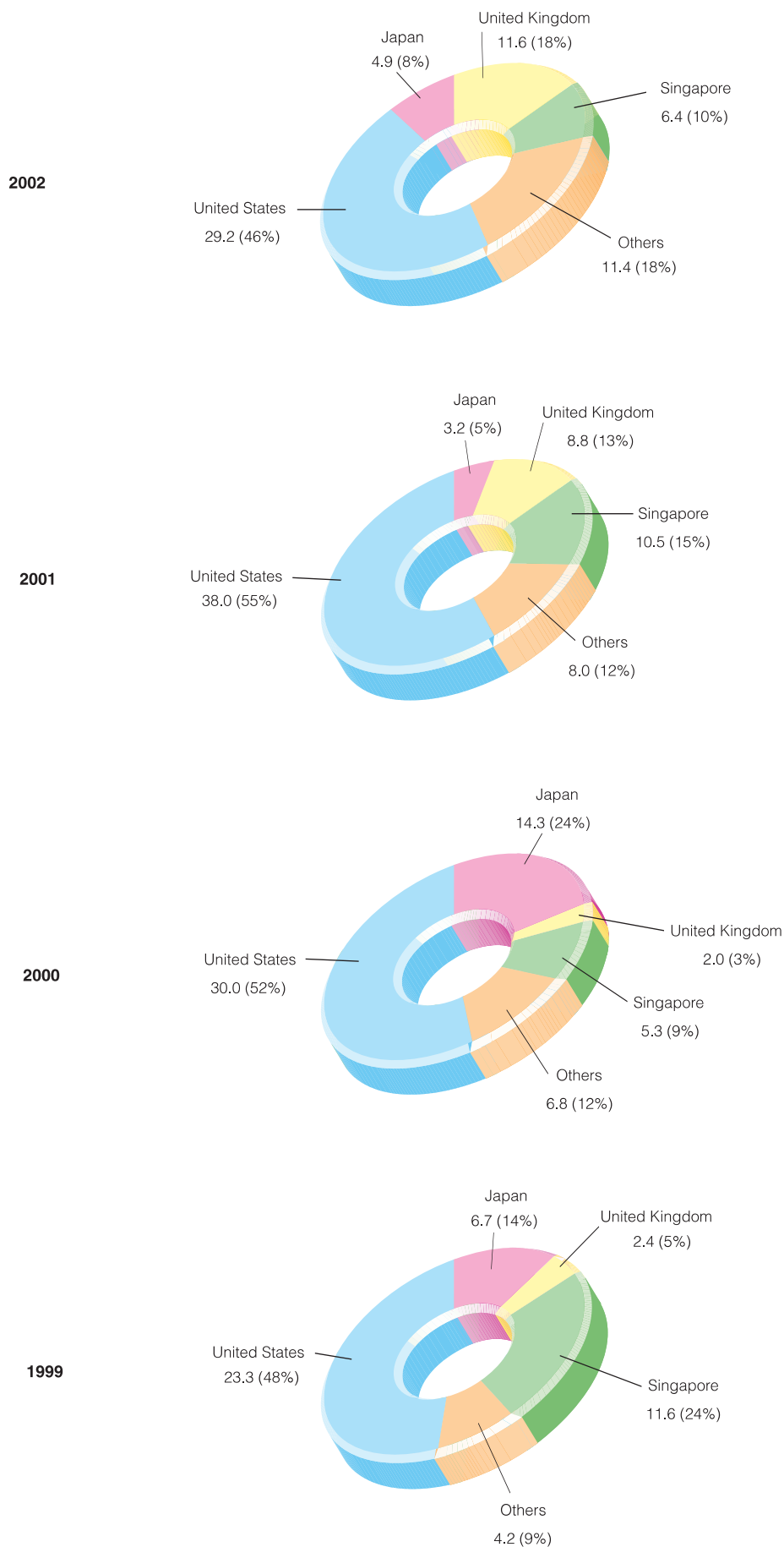


Figure 7.6: Major Sources of Royalty Receipts, 1999-2002

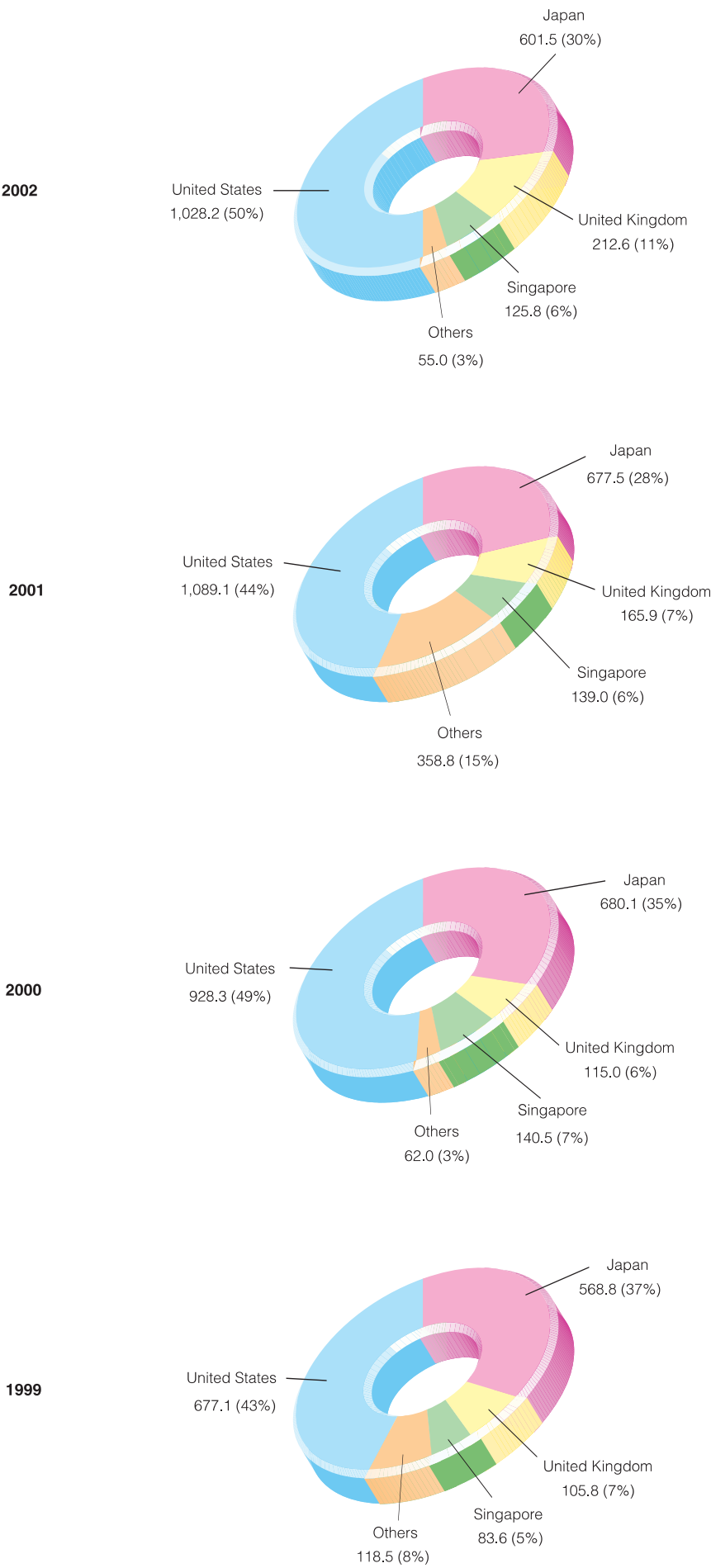


Figure 7.7: Major Destinations of Royalty Payments, 1999-2002

7.4.2 Contracts and Professional Charges

For contracts and professional charges, the United States accounted for the largest share for both payments and receipts, constituting 24.8% and 38.5% of the total amounts respectively in the year 2002. Singapore was second in position for both payments and receipts, followed by United Kingdom, Japan and Hong Kong (Figures 7.8 and 7.9).

The top five countries formed the bulk of payments and receipts in contract and professional charges. With total payments of RM 4.8 billion and total receipts of RM 3.5 billion in 2002, they constitute 69.8% and 77.9% of total payments and receipts respectively. These trends were similar to those in 2000, where the same countries cumulatively accounted for 70.1% of total payments and 75.4% of total receipts.

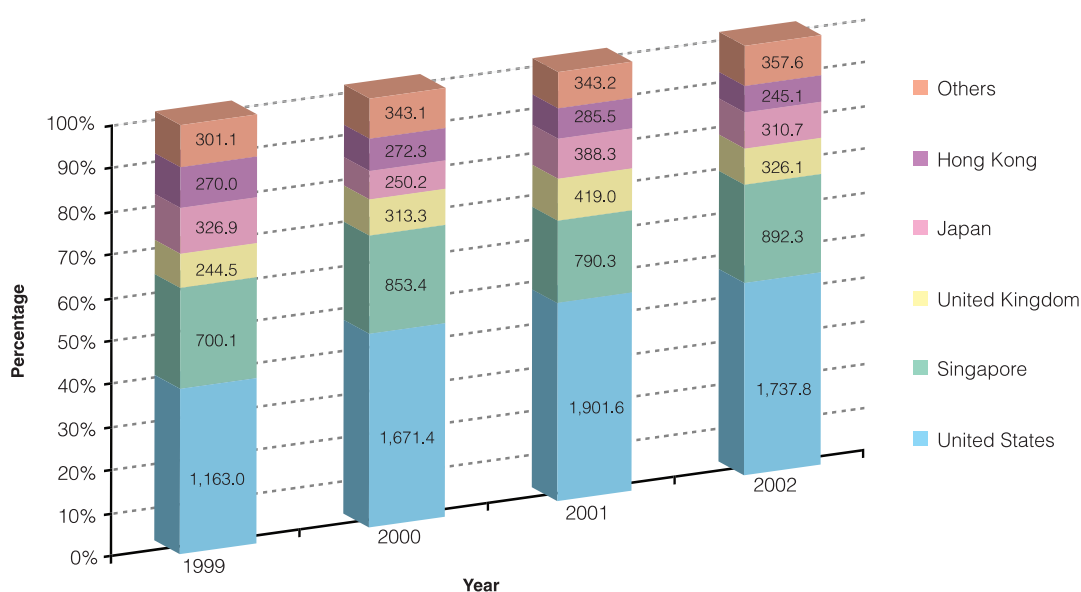


Figure 7.8: Major Sources of Contracts and Professional Charges Receipts, 1999-2002

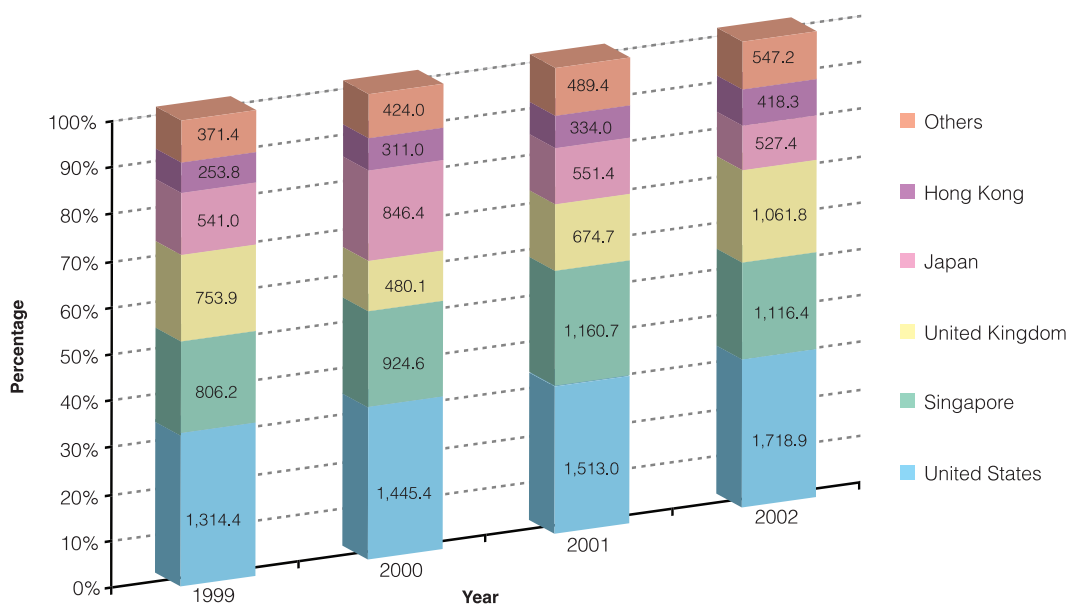


Figure 7.9: Major Destination for Contracts and Professional Charges Payments, 1999-2002

7.4.3 Construction and Engineering

The United States accounted for the largest share of both payments and receipts in construction and engineering, constituting 36.2% and 22.2% in each of the trade flows in the year 2002 respectively. In absolute figures, payment made to United States was RM 1.0 billion and receipt was RM 922.2 million in 2002. This is in contrast to the trend in 2000, where Japan ranked first in the destination for payments for construction and engineering services,

accounting for 44.3% of the total payment for that year. In addition, payments to Japan had reduced from RM 3.2 billion in 2000 to RM 925.3 million in 2002 (Figures 7.10 and 7.11) .

Japan ranked second for both payments and receipts, followed by Singapore and United Kingdom. South Korea ranked fourth for payments, and Germany ranked fourth for receipts. Cumulatively, the top five countries accounted for 71.0% of the total payments and 74.7% of the total receipts.

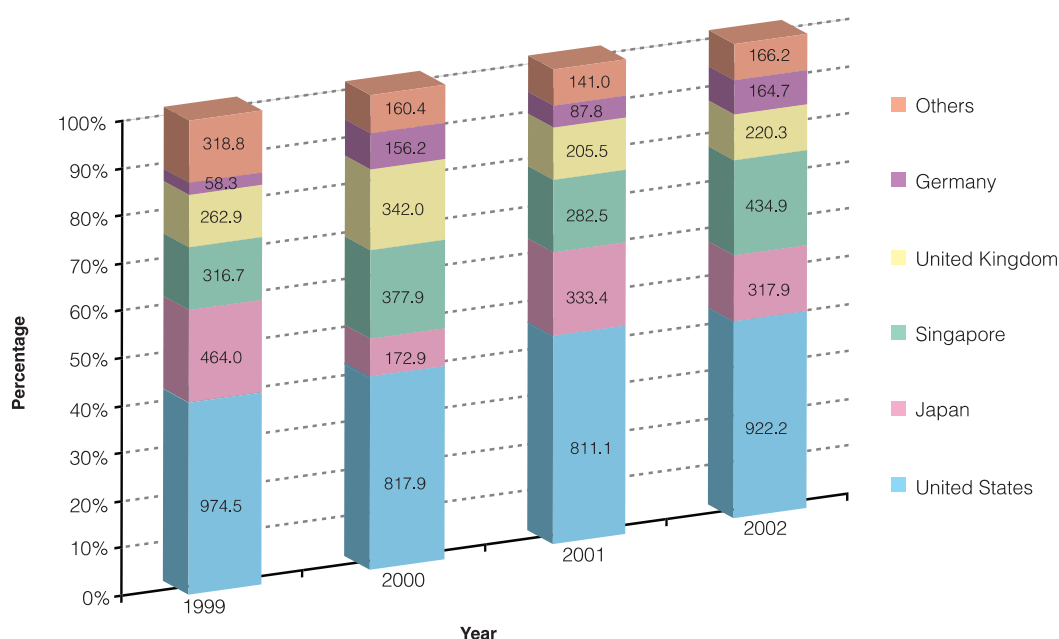


Figure 7.10: Major Sources of Construction and Engineering Receipts, 1999-2002

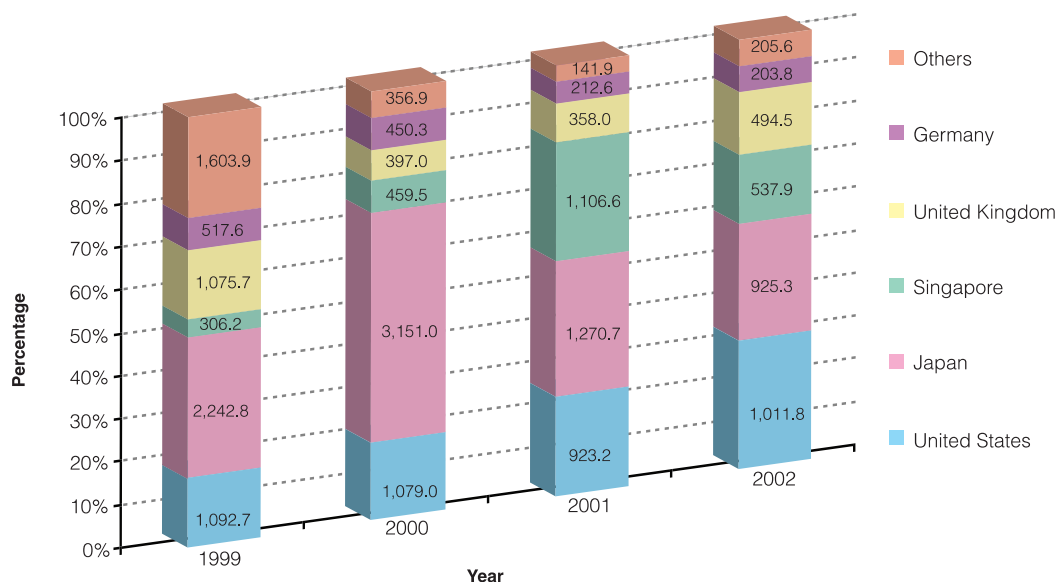
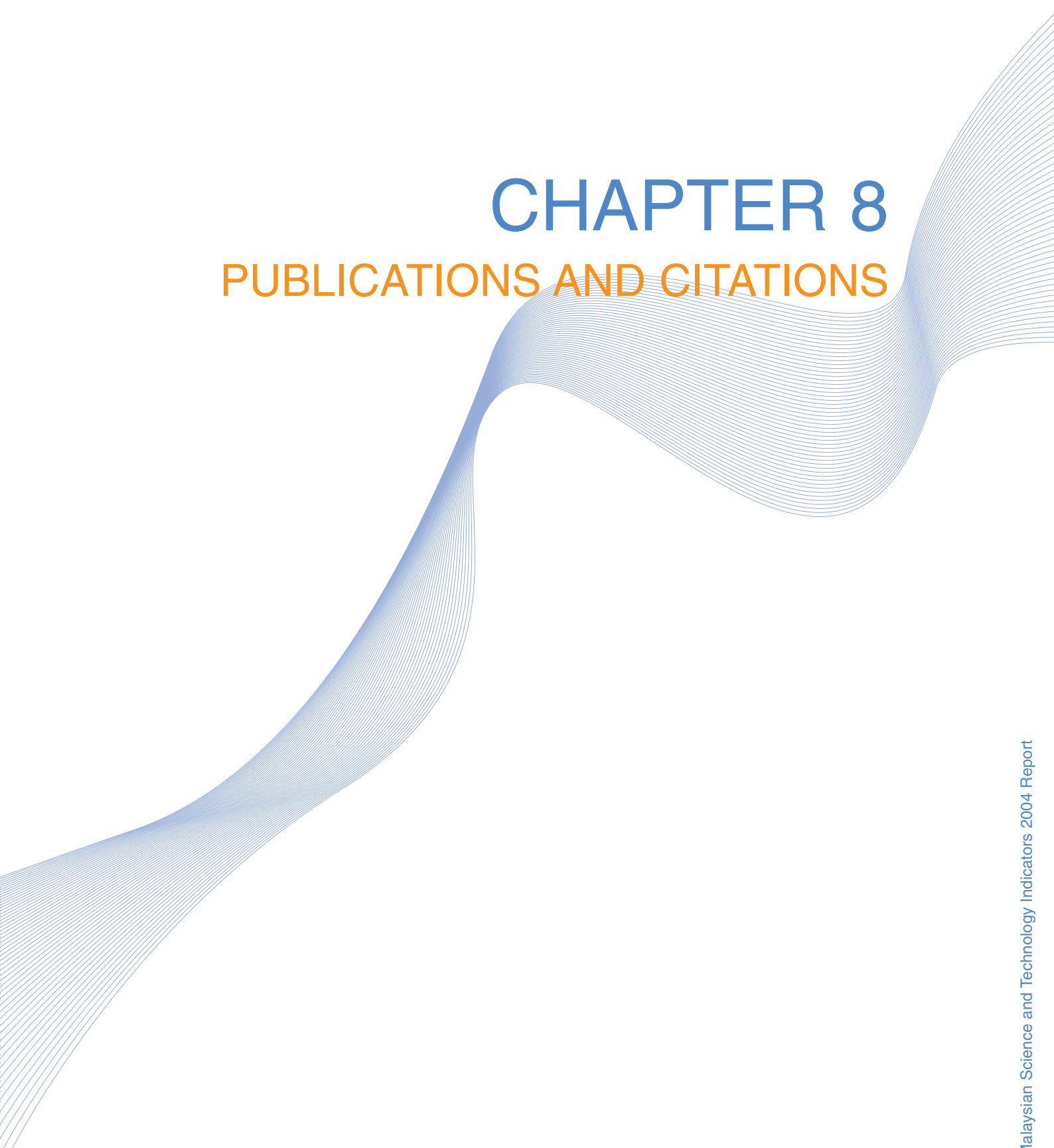


Figure 7.11: Major Destinations of Construction and Engineering Payments, 1999-2002

In summary, Malaysia continues to register a trade surplus in high technology goods, although the trends indicate decreasing surplus from the peak of RM 51.5 billion in 1999 to RM 34.9 billion in 2002. However, the country posted an improvement in the trade deficit of medium-high technology goods, where the figure has improved from the highest point of –RM 22.2 billion in 2000 to – RM 17.3 billion in 2002. Overall, exports in medium and high technology goods are still higher than imports, which run parallel to the overall trade surplus that the country is enjoying in all categories.

The picture is not so rosy for technology related services. The country registered a net outflow of money, amounting to RM 6.8 billion in 2002 for the payment of royalties, contracts and professional charges and construction and engineering. Although this figure is an improvement from the highest deficit achieved in 2000 (RM 7.9 billion), coverage ratio (51.3%) in 2002 is far lower than the highest achieved in 1998 (72.7%). Data shows that the problem lies with royalties, which registered a meagre growth of 0.1% in receipts but high growth of 17.4% in payments over the last 10 years.

In the case of coverage ratio, three distinct patterns can be observed between the categories of royalties, contracts and professional charges, and construction and engineering. The coverage ratio for royalties remained sluggish at 3% since 1998 while contracts and professional charges worsened to 65% in 2002 (as compared to 79% in 2000). However, construction and engineering recorded an improvement from a coverage ratio of 35% in 2000 to 56% in 2002.



CHAPTER 8

PUBLICATIONS AND CITATIONS

Bibliometrics is usually defined as the application of mathematical and statistical methods to the entire scientific literature, books and documents included (Pritchard, 1969). It has become a generic term for a range of approaches directed at quantifying output levels, collaboration patterns and impact characteristics of scientific research (Okubo, 1997). The advantage of bibliometric data on research documents is that they provide useful insights into the performance and visibility of institutions, countries and regions. When authors publish, they tell us what they are doing, with whom they did it, when and where it was done. These literature based or output based measures enable systemic comparisons of scientific performance of institutions, countries and regions across a range of scientific fields (May, 1997).

Scientific knowledge itself might be largely intangible, but the bibliographic or written information ('codified knowledge') resulting from scientific research has an objective existence and can be studied and referred to through bibliometric studies. Some important measures of knowledge production, transfer and utilisation can thus be derived from the publications in which scientific knowledge is embodied. These publications represent an intellectual contribution to a research topic or sub-field. The majority of scientific researchers especially academics, publish their major research findings in the open international scientific and technical journals. In the process researchers usually acknowledge work that has influenced them by citing the relevant source documents (research articles, books, reports, etc) in the reference lists or footnotes of those publications. In doing so, they leave a paper trail of their scientific activities, research topics, collaborative linkages and utilisation of external sources. The many thousands of articles, notes, letters and reviews that are published in those journals and millions of citations between these journal papers, provide a way of tracking knowledge communication and dissemination processes in science and thus, indirectly providing empirical data on research capacities and scientific activity of knowledge producing entities (Tijssen and van Leeuwen, 2003).

As reported by Tijssen and van Leeuwen, most large scale macro-level bibliometric studies are based on the analysis of research papers and citation links between papers published in international scientific and technical journals that are processed by the Institute for Scientific Information (ISI) Thompson Scientific which is based in Philadelphia, NJ, USA, for its series of international, multidisciplinary bibliographic databases. This being the case, Malaysia's visibility and research profile in the mainstream or internationally accepted scientific literature is derived from the ISI databases.

The advantages of the ISI Thompson Scientific databases are:

- i) the journals and scientific publications included in its databases follow some quality criteria (e.g. most journals are peer-reviewed), and
- ii) it is currently the only source that allows for a complex analysis of publications by countries, institutions, single authors and scientific fields or disciplines.

However, in relation to the almost absolute reliance on the ISI databases, there are certain limitations.

- i) Although the ISI databases are quite large in terms of indexed journals, its collective content of worldwide scientific publication output and research activity is not necessarily a good reflection of all worldwide scientific publication and research activity especially in the social and behavioral sciences, law and the humanities.
- ii) The databases are biased in favour of English-language journals. Non-English journals are not as comprehensively indexed and thus articles in the Malay language will not be reflected in these databases.

In spite of these limitations, the international journal publications in these databases provide a satisfactory representation of internationally accepted (mainstream) research, especially high-quality 'laboratory based' basic research in the natural sciences, medical sciences and life sciences (Tijssen and van Leeuwen, 2003).

In view of the importance of publications and citations as indicators of scientific knowledge creation and diffusion, the Malaysian Science & Technology Information Center (MASTIC), Ministry of Science, Technology and Innovation commissioned a national bibliometric study to be carried out in 2003. The aim of the study was to create a national bibliometric database for Malaysia. This study covered 13,475 papers of over 16,828 scientists from 105 countries in 59 S&T subject fields over the period 1955-2002 (MASTIC, 2003). The findings of the national bibliometric study however, need to be analysed separately due to data definition and input differences when compared to the ISI databases. To elaborate, as an example, the ISI subject fields are divided into 2 categories i.e. (1) standard version, which covers 24 broad subfields in the sciences and social sciences, and (2), deluxe version which consists of 105 narrower fields including the humanities (Appendix I and II). On eliminating the non S&T fields, the standard and deluxe fields total 19 and 82 fields for the ISI databases while in the case of the national study, 59 fields in S&T have been identified. Thus any attempt to draw comparisons between the ISI databases and the national bibliometric study has to be done with caution.

8.1 Bibliometric Database and Indicators

The most widely used databases are the Institute for Scientific Information (ISI) databases.

Bibliometric indicators enable an output-oriented 'systems analysis' of research capabilities, activity and related scientific interactions. These bibliometric indicators, acting as impartial 'observers' of science, provide objective data on several key features

of research capabilities, collaboration, outputs and impacts (Tijssen and van Leeuwen, 2003).

The most commonly used journal-based bibliometric indicators are publication counts and citation counts. Publication count is the most basic bibliometric measure where the measure is simply to count the number of publications produced. The number of papers published in international journals provides estimates of the volume of research activity and related knowledge production (Tijssen and van Leeuwen, 2003). It has to be noted that counts of publications in the ISI databases is not equal to research activity, but rather to the production of publicly available, research-based codified knowledge for the international research community or in other words, that which is publicly accessible to the international research community.

The second bibliometric indicator or measure is citation counts. If publication counts measure output, counting the citations received by papers published provide a quantification of the transfer and utilization of knowledge. This is based on the basic premise that a frequently cited paper has had a greater influence or impact on subsequent research activities than a research paper with no citations or only a few citations. The relative number of citations is also often considered a proxy measure of visibility within the research community.

However, when interpreting citations as an output of research activity, one has to be mindful about the many reasons for one research article citing the other, not all of which are directly related to the scientific quality of the cited work or the contributions of researchers and institutions as well as the frequent occurrence of self citation. The bibliometric data used in this report are based on the following ISI databases:

- i) National Science Indicators (NSI) (commissioned by MASTIC), and
- ii) National Citation Report - Malaysia (NCR) (commissioned by MASTIC)

Chapter 8 Publications and Citations

The NSI database (1981-2002) offers measures on national performance in the sciences, social sciences and humanities for over 170 nations and 4 regions, viz, Asia-Pacific, Asia-Pacific (excluding Japan), the European Union and Latin America. This database contains the number of ISI – indexed papers from each nation and region and the number of times the papers were cited through 2002. Twenty-four broad subfields in the sciences and social sciences (standard version) or 105 narrower fields including the humanities (Deluxe Version) are compared on their overall performance.

On the other hand, the National Citation Report – Malaysia is an electronic database of Malaysia’s journal articles in the sciences, social sciences and humanities.

8.2 National Science Indicators (NSI) Database

8.2.1 An Overview of Publications Output By Country

The NSI database provides data on the ranked percentage share or output of papers by country, for the period 1981-2002 and the ranking by country in terms of the national performance of 178 nations in the sciences, social sciences and humanities over a cumulative 22 year period. (Figure 8.1a and 8.1b)

The United States had the highest output of papers with over 4.9 million papers, or 37.64% of the world’s output. Next in rank was the UK (9.06%) and thirdly, Japan (8.13%) (Figure 8.1a). Figure 8.1b and 8.1c show the countries with below 1% share or output of world’s papers. Malaysia’s share of output of papers totaled 10,538 papers or 0.08% of the world output, which placed Malaysia in the 55th position together with Kenya, Iran and Slovenia. Comparing Malaysia’s performance with countries in this region with similar economic standing, it is interesting to note that India was at the 11th position, China (14th), South Korea (25th), Taiwan (26th), Singapore (42nd) Thailand (52nd).

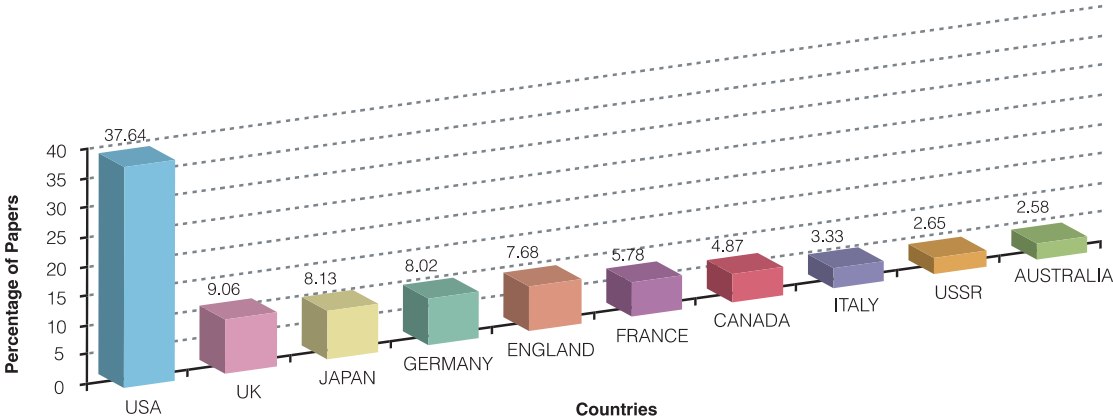


Figure 8.1a: Percentage Share of World Papers in 22 Year Period (The Top 10 Countries), 1981- 2002

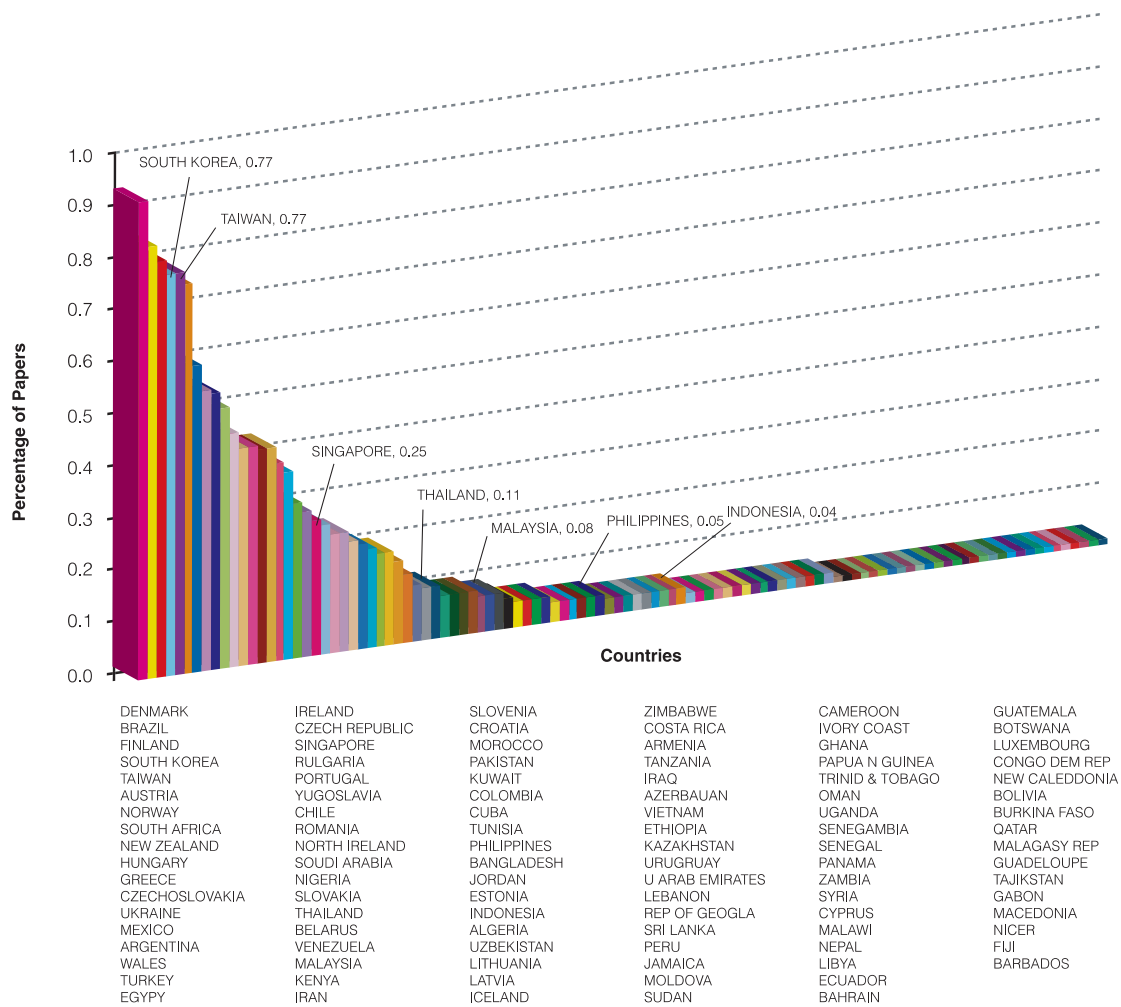


Figure 8.1b: Percentage Share of World Papers (Below 1%) in 22 Year Period, 1981- 2002

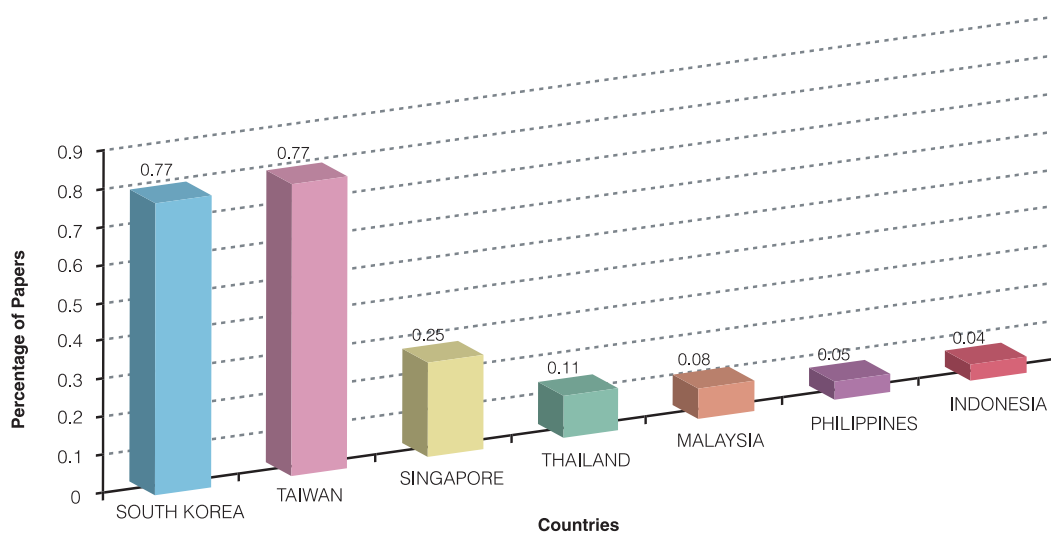


Figure 8.1c: Percentage Share of World Papers in 22 Year Period (Selected Asean Countries, Taiwan & South Korea), 1981-2002

Figure 8.2 shows the percentage output of papers for selected countries over the cumulative 22 year period (1981-2002). As can be seen, the largest contributor to the world's

publication output was the US with over 37%, followed by the United Kingdom and Japan with more than 8% of output.

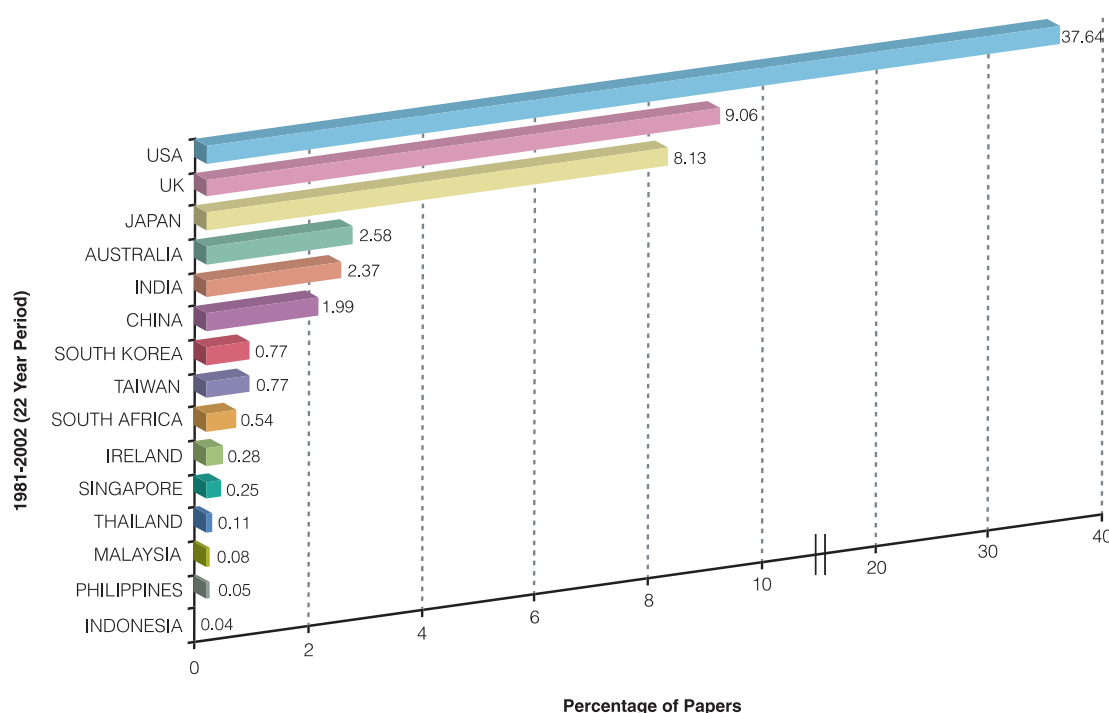


Figure 8.2: Percentage Share of Papers For Selected Countries, 1981-2002

Figure 8.3 shows the output pattern for selected countries in 5 year overlapping periods. The total output for the US surpassed that of the other countries. However its growth pattern showed a decline in the output of papers in the nineties. Its closest competitors although lagging behind in total output, showed a general increase in publication output in the nineties. This general pattern of growth in publication output was also true for its Asian counterparts in the nineties. Nonetheless, the publication output gap still remained wide compared to the US, as the knowledge production in the US is more than three times that of the UK and Japan and almost 38 times that of other newly industrializing Asian countries which individually, contributed less than 1% of the worlds' share. For Malaysia, it is obvious that the pace of growth in the eighties has been minimal at about 1% but the nineties had seen a slight increase.

8.2.2 Publications of Malaysia

Figure 8.4 provides an insight into the publication output of Malaysia in the 105 subject fields (deluxe fields) of the ISI database. As can be seen the subject coverage is wide and includes the sciences, social sciences and the humanities. The ISI subject classification is provided in Appendix 1. From the fields covered, Malaysia had publications in all the 105 fields. Nonetheless, the figures show that there was a bias toward the S&T fields rather than the social sciences and humanities in which the productivity was higher for S&T fields.

The most productive field was Physical Chemistry/Chemical Physics with a total of 838 papers or 7.95% of total Malaysian output. Second in line was Materials Science and Engineering, followed by Organic Chemistry/Polymer Science in third position and fourthly, is Environment/Ecology.

On combining fields or using broader fields, i.e. using standard fields as in the Appendix 1, the four fields with the highest productivity or output in Malaysia were Clinical Medicine, Chemistry, Plant and Animal

Sciences, and Agricultural Sciences, as shown in Figure 8.5. The less productive or weaker fields were Astrophysics, Computer Science and Neurosciences in Malaysia with less than 1% of papers.

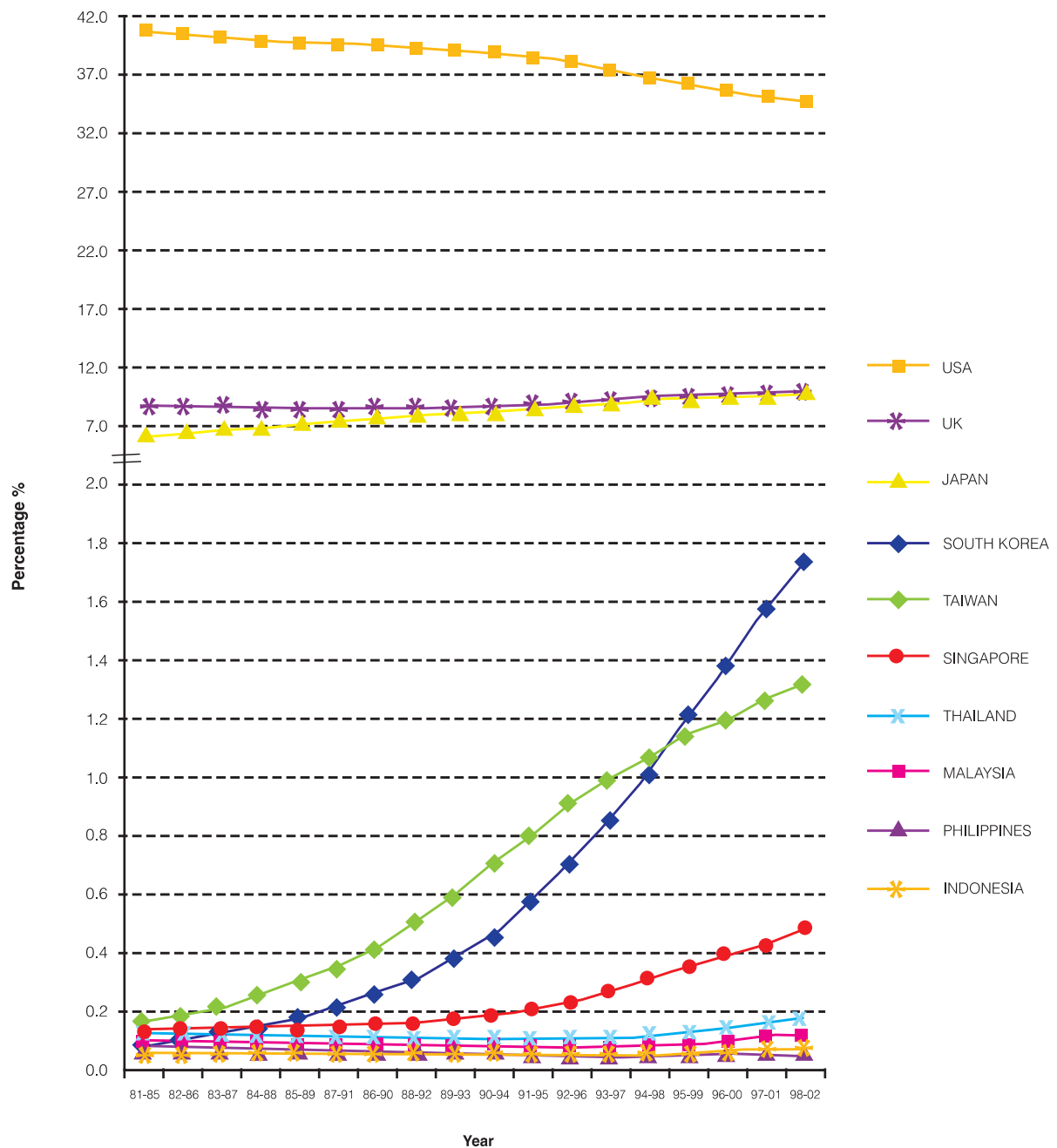


Figure 8.3: Percentage of World Papers for Selected Countries in 5 Years Overlapping Periods, 1981-2002

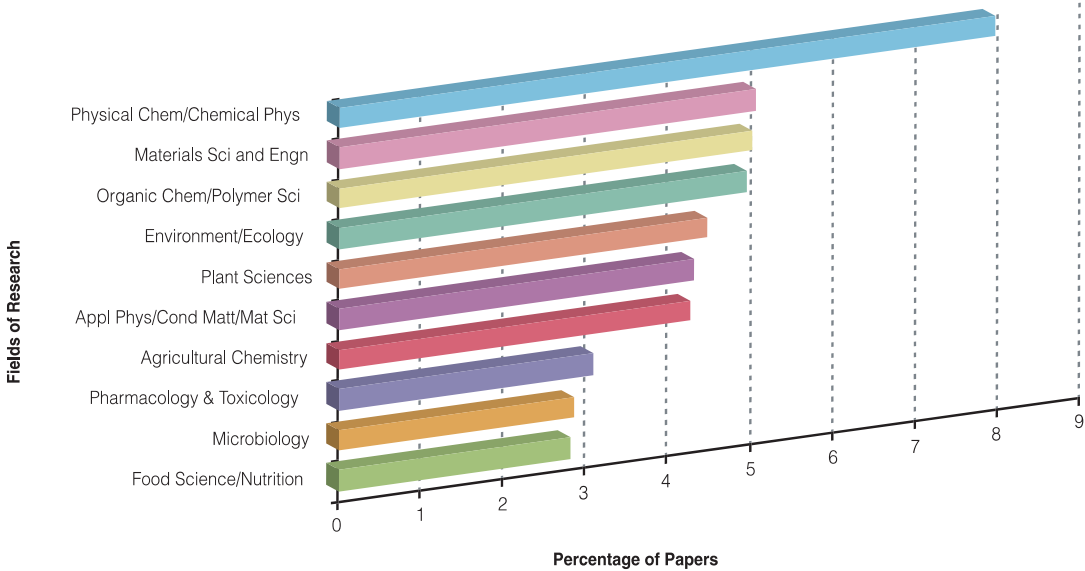


Figure 8.4: Malaysian Scientific Papers by Top 10 Field of Research, 1981-2002

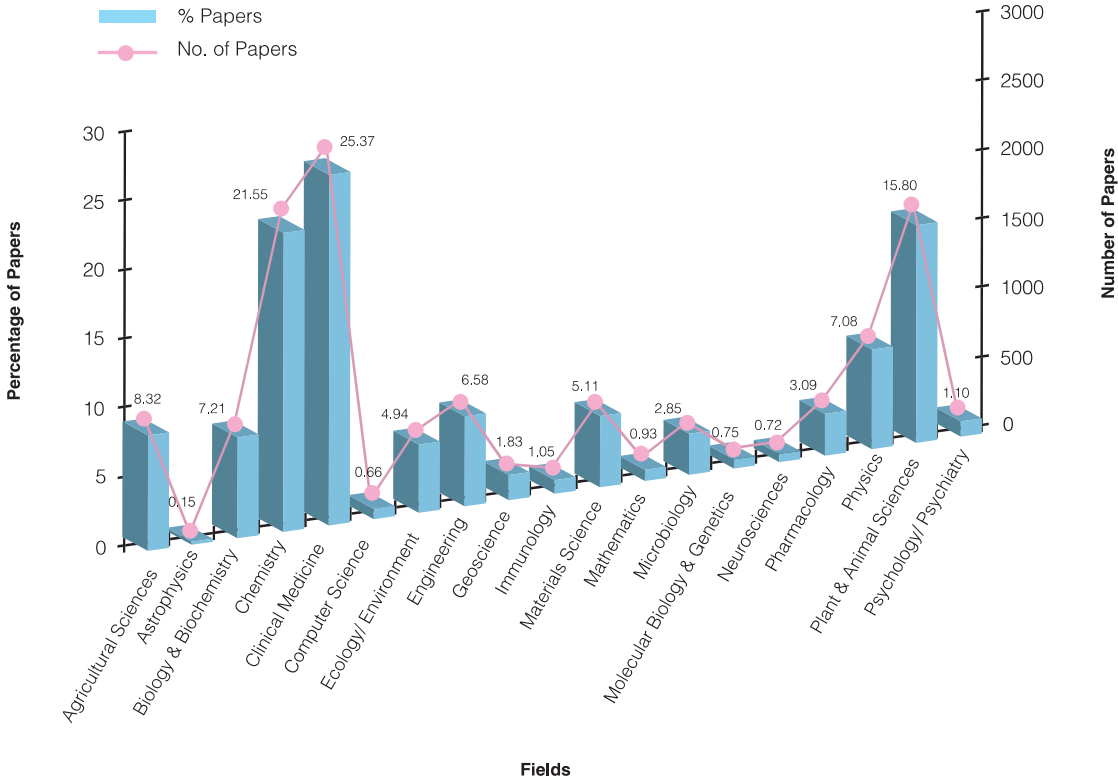


Figure 8.5: Percentage and Number of Papers for Malaysia by Standard Fields, 1981- 2002

Figures 8.6a and 8.6b show the international standing of Malaysian papers as it shows the number of papers and the

percentage of Malaysian papers compared to the world output of science papers for the years 1981-2002.

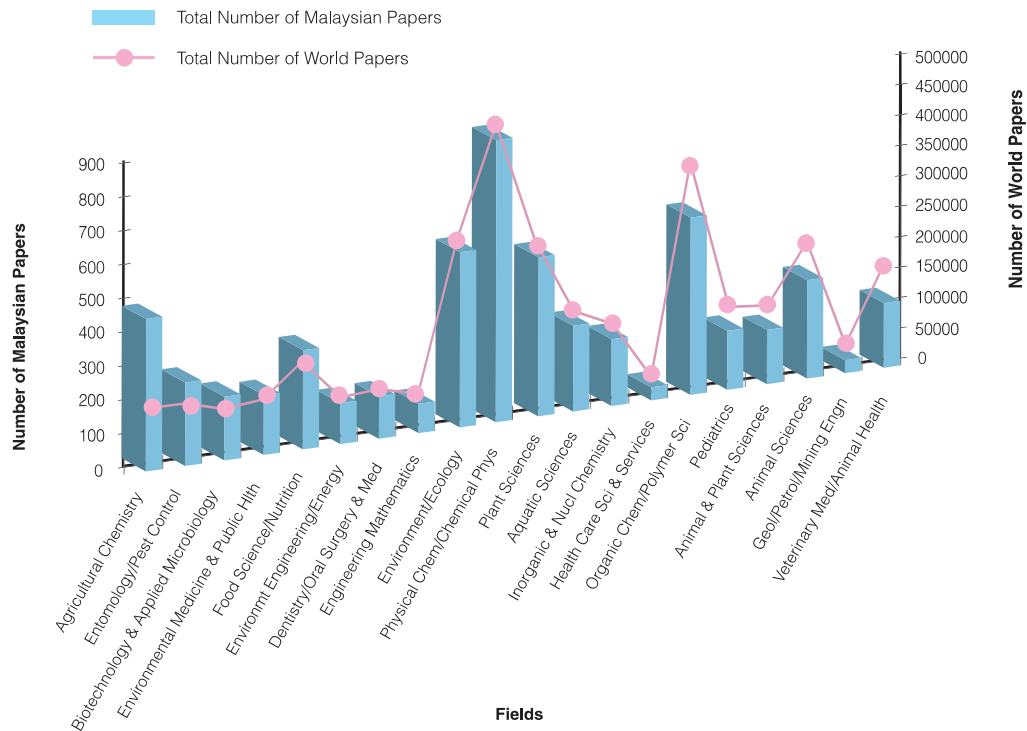


Figure 8.6a: Total Number of Top 20 Malaysian Papers to Scientific Papers, 1981-2002

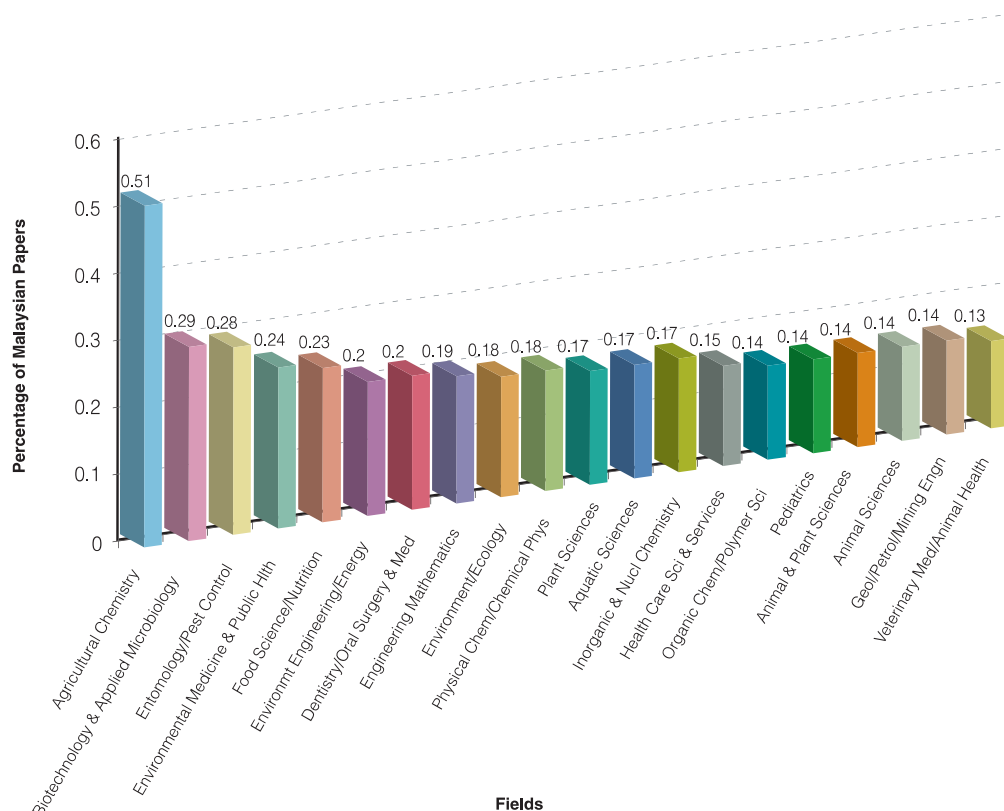


Figure 8.6b: Percentage of Malaysian Papers by Ranked Field of Research to Scientific Papers, 1981-2002

The international comparison by fields (i.e. deluxe fields as in Appendix I) shows that Malaysia's share of papers in Agricultural Chemistry was the highest among the science and technology fields as it amounted to 0.51% of the world output. Although Physical Chemistry/Chemical Physics was the most productive field in Malaysia, in international terms, Malaysia's share in this field amounted to only 0.18% of the world output (Figure 8.6b).

Bearing in mind the ISI subject field classification i.e. standard and deluxe fields as in Appendix I, on comparing standard fields or broader fields, the share of Malaysian papers to the world output or her relative contribution to the world output for standard fields is as shown in Figure 8.7. Malaysia's share or relative contribution to the world was highest for Agricultural Sciences, Ecology/Environment and Plant and Animal Sciences.

In terms of new scientific fields or future/key-technologies, namely, the fields of biotechnology, nanotechnology, space science, nuclear engineering, metallurgy and cell and developmental biology, Malaysia's share of papers was still negligible and lagging behind that of other fields.

Figure 8.8 shows the number of papers/ publications by top 10 fields of research for four Asian countries i.e. Taiwan, Thailand, Philippines and Malaysia. As can be seen the top field of research with the highest number of publications for Taiwan was Applied Physics/Material Sciences, for Thailand it was Medical Research, for Philippines it is Agriculture/Agronomy whilst for Malaysia, Physical Chemistry/Chemical Physics occupied the top position.

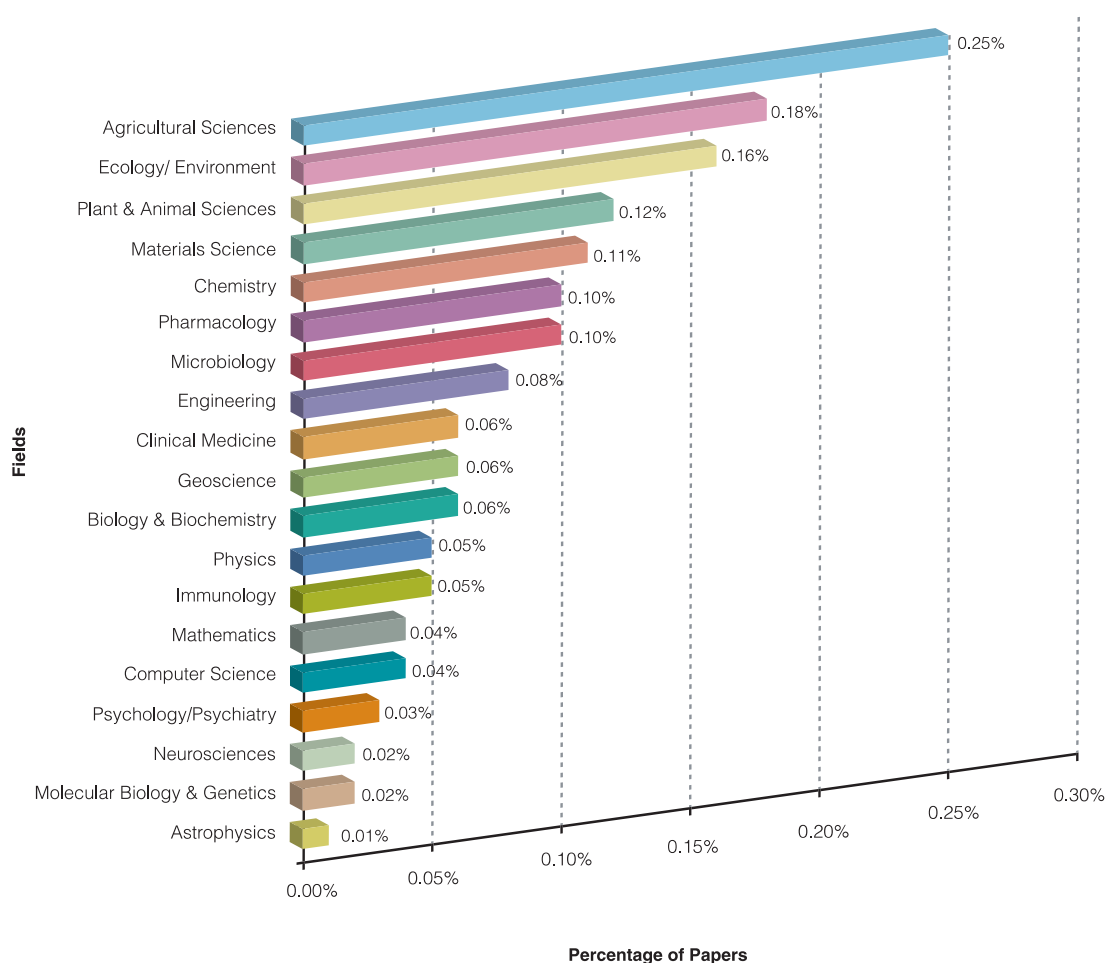


Figure 8.7: Percentage of Malaysian Papers to Scientific Papers by Standard Fields, 1981-2002

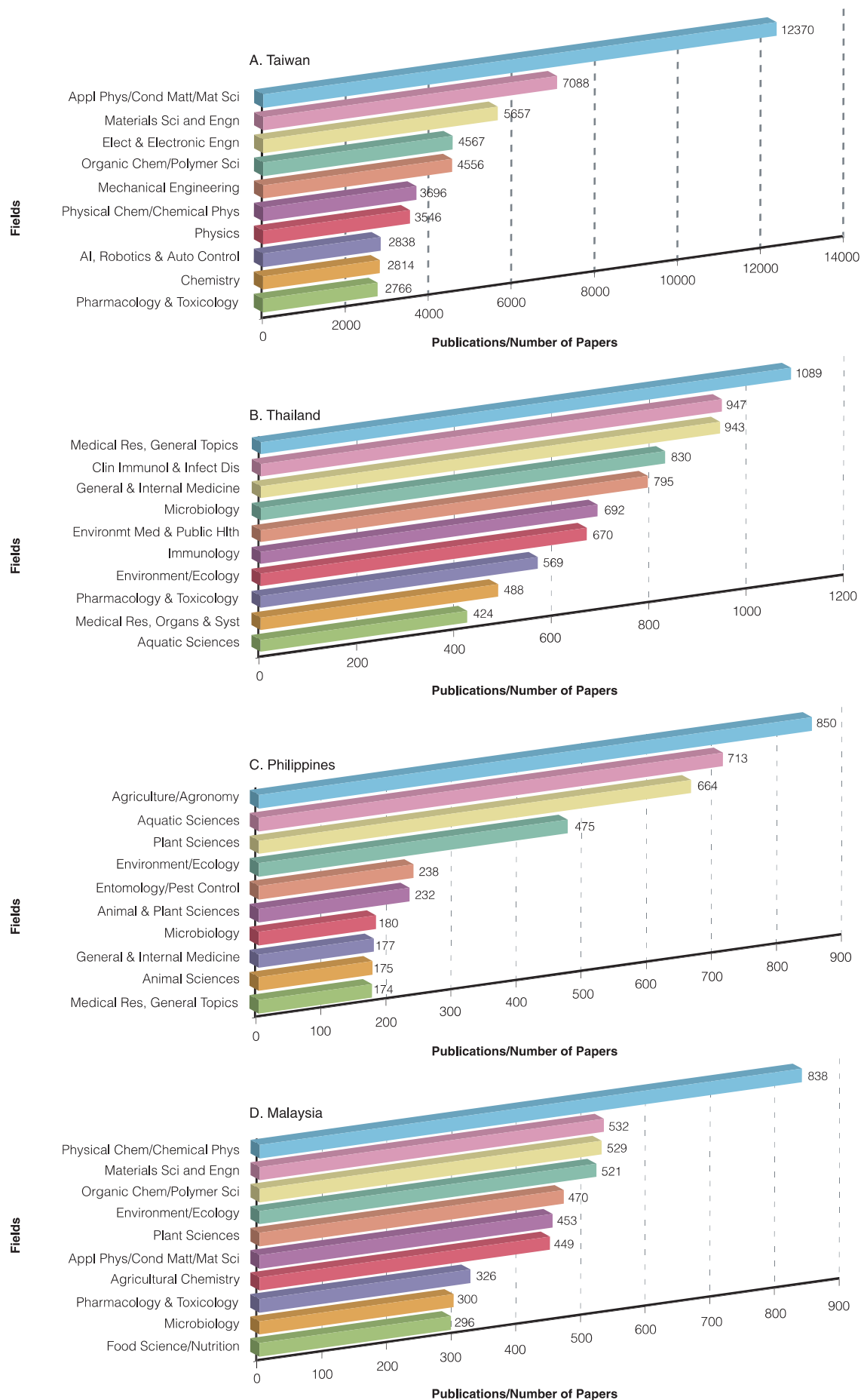


Figure 8.8: Publications/Number of Papers by Top 10 Fields of Research for Taiwan, Thailand, Philippines and Malaysia, 1981-2002

8.3 National Citation Report - Malaysia

As noted earlier the second bibliometric indicator or measure is citation counts. This measure is directly related to the influence or impact a paper has had on subsequent research. A paper that has been cited more frequently is said to have a greater influence over another that has no citations or few citations. Based on the database from National Citation Report—Malaysia database from ISI, the findings are presented below.

8.3.1 Authors' Contribution and Impact

Figures 8.9a shows that the top performer or author in terms of publications was Fun Hoong Kun of Universiti Sains Malaysia (USM) with 582 papers, mostly in the field of Physical Chemistry/Chemical Physics, while the author with the most citations or impact was Ng Seik Weng of Universiti Malaya (UM), in the same field (Figure 8.9b). This is from ISI's National Citation Report in which the Malaysia Database showed a total of 16,437 authors.

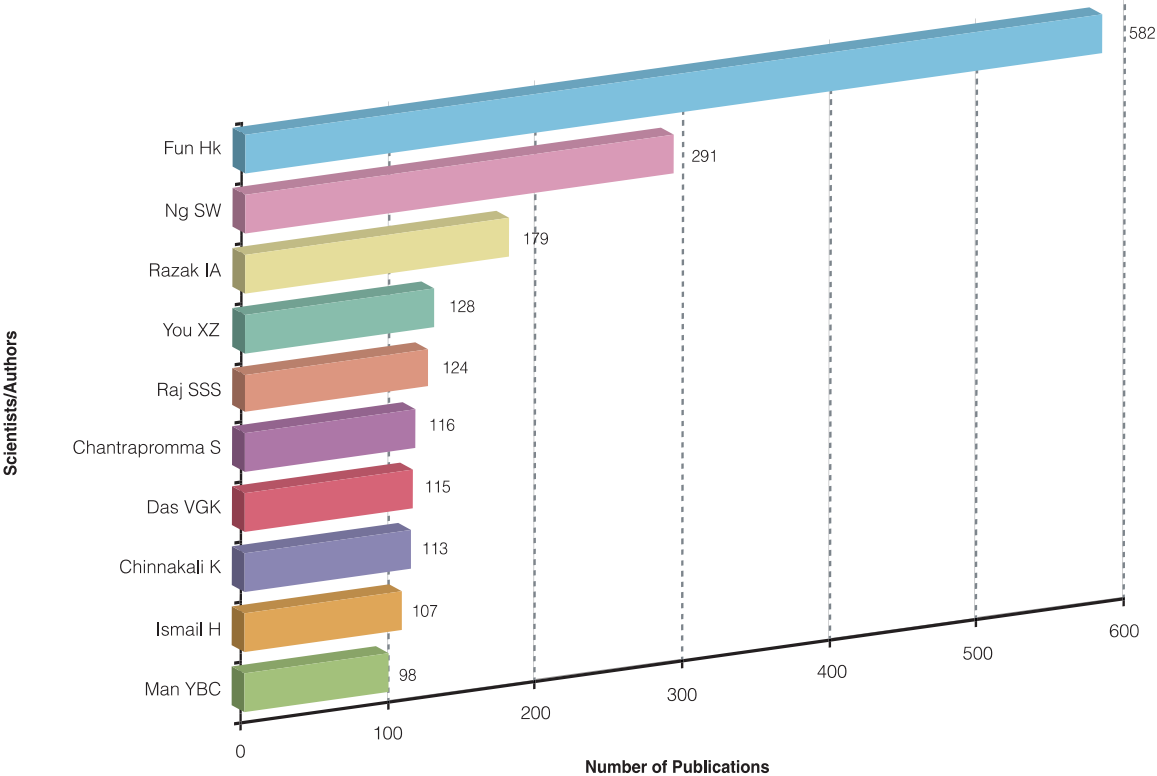


Figure 8.9a: Top 10 Individual Scientists'/Authors' by Publication, 1981-2002

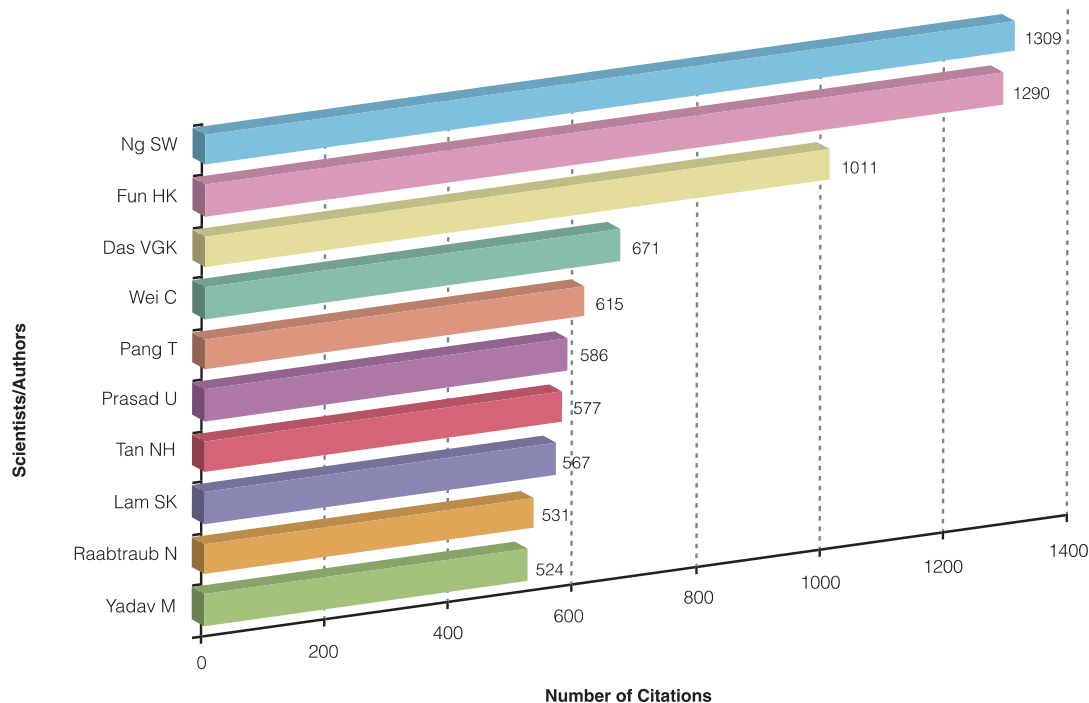


Figure 8.9b: Top 10 Individual Scientists/Authors' Impact by Citations, 1981-2002

8.3.2 Scientific Collaboration and Cooperation

Data from the NCR-Malaysia is also used to identify scientific collaboration and cooperation between countries as publications or papers with addresses from institutions in different countries are indicated and can be identified to indicate collaboration between countries.

In general collaborative work among Malaysians and most of the other nations of the world ranging from Algeria to Zimbabwe was evident. As shown in Figure 8.10, the highest collaboration or cooperative work for Malaysia was with England where a total of 944 source papers carried these countries in their addresses indicating collaboration. This is followed by the United States and Australia. It may be said that collaborative or cooperative work seems to be guided by research interest and language compatibility rather than geographic proximity.

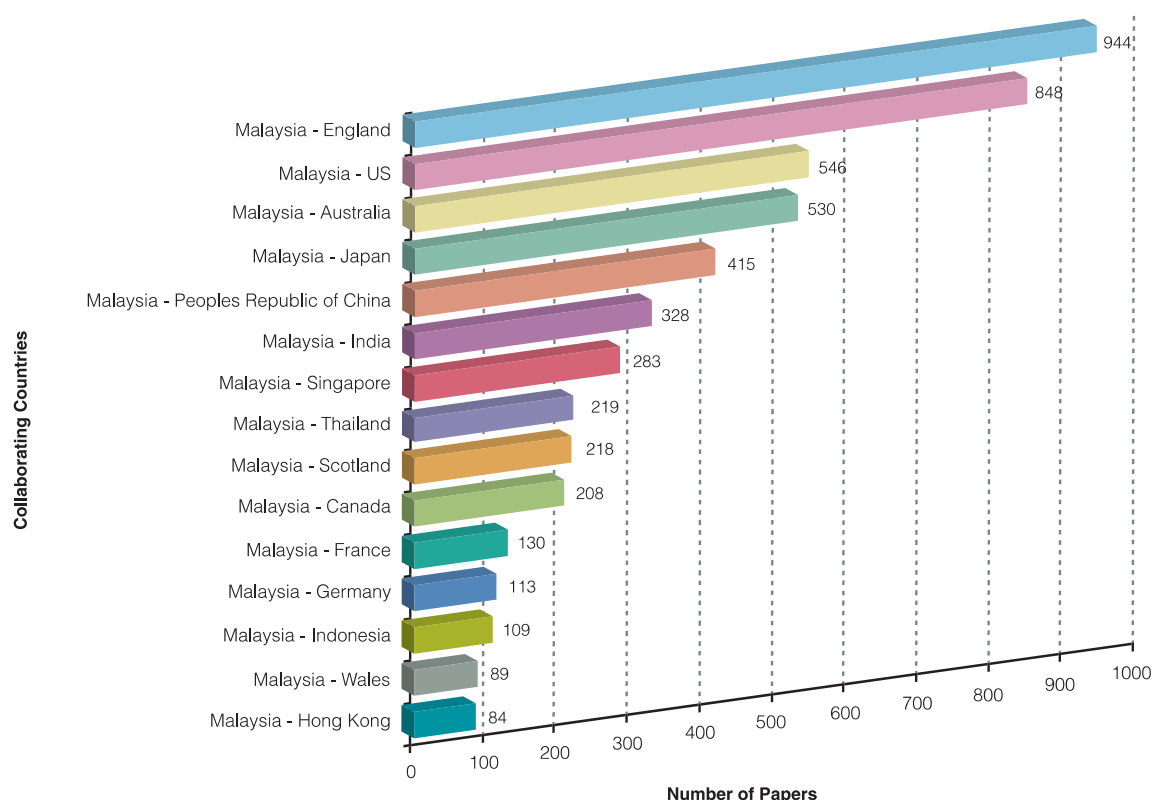


Figure 8.10: Countries that Collaborated with Malaysia sorted by Total Number of Source Papers/Publications, 1981-2002

In terms of institutional or organisational collaboration, USM was the most active in its collaborative effort. Data from the NCR shows that the highest cooperative work was between Universiti Sains Malaysia and Nanjing University of China where a total of 179 source papers carried the names of these organizations. This is shown in Figure 8.11.

Publication output and citation impact of Malaysian institutions/ organizations is shown in Figure 8.12. On examining output by organisations' or institutions' names, it may be said that the universities with a longer history tends to have higher output and citation impact. Figure 8.12 shows Universiti Malaya has the highest number of papers at 4079 papers which received a total of 18859 citations. Next in line is USM at almost half the output level of Universiti Malaya and citation impact, followed by UPM and UKM. Among the public research Institutes in Malaysia, the Institute of Medical Research (IMR) and Palm Oil Research Institute of Malaysia (PORIM)

were the highest contributors with 128 and 93 papers respectively. The citations these papers received totaled 799 for IMR and 427 for PORIM.

On examining the cited papers among these organisations showed that the significance of their influence as they received an average of 6.24 cites per paper in the case of the IMR and 4.59 cites per paper in the case of PORIM as compared to 4.62 cites per paper for University of Malaya and 2.71 cites per paper for USM.

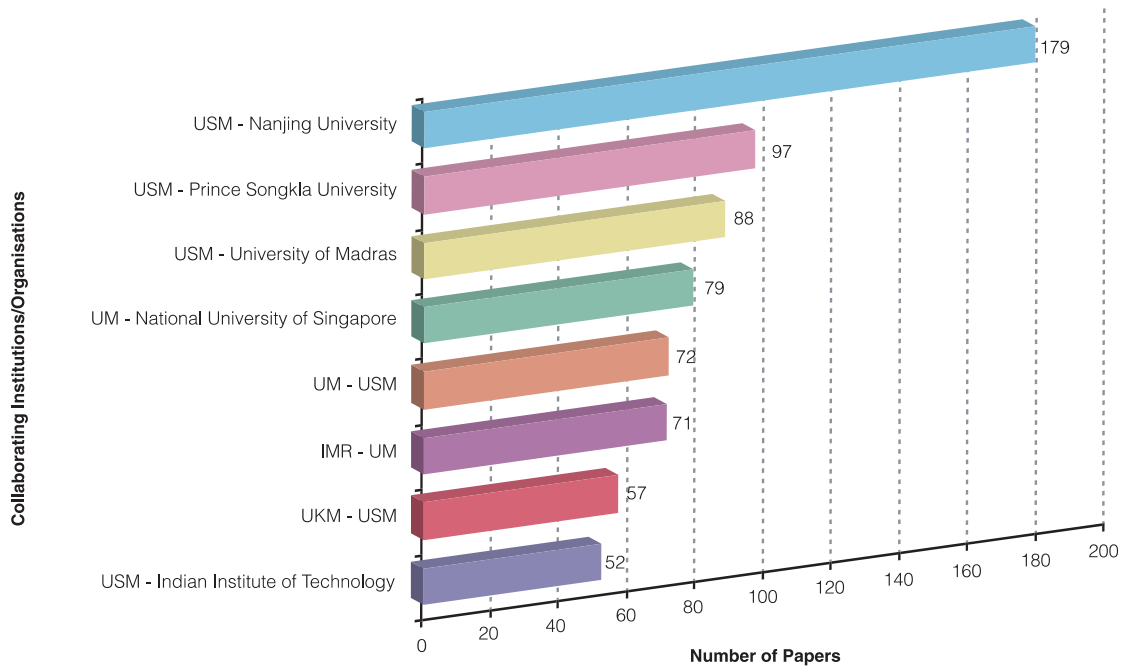


Figure 8.11: Collaborating Institutions/Organisations by Number of Source Papers, 1981-2002

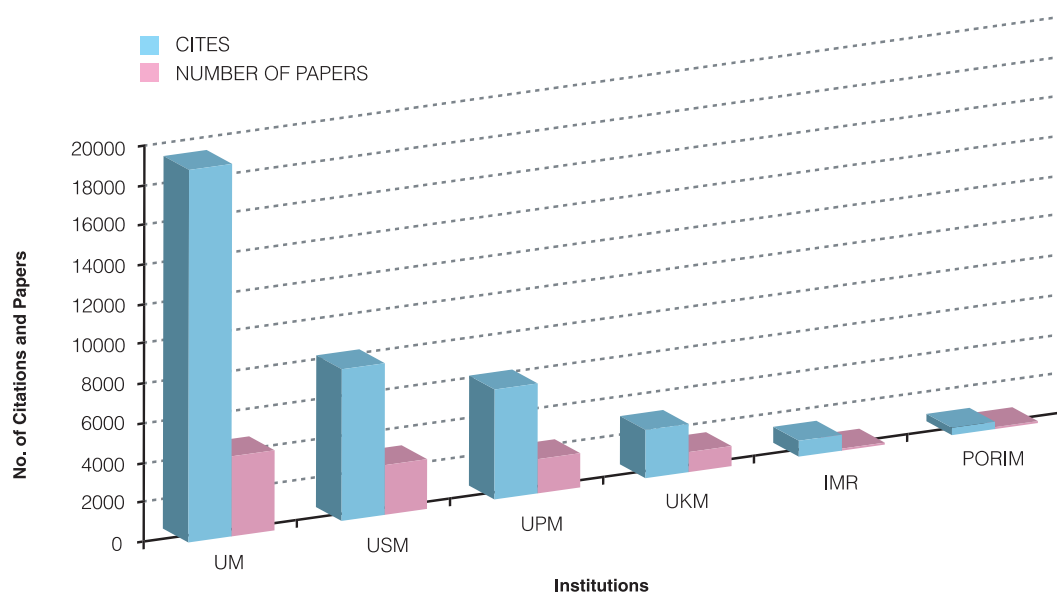


Figure 8.12: Publication Output and Citations in Malaysia by Institutions, 1981-2002

Figure 8.13 shows the percentage of papers cited relative to the world for all fields for selected countries in five year overlapping periods. As can be seen the citation impact of papers from the UK took the lead in the early eighties but was overtaken by the US in the late eighties and early nineties and the US currently leads the way. Asian counterparts on the other hand, lagged far behind at under 1% although in the case of Philippines, Taiwan and

South Korea, the percent cited relative to the world shows an increase in the mid-nineties.

For Malaysia, in terms of citations, the percentage of Malaysian papers cited remained around 1% and had not seen any significant increase over the period of 1981-2002.

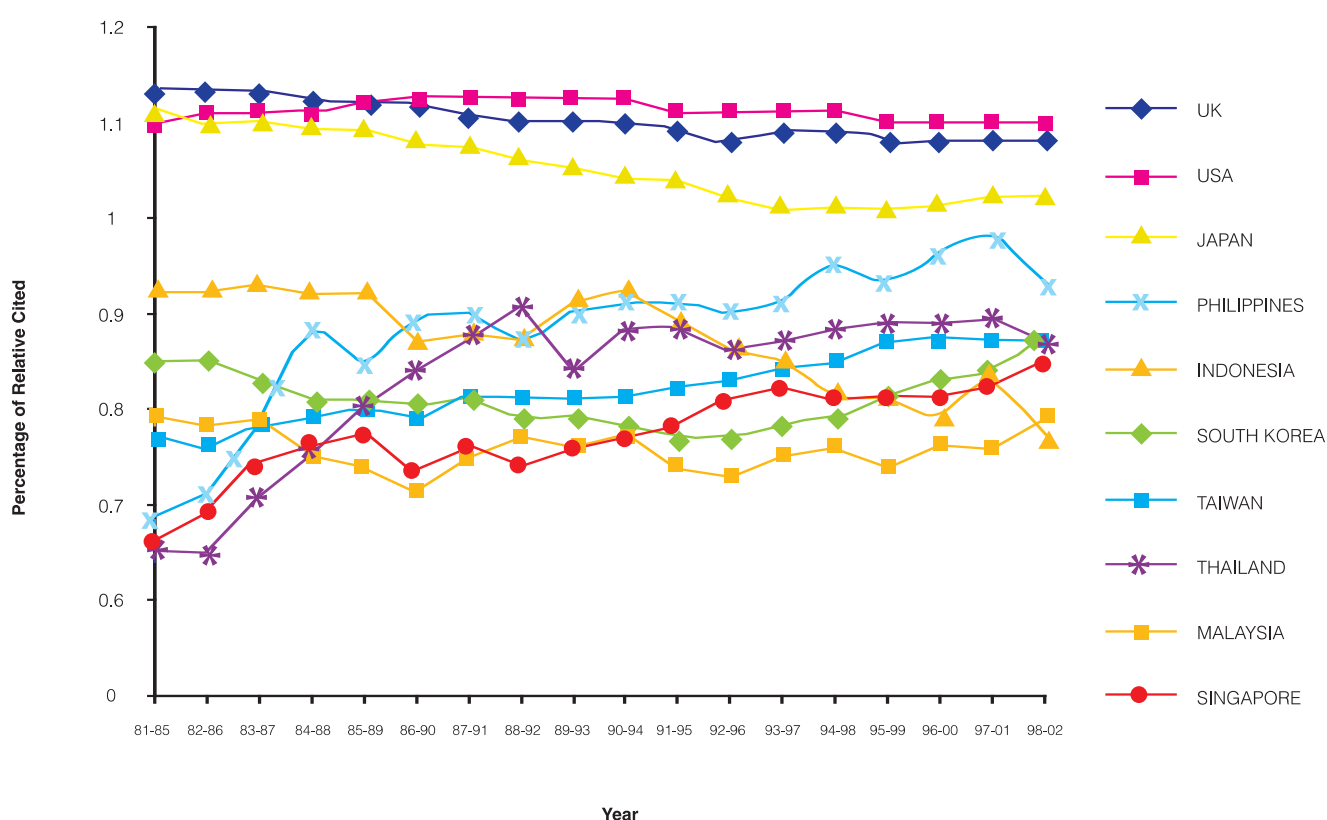


Figure 8.13: Percentage of Cited Relative to World for Selected Countries in 5 Years Overlapping Periods, 1981-2002

Figure 8.14 shows the citation impact of Malaysian papers by fields for the period 1981-2002. The fields that received the highest number of citations in Malaysia are Organic Chemistry/Polymer Science (3615 citations), Environment/Ecology (2847 citations), Agricultural Chemistry (2698 citations) and Microbiology (2564 citations). In relation to citation impact, it is noteworthy that Malaysia was listed as a new entrant to ISI Thompson's Essential Science Indicators (ESI) database which is considered the "cream of the cream" of scientific data bases, in the field of immunology. Malaysia had the highest total citations in the field of Immunology, in

December 2002. (Note: To gain entry into the ESI ranking, a citation threshold or criteria is applied to each field. For scientists and institutions, the criterion for selection is if they are in the top 1% by total citations in a given field, and for countries and journals, they are selected only if in the top 50%).

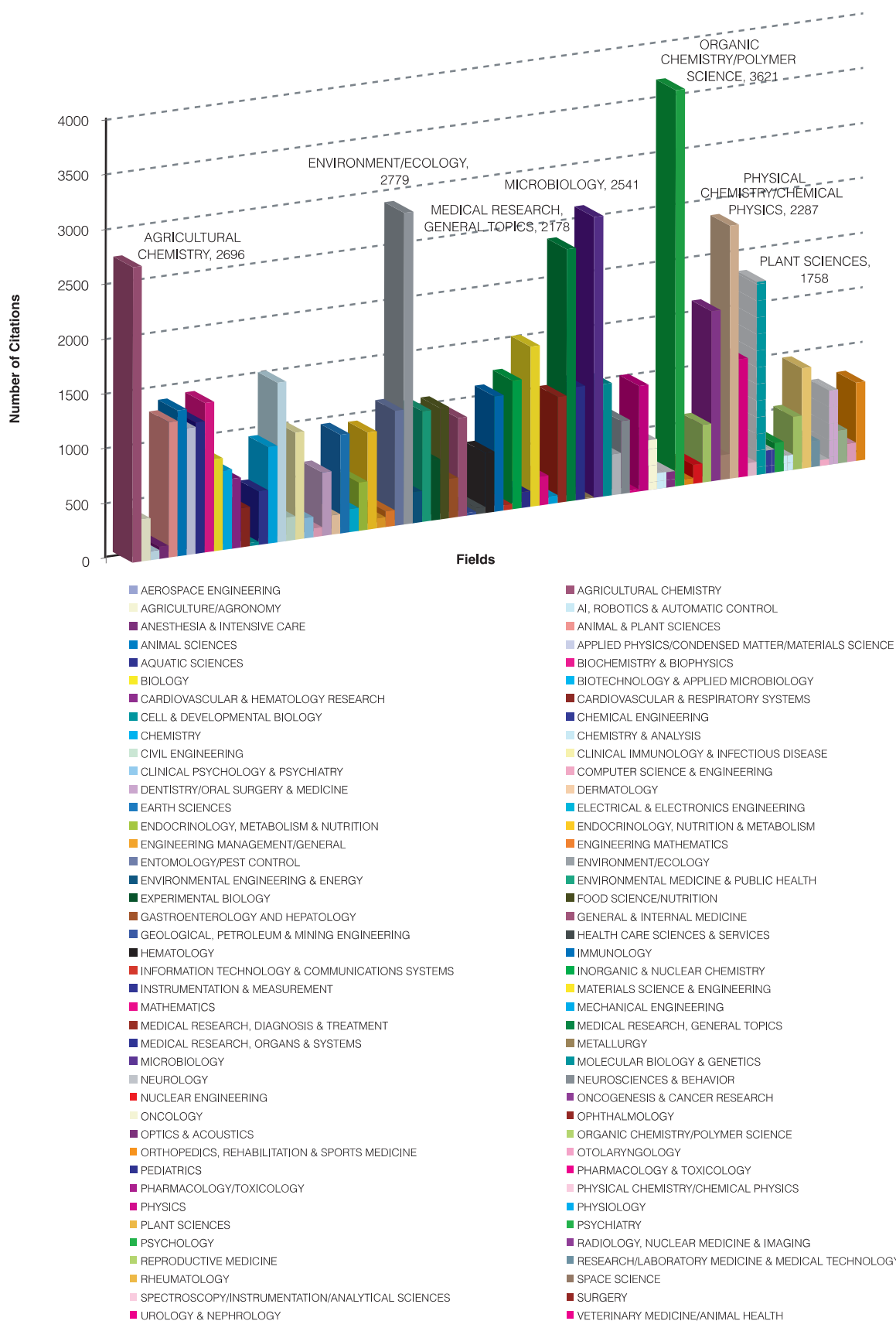


Figure 8.14: Citation Impact of Malaysian Papers by Field, 1981-2002

Figure 8.15 shows the comparative citation impact of the top ten fields of research for four Asian countries namely, Taiwan, Thailand, Philippines and Malaysia. On comparison, the four countries have a differing top field of research although there may be some common fields within their top ten fields. Taiwan received the highest number of citations among the four selected Asian countries, followed by Thailand, Philippines and Malaysia. The top field of research in Taiwan was Applied Physics/Material Science, in Thailand it was Medical Research. In Philippines it was Plant Sciences whilst in Malaysia it was the field of Organic Chemistry.

In conclusion it may be said that the higher productivity in the medical and life sciences publications in Malaysia could be linked to the greater investment and funding geared toward national policies which may well be related to political will (e.g. war against cancer), scientific developments (e.g. revolutionary findings in molecular biology) and socio-economic needs (e.g. aging society, spread of diseases such as SARs, JE etc.). Malaysia's contribution in these fields when compared to the world was, however insignificant when compared to US, UK and its more developed Asian counterparts. Among the Asian countries, Japan contributed the most to the world output. Malaysia's contribution to the world was more significant in the field of agricultural sciences, particularly agricultural chemistry, although the amount of her contribution was still a very modest 0.51% of the world output. Malaysia has still a long way to go in the S&T fields in terms of publication output.

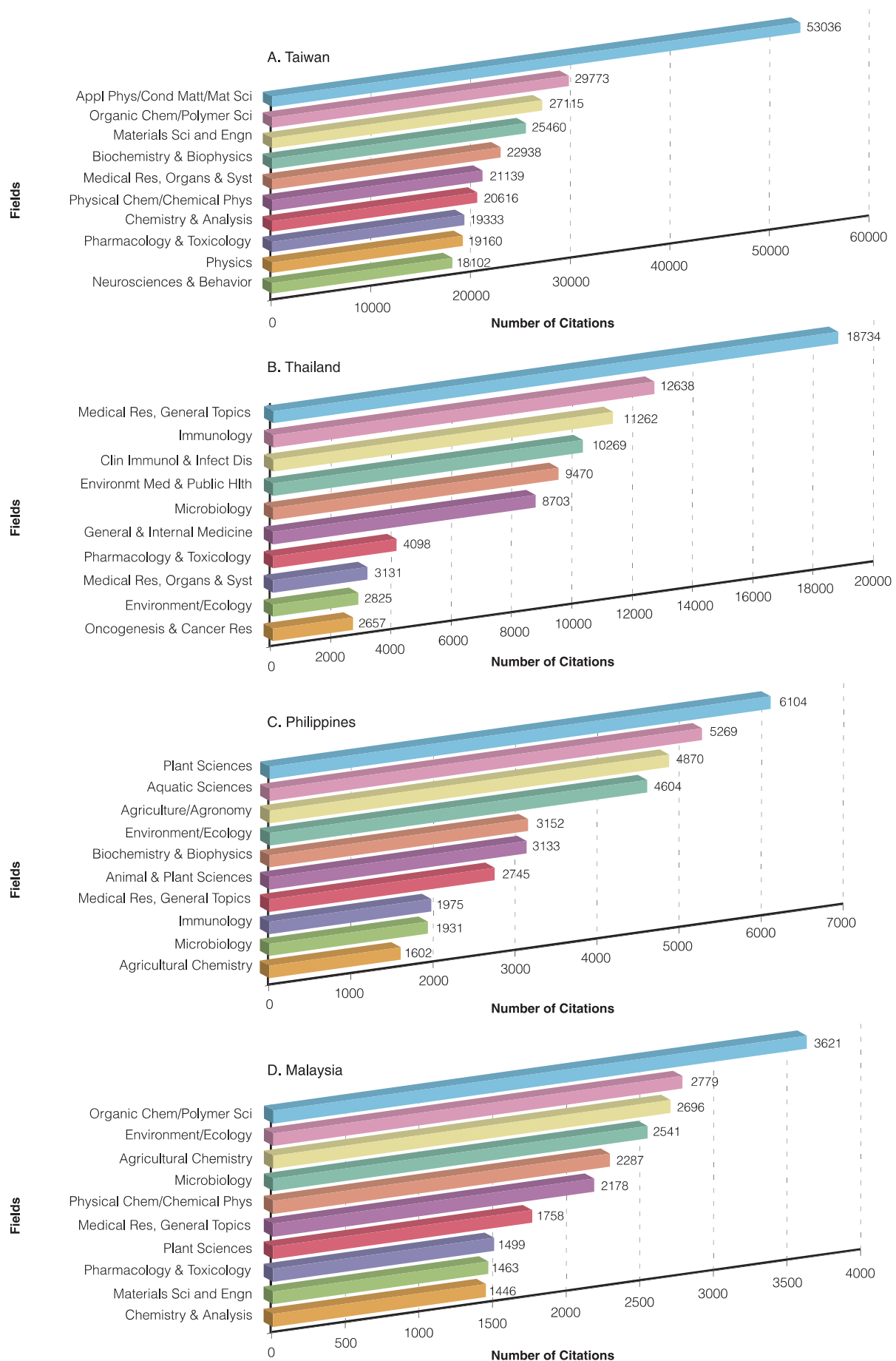
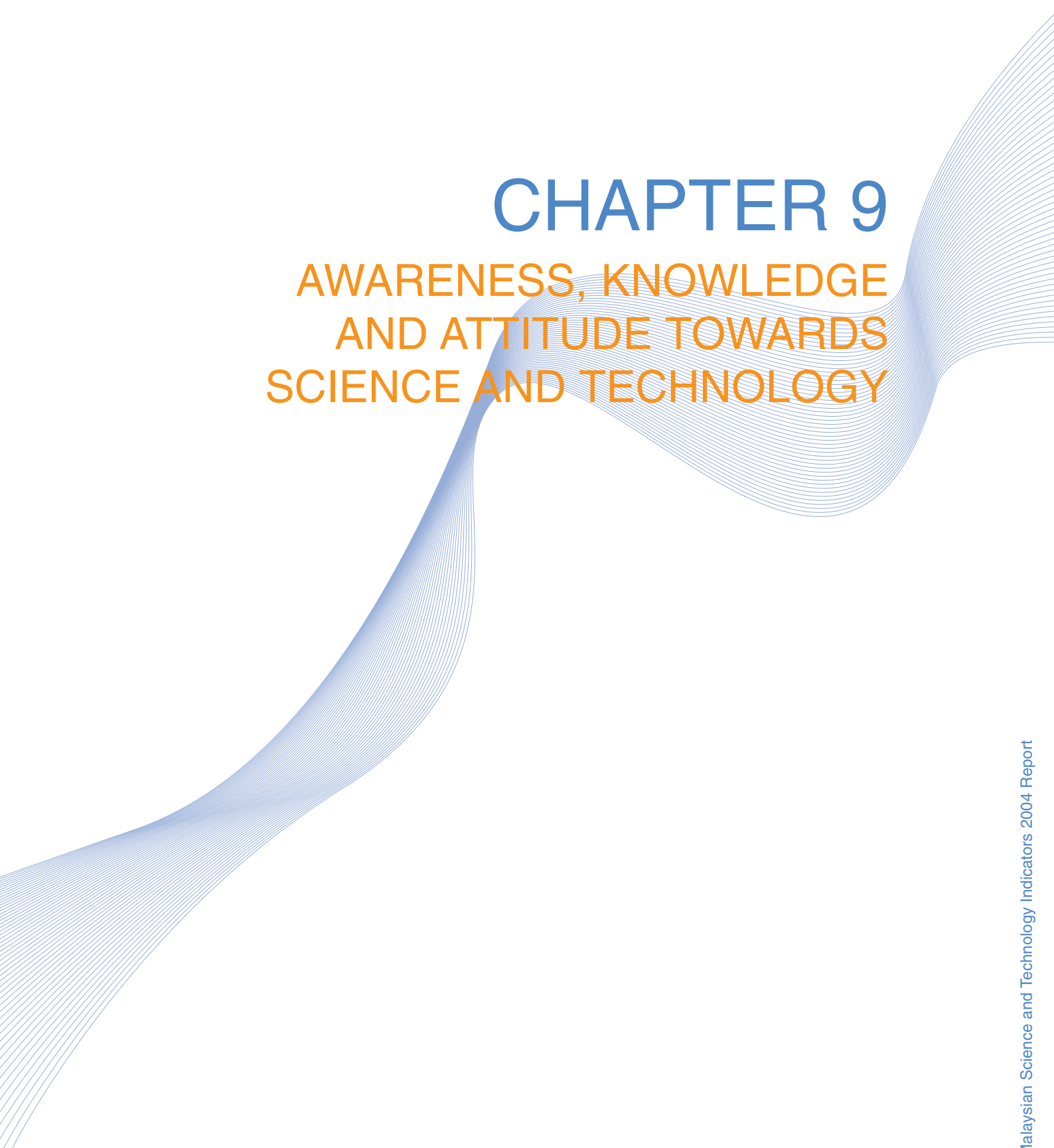


Figure 8.15: Number of Citations of the Top 10 Fields for Taiwan, Thailand, Philippines and Malaysia by Fields, 1981- 2002

A decorative graphic consisting of numerous thin, parallel blue lines that flow and curve across the page, creating a sense of movement and depth. The lines are more densely packed in some areas, creating a darker blue effect, and more spread out in others, creating a lighter effect.

CHAPTER 9

AWARENESS, KNOWLEDGE AND ATTITUDE TOWARDS SCIENCE AND TECHNOLOGY

Public awareness and understanding of science and technology continue to be a concern of most nations today as we live in a world which is driven by science and technology. Our next generation will undoubtedly live in a significantly more scientific and technological environment, witnessing an even far more rapid technology cycle. The pervasiveness of science and technology in modern society has made it impossible for countries to be complacent or ignorant about the level of public interest in and understanding of science and technology. In fact, public interest, awareness and understanding of science and technology must be regarded as an integral component of science and technology policy in any country in the present era of extensive reliance on technology for sustainable competitive advantage. Recognising that technological gap exists between the developed nations and developing countries, it is all the more important for Malaysia to understand the nation's current situation about its people's interest, awareness as well as their understanding of science and technology. In particular, young people's interest and understanding of science and technology has profound implications for public policy makers in terms of the directions for science and technology policies. Advanced industrialised countries such as the US, Japan and the OECD countries are constantly monitoring the level of public understanding of science and technology among its youths. The outcome of this constant monitoring of the status of public understanding of science and technology are some policy directions identified by OECD countries that include enhancing science education in primary and secondary levels and increasing opportunities for life-long science-based learning.

In order to meet the challenges of the 21st century that is constantly driven by the knowledge-based environment, Malaysia needs a society that not only has an interest in science and technology, and awareness of the importance of science and technology, but also a wealth of knowledge in science and technology. It is knowledge creation and diffusion in science and technology that can drive innovation, economic growth,

development and well-being. Given the importance of science and technology, it is obvious that Malaysia needs to monitor the status of public understanding of science and technology.

This chapter presents the findings on public awareness, interest, and attitude toward science and technology and the level of understanding of science and technology, especially among young people. The inputs for this chapter are drawn solely from the survey of "Public Awareness of Science and Technology in Malaysia, 2002".

9.1 Perceived Knowledge of Science & Technology (S&T) - related and General Issues

Overall, there has been an improvement in the level of perceived knowledge about S&T-related and general issues for year 2002 compared to year 1998 and 2000. Based on a Likert-type scale of 1 to 4 (with 1 indicating no knowledge and 4 excellent knowledge), the mean score for all the issues included in the study shows a moderate improvement with no one statement with a mean score of less than 2 compared to year 1998 and 2000 in which three of the issues had a mean score of less than 2, respectively (Figure 9.1). However, none of the statements had a mean score of at least 3, indicating that there is a tremendous opportunity for improvement. For the 11 issues examined, eight enjoyed an improvement in the score while the remaining three showed a decline in the knowledge score. The level of perceived knowledge reported range from 2.04 to 2.78. Issues on environmental pollution continued to enjoy the highest level of reported perceived knowledge with a mean score of 2.78 even though this score paled in comparison with the score for 1998 and 2000. The other two issues that had a lower level of perceived knowledge compared to 1998 and 2000 were "new inventions from Malaysia" and "economy and business". Findings from the 2002 survey on Public Awareness of Science and Technology suggest the influence of environmental factors on perceived knowledge for certain issues. For example, in 1998 when

Malaysia was battling the Asian crisis, there was a high level of reported perceived knowledge on economy and business. The score was lower in 2000 when Malaysia began to experience an improved economy while in 2002, the level of perceived knowledge in this area dropped further as Malaysia is experiencing growth again.

foreign policies” which again, is reflective of the influence of macro-environmental forces. The improvement in the level of perceived knowledge in this issue can be attributed to the widespread media coverage on international issues resulting from dynamism of the events post September 11 incidents.

The issue with the largest improvement in score was “international and

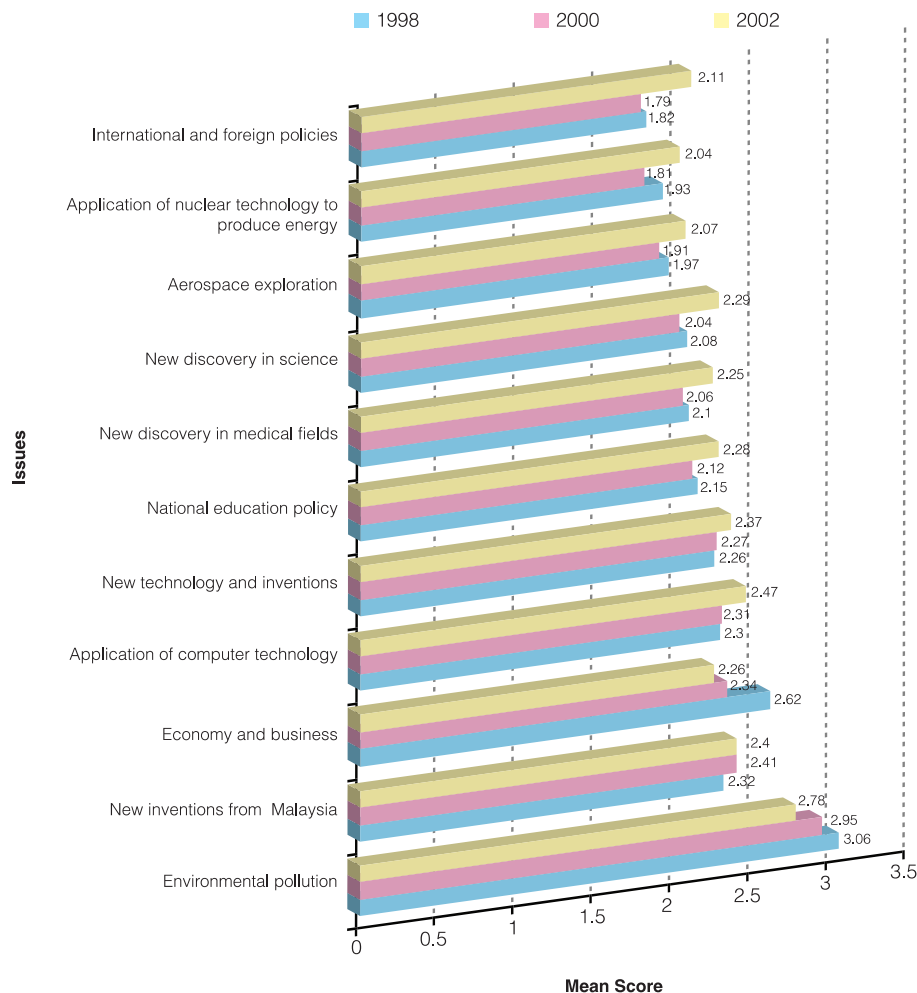


Figure 9.1: Perceived Knowledge about Various General and S&T Issues, 1998-2002
Knowledge Score: 4 = Excellent, 3 = Average, 2 = Poor, 1 = None

9.1.1 Gender Comparison

Overall, males were generally more aware and had a higher level of perceived knowledge in S&T-related and general issues compared to women as indicated by the scores for the issues included in the study (Figure 9.2). Consistent with the findings for the overall sample, males and females perceived to have better knowledge in all areas except “environmental pollution”, “new inventions from Malaysia”, and “economy and business” compared to findings of year 1998 and 2000. The males did not have any scores that was less than 2.0 whereas females reported a mean

score of 1.99 in their level of perceived knowledge in “application of nuclear technology to produce energy”. The three issues that males and females reported a high level of perceived knowledge were: “environmental pollution”, “application of computer technology”, and “new inventions from Malaysia”. The three areas with the least perceived knowledge were: “application of nuclear energy to produce energy”, “aerospace exploration”, and “international and foreign policies”. Compared to the findings of 1998 and 2000, the increase in the level of perceived knowledge for international and foreign policies was remarkable.

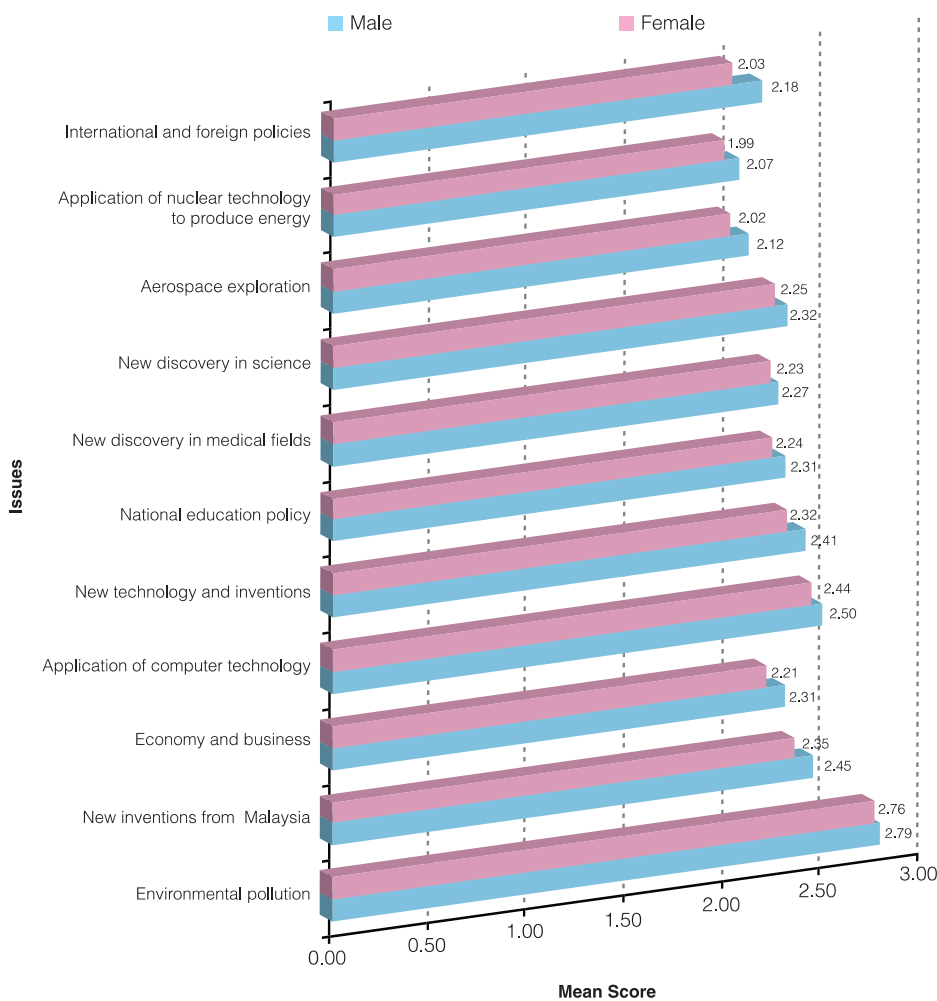


Figure 9.2: Perceived Knowledge about Various General and S&T Issues by Gender, 2002
Knowledge Score: 4= Excellent, 3= Average, 2= Poor, 1= None

9.1.2 Age Group Comparison

The level of awareness and perceived knowledge about S&T-related and general issues among the three age groups, namely, children (12-14 years), youths (15-20 years) and adults (21-60 years) were examined. Findings show that youths were consistently the group with the highest level of perceived knowledge compared to children and adults (Figure 9.3). As perceived knowledge in S&T-related and general issues is expected to be positively correlated with the years of education, it is within expectation that children scored the lowest in all areas compared to youths and adults since substantial knowledge in science and technology-related issues are

only covered in secondary school curricula. Children reported scores of less than 2.0 for five of the issues examined. These issues were: “economy and business”, “aerospace exploration”, “application of nuclear technology to produce energy”, and “international and foreign policies”. Youths and adults did not score less than 2.0 for any of the issues examined.

Within group comparisons for year 2002 and prior years show that children fared better in all issues examined except in 3 areas: “environmental pollution”, “new inventions from Malaysia” and “aerospace exploration”. For youths, there has been an improvement in the level of reported perceived knowledge



Figure 9.3: Perceived Knowledge about Various General and S&T Issues by Age Group, 2002
Knowledge Score: 4=Excellent, 3= Average, 2= Poor, 1= None

compared to earlier years in all areas except for one issue, that is, “environmental pollution” (mean = 2.98) compared to year 2000 and 1998 (mean = 3.07 and 3.14, respectively). The level of perceived knowledge reported by the adults was similar to the overall findings in which a lower score could be observed for three of the issues, namely, “environmental pollution”, “new inventions from Malaysia”, and “economy and business”. The drop in the level of knowledge in economy and business and environmental pollution among adults signaled a decline in interests which might produce a negative impact on the younger age groups. Adults play a critical role in imparting knowledge to the younger generations. At the same time the ability of adults in influencing and stimulating interest among the younger generation in science and technology cannot be under-rated.

9.2 Stated Interest in S&T-related and General Issues

Expressed interest in S&T-related and general issues is an important source of information that provides the necessary input for policy decision-making in areas that could provide an impetus to improve the level of interest and hence the level of knowledge in S&T. Following the argument that science and technology is important for development, it is then obvious that building a society with a strong foundation in science and technology is crucial. A science and technology-oriented society begins with an expressed interest in S&T among its populace. In the survey of Public Awareness of Science and Technology 2002, interest of the public in S&T-related and general issues was examined.

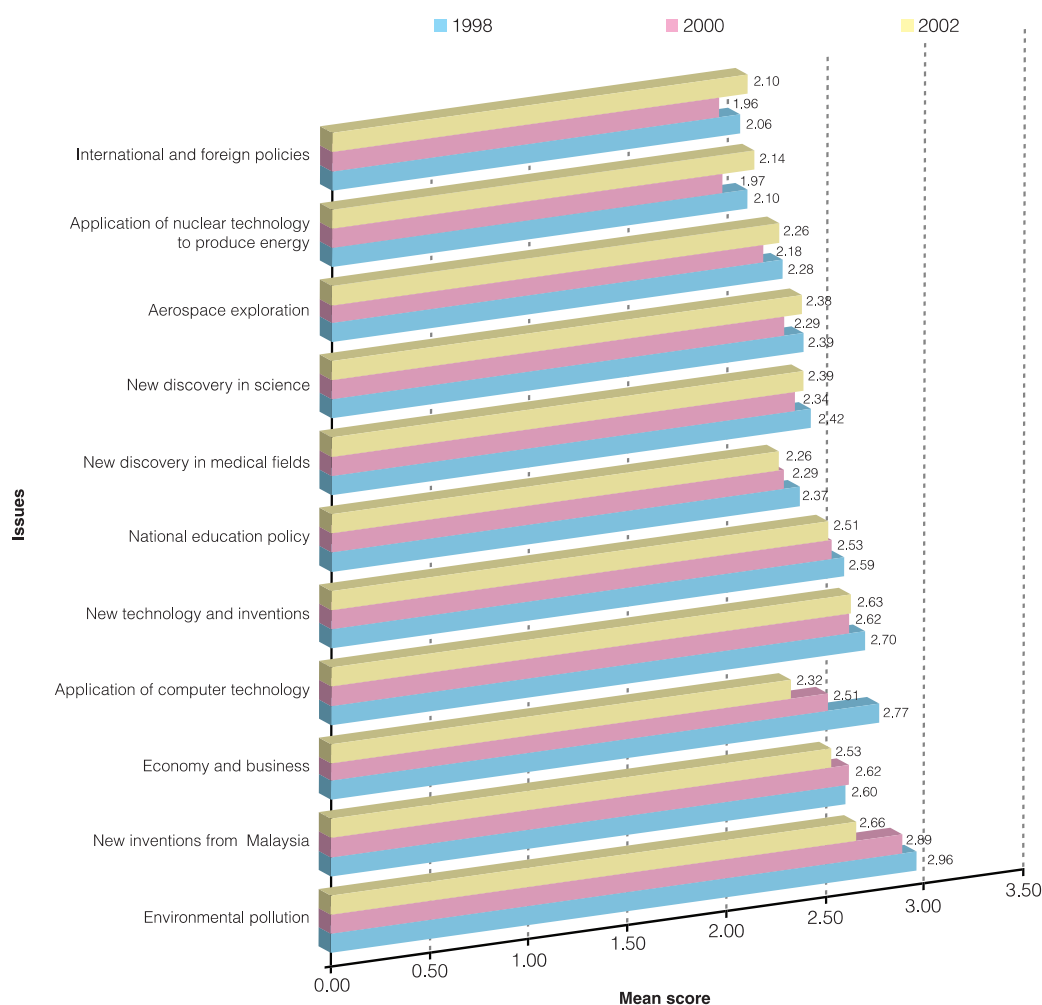


Figure 9.4: Interest about Various General and S&T Issues, 1998-2002

Interest Score: 4= interested, 3= moderately interested, 2= slightly interested 1= not interested

Figure 9.4 shows the overall level of interest in S&T-related and selected general issues. Overall, the level of interest shown was low. Based on the scale of 1 to 4, the highest level of interest reported was 2.66 in the area of environmental pollution while the lowest level of interest was for the issue of “international and foreign policies” (mean = 2.10). In addition to the general lack of interest in the issues examined, the level of interest had deteriorated for five of the 11 issues examined compared to findings of year 2000. These five areas were: “environmental pollution”, “new inventions from Malaysia”, “economy and business” “new technology and inventions”, and “national education policy”. For issues that received an improvement in the level of interest, the increase has been marginal with the greatest increase in the mean score (0.17 point) registered for the issue “application of nuclear technology to produce energy”. A comparison of the findings for 2002 and 1998 shows that the decline was far more disturbing

for 2002 as the level of interest has dropped for all issues except “application of nuclear technology to produce energy” and “international and foreign policies”. The extent of increase in interest was again very marginal while the decline in the level of interest expressed was greater.

9.2.1 Gender Comparison

Generally, males had a higher level of expressed interest in S&T-related and general issues compared to their female counterparts. Unlike findings of 2000 where females showed a higher level of interest in three fields out of the 11 examined, the survey results of 2002 show that females scored lower in all areas in terms of interest expressed (Figure 9.5). The mean scores for males and females indicated that the top three issues that attracted their interest were: “environmental pollution”, “application of computer technology”, and “new inventions from Malaysia”. The findings were

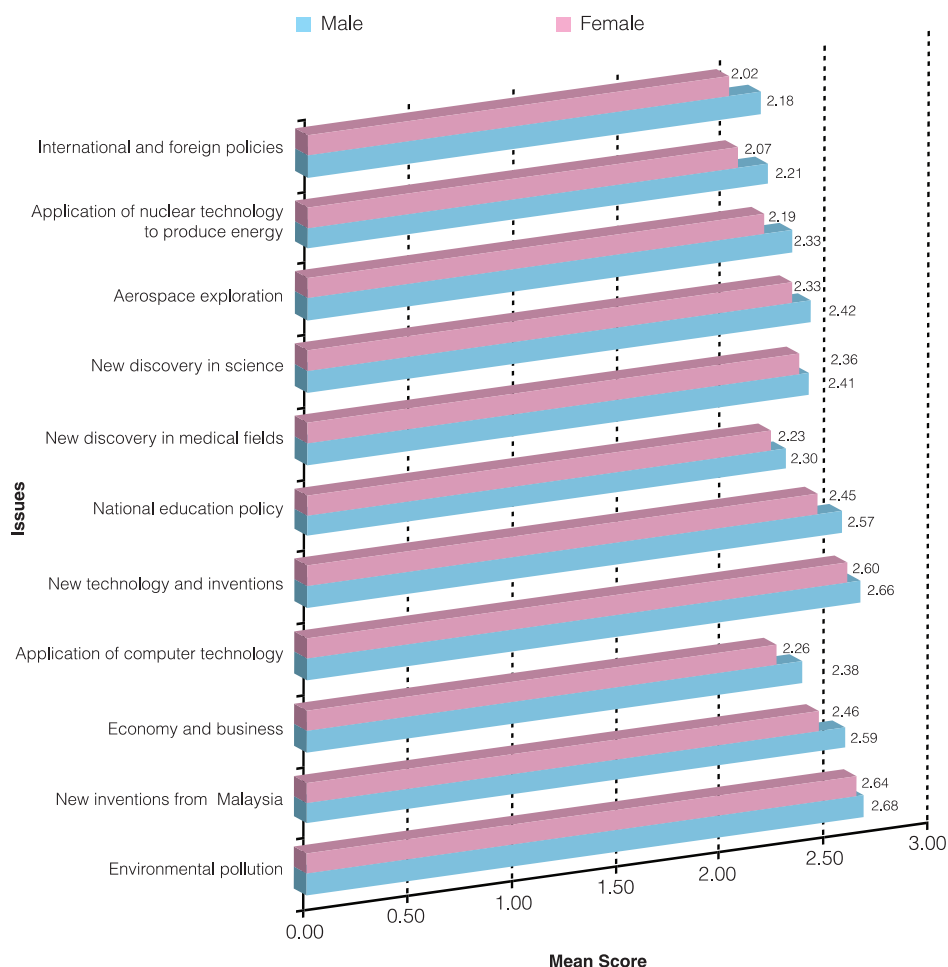


Figure 9.5: Interest about Various General and S&T Issues by Gender
Interest Score: 4= interested, 3= moderately interested, 2= slightly interested, 1= not interested

consistent with the level of perceived knowledge reported by the respondents. Although the perceived knowledge in international and foreign policies reported by both the gender has increased, their expressed interest in this issue remained the lowest for year 2002. This is again consistent with past findings in which findings showed that interest in international and foreign policies was the lowest among the 11 issues examined.

9.2.2 Age Group Comparison

Comparing the interest level among the three age groups, it is obvious that the youths had the highest level of interest compared to children and adults (Figure 9.6). Generally, youths had the highest mean score for all areas except for “economy and business” in which the adults reported a similar score. Consistent with results obtained in the past, adults reported a higher level of interest compared to children in nine out of the 11 areas that were examined. The only two areas that children showed greater interest than adults were “aerospace exploration” and “application of computer technology”. This is an encouraging trend as children had consistently shown greater interest in these two areas since 1998. Perhaps, this trend is to be expected since the use and application of computer technology are in line with the government’s aspiration to cultivate computer literacy in Malaysia. The implementation of the smart school concept is another factor that could have sustained the level of interest among children in the application of computer technology.

Children, youths and adults showed little interest in international and foreign policies while their interest in environmental pollution remained the issue with the highest mean score. For the adults, interest in application of nuclear technology to produce energy was the lowest followed by international and foreign policies.

Within group comparisons in the level of interest among youths show that there was a decline in four of the 11 issues examined. They were “environmental pollution”, “new

inventions from Malaysia”, “economy and business”, and “new technology and inventions”. The level of interest remained the same for “application of computer technology” whereas the remaining areas experienced an increase in the level of expressed interest. For the adults, their level of expressed interest has improved for six of the areas while the remaining five suffered a decline. The persistent decline in the interest since 1998 was observed in four areas: “economy and business”, “environmental pollution”, “new technology and inventions”, and “national education policy”.

For the children only two of the 11 issues had a lower score in the level of expressed interest compared to the findings of 2000. This shows that there has been a rebound in the level of interest and this is encouraging since the findings of 2000 saw a decline in interest in all but one issue compared to 1998.

9.3 Attitude Towards Science and Technology

The global environment that is continuously being driven by science and technology has given rise to the widespread recognition about the importance of science and technology. Humankind has long since realized the advantage of passing on to the next generation the appropriate attitude toward science and technology as a continuous effort to nurture skilled human resources in these areas. With this background in mind, it is therefore crucial to know the status of the attitude of Malaysians toward science and technology.

For the survey of Public Awareness of Science and Technology, 2002, a total of 15 statements were examined of which four statements were new. The new statements were: “Government should support S&T research”, “S&T is very important for societal advancement”, “Without S&T, humans cannot progress”, and “Civilisation has been created without the help of science and technology”. For the existing 11 statements, the percentage of respondents agreeing with the statements had dropped substantially (Figure 9.7). The

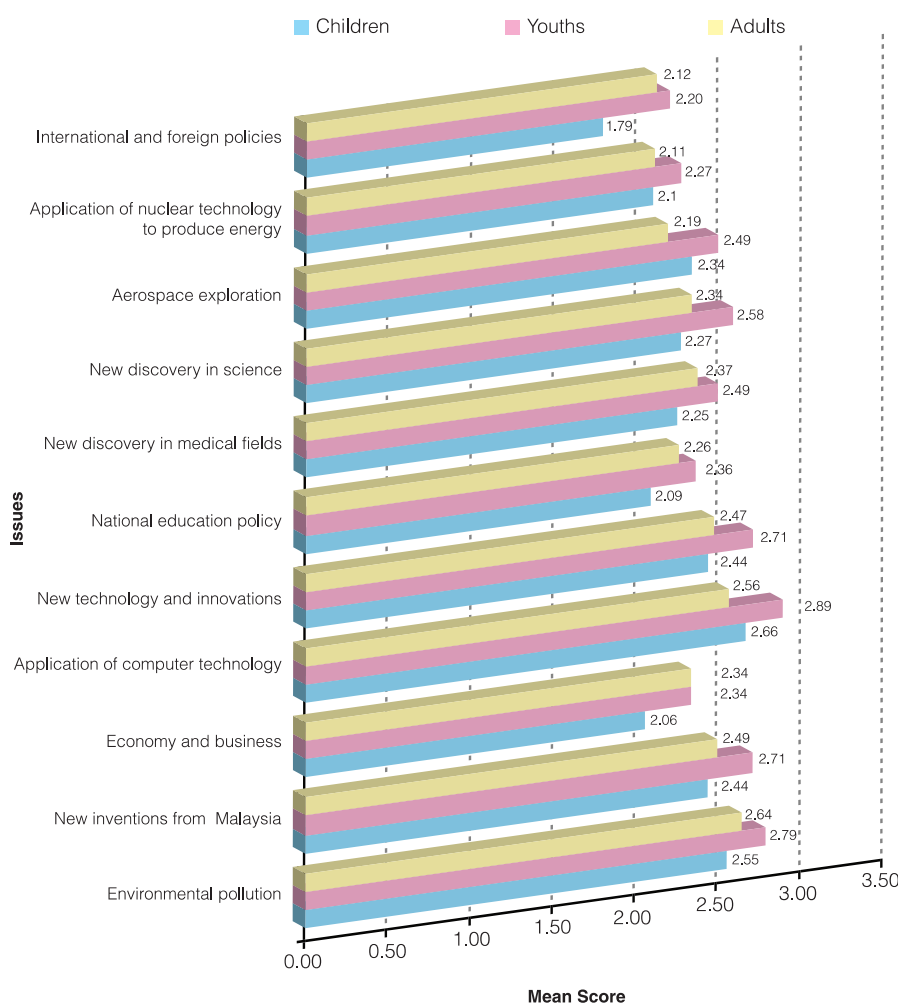


Figure 9.6: Interest about Various General and S&T Issues by Age Group, 2002
Interest Score: 4= interested, 3= moderately interested, 2= slightly interested, 1= not interested

decline in the percentage of respondents agreeing with statements that relate to the role of science and technology does not augur well for the development of S&T, especially in an era that is S&T-driven. The statement “S&T make our life healthier, easier and more comfortable” continued to enjoy a high percentage of agreement at 80.6% even though the percentage agreeing with this statement has dropped by 6.5% from 2000. The statement with the most substantial drop in the percentage of respondents agreeing with it was “New inventions will counteract harmful consequences of technological development” (26.1 percentage point decline). The percentage of respondents agreeing with the statement “Daily chores are more interesting with the application of S&T” has dropped drastically from 86.2% in 2000 to

67.8% in 2002. Similarly, for statements “Most scientists work toward improving life” and “I need to know about science in my daily life” had suffered substantial drop in percentage of respondents agreeing with them.

For the new statements, as high as 79% of the respondents agreed with the statement that government should support S&T research. Only 35.6% agreed with the statement that civilisation had been created without the help of science and technology. The low percentage of agreement supported the importance of science and technology in the development of society. This is reflected in the percentage of respondents agreeing with the statement “S&T is important for societal advancement”.



Figure 9.7: Attitude Towards Science and Technology, 1998-2002

Note: (*) : Indicates issues not included in the 1998 and 2000 study

9.3.1 Age Group Comparison

The attitude of all the three age groups toward science and technology had grown less favourably, with the percentage decline being most drastic among children (Figure 9.8). Youths remained the group with the most favourable attitude toward science and technology even though the decline cut across all age groups. For children, they were least positive about S&T-related benefits. For example, the percentage of children who agreed with the statement "Daily chores are more interesting with the application of S&T" has dropped by 28%. For the same statement,

the percentage decline was 19% for the adults and 11.9% for youths. For the new statements that were added in the Survey of 2002, youths were more positive compared to the adults as well as children. As high as 84% agreed that government should support S&T research compared to children (71.6%) and adults (79.0%).

9.3.2 Rural Urban Comparison

Findings of the 2002 survey indicated that urban respondents in general had a more positive attitude toward science and technology compared to those in the rural areas (Figure

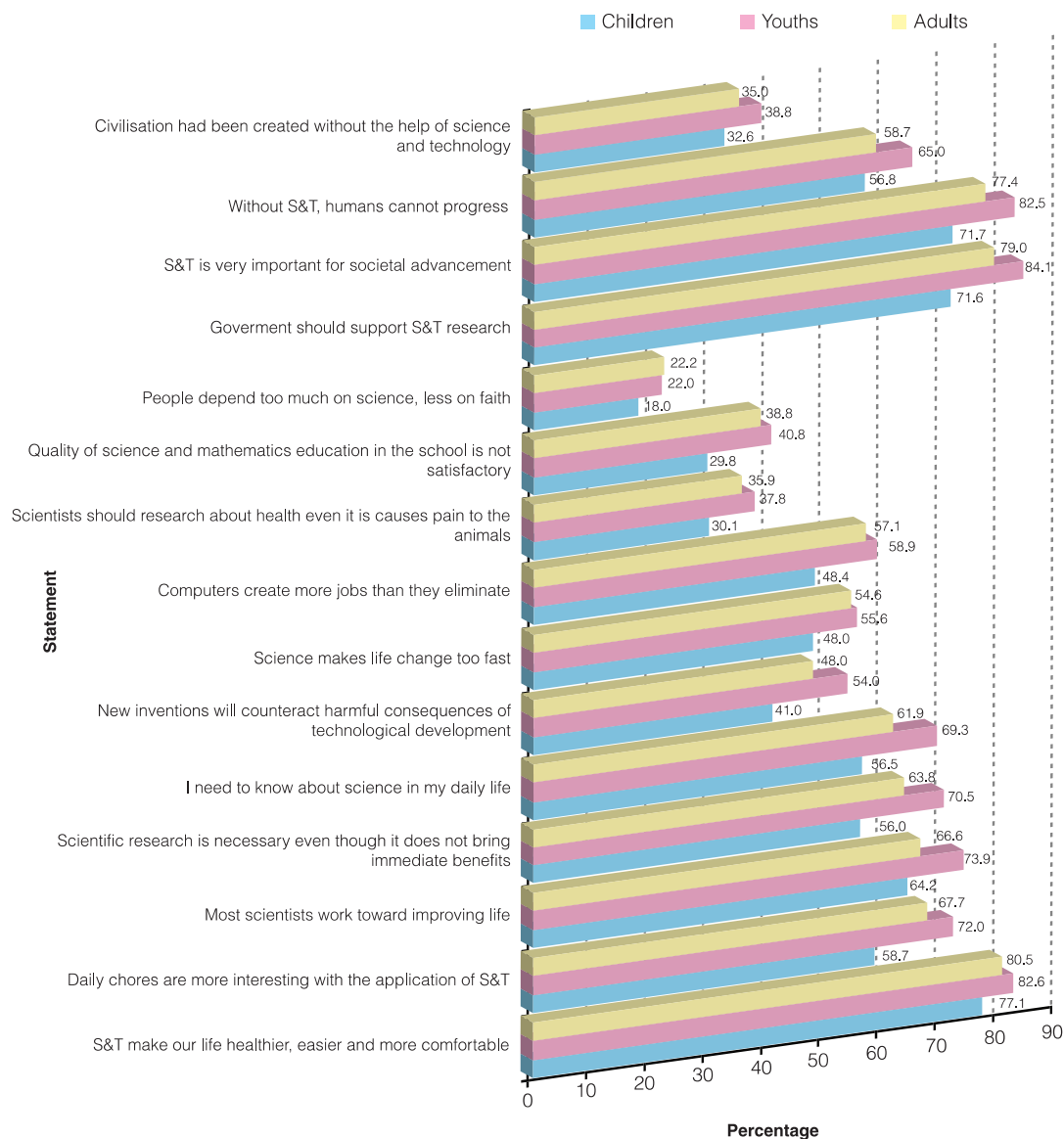


Figure 9.8: Perception and Attitude Towards Science and Technology by Age, 2002

9.9). For the new statements added, a larger proportion of urban respondents agreed, indicating a more positive attitude toward science and technology. The statement in which the difference between urban and rural respondents is the greatest was “I need to know about science in my life” as 66.3% of the urban respondents agreed while only 59.5% of rural folks did so. The smaller percentage (34.4%) of urban respondents who agreed with the statement “Civilisation had been created without the help of science and technology” was lower compared to rural respondents (36.7%) confirmed that urban respondents had a more positive outlook toward S&T.

9.3.3 Educational Level and Attitude Towards S&T

Consistent with expectations, respondents with university education had a more positive attitude toward S&T compared to those with secondary or primary school education (Figure 9.10). More than 80% of those with tertiary education agreed that “S&T make life healthier, easier and more comfortable”, “Government should support S&T”, and “S&T is very important for societal advancement”. Those with secondary level of education had a substantial percentage (81.1%) agreeing with the statement “S&T

make our life healthier, easier, and more comfortable”. For those with primary level of education, 70.1% of the respondents reported in agreement with the same statement, i.e., “S&T make life healthier, easier and more comfortable”. Notwithstanding the level of education, a smaller percentage of respondents agreed that “Quality of science and mathematics education in the school is not satisfactory” compared to previous years, hinting that a higher percentage agreed that quality of science and mathematics education is satisfactory. Analysis of their understanding of science and technology will throw some light on the status of scientific literacy among the Malaysian population.

Regardless of the level of education, all respondents showed low level of agreement with the statement “Civilization had been created without the help of science and technology”. This indicates that indirectly the respondents acknowledged the role of science and technology in civilization. This assertion is further supported by the low level of agreement with the statement “People depend too much on science, less on faith” (22.7%, 21.9%, and 19.6% for tertiary, secondary and primary school education, respectively).

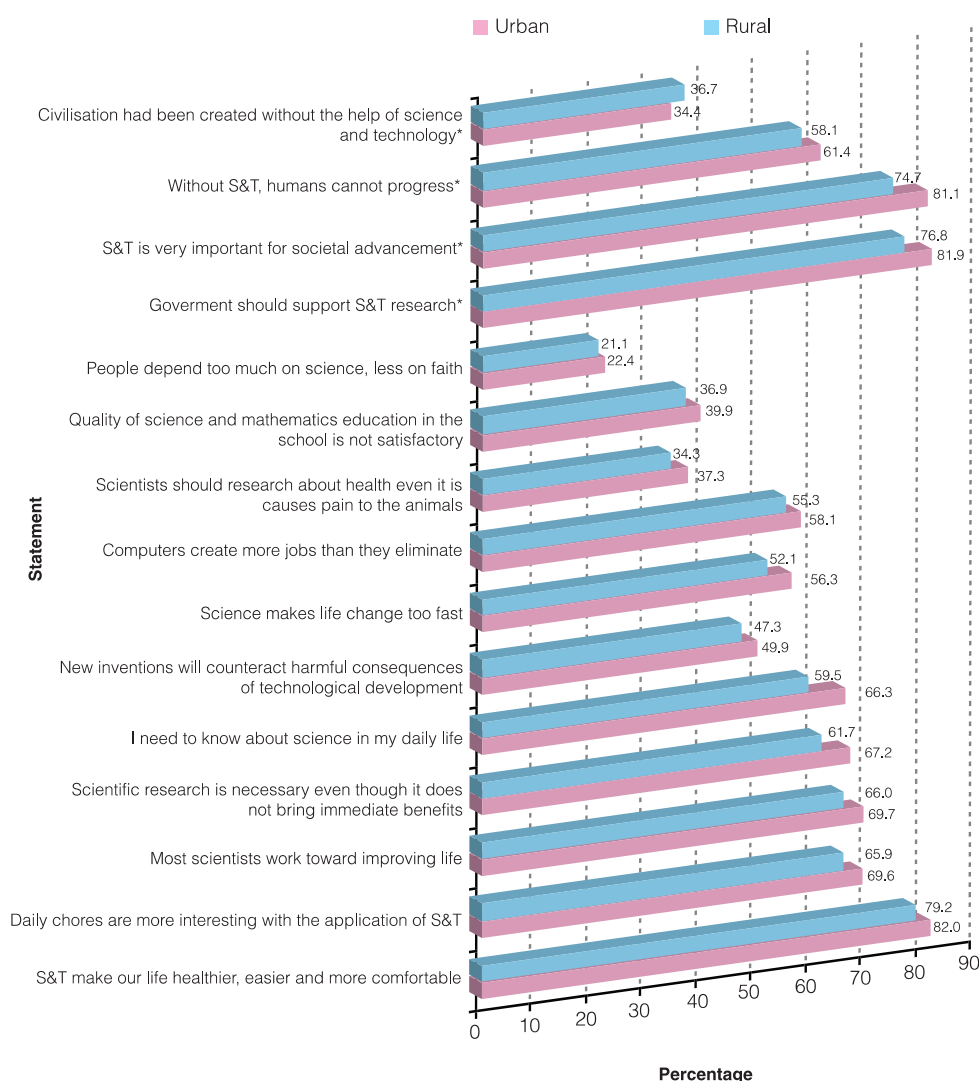


Figure 9.9: Attitude Towards Science and Technology by Locality, 2002

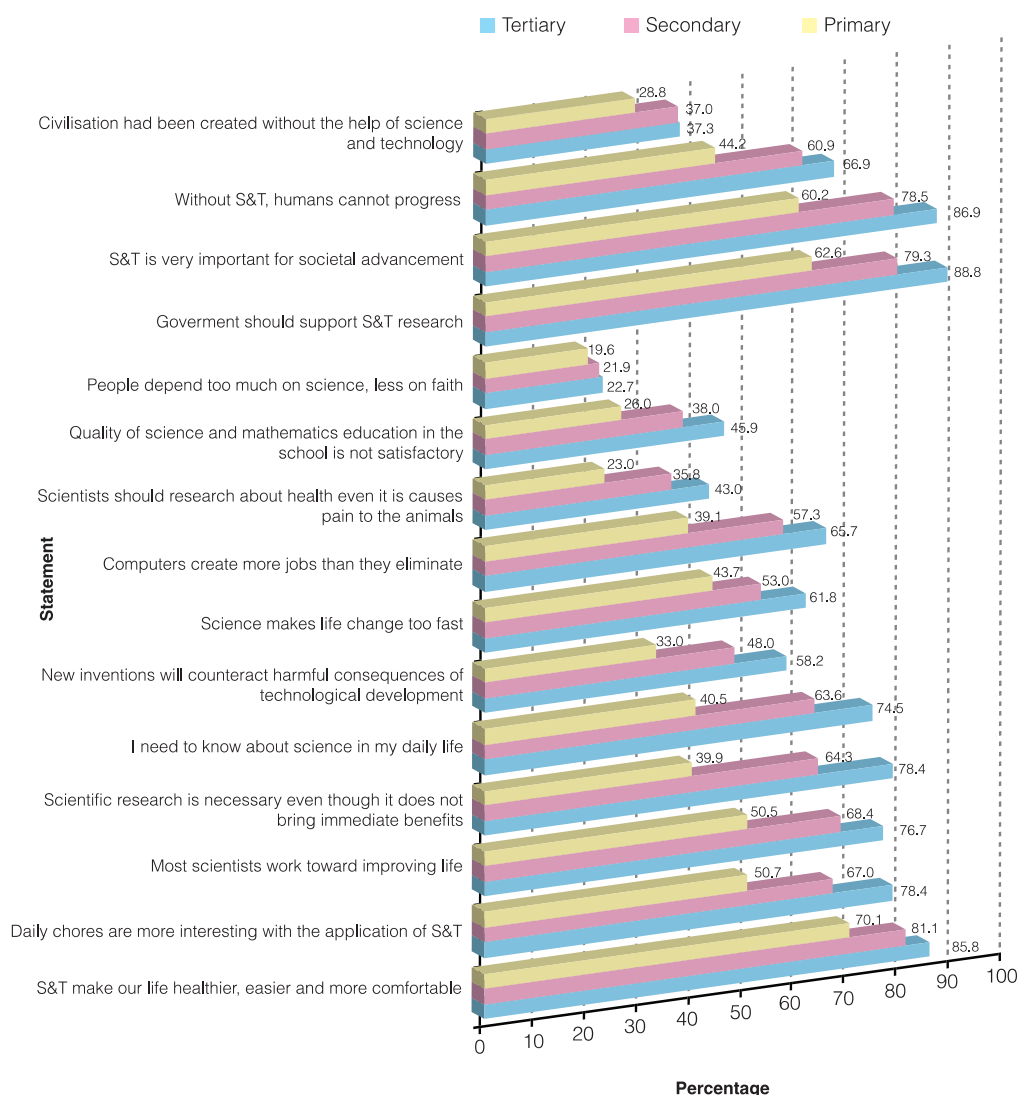


Figure 9.10: Attitude Towards Science and Technology by Level of Education, 2002

9.3.4 Gender Comparison

On the whole, a slightly higher percentage of males compared to females agreed with the statements examined in the Survey (Figure 9.11). Both genders shared similar attitude about science making life healthier, easier and more comfortable. Almost an equal percentage of males and females agreed that government should support S&T research, quality of science and mathematics education is not satisfactory, new inventions will counteract harmful consequences of technological advancement, and that S&T is very important for societal advancement. The only statement that males and females differed in the percentage of respondents in agreement

was “Scientists should research about health even if it causes pain to animals” in which 37.5% of males agreed compared to 34.0% of females.

For males, statements that were met with high level of agreement were: “S&T make life healthier, easier and more comfortable”, “Government should support S&T research” and “S&T is very important for societal development”. Similarly, a high percentage of females also showed agreement to these three statements.

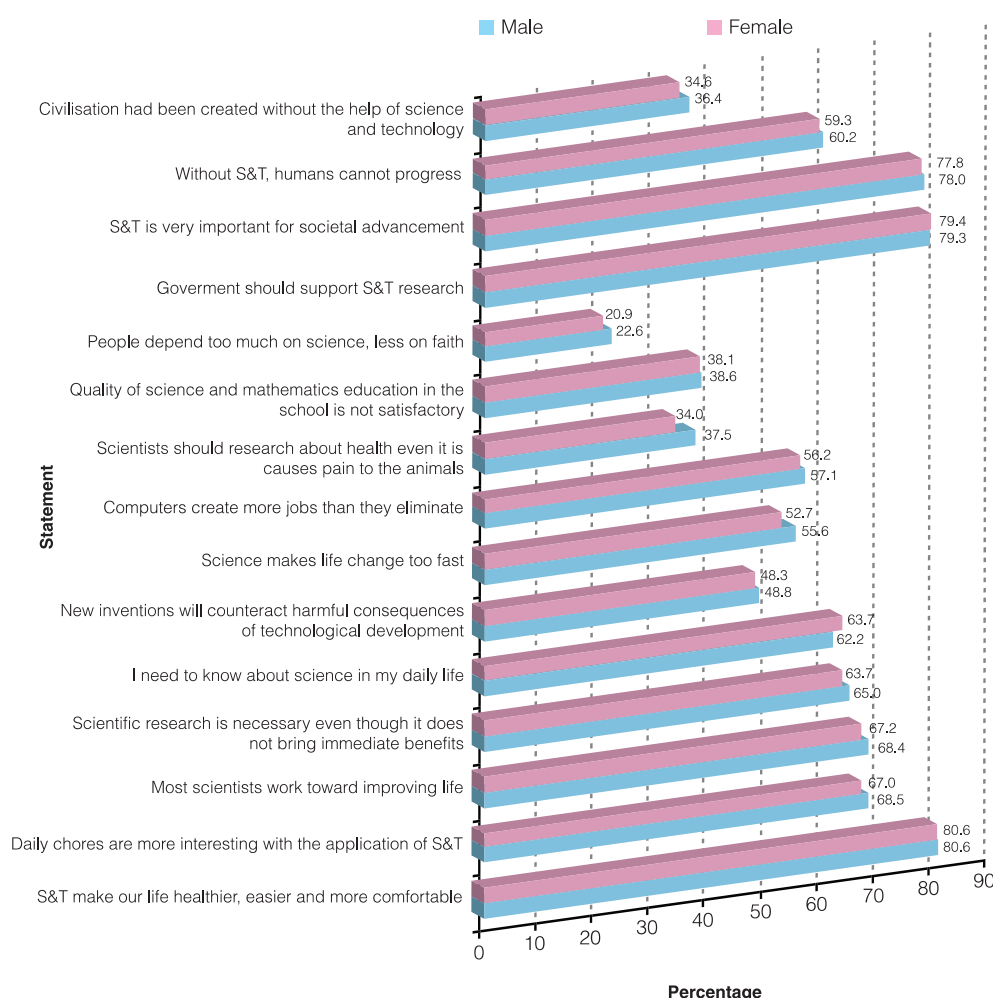


Figure 9.11: Attitude Towards Science and Technology by Gender, 2002

9.4 Understanding of Scientific Terms and Concepts

The scientific literacy among the public has deteriorated over the years. Scientific literacy is crucial for development in as much as it is necessary for the adoption of science and technology in our everyday life. The overall level of understanding of scientific terms and concepts has dropped drastically in 2002 in which only 47.9% of the respondents had correct answers compared to 57.7% in 2000. The Survey of 2002 shows that more than 70% of the respondents had correct answers for three questions, namely, “smoking causes lung cancer”, “the oxygen we take in comes from plants”, and “the earth goes round the sun” (Figure 9.12). For the item “smoking causes lung cancer” the percentage of respondents who had the correct answer dropped almost 10% from 94% in 1998 to 84.5% in 2002. This is alarming since it is common knowledge that smoking causes lung cancer.

Between 60-69% knew that “light travels faster than sound” and “the center of the earth is very hot”. Among the answers that had very low level of correct answers were: “lasers function by combining sound wave” (13.2%), “all radioactivity is manmade” (14.5%) and “antibiotics kill viruses as well as bacteria” (16.2%).

Examining the individual items shows that the item “milk that is contaminated by radioactivity will be safe to drink after boiling” had registered the largest drop in the percentage of correct answer, from 63.8% to 34.7%, a drop of 29.1%. Other items that suffered drastic drop in the percentage of correct answer were: “all radioactivity is man made” (18.5% decrease), “lasers function by combining sound wave” (20.9% decrease), and “the earliest human lived at the same time as the dinosaurs” (20.2% decrease).

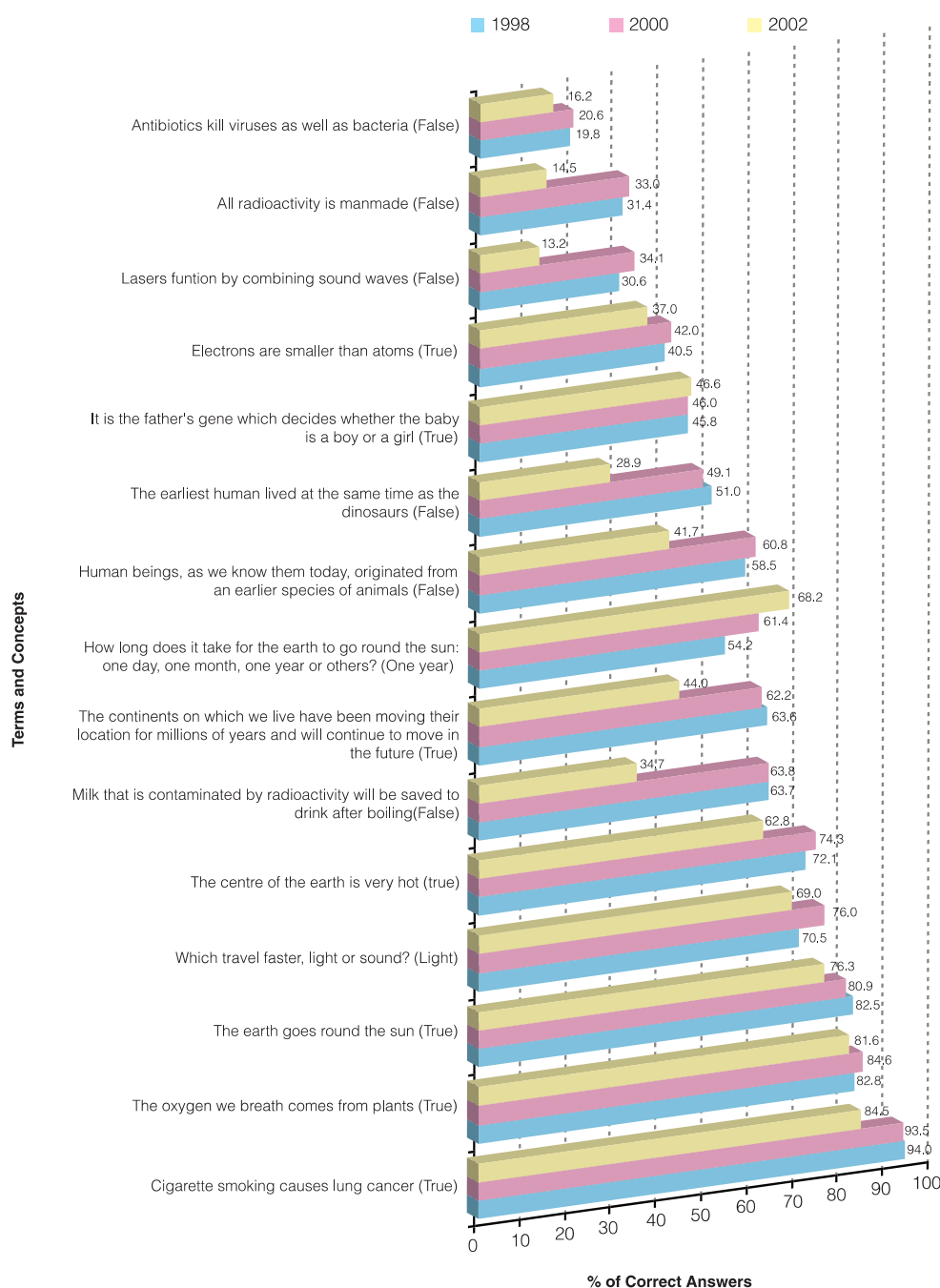


Figure 9.12: Understanding of Scientific Terms and Concepts, 1998-2002

9.4.1 Age Group Comparison

Consistent with the findings for level of perceived knowledge and interest expressed, youths had the highest average percentage of correct answers at 49.1% followed by adults (42.8%) and children (38.3%). Children experienced the largest decline in the average percentage of correct answers with a decline of 17.5%, from 55.8% in 2000 to 38.3% in 2002. Adults also had a substantial drop in the average percentage of correct answers, from 57.1% to 42.8% in 2002

while the average percentage of correct answers among youths dropped from 60.8% to 49.1%.

Generally, youths scored the highest percentage of correct answers for all items except for the item “man as we know today, originated from an earlier species of animals” for which the adults fared better (39.9%) compared to youths (37.3%) (Figure 9.13). Comparing adults and children, adults performed better in all areas except “the oxygen we take in comes from plants” and “the

earth goes round the sun” for which the children showed a better performance.

Within group comparison shows that youths had the lowest percentage of correct answer for the statement “lasers function by combining sound waves” (13.6%) while the answer for “cigarette smoking causes lung cancer” had the highest percentage of correct

answer (85.9%). Children and adults showed similar pattern of correct answers. All the three age groups had the same order of correct answers in that the three statements that had the highest percentage of correct answers were: “cigarette smoking causes lung cancer”, “the oxygen we breath comes from plants”, and “the earth goes round the sun”.

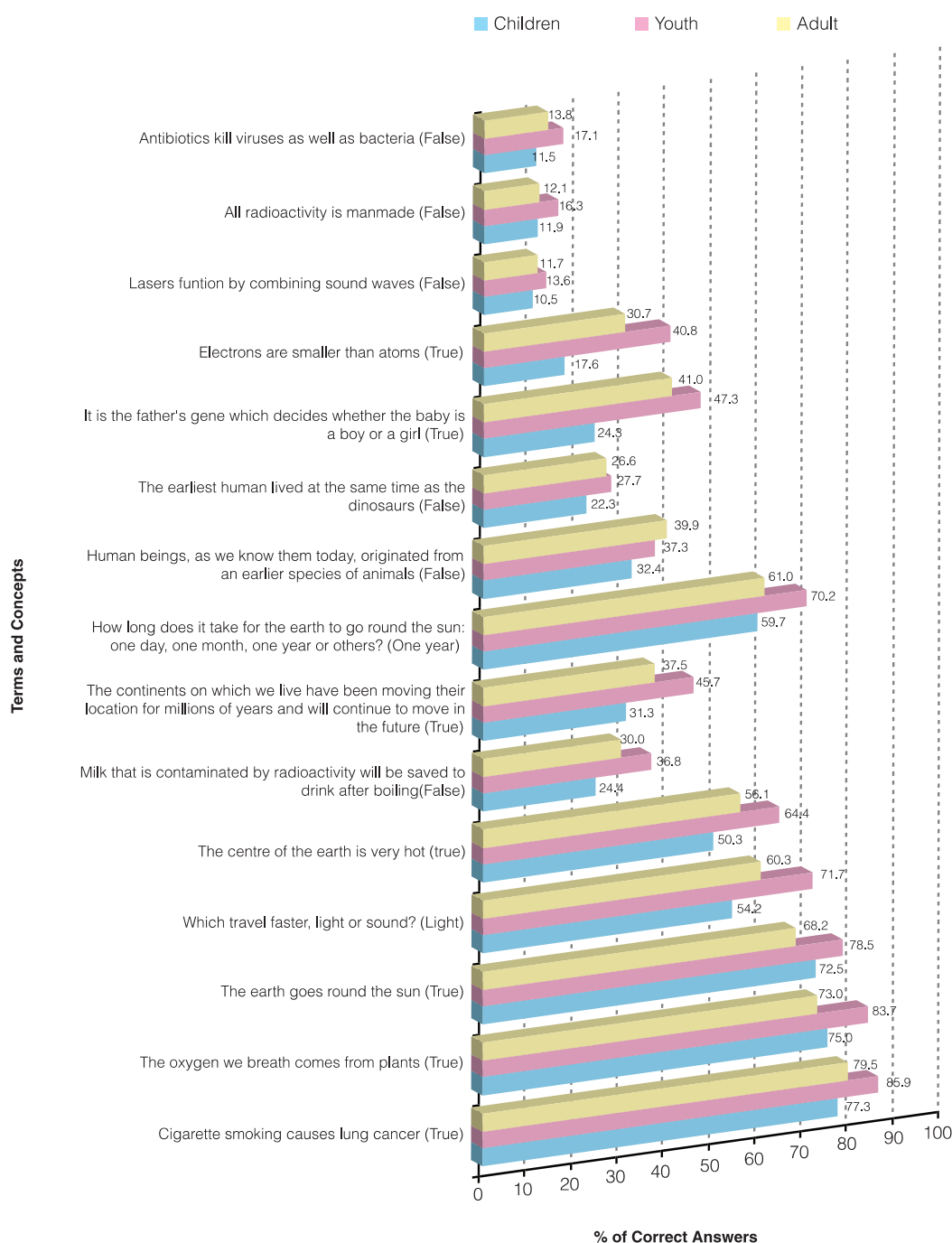


Figure 9.13: Understanding of Scientific Terms and Concepts by Age Group, 2002

9.4.2 Understanding of Scientific Terms and Concepts by Educational Streams

For the Survey of 2002, a new educational stream known as the technical/vocational stream was added. Overall, the respondents from the science stream had the highest average percentage of respondents with the correct answers (58.1%),

followed by those in the technical/vocational stream (51.7%). Occupying the third place was the commerce stream (48.9%) and subsequently the religious stream (46.7%) and arts streams (44.9%). The stream that fared the worst was the arts stream. This is not surprising as those from the arts stream would not be expected to have an interest and hence high level of scientific literacy.

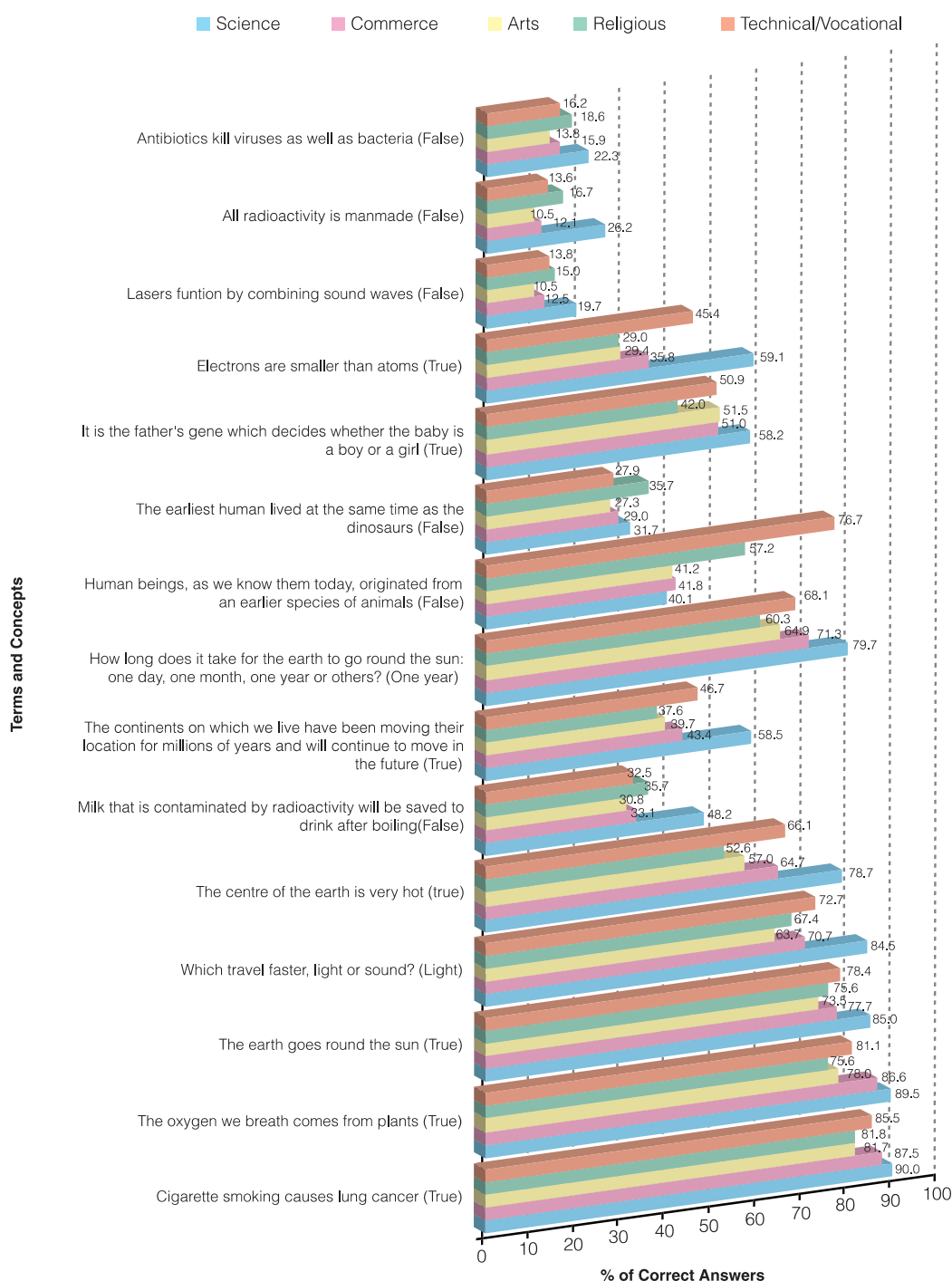


Figure 9.14: Understanding of Scientific Terms and Concepts by Educational Streams, 2002

Examining the individual items, those from the science stream had the highest scores among all the educational streams except for “human beings, as we know today, developed from an earlier species of animals” for which 76.7% of the respondents from technical/vocational stream had correct answers compared to only 40.1% from the science stream (Figure 9.14). Besides the technical/vocational stream, those in the religious and commerce streams and even the arts stream performed better.

9.4.3 Understanding of Scientific Terms and Concepts by Gender

Comparing males’ and females’ performance on the understanding of scientific terms and concepts, males fared better as their overall score of correct answers was 44.9 compared to 42.3 for females. Males consistently performed better than females in all areas. The only statement that females performed marginally better than males was “cigarette smoking causes lung cancer”.

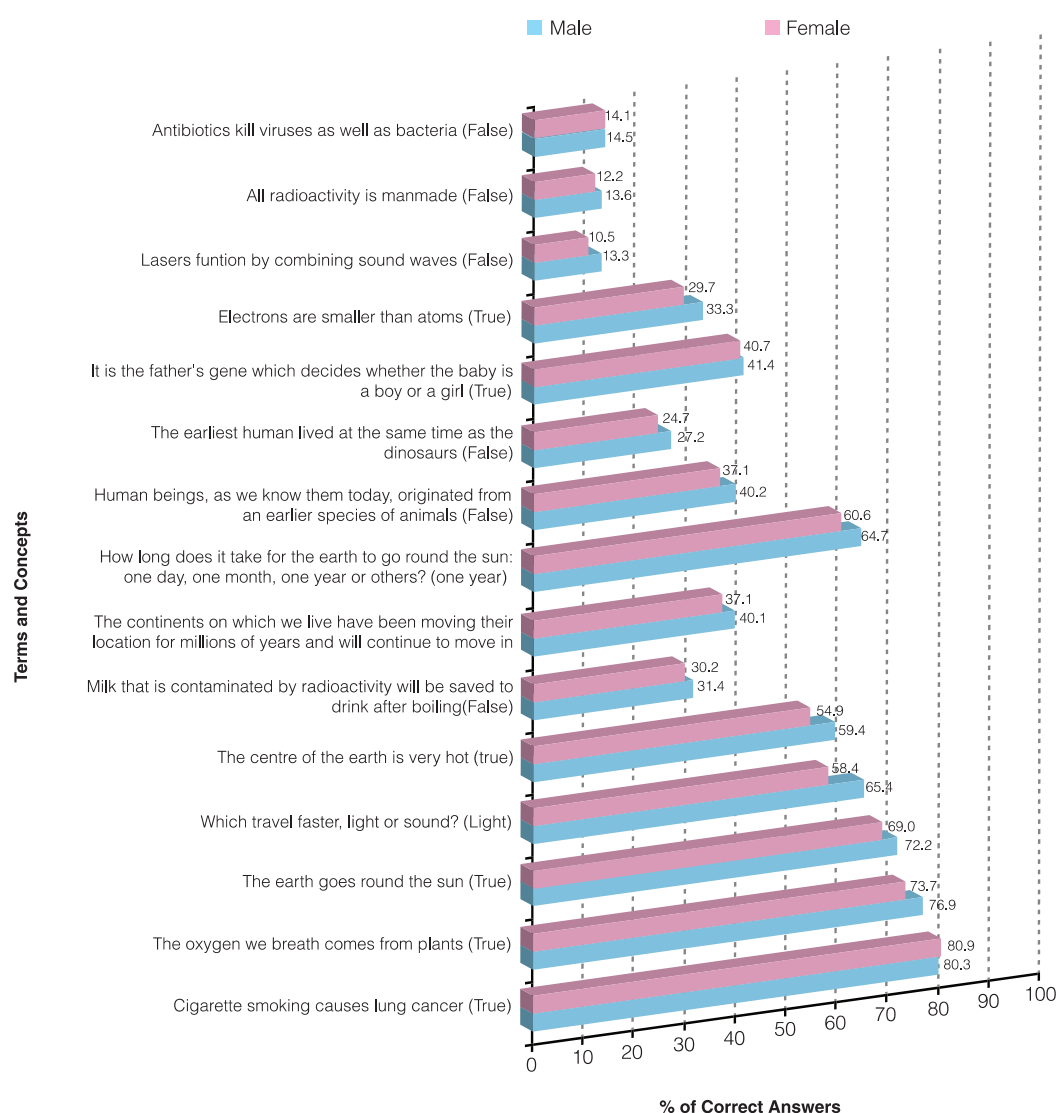


Figure 9.15: Understanding of Scientific Terms and Concepts by Gender, 2002

9.5 Sources of Information and Media Habits

An understanding of information and media habits is important so that efforts directed at improving the level of scientific literacy among Malaysians can be conducted through the appropriate communication channels. Television remained the most popular source of information with 98.4% of the respondents watching television (Figure 9.16). The trend of adopting television as a source of information has been increasing since 1998 due probably to the introduction and adoption of cabled television channels that provide a variety of programmes catered to diverse interests. The next popular source of information was newspapers (89.9%) followed by radio (85.3%). The popularity of magazines suffered a major decline in 2002 as only 64.2% reported magazines as a source of information compared to 82.3% in 2000. The Internet as a source of information has increased marginally among the respondents surveyed, from 40.2% in 2000 to 43.9% in 2002.

9.5.1 Media Habits by Age Group, Locality, Educational Level and Gender

For more effective dissemination of scientific information, it is necessary to know the different media habits among different groups in Malaysia. Among the three age groups surveyed, youths were the top users of the various media (Figure 9.17). Television remained the most popular. This is probably due to the audio visual appeal that makes it most interesting. While the media habits among the three groups did not differ much in terms of television usage, there were differences in terms of Internet, radio and magazines and scientific magazines, and newspaper usage pattern. By far the greatest difference was for the Internet usage pattern in which 60.6% of the youths used the Internet compared to 37.1% children and 40.0% adults. For newspapers, 94.4% of youths read newspapers compared to 89.8% adults and 81% children. This is contrary to expectations, as newspapers as a source of information is widely recognised and used by adults.

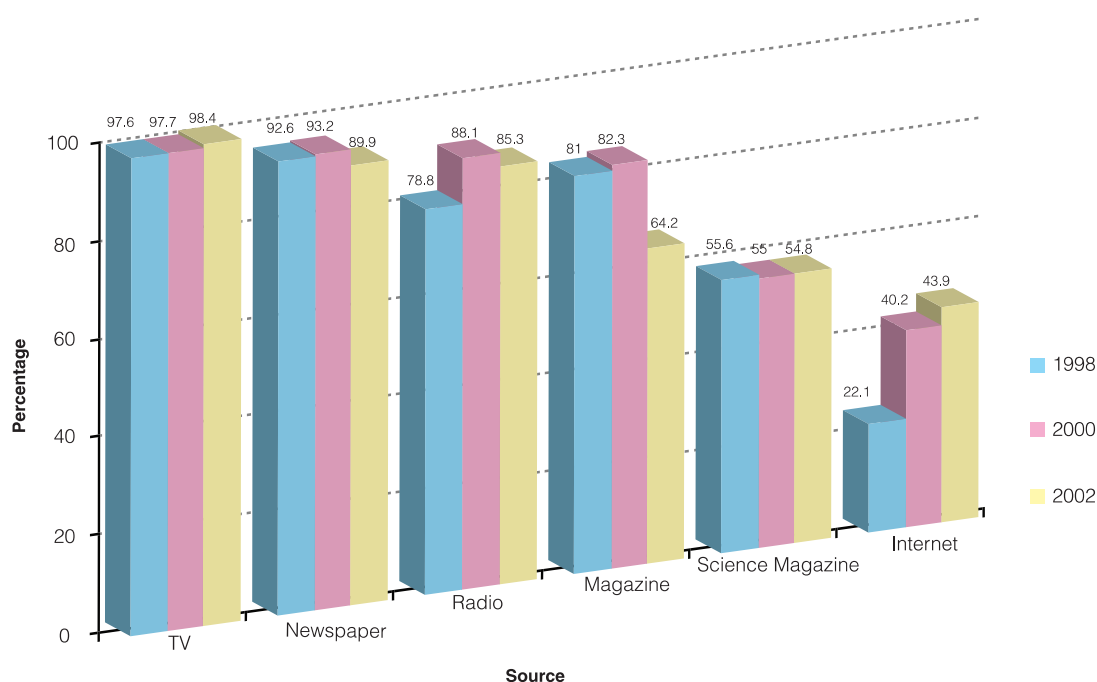


Figure 9.16: Media Habits, 1998-2002

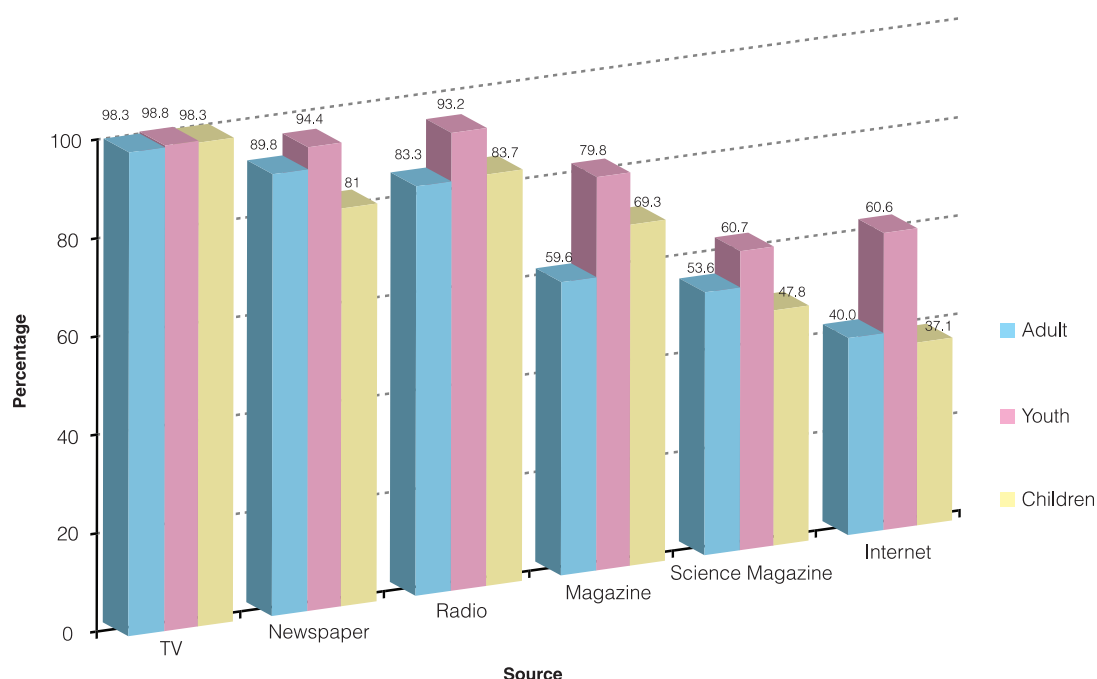


Figure 9.17: Media Habits by Age Group, 2000

Within group comparison shows that the percentage of youths using newspapers, magazines, and scientific magazines in 2002 dropped compared to 2000. There was a marginal drop in the usage of newspapers among youths, from 95.7% in 2000 to 94.4% in 2002. This indicates the trend that printed media has declined in popularity as a source of information. Whilst the use of the Internet is on the rise, the actual usage of the Internet has to be examined. In the year 2002, youths increased their usage of television from 97.2% in 2000, to 98.8% in 2002.

Television was the only media that received an increase in popularity among children. For all the rest of the media sources, there was a decline. The drop in the percentage of children reading magazines and scientific magazines was most noticeable in which the drop was about 13-15% compared to the readership in 2000. The usage of the Internet has dropped among children even though it was a marginal drop. For adults, television was the most popular source of information that recorded an increase in popularity. The other media that saw an increase in usage among adults were science magazines and the Internet. The percentage of users among adults for newspapers, radio and

magazines had dropped in 2002 compared with 2000.

Comparing the media habits by locality shows that urban and rural respondents liked to watch television (Figure 9.18). The media that showed marked difference in habits were the Internet and newspapers. As high as 93.7% of urban respondents read newspapers compared to only 86.2% among the rural respondents. For the Internet, 54% of the urban dwellers used the Internet compared to only 33.5%. Infrastructure and computer literacy, which are related to the level of educational achievement, could be among the constraints that hinder the adoption of the Internet in the rural areas. There was little difference in the usage pattern for radio between the rural and urban respondents.

Education is an important influence in the pattern of media usage. Those with primary level of education showed a generally low level of usage pattern for all the sources included, except for television, due perhaps again to its audio and visual appeal (Figure 9.19). Among those who had university education, the usage pattern was high for all types of media, in particular the usage of the Internet (73.6%) and newspapers (98.1%). For those with secondary

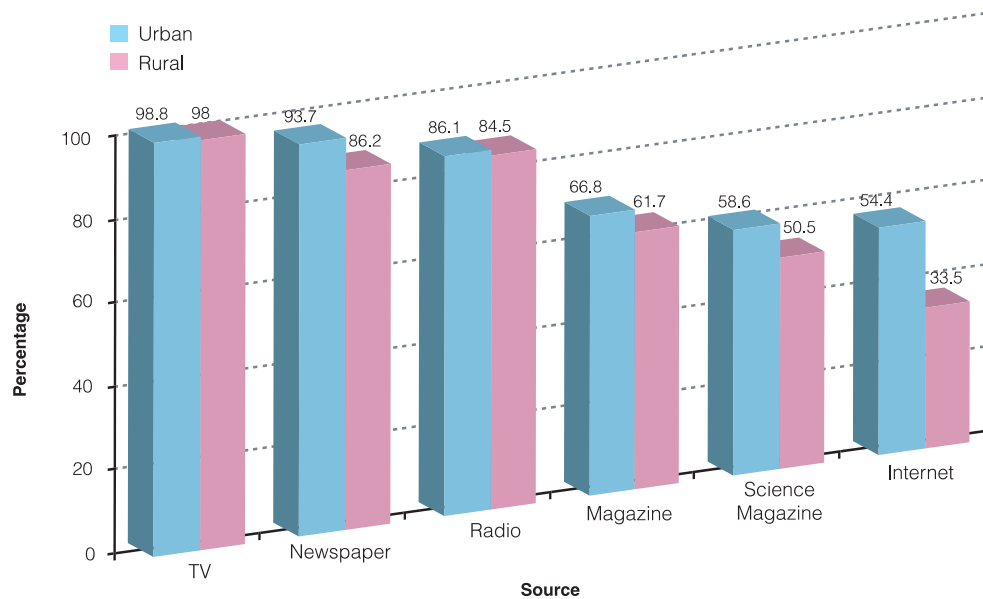


Figure 9.18: Media Habits by Locality, 2002

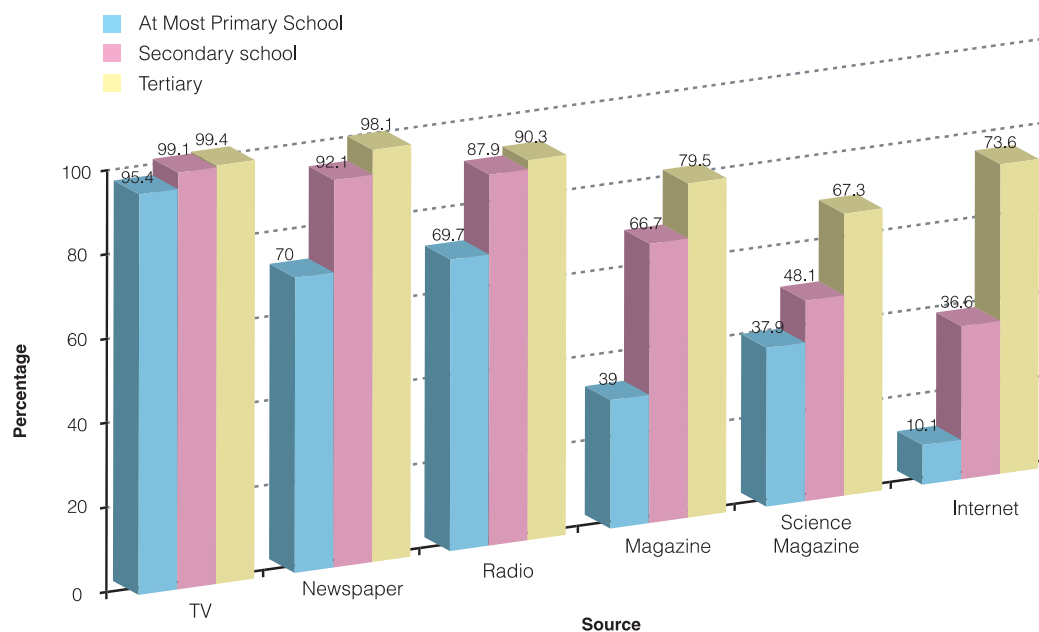


Figure 9.19: Media Habits by Level of Education, 2002

level of education, they preferred television, newspapers and radio.

Within group comparison shows that although a high percentage of those with university education were users of the various media, the usage penetration dropped in terms of magazine and scientific magazine readership. In 2002, only 79.5% of the university graduates read magazines

compared to 92.8% in 2000. Similarly, only 67.3% read scientific magazines compared to 74% two years earlier. Varying degree of increase in the usage of the Internet, television, newspapers and radio could be observed among respondents with university education. Respondents with secondary education showed differing patterns of media usage. The percentage of users for the Internet has dropped from 38% in 2000 to 36% in 2002

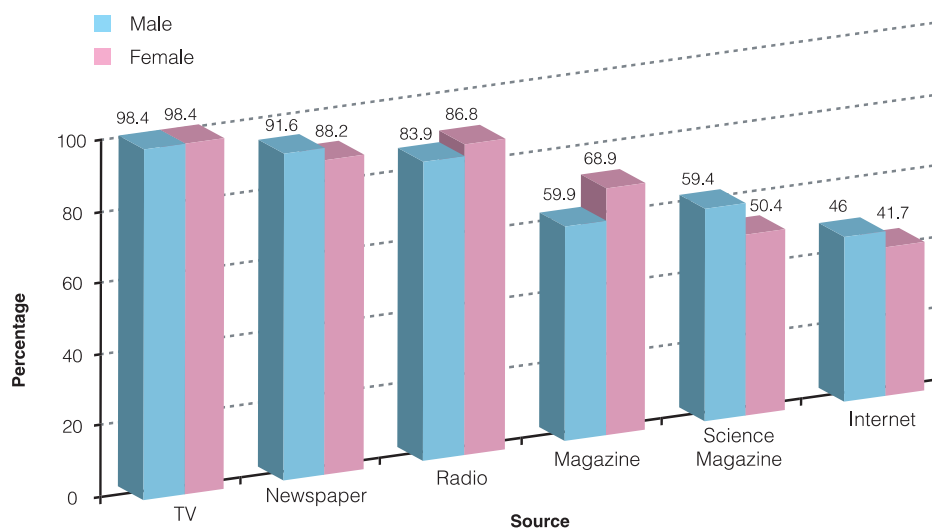
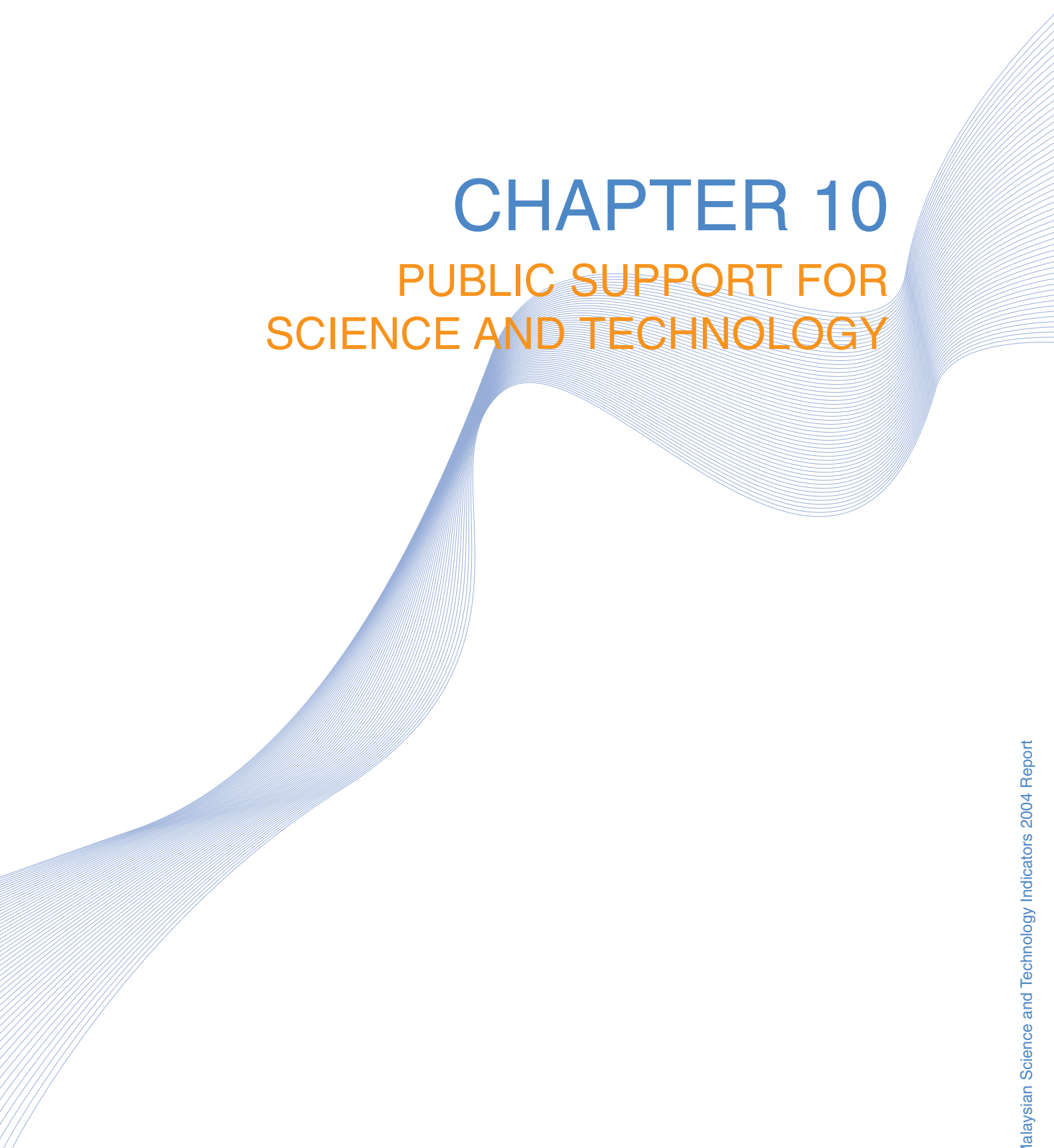


Figure 9.20: Media Habits by Gender, 2002

contrary to general believe that usage of the Internet is on the rise. Decline in the usage pattern could be observed for all the media except for television in which a marginal increase was recorded, i.e. from 97.8% in 2000 to 99.1% in 2002.

Intra-group comparison of those with primary education shows that there was a drop in all media usage except for scientific magazines. This is most surprising considering the fact that there was an overall decline in science magazine readership, even among those who with university education.

Comparing the media habits of males and females shows that an equal percentage of male and female watched television, confirming that watching television is not gender bias (Figure 9.20). However, for newspapers, science magazines, and the Internet, a higher percentage of males compared to females reported using these sources of information. More females liked the radio and magazines compared to males.

A decorative graphic consisting of numerous thin, parallel blue lines that form a wavy, ribbon-like shape. It starts from the bottom left, curves upwards and to the right, then loops back and curves downwards and to the right, ending near the top right corner. The lines are closely spaced, creating a sense of motion and depth.

CHAPTER 10

PUBLIC SUPPORT FOR SCIENCE AND TECHNOLOGY

This chapter is devoted to the types of schemes provided by various government agencies to support or accelerate technology-based activities such as research and development, commercialisation, acquisition of technology, and etc. in the nation's drive to become one of the world's most competitive industrialised economies by 2020. The first attempt at providing information and analysis of the government support for science and technology appeared in the 1998 Science and Technology Indicators Report that carried a chapter on the various incentives, schemes and programs offered by the Government for the development of science and technology in Malaysia. A review of the number of applications and approvals for the incentives was presented in the Science and Technology Indicators Report, 2000. While the chapter in the 1998 Report serves to create awareness with respect to the numerous incentives, the 2000 Report gives an indication as to the extent of the utilisation of incentives and schemes for the development of science and technology in the country.

To encourage further the development of science and technology, the Government of Malaysia has introduced new schemes. In addition to introducing the new schemes, this chapter will continue to provide an update on the status of applications and approvals for the existing schemes. This serves to indicate the extent of application and usage of the various incentives. As was the case in the last report, there still exist gaps in data and hence limits the completeness and comprehensiveness of this report. Due to data gaps, it is recommended that any attempt to draw conclusions from this chapter should be made only after having considered this shortcoming.

10.1 New Schemes Introduced in 2002

The government of Malaysia has introduced four additional schemes in its effort to encourage further the development of science and technology in the country. These are the Technology Acquisition Fund for Women (TAF-W), the E-Manufacturing Grant, the Grant for Rosettanet Standard

Implementation for Small and Medium Size Enterprises (SMEs), and the Grant for Upgrading Engineering Design Capabilities.

10.1.1 Technology Acquisition Fund for Women (TAF-W)

The Technology Acquisition Fund for Women (TAF-W) was introduced the Ministry of International Trade and Industry as an extension of the existing TAF scheme. The TAF-W specifically caters to women entrepreneurs, providing partial grants to them to enhance their technology levels and production processes. This fund hopes to upgrade the technological capabilities, technical skills and expertise of women-owned companies in order to enhance the competitiveness of these companies and to integrate them into the mainstream of manufacturing. It offers two forms of assistance for the successful applicants: Acquisition of technology and training overseas.

Acquisition of Technology

Acquisition of technology is further categorized into three distinct classifications, namely, technology licensing; acquisition of patent rights, prototypes and design; and purchase of high tech machinery and equipment.

(i) *Technology Licensing*

The objective of this grant is to enhance the design and production of new and existing products and processes. The technology to be acquired should include design, blueprints, manufacturing know-how, training, technical support and proprietary equipment. Partial grant of up to a maximum of 70% or RM 1 million whichever is lower will be given to successful applicants. Expenses that are eligible for approvals include design, blueprints, manufacturing know-how, training, technical support and proprietary equipment.

(ii) *Acquisition of Patent Rights, Prototypes and Design*

Grants are allocated to facilitate the transfer of technology to enable the

development of new processes and products. All acquisition must include manufacturing rights from technology provider for manufacturing purposes. As in the case of technology licensing, partial grant of up to a maximum of 70% or RM 1 million whichever is lower, will be given to successful applicants. Eligible expenses include cost of procuring patent, registered design and or procuring prototype.

(iii) *Purchase of High Tech Equipment and Machinery*

The objective of technology acquisition through purchase of high tech equipment and machinery is to enhance the current production processes and the physical development of new products. Partial grant of up to a maximum of 50% or RM 1 million of the total cost for the purchase of machinery or equipment whichever is lower will be granted. Only cost of machinery is eligible for consideration.

Training Programme (Overseas)

Overseas training programmes fall into the following categories: Placement of Malaysian in Technology Companies or Technology Institutes and Foreign Expert Sourcing Programme.

(i) *Placement of Malaysian in Technology Companies or Technology Institutes*

The objective of this programme is to expose Malaysians and upgrade their knowledge on technology development in foreign technology companies or institutes excluding affiliated or subsidiary companies overseas. Placement takes the meaning of job attachment or on-the job training. Partial grant up to a maximum of 50% of the total cost or RM30,000, whichever is lower for each person; and subject to a maximum of 3 persons eligible for funding per project. The training period should not exceed three months. Expenses that are eligible for funding include airfare, accommodation, and daily allowances.

(ii) *Foreign Expert Sourcing Programme*

The objective of this programme is to assist companies to engage foreign technical experts and consultants in upgrading their products and processes. Partial grant up to a maximum of 50% of the total cost or RM30,000, whichever is lower will be eligible for funding. Similar expenses are eligible for funding in addition to the professional fees for foreign experts.

10.1.2 E-Manufacturing Grant

The E-Manufacturing Grant - ERP, introduced in 2002, provides funding to Small and Medium Enterprises (SMEs) to adopt Information and Communication Technology (ICT) aimed at improving competitiveness, efficiency and productivity. The objective of E-Manufacturing Grant is to assist SMEs in the acquisition of Enterprise Resource Planning (ERP) software; or to subscribe to on-line ERP system. The maximum grant allocated per company is RM 500,000. The funding is in the form of a matching grant where 50% of approved project cost is borne by the Government and the remainder by the applicant. Priority is given to: (1) SMEs that manufacture products or are involved in activities or services promoted under the Promotions of Investment Act (1986); and (2) those companies that participate in the Industrial Linkage Programme. Eligible expenses include the following:

- Purchase of ERP software or first-year subscription to on-line ERP system;
- Implementation charges including system study, customisation and training;
- Purchase of related networking equipment and server; and
- Other software such as Computer Integrated Manufacturing (CIM), Enterprise Resource Management (ERM), Materials Resource Planning (MRP), and Supply Chain Management (SCM) can also be considered based on the capabilities of SMEs.

10.1.3 Grant for RosettaNet Standard Implementation for SMEs

Introduced at the end of 2002, the RosettaNet Standard Implementation for SMEs scheme provides assistance to SMEs in the Electrical and Electronics (E&E) sector to implement RosettaNet, an Internet based common messaging standard for global supply chain management. The RosettaNet enables companies in the supply chain to communicate and conduct business electronically through common codes for sourcing of parts and components. The objective of the grant is to assist SMEs in the E&E sector to implement the RosettaNet Standard through subscription to hosted services offered by Application Service Provider (ASP) registered with RosettaNet (M) Berhad.

The maximum grant allocated per company is RM30,000. The funding is in the form of a grant, where 70% of approved project cost is borne by the Government and the remainder by the applicant. Expenses that are eligible for other Government grants are not entitled under this scheme. Eligible expenses are:

- One time registration fee with ASP of RosettaNet;
- First year licensing fees of RosettaNet Application / Software;
- Professional fees to carry out system integration works, interfacing between enterprise applications and the middleware;
- Purchase of related computer hardware, peripheral and networking equipment;
- Setup and installation cost for connection to RosettaNet (including costs of acquiring firewall, modem, router and remote access server); and
- Related training fees.

RossettNet Malaysia Bhd, which specializes in promoting e-business standards for global supply chain has managed to attract 62 companies, of which 42 are local companies and 20 foreign to adopt the standards (The

Star, StarBiz, p. 5). Of these 62 companies, some have already implemented the standard while others are still in the decision-making process.

10.1.4 Grant for Upgrading Engineering Design Capabilities

Introduced in 2002, the grant provides assistance for SMEs to enhance their engineering design capabilities. This would enable SMEs to undertake their own designs in-house. The objective of the scheme is to provide grant for SMEs to acquire related design software, hardware and training. The maximum grant allocated per company is RM300,000. Funding is in the form of a matching grant where 50% of approved project cost is borne by the Government and the remainder by the applicant. Eligible expenses include: purchase of design software (CAD, CAM, and CAE) or subscription fee/license fee for on-line engineering design services; purchase of related computer hardware, peripheral and networking equipment; and related training. Priority is given to SMEs, which either manufacture products or are involved in activities or services promoted under the Promotion of Investments Act (PIA), 1986; and participate in the Industrial Linkage Programme (ILP).

10.2 Applications and Approvals for S&T-related Schemes

10.2.1 Technology Acquisition Fund (TAF)

Technology Acquisition Fund (TAF) is a scheme administered by Malaysian Technology Development Corporation (MTDC), a joint venture company between the Government and the private sector. Its main objective is to facilitate the acquisition of strategic technologies by the industrial sector. During the period 1999-2000, a total of 176 applications were made compared to the period 2001-2002 in which only 54 applications were received (Figure 10.1). The drop in the number of applications is drastic. Generally, the decline in the number of applications was experienced by all industries. Many of industries did not

have one single application for the entire period of 2001-2002. The Electrical & Electronics industry emerged as the industry that had the greatest number of applications, followed by the chemicals industry. A few industries had four applications: Mould, Tools & Die, Industrial Products, and Metal Based and Advanced Material Industries.

The number of approvals granted for the period 2001-2002 dropped as many as 30

compared with the approvals for 1999-2000. In line with the declining number of applications and approvals, the amount granted has also dropped significantly for the period 2001-2002 compared with 1999-2000. The decrease in the amount granted was about RM24 million. Figure 10.2 illustrates this fact. Figure 10.3 shows the number of projects granted assistance under the fund from 1999 to 2002 and the corresponding amounts awarded.

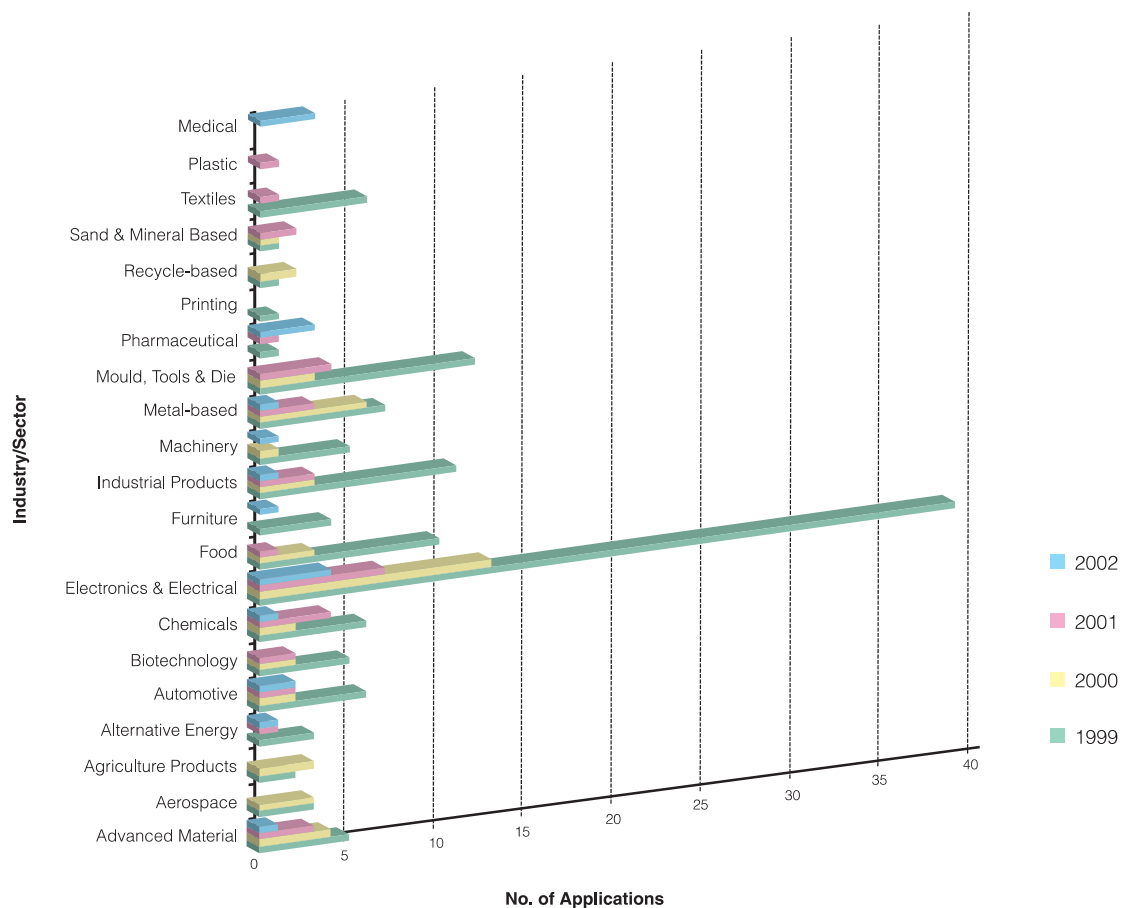


Figure 10.1: Applications of Technology Acquisition Fund (TAF) by Industry, 1999-2002

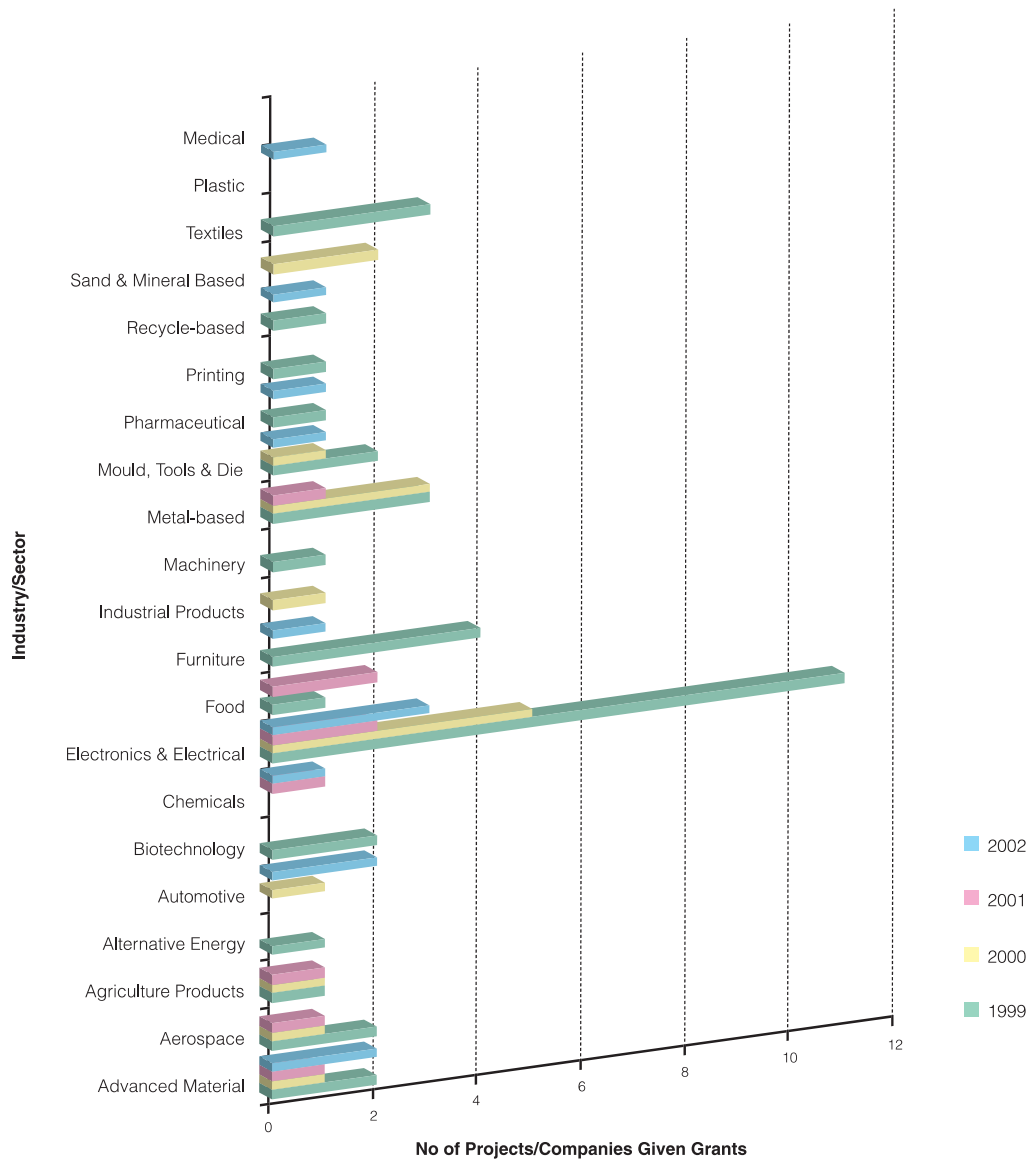


Figure 10.2: Technology Acquisition Fund (TAF) Grants by Industry, 1999-2002

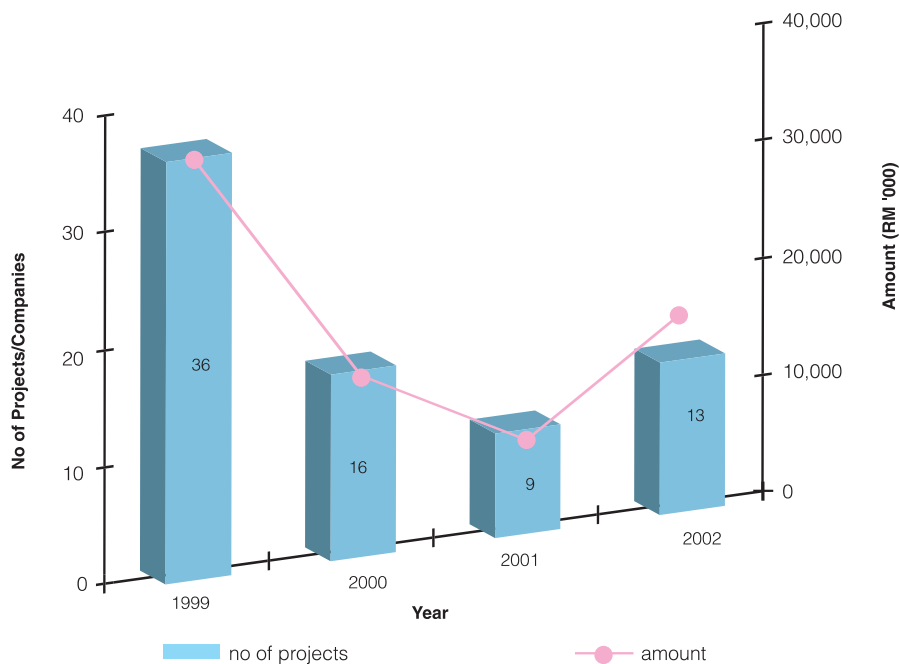


Figure 10.3: Amount and Number of Projects/Companies Approved under Technology Acquisition Fund (TAF) Grants, 1999-2002

10.2.2 Commercialisation of R & D Fund (CRDF)

In addition to the various types of tax incentives to promote R&D activities, CRDF is an impetus towards the commercialisation of R&D activities, in particular for public sector R&D activities that have commercial potential. The major objectives of CRDF are to enhance the competitiveness and capacity of Malaysian industrial sector by promoting the commercialisation of indigenous technology and to accelerate commercialisation of R&D efforts by local universities and research institutions, companies and individual

researchers or inventors. Figure 10.4 shows the status of applications and approvals for CRDF. There was phenomenal decrease in the number of applications in the 2001-2002 period as compared to the 1999-2000 period, i.e., from 99 to 17, respectively. Due to the small number of applications, the number of projects approved for the grants correspondingly decreased from 26 for the period 1999-2000 to 10 only for the reference period of 2001-2002. While E&E was the sector with the highest number of applications in 1999-2000, it had only one application in 2002. Biotechnology, which had five applications in 1999, did not have any applications for the entire period of

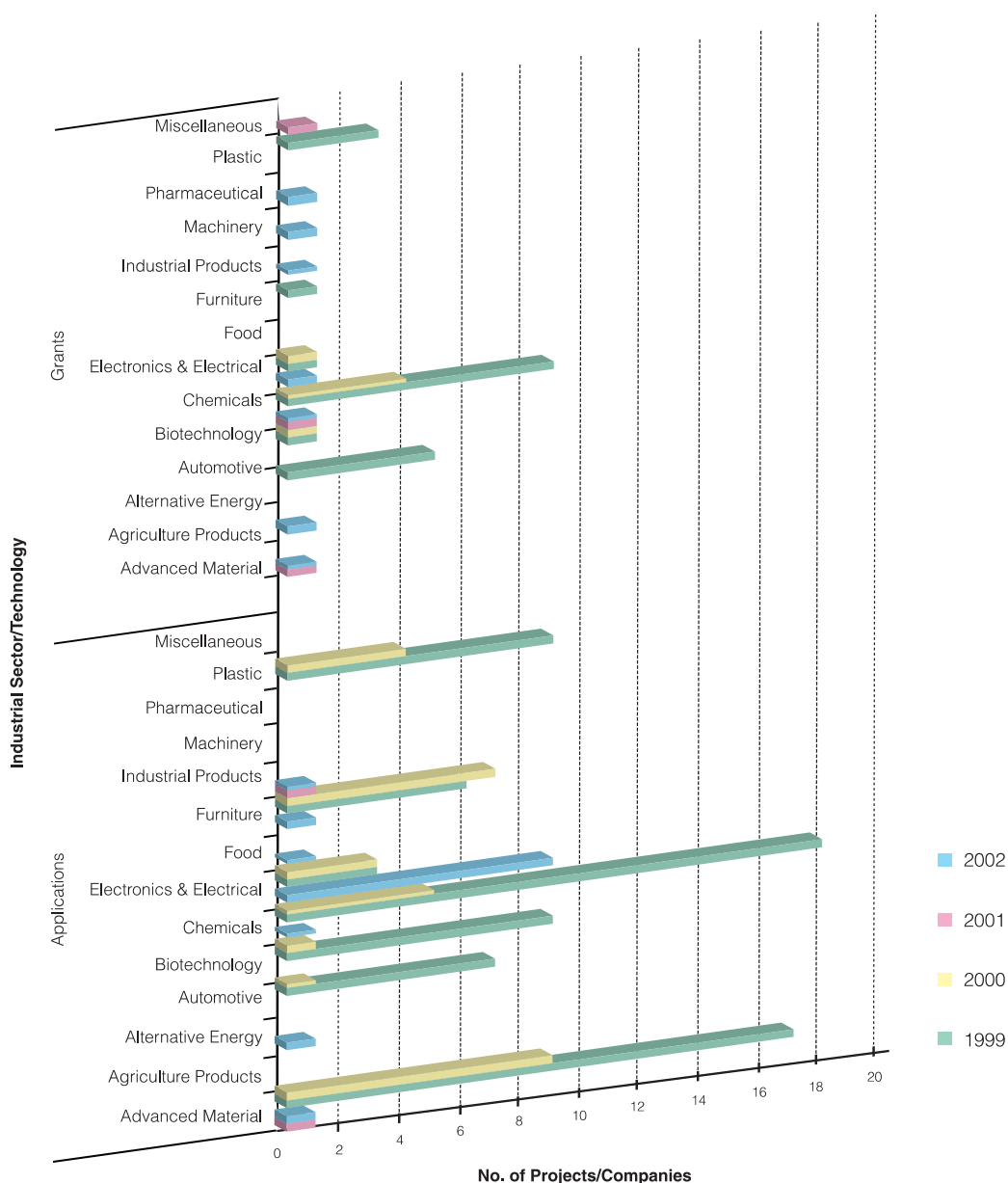


Figure 10.4: Commercialisation of R&D Fund (CRDF) Applications and Grants by Sector, 1999-2002

2001-2002. This is disturbing since biotechnology is the field of research for which growth prospect is highly rated. If the number of applications is any indication of the usefulness of the fund, relevant agencies need to re-examine the whole scheme. The amount granted dropped from RM24.4 million to RM11.9 million, representing a drop of about RM12 million, between 1999-2000 and 2001-2002.

10.2.3 Double Deduction for Income Tax Purposes

Double deduction on revenue expenses incurred in research and development as an incentive for carrying out R&D activities has been a popular scheme among industries. There was a marked increase in the application for double deduction for expenses related to R & D in the reference period of 2001-2002 as compared to the corresponding period of 1999-2000. The number of applications in the current period increased to 582 and 684 for 2001 and 2002, respectively from 162 in the previous year. This is attributable to the huge surge in applications from the automotive parts industry that had experienced an increase in the number of projects of about 10 times the number of projects applied in 2002 compared to that of 2000. Other industries that had substantial increase in the number of applications were electrical products, chemical industries, synthetic rubber products, and water treatment industries. The industry that had a significant increase in the number of applications was the electronics industry. However, the increase in the number of applications did not bring about a corresponding increase in the amount of double deductions granted for some of the industries as can be seen from a major drop in the amount approved for 2001 and 2002 compared to year 2000. These industries include agriculture, concrete-based industries and electronic component industry which suffered the largest decline. This could be due to the slowdown in the economy of the US following the September 11 attack. As the electronics sector is dependent on external market, it is thus sensitive to changes in the global economy. On the other hand, automotive parts industry registered a significant increase in the amount of deduction approved. Figure

10.5 illustrates the total number of projects approved by the Inland Revenue Board (IRB) for double deduction.

Figure 10.6 shows the amount of R & D expenditure allowed by the IRB for double deduction by sectors for 2001 and 2002. The amount allowed for double deduction increased from RM51 million in 2000 to slightly more than RM57 million in 2001 and subsequently to RM123 million in 2002, registering an impressive growth over the years. It can be seen that double deduction for R&D expenditures remains widely used by various industries. For year 2001, the industry that had the largest amount approved was the semiconductor industry with a total deduction of RM24.6 million followed by the agriculture-palm oil, rubber, cocoa, and fruit sector with deductions amounting to RM12.5 million. For the year 2002, there was a strong surge in the amount of double deductions granted to the automotive parts industry, from RM0.8 million in 2000 and 2001 to RM87.8 million in 2002. The phenomenal expansion in the amount of deductions granted is in line with the development in the automotive industry that now sees a total of 4 national automobile manufacturers versus two in the recent past. In addition, the impending AFTA 2005 has spurred more R&D activities within the local automobile manufacturers in preparation to face the challenges of AFTA.

A closer look at the double deductions by type of expenditures shows that the largest amount has been spent on export promotion reflecting the open nature of the national economy. Figure 10.7 presents the amount of expenditure granted by type of expenditure. In the year 2002, the largest amount was spent on export promotion followed by advertisement of Malaysian brands. Similar pattern was also observed for 2002.

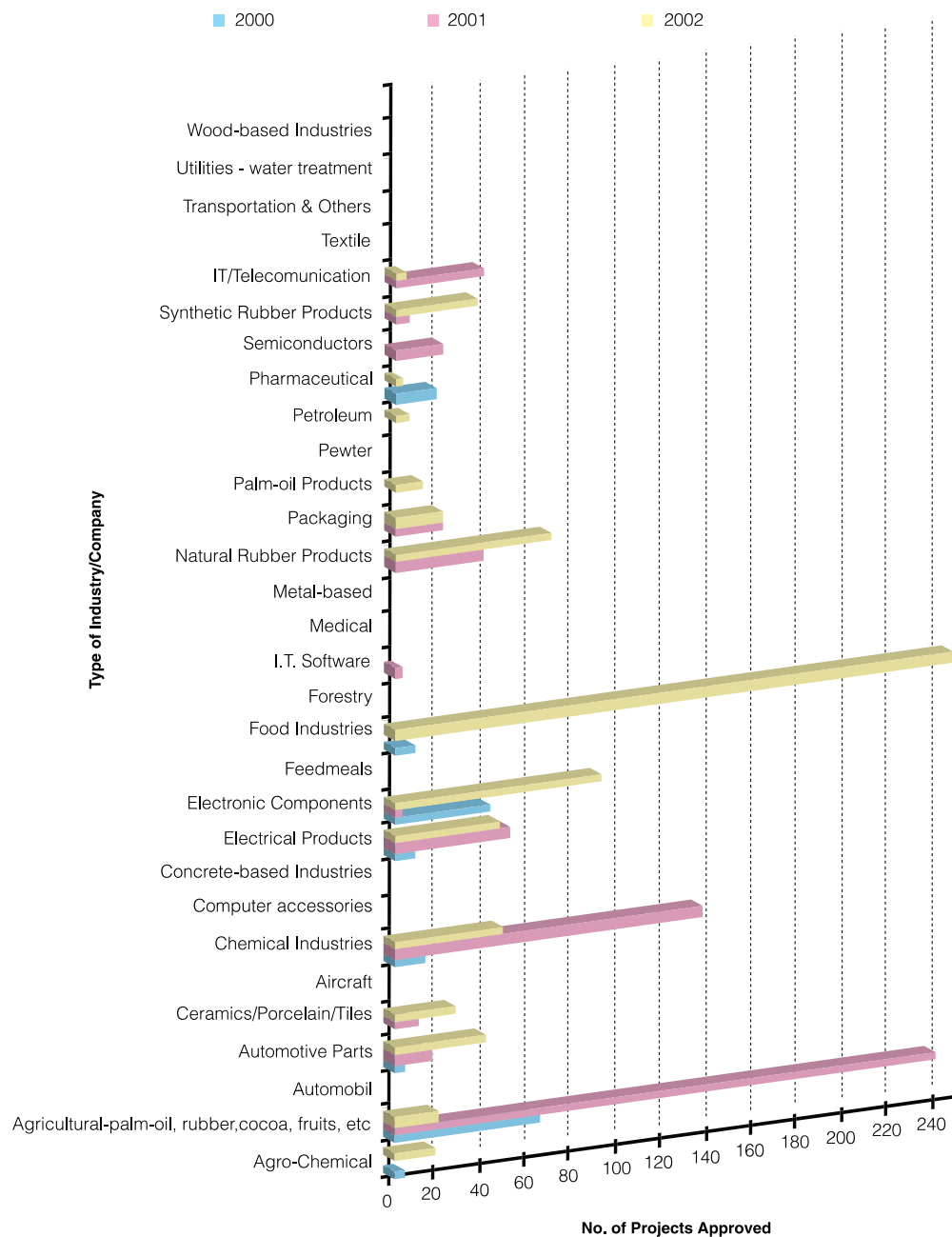


Figure 10.5: Double Deduction for R&D Expenditure by Sector, 2000-2002

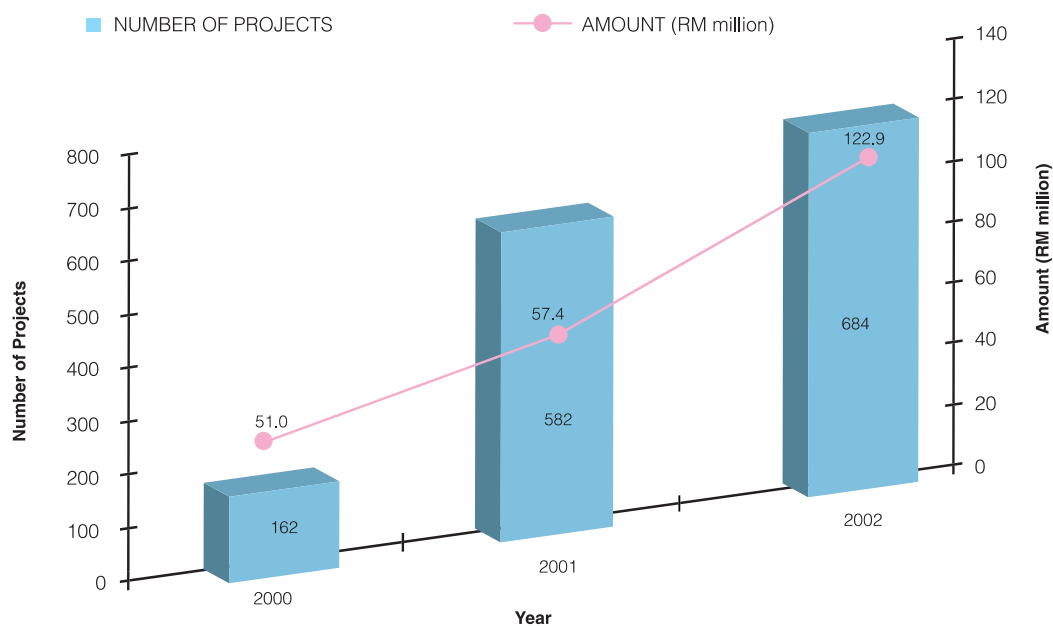


Figure 10.6: Number of Companies and Amount Granted Double Deduction, 2000-2002

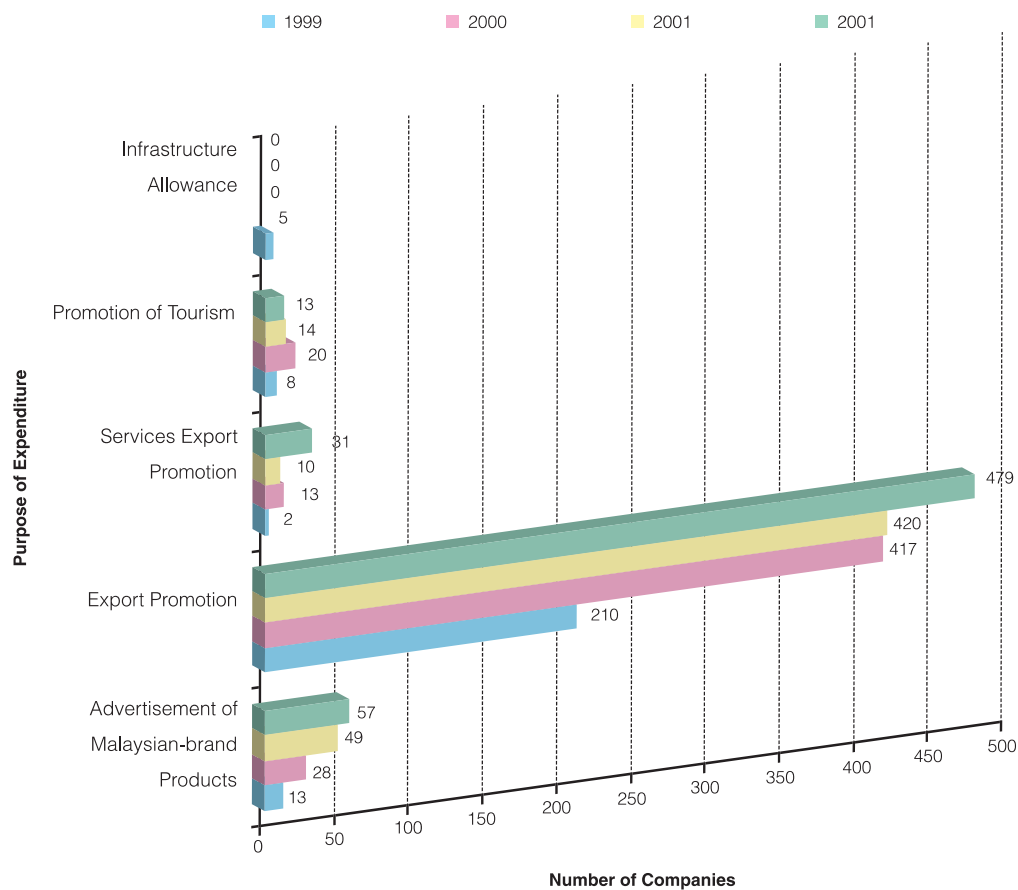


Figure 10.7: Number of Companies Granted Double Deductions by Purpose, 1999-2002

10.2.4 Industrial Technical Assistance Fund (ITAF 2)

The ITAF was established in 1990 to assist small and medium scale industries (SMIs) to conduct consultancy studies, product design and development, quality and productivity improvements and market development. ITAF 2, which is a scheme for product and process improvement, provides matching grants for product and process

upgrading; and ITAF 3 allocates funds for the upgrading of productivity and quality as well as for the documentation of certification.

Figure 10.8 illustrates the number of approvals for ITAF 2 by industry for 2001 and 2002. In 2001, the number of approvals for ITAF 2 was 30 compared with 36 in 2000. In 2002, the number of approvals surged to 63, registering an improvement of 75% over the last two years. This could be due to the lag

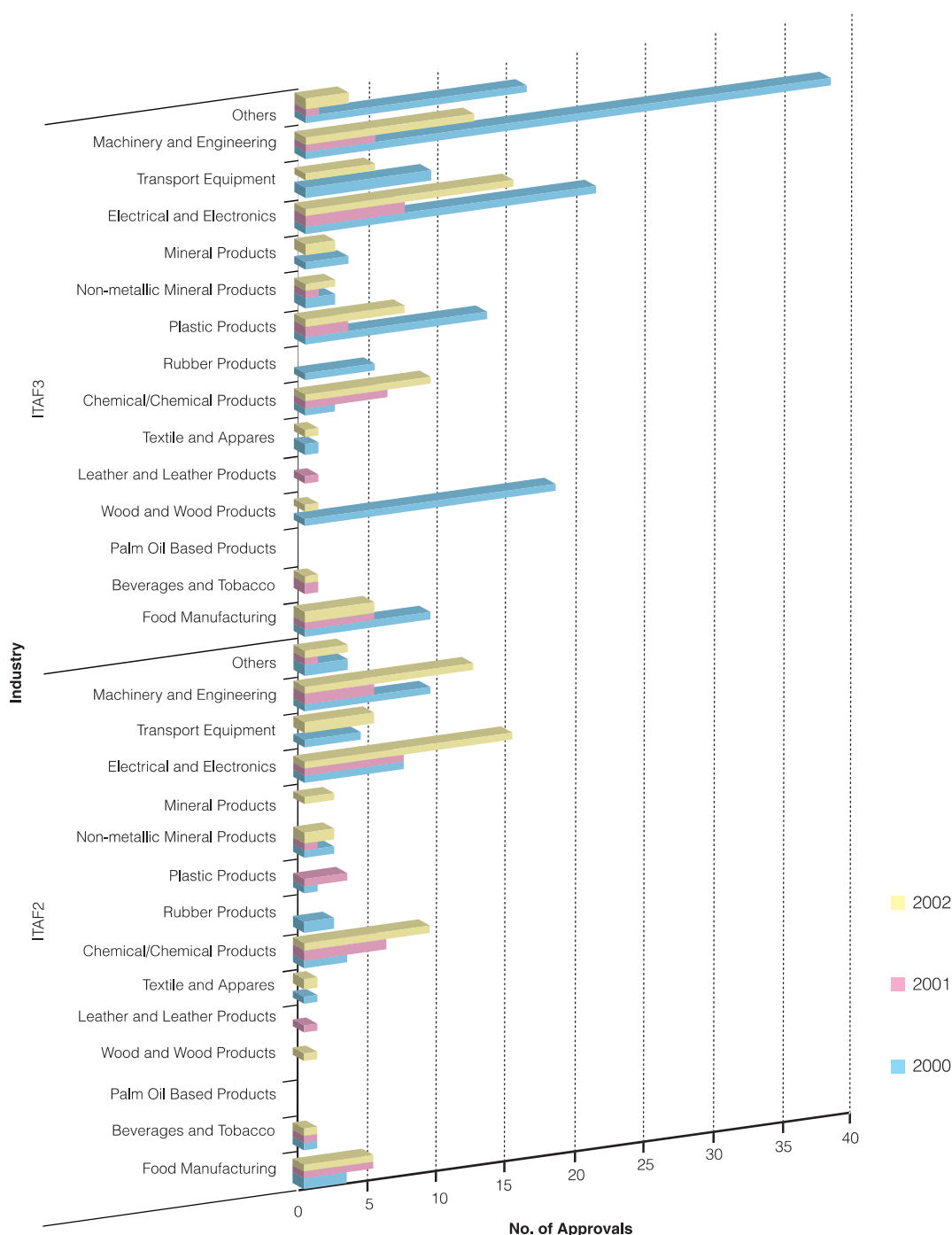


Figure 10.8: Approvals of Industrial Technical Assistance Fund (ITAF) by Industry, 2000-2002

between the time of application and approval. The amount of grants approved corresponds to the number of approvals; i.e., a drop was observed for 2001 while in 2002, there was an increase in the amount granted.

As for ITAF 3, approvals increased substantially from year 2000. In 2000, the number of approvals was 137 as compared to 272 and 429 for 2001 and 2002, respectively. Correspondingly, the size of grants increased from about RM5 million in 2000 to RM9 million

in 2001 and RM13.7 million in 2002.

Figure 10.9 provides an indication of the total amount disbursed under the ITAF by industry in 2001 and 2002. In 2001, about RM1.6 million was provided to successful applicants under the ITAF 2 scheme, and about RM9 million was disbursed under ITAF 3. In 2002, the amount for ITAF 2 increased to about RM3.5 million while the amount approved for ITAF 3 reached about RM13.7 million.

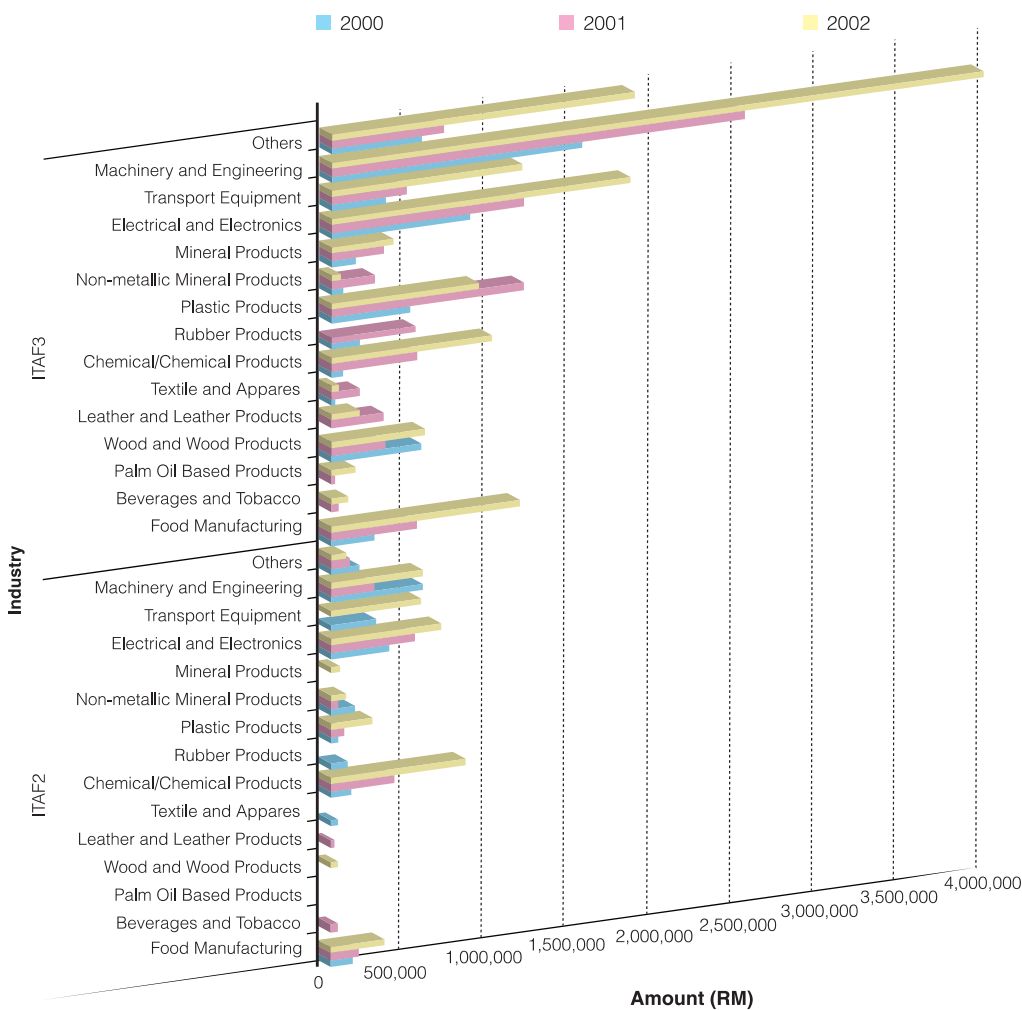


Figure 10.9: Total Amount of Industrial Technical Assistance Fund (ITAF) by Industry, 2000-2002

10.2.5 Demonstrator Application Grant Scheme (DAGS)

Introduced in 1998, DAGS aims to develop the information and communication technology industry in Malaysia. Under the Eighth Malaysia Plan (2001-2005), the amount of allocation was increased to RM100 million from the initial funding of RM50 million in 1998. This scheme seeks to promote the development of software and content industries in order to achieve greater competitiveness in view of intense competition in the global market. Figure 10.10 contrasts the number of approvals against the number of applications for the DAGS by sector between 2000 and 2002. Figure 10.11 shows the corresponding amounts approved for the successful applicants. The classification adopted prior to 2001 was based on sector, namely public, private and non-government organizations. From 2001 onwards, the applications and

approvals are classified as social digital inclusion, E-public services and economic competitiveness which reflect the purpose for which the fund is applied.

Data on applications were not available prior to 2000. In 2001, a total of 51 applications were received versus 14 in 2002, representing a decrease of 37 applications. Corresponding to the decrease in the number of applications, the amount applied dropped from RM100.4 million in 2001 to RM33.3 million in 2002. From the number of approvals and amounts approved, it is clear that the private sector had been the most active sector in utilizing the scheme. This was followed by the public sector and non-government sectors. Analysing the data using the new classification, it is clear that E-Public Services were the major user of this scheme followed by social digital inclusion (2001) and economic competitiveness in 2002.

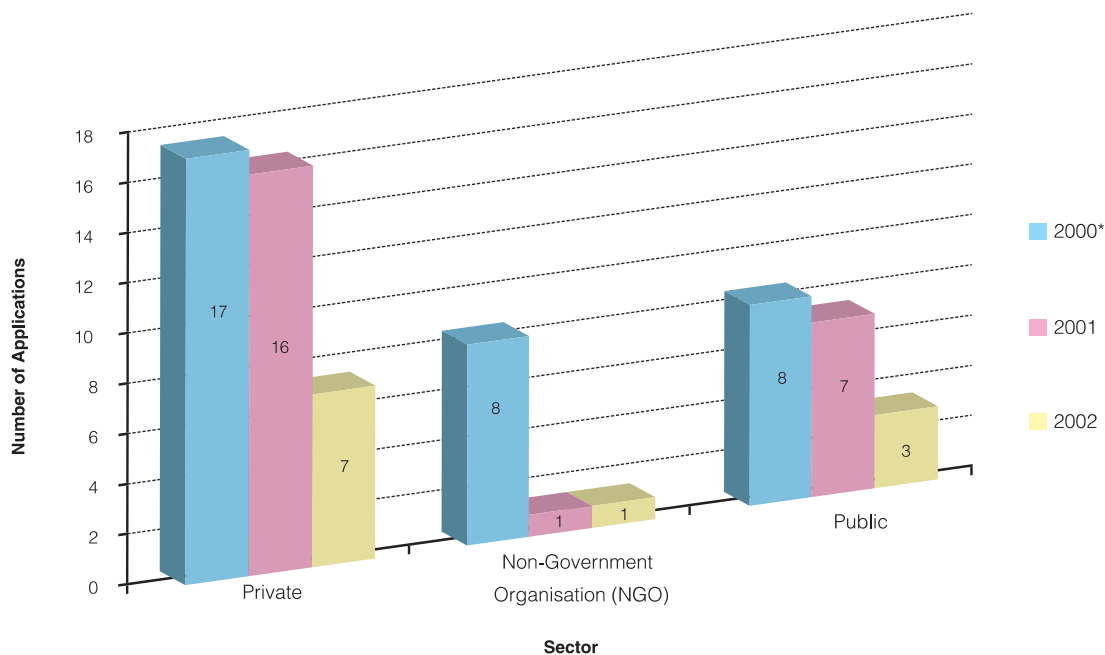


Figure 10.10: Number of Approvals under the Demonstrator Application Grant Scheme (DAGS) by Sector, 2000-2002

Note: (*) Includes data for year 1999

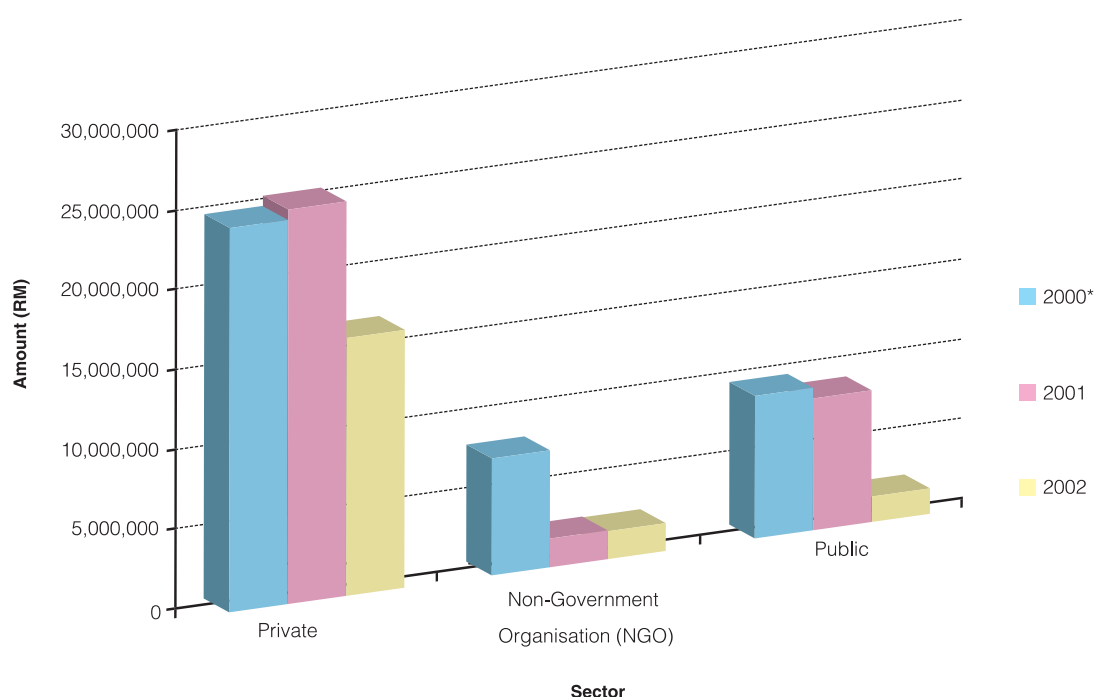


Figure 10.11: Amount Approved under the Demonstrator Application Grant Scheme (DAGS) by Sector.

Note: (*) Includes data for year 1999

10.2.6 Multimedia Super Corridor (MSC) Research and Development Grant Scheme (MGS)

The MGS is a scheme administered by the Multimedia Development Corporation (MDC) designed to assist local or joint venture companies in developing multimedia technologies and applications in order to develop the information and communications technology (ICT) industry in the country. Figure 10.12 illustrates the number of applications and approvals made for the MGS by industry between 2000 and 2002. Figure 10.13 shows the amounts of those applications, and the amounts approved.

In 2000, 10 out of the 24 applications were approved, totaling close to RM22 million against the amount applied of RM138.9 million. In 2001, the number of applications dropped to 13 resulting in the decline in the number of approvals to 6 with the total amount approved decreasing to around RM12.5 million (Amount applied was RM50.5 million). Total applications and approvals rose slightly in 2002 to 16 and 8

respectively with the total funds disbursed reaching to about RM16.1 million.

The industries that were active in the application for funding were the business application software and the engineering application software industries for both 2001 and 2002. However, in 2001, the industry that received the largest amount of funding was the computer telephony industry followed by the optical networking technology industry. For year 2002, the industry that received the largest amount of funding was the engineering application software industry followed by networking technology industry.

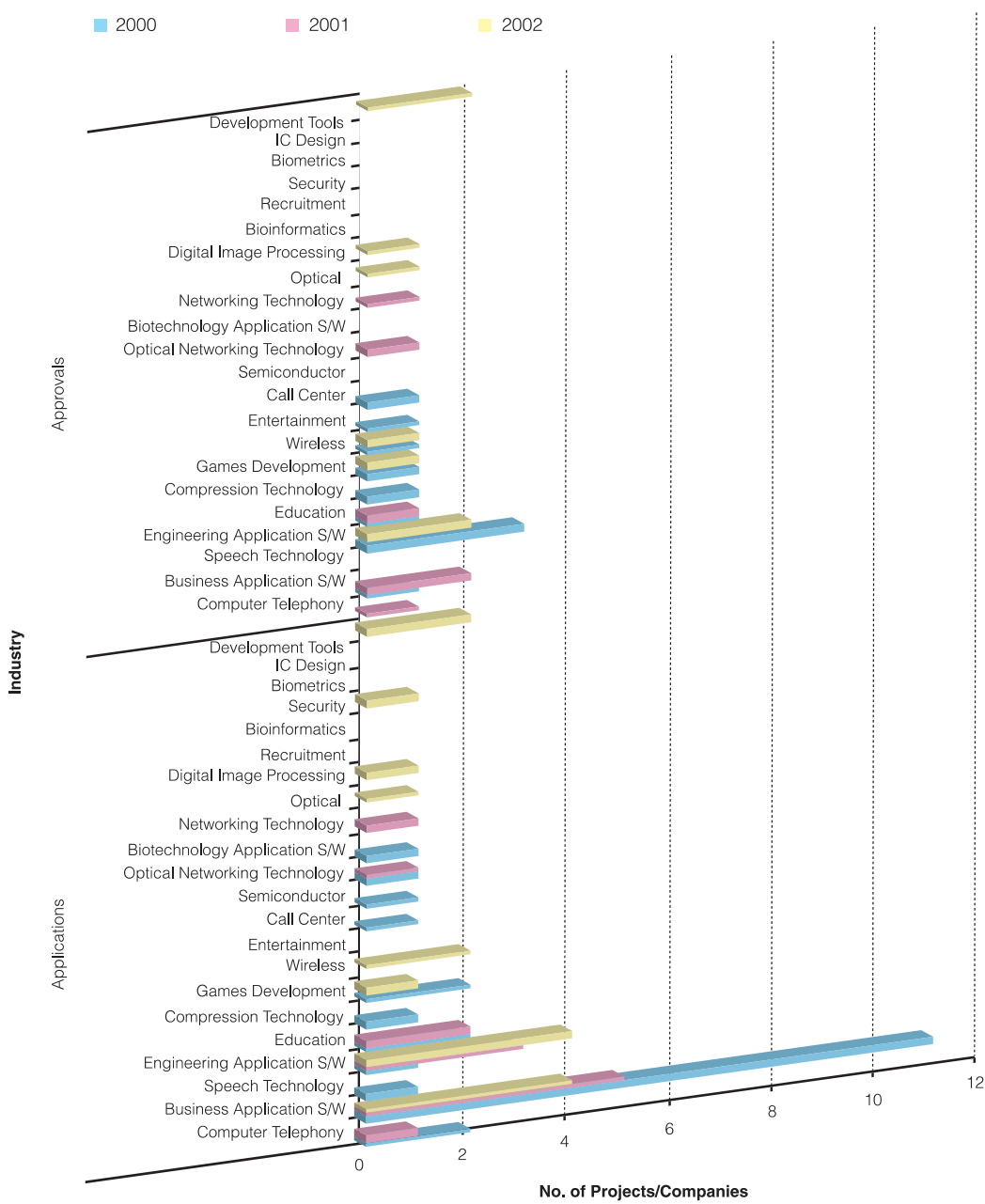


Figure 10.12: Number of MSC Research and Developments Grants Scheme (MGS) Applications and Approvals by Industry, 2000-2002

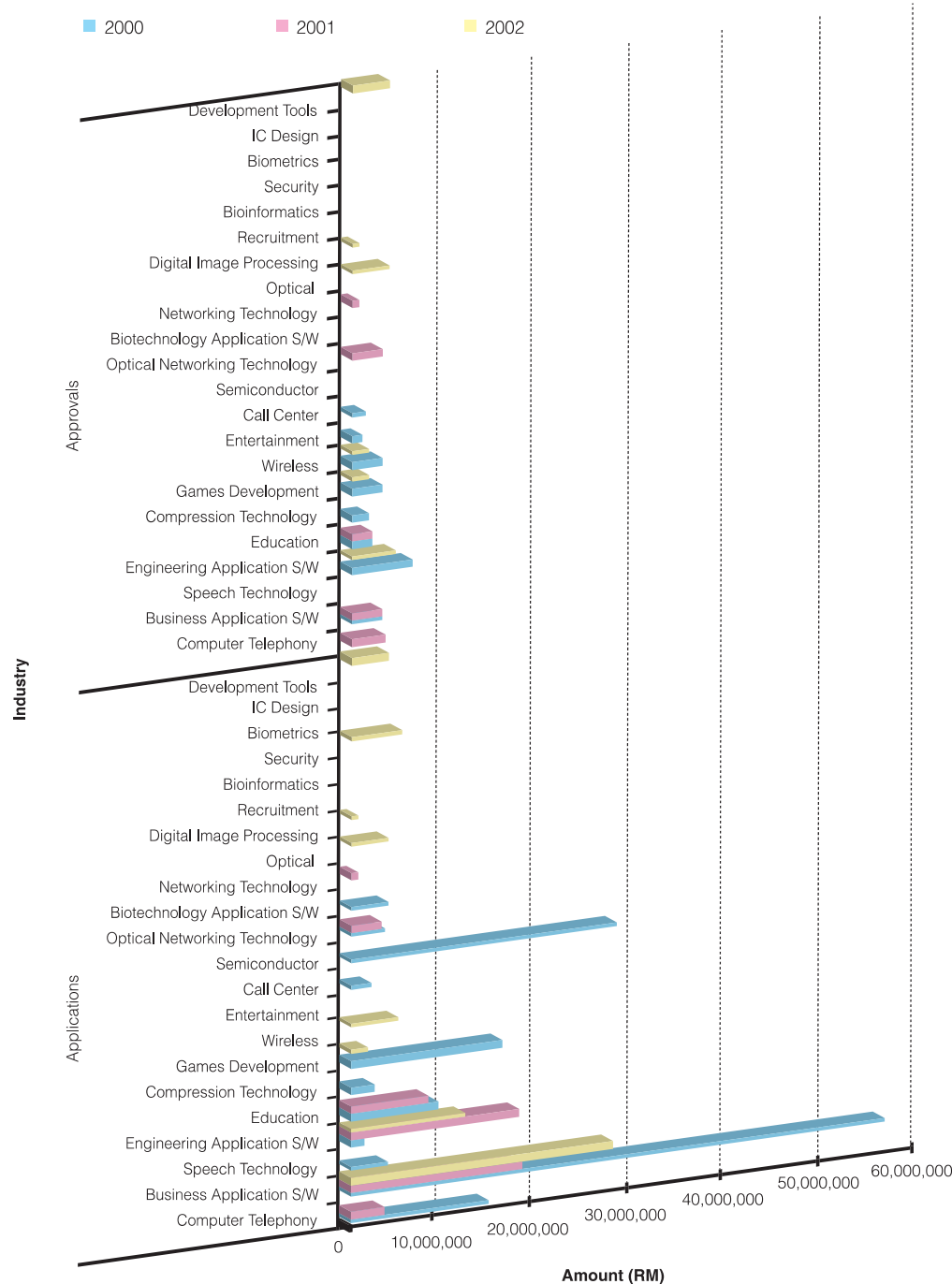


Figure 10.13: Amount of MSC Research and Development Grant Scheme (MGS) Applications and Approvals by Industry,2000-2002

10.2.7 Industry R & D Grant Scheme (IGS)

The IGS was established by the then Ministry of Science, Technology and the Environment (now known as the Ministry of Science, Technology and Innovations) with the intention of encouraging the private industries in Malaysia to be more active in research and development so as to be better equipped to compete globally. Figure 10.14 illustrates the number of approvals given under the IGS between 1999 and 2002, and the corresponding amounts approved. There is a declining trend in

the number of projects approved and the corresponding grants awarded from 24 projects approved amounting to some RM54 million in 1999 to 16 approvals in 2002 totaling close to RM36 million in 2002. For year 2001, only 9 projects were approved. Figure 10.15 shows the number of applications and approvals by sector in 2002, while Figure 10.16 shows the amounts applied for and approved by sector in the same year. The industry that was the most active in terms of the number of applications as well as the amount applied was the ICT industry for both 2001 and 2002.

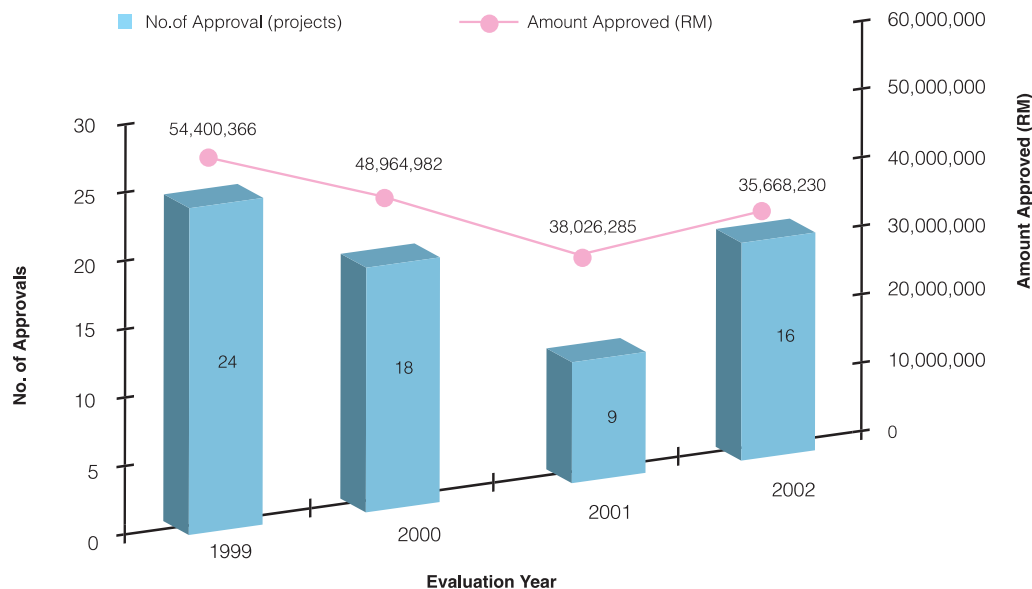


Figure 10.14: Approvals of Grants under the Industry R&D Grant Scheme (IGS), 1999-2002

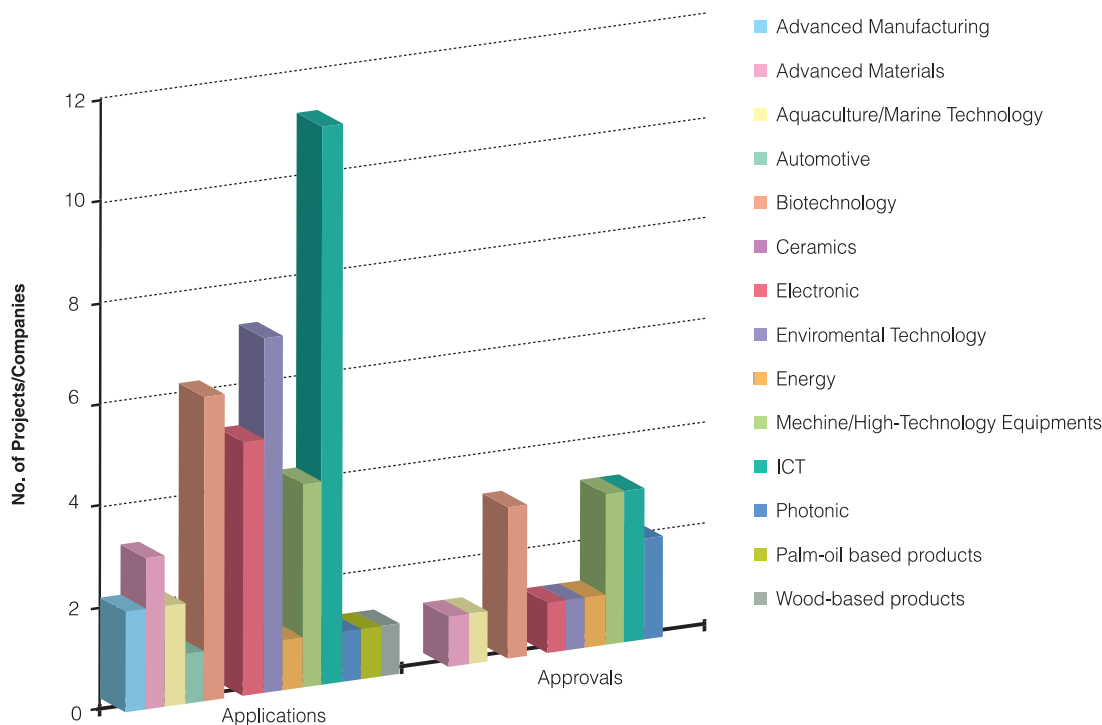


Figure 10.15: Industry R&D Grant (IGS): Number of Applications and Approvals by Sector, 2002.

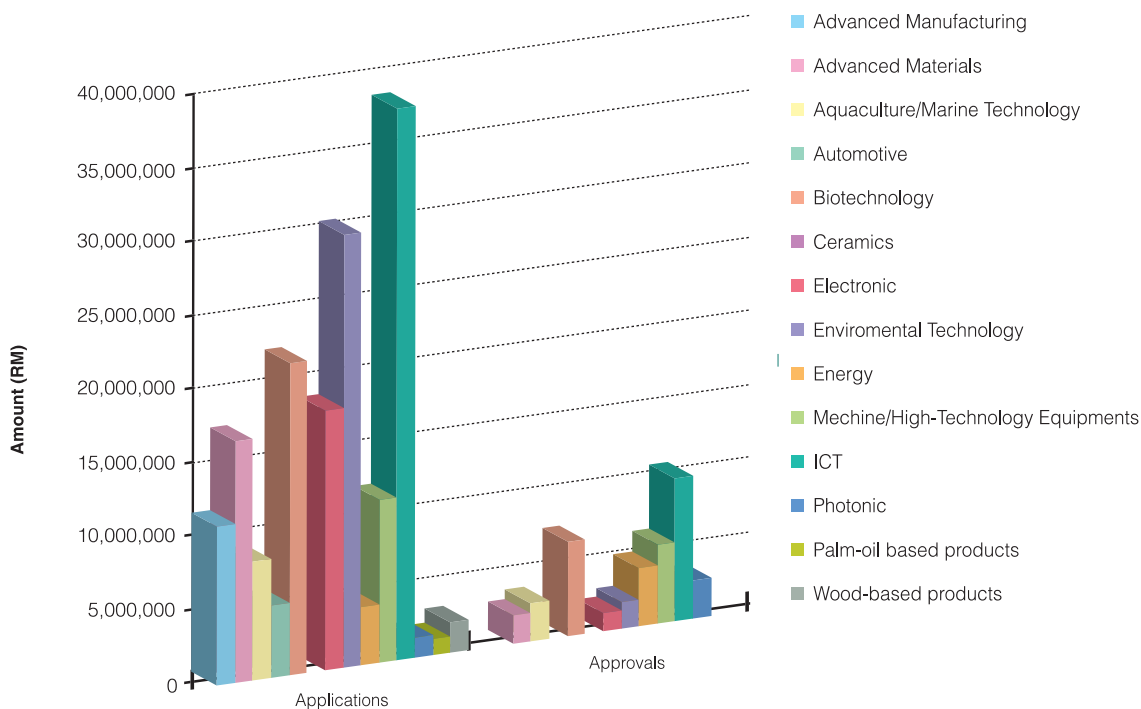


Figure 10.16: Industry R&D Grant (IGS): Amount Applied and Approved by Sector, 2002

10.2.8 Intensification of Research in Priority Areas Program (IRPA)

IRPA is a major effort by the Ministry of Science, Technology and Innovation to encourage research and development activities, particularly in the national R & D priority areas, in the public sector. R&D activities in areas which have the potential for enhancing the national socio-economic position of the nation are given funding support. In addition, this scheme is also aimed at enhancing R&D linkages between the public and private sectors. Although the scheme emphasises activities that will lead to commercialisation, some funding allocation is also given to research activities directed towards knowledge advancement as a long-term measure for building capacity towards the development of K-economy. The parties eligible to apply for funding under the IRPA program are public research institutions and universities.

IRPA by Institution

Figure 10.17 gives a picture of the number of projects granted under IRPA to public institutions in 2001 and 2002. Figure 10.18 gives an indication of the amounts approved by the ministry for those projects. The most active institution in this program is by far UPM, followed by UTM, USM and UKM in which the number of projects approved were 166, 125, 124, and 114, respectively. For public institutions, the most active organization was MARDI with a total number of 63 projects approved. The next most active institution was FRIM followed by SIRIM with 34 and 26 projects approved, respectively.

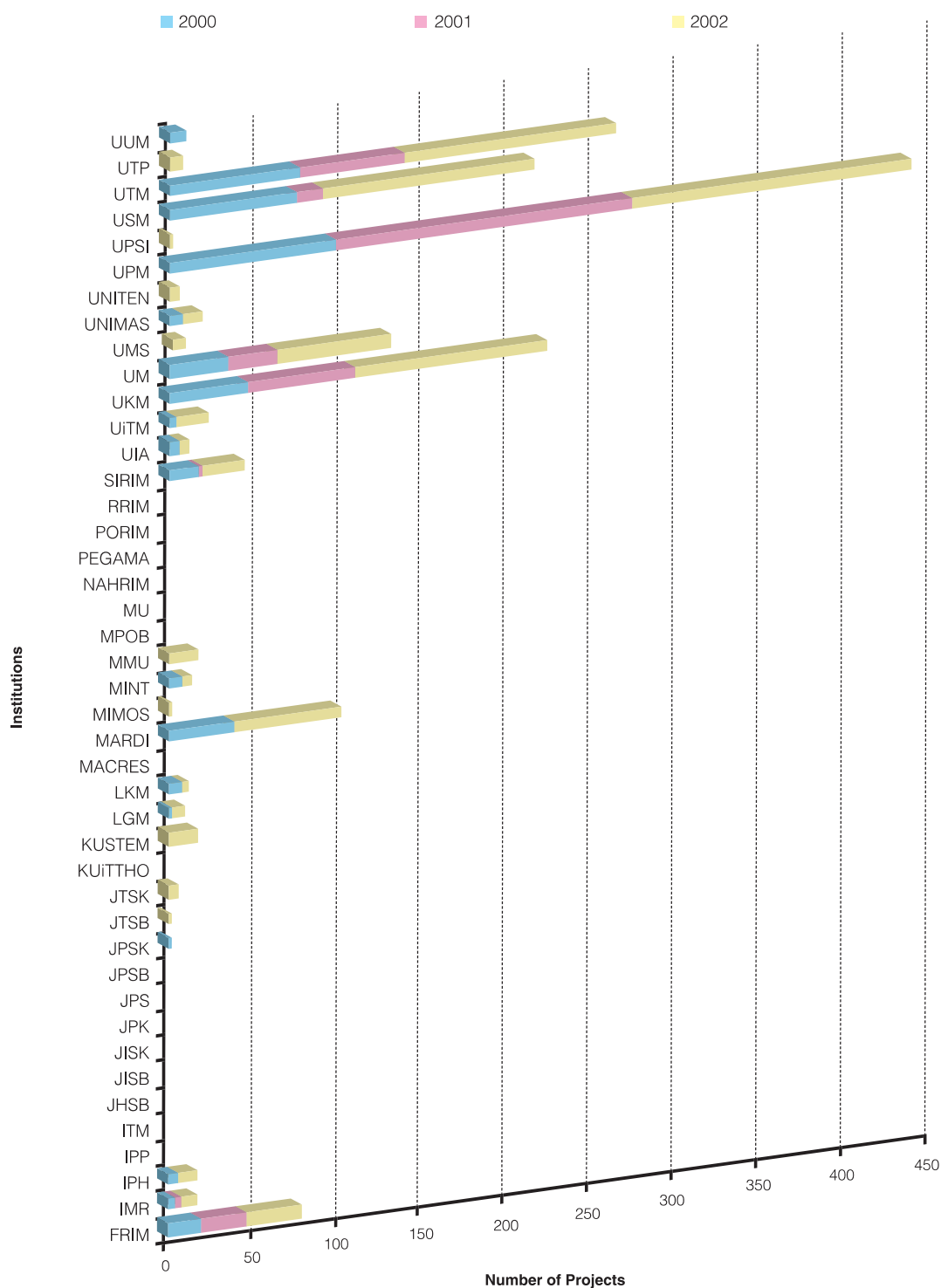


Figure 10.17: Number of Projects Granted under IRPA by Institution, 2000-2002

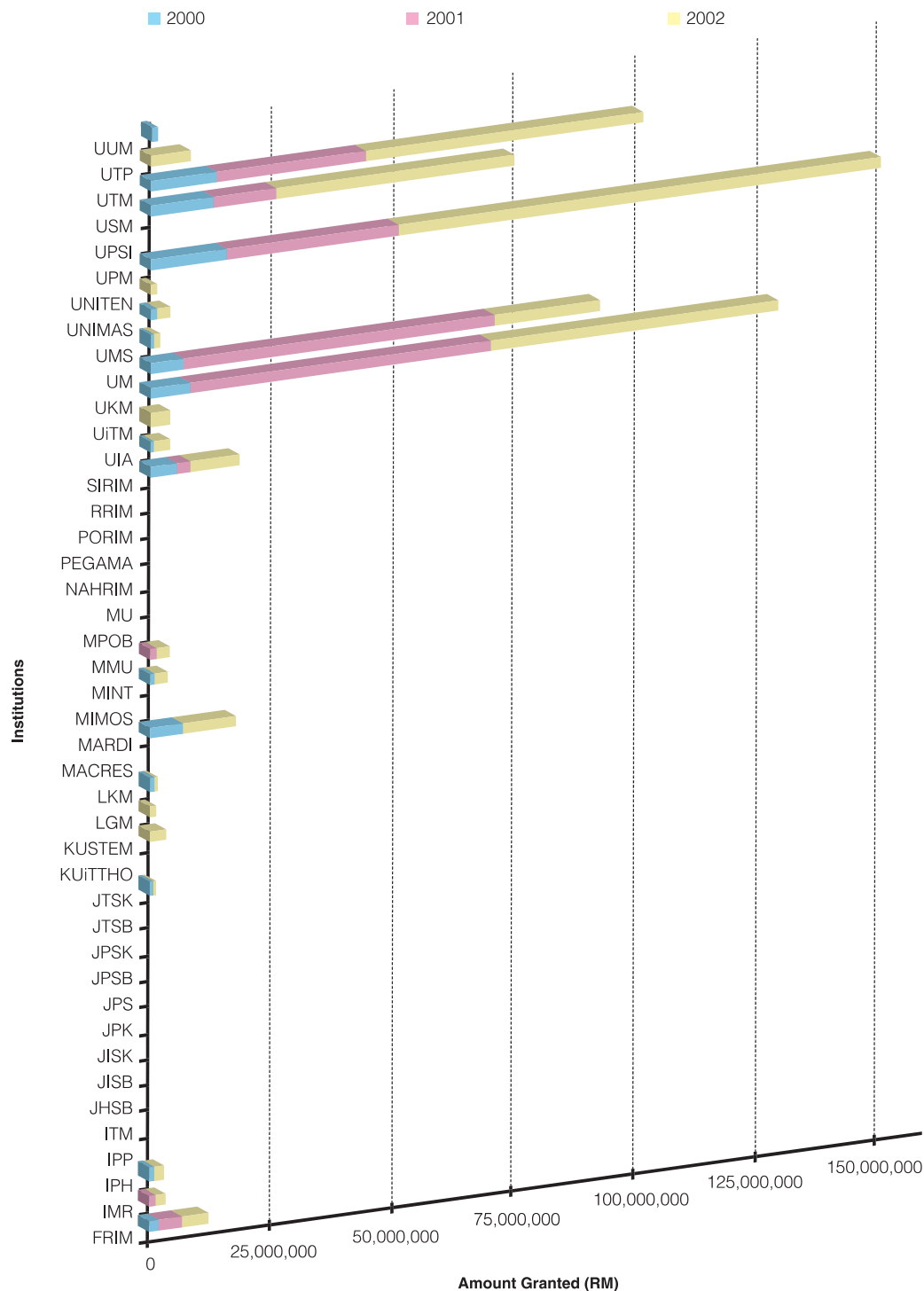


Figure 10.18: Total Amount of Grants under IRPA by Institution, 2000-2002

IRPA by Sector

Figure 10.19 shows the amounts applied for under the IRPA program by sector while Figure 10.20 shows the amounts approved for disbursement. In both instances, the manufacturing and construction sector was far ahead of all the other sectors with grants of up to RM108 million approved from the RM130 million applied for in 2001, and RM170 million

approved from RM263 million applied for in 2002. This is followed by Science and Engineering, Health, and Agro Industry sectors respectively. Comparing the amount approved in year 2000, 2001 and 2002, it can be seen that the amount approved increased substantially from RM70 million in 2000, to RM218 million and RM353 million for 2001 and 2002, respectively.

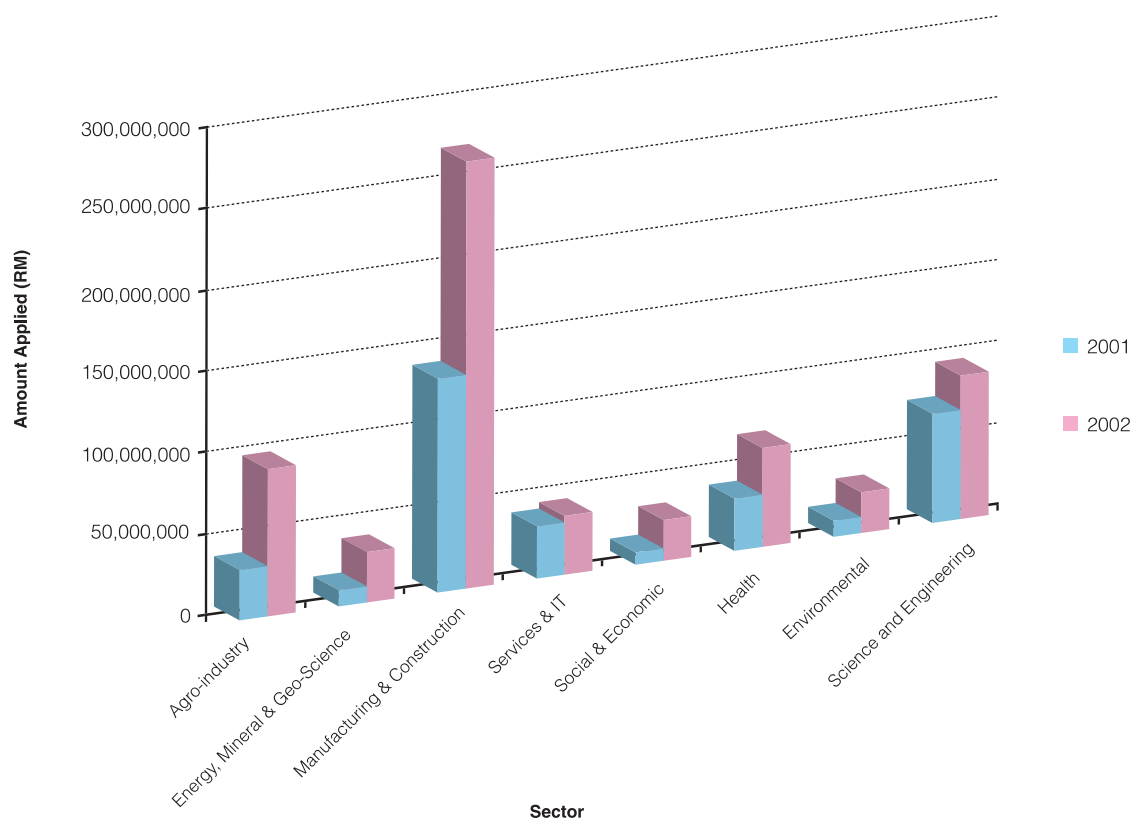


Figure 10.19: Applications for Intensification of Research in Priority Areas Program (IRPA) by Sector, 2001-2002

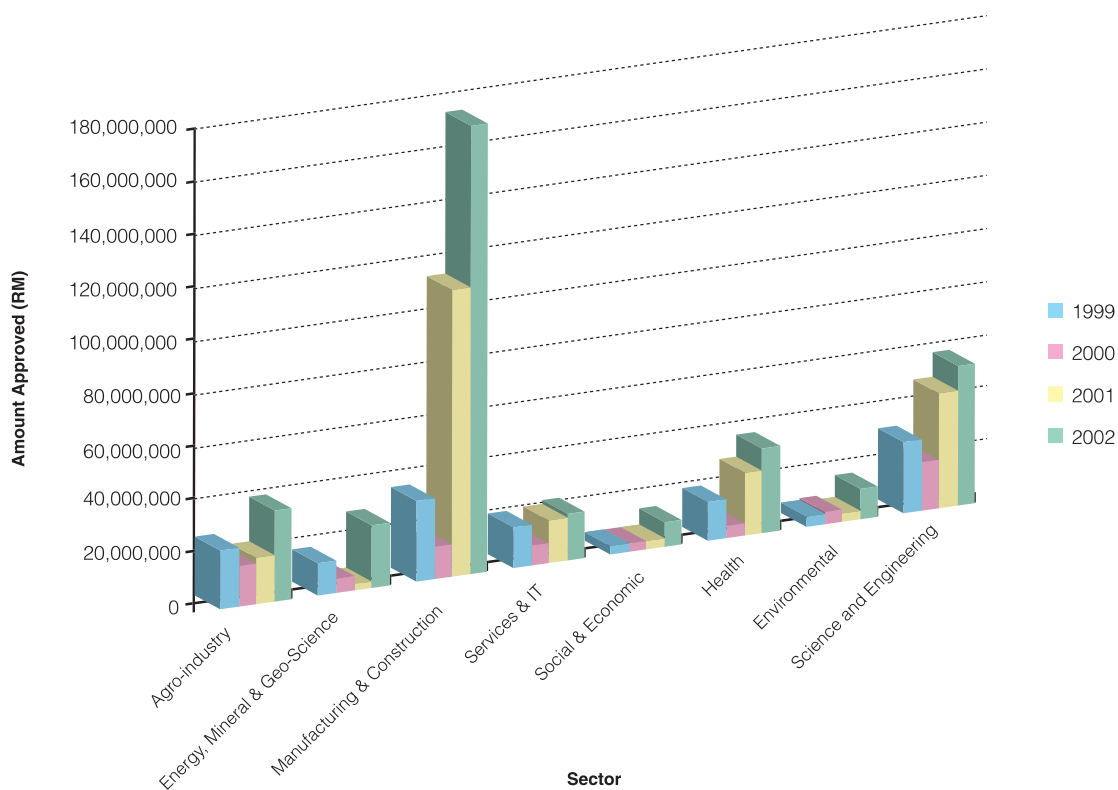
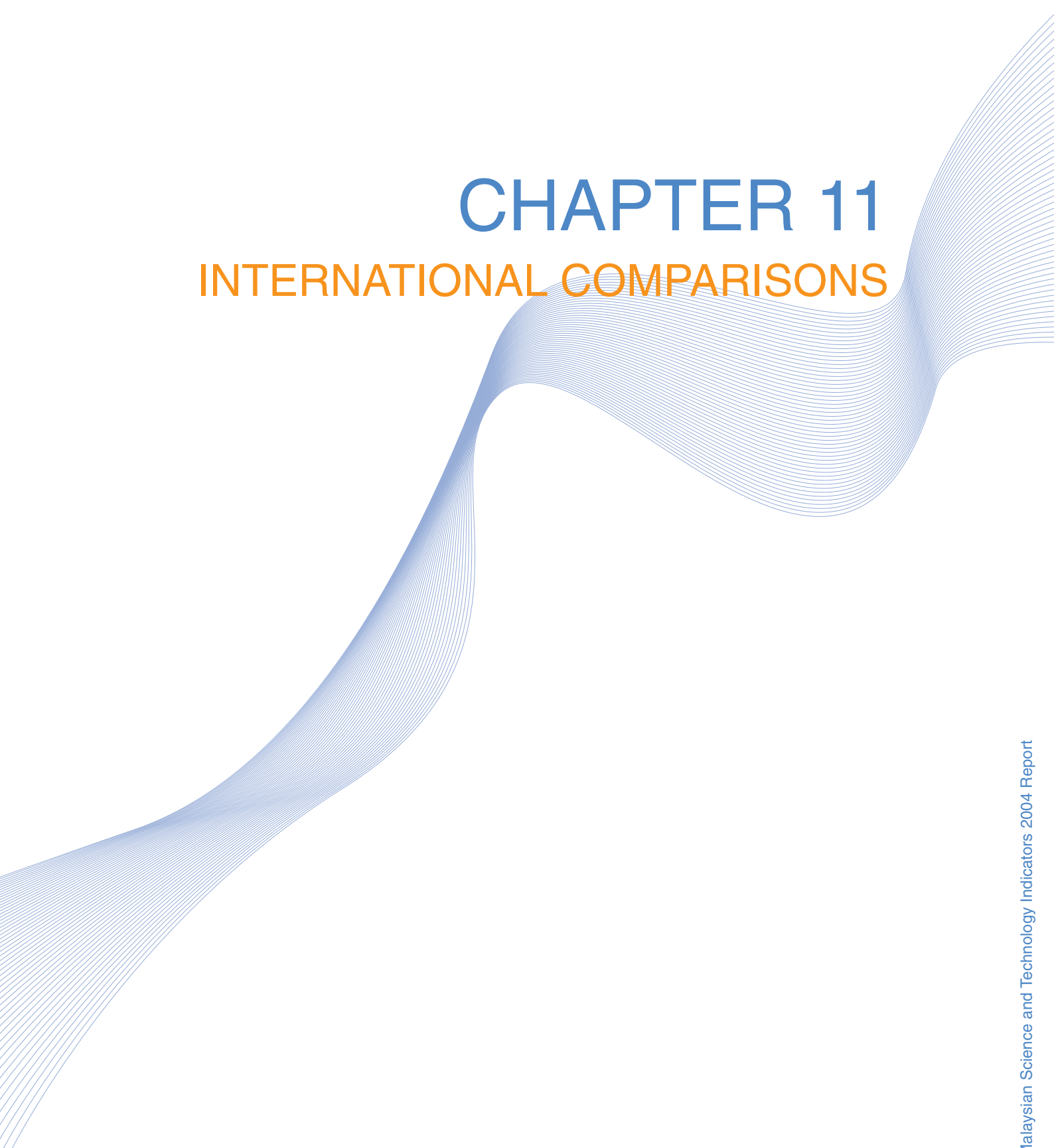


Figure 10.20: Approvals of Grant under Intensification of Research in Priority Areas Program (IRPA) by Sector, 1999-2002



CHAPTER 11

INTERNATIONAL COMPARISONS

Science and technology indicators (STI) are frequently used, amongst others, to internationally benchmark a country's achievements in developing its knowledge base in science and technology. For policy makers, the usefulness of undertaking such an exercise is in the identification of and policy formulation to address any remaining gaps in science and technology performance. This is not merely an exercise that is knowledge for knowledge's sake as the level of science and technology knowledge base is a crucial aspect of the economic competitiveness of a country.

This chapter compares Malaysia's achievements in science and technology with those of other countries. As in the previous 2000 Malaysian Science and Technology Indicators Report, the countries that are chosen for comparison are mostly OECD countries. This decision is entirely due to data availability. Not all the indicators are comparable; hence, only selected indicators from the previous chapters are used for international comparisons.

To put the benchmarking exercise in a proper perspective, the differences between

the Malaysian economy and those of OECD countries ought to be highlighted at the onset. One measure that can be used to compare Malaysia's level of economic development with other countries' is the gross national income (GNI) per capita. Malaysia's GNI per capita in year 2002 is around USD3,540. Malaysia's GNI per capita is only about one tenth to one fifth of the GNI per capita of most of the OECD countries (Figure 11.1).

There are also significant differences between the structure of the Malaysian economy and the OECD economies. The most striking difference appears in the sectoral composition of the economies. In most of the OECD economies, the services sector accounts for more than 60% of the national product (measured by gross domestic product or GDP). The agriculture sector accounts for less than 5% of GDP in most OECD economies while the manufacturing sector's share of the GDP is around 21 – 44% (Figure 11.2). In the case of Malaysia, its services sector accounts for less than 50% of the GDP while the agriculture and manufacturing sector accounts for 12% and 40% of the GDP, respectively.

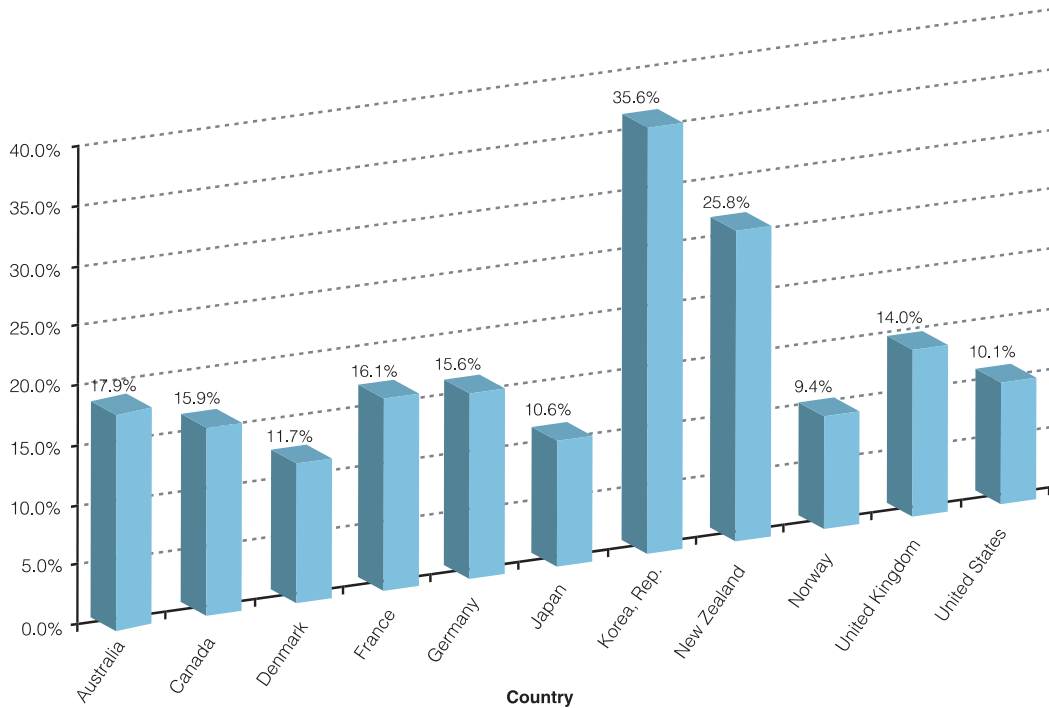


Figure 11.1: Malaysia's GNI Per Capita as a Percentage of Major OECD Countries' GNI Per Capita, 2002

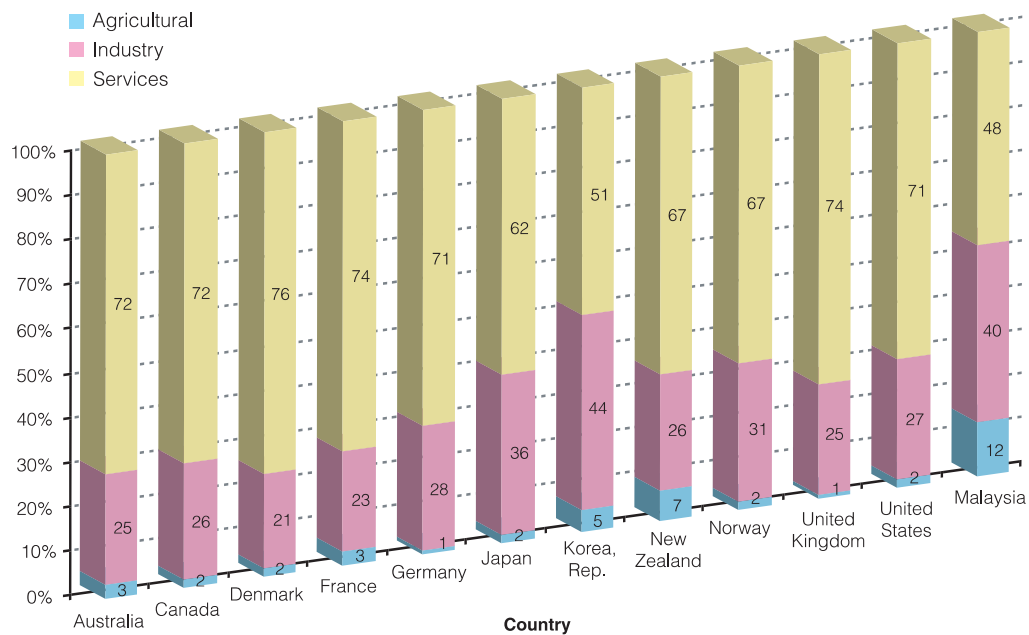


Figure 11.2: Output Structure of Selected OECD Countries, 2000

11.1 Education

One comparative indicator of education that measures the level of science and technology in a country is the share of science and engineering (S&E) tertiary degrees in the total number of new tertiary degrees granted. The measure of S&E degrees as a percentage of total new degrees (in both public and private universities) for 2000/2001 was

around 26.4% in European Union countries (Figure 11.3). The corresponding figure in the United States was about 15.8%. Data availability in Malaysia is significantly limited to the major public tertiary institutions. The available data from such institutions indicated that the science and engineering's share of the total new degrees granted in public tertiary institutions in Malaysia was around 37.1%.

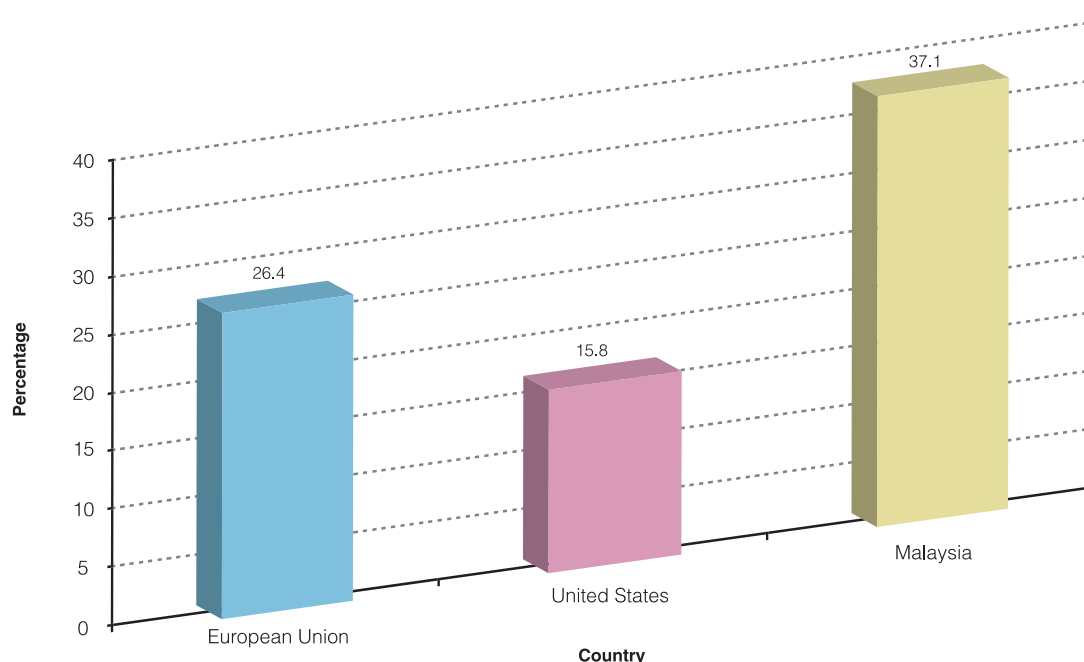


Figure 11.3: S&E Degrees as a Percentage of Total New Degrees 2000/2001

11.2 R&D Expenditure

The level of R&D in Malaysia is relatively low compared to those observed in more developed countries. The country's gross domestic expenditure on R&D (GERD) as a percentage of Gross Domestic Product (GDP) stood at 0.69 in year 2002. The corresponding figures for more developed countries was in the range between 1.5 (Australia) to 3.1 (Japan). The relatively low level of GERD as a percentage of GDP in Malaysia is consistent with its level of development. This can be seen in Figure 11.4 which plots the GERD as a percentage of GDP against Gross National Income (GNI) per capita for various countries.

11.3 Human Resources and R&D

Aside from R&D expenditure, another input type of measure of R&D effort is the number of researchers per labour force employed in an economy. The number of researchers per 10,000 labour force was around 50 to 90 in most of the OECD countries in the year 2001/2002. The corresponding figure for Malaysia for the year 2002 was 18 researchers per 10,000 labour force. This is around 20-36% of the levels observed in OECD countries. This modest achievement is also consistent with the country level of development (Figure 11.5).

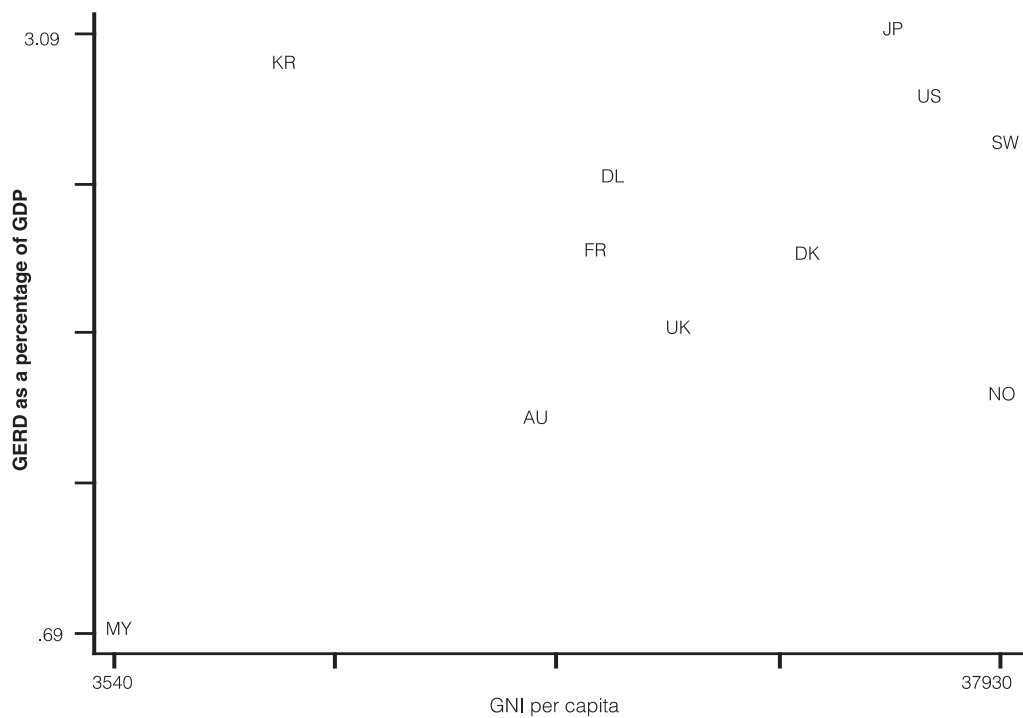


Figure 11.4: Gross Domestic Expenditure on R&D (GERD) as a Percentage of GDP, 2001/2002

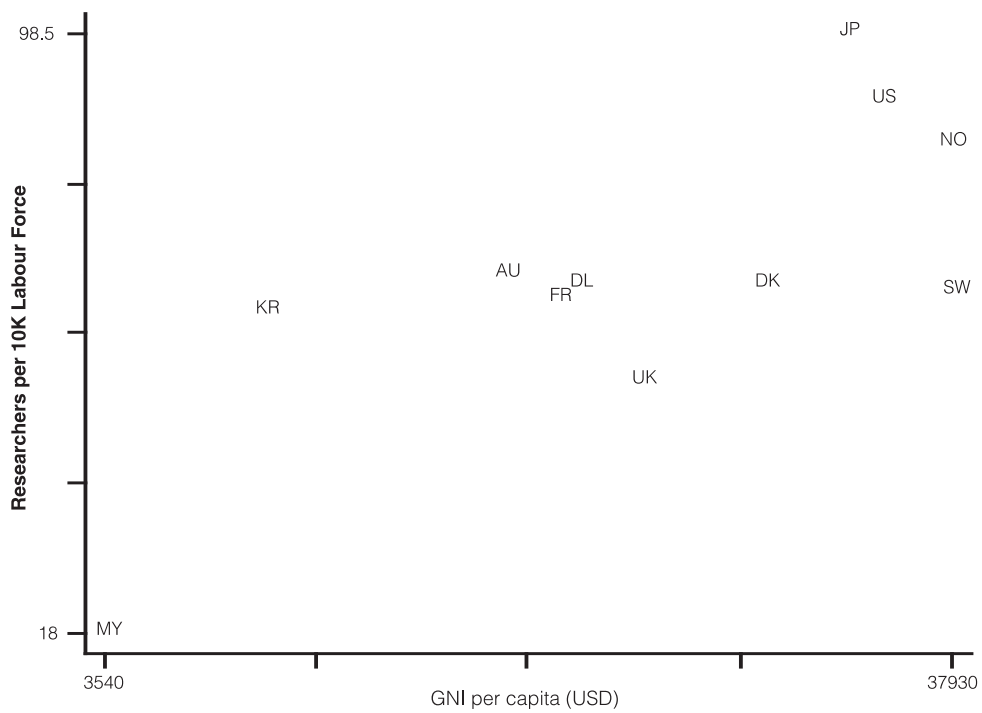


Figure 11.5: Researchers per 10,000 Labour Force, 2001/2002

11.4 Innovation

The overall level of innovation in the Malaysian manufacturing sector was slightly lower than that observed in developed countries (Figure 11.6). The percentage of innovating firms in the manufacturing sector in Malaysia (35%) exceeded that of Portugal (26%) and Spain (29%). However, the incidence of innovation in other European countries such as Ireland (74%), Denmark (71%) and Germany (69%) was significantly higher than that in Malaysia. Countries with comparable levels of innovation included Finland (36%) and Belgium (34%).

The pattern of innovation across firms of different sizes in Malaysia is similar to that observed in other countries (Figure 11.7). Firms are classified in terms of three classes: small-sized firms (< 49 employees), medium-sized firms (50-249 employees) and large-sized firms (> 250 employees). In general, large-sized firms are more innovative than their smaller counterparts. The innovation gap between large firms and medium sized firms are almost the same as that between medium sized firms and small firms.

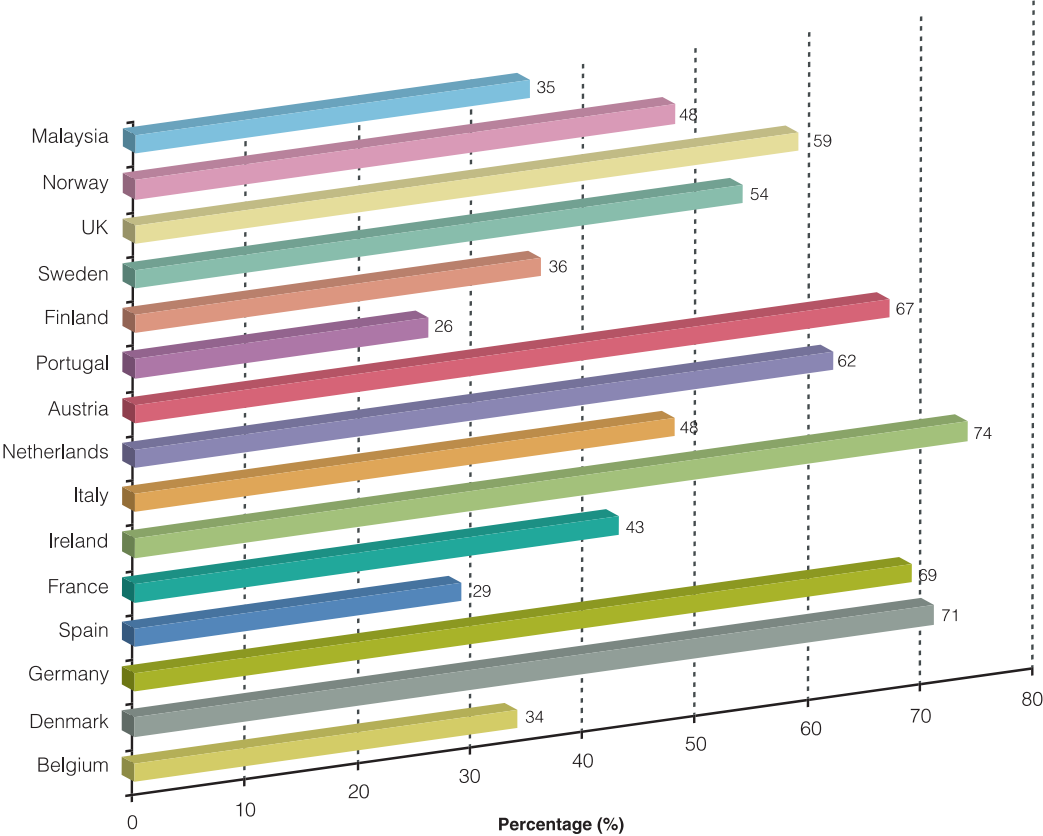


Figure 11.6: Number of Innovators in Selected Countries (%)

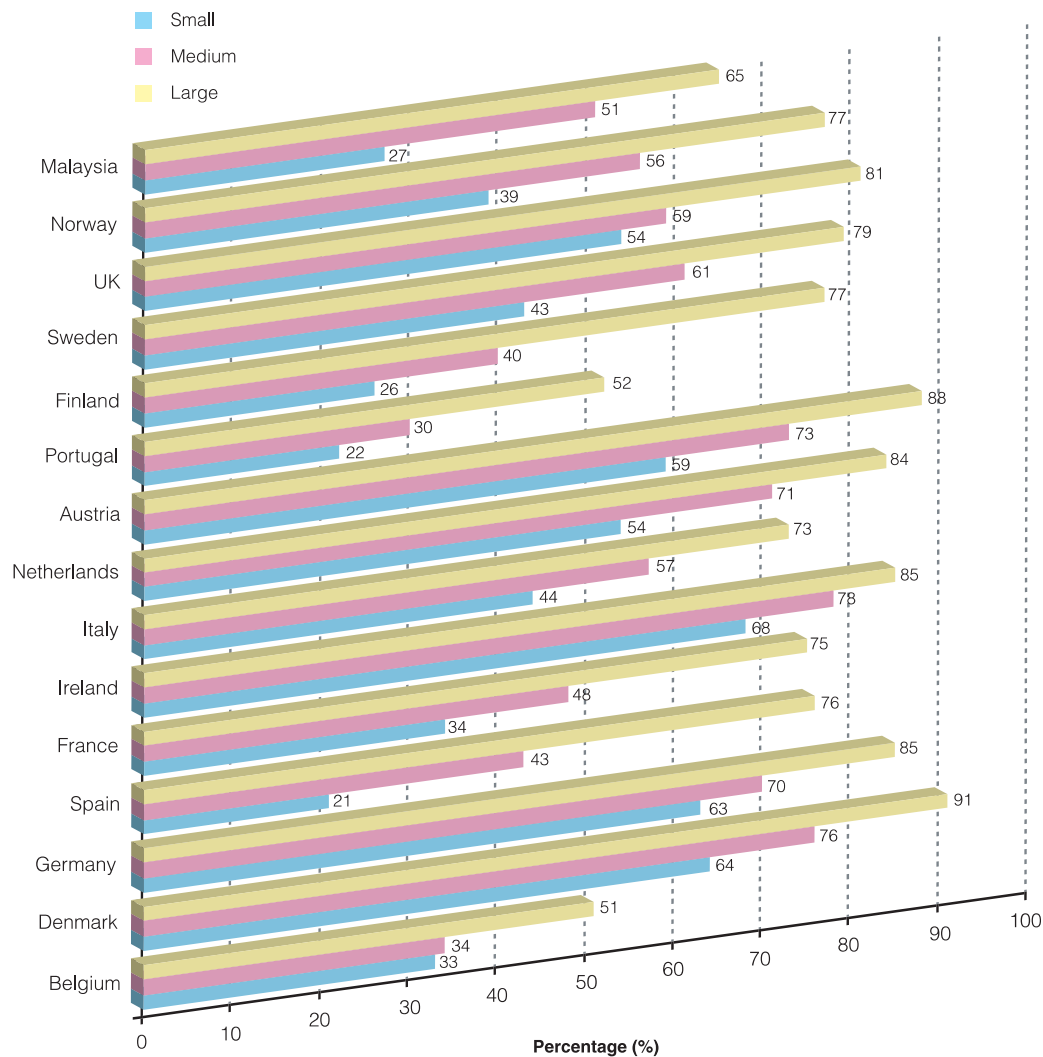


Figure 11.7: Number of Innovators (%) by Firm Size in Selected Countries

11.5 Trade in Technology

The link between a country's achievements in science and technology and its export competitiveness is partly reflected in the manufacturing export shares of high-technology and medium-high-technology manufacturing industries. Figure 11.8 shows

that the manufacturing export shares of high technology of the manufacturing industries in Malaysia (at 40.4%) was comparable to that observed in some of the developed countries such as France (25.4%), Germany (20.6%), Japan (30.8%), Republic of Korea (32.4%) and the United Kingdom (40.3%).

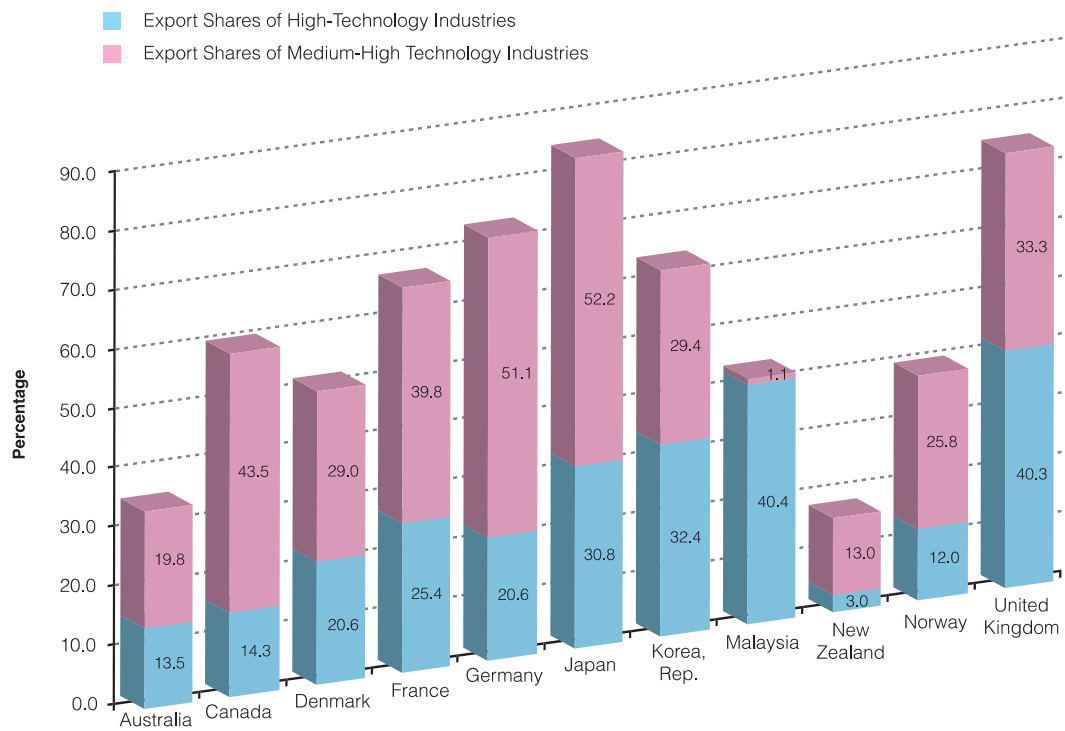


Figure 11.8: Export Shares of High-Technology and Medium-High-Technology Industries, 2001/2002

11.6 Publications and Citations

The quantity of science and engineering (S&E) publications is a useful measure of the stocks and flows in a country’s knowledge base in science and technology. Malaysia’s per capita output of S&E articles at 21.9 during the 1999-2001 period was significantly below that observed in more developed countries such as Japan (445.6), United States (722.2) and United Kingdom (821.9). However, there are indications that even after adjusting for the level of development, Malaysia’s per capita output of S&E articles is low. For example, whilst South Africa’s income per capita is lower than Malaysia’s, its per capita output of S&E articles at 55.8 was higher. A comparison of these figures in the context of different levels of development (measured by GNI per capita) shows some relationship between the per capita level of S&E publications and the level of economic development (Figure 11.9).

11.7 Public Awareness and Attitude Towards S&T

The general level of public awareness and understanding of knowledge in science and technology is an important broad measure of the stock of general knowledge in S&T. Surveys are usually carried out to ascertain the level of this knowledge via a series of questions. Overall, the level of public awareness of S&T related terms and concepts are lower in Malaysia compared to those in Europe, Japan and the United States (Figure 11.10). However, there were a few instances where the Malaysian public’s understanding was comparable to that observed in developed countries.

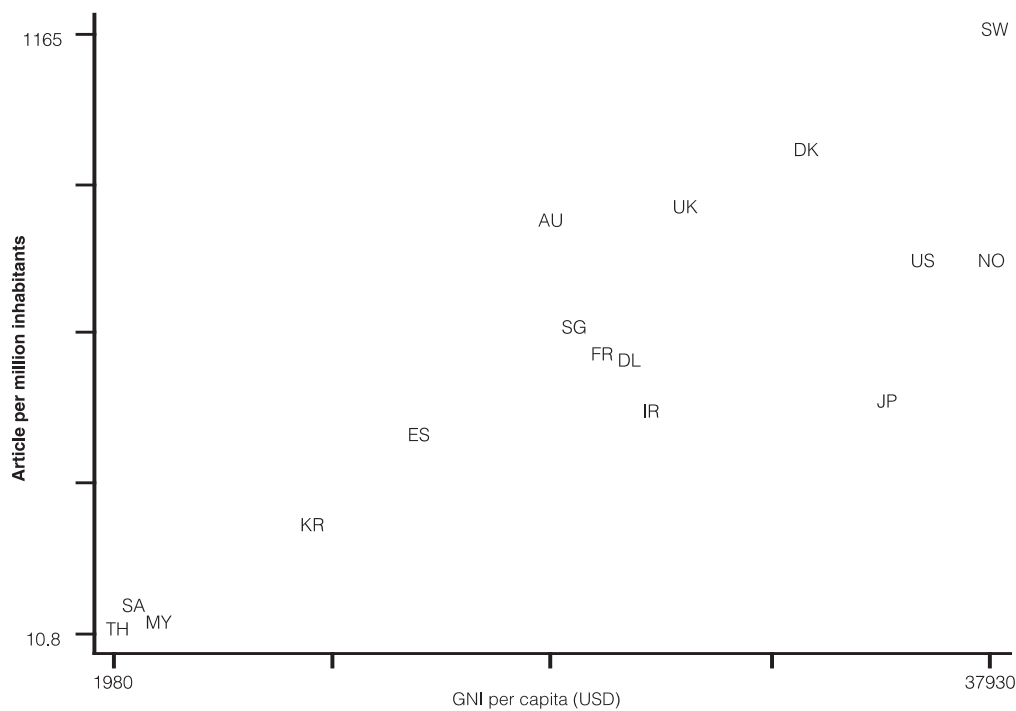


Figure 11.9: Per Capita Output of S&E Articles (1999-2001) and GNI PerCapita (2002)

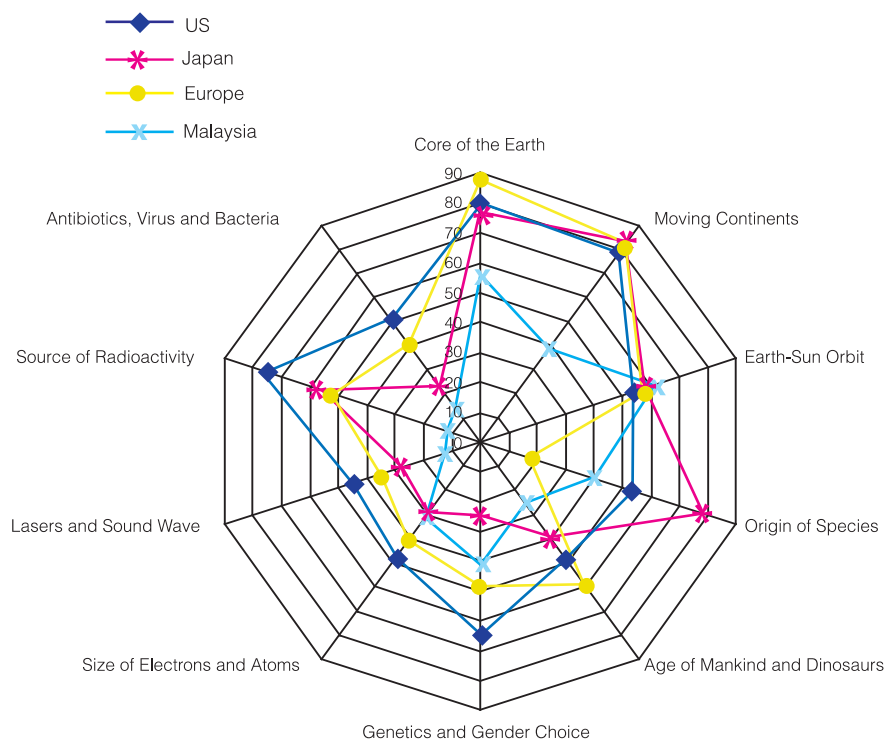


Figure 11.10: Percentage of Correct Answers for S&T Terms and Concepts

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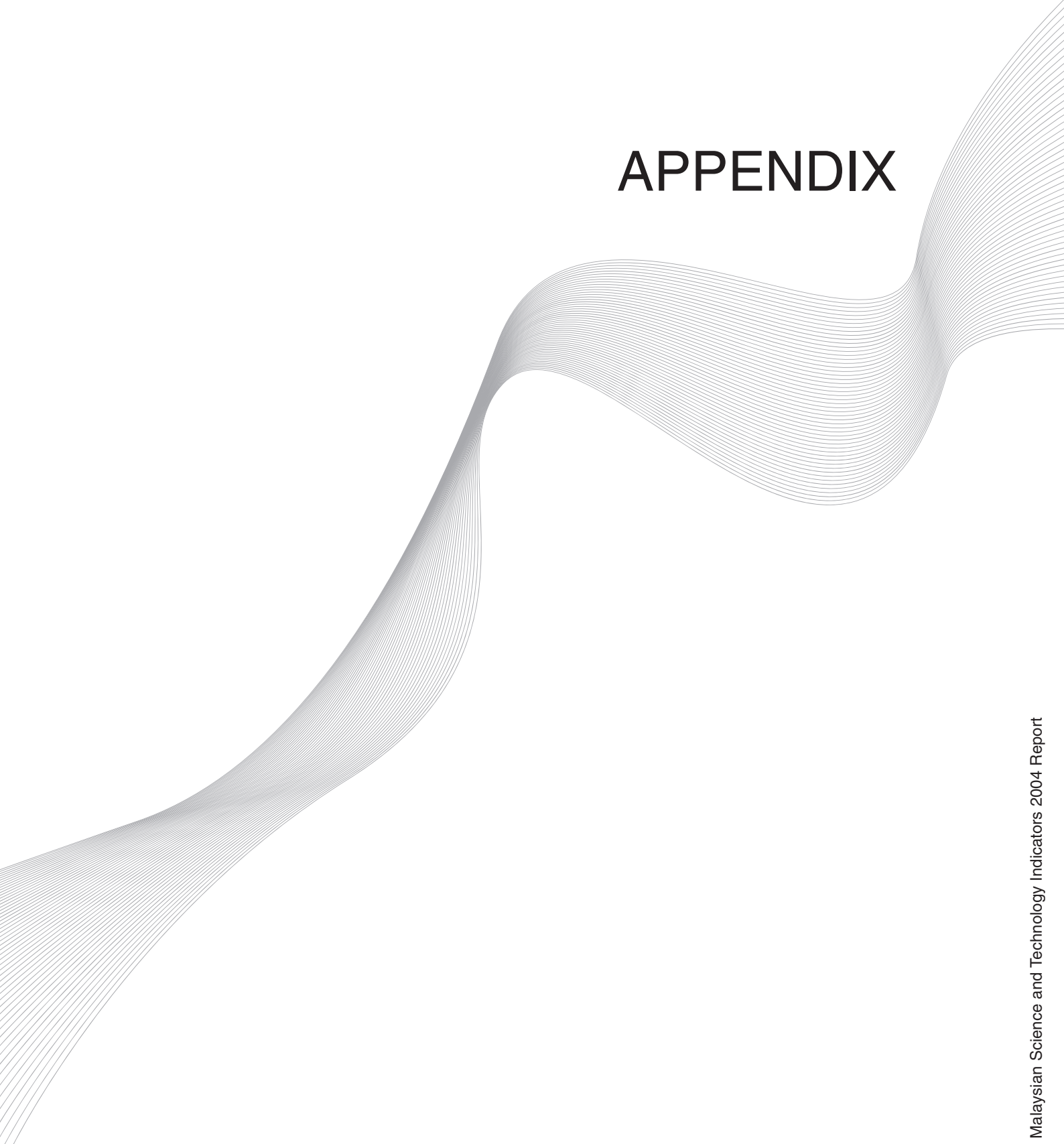
Malaysia: Key Socio - Economic Indicators 1998 - 2002

Malaysia: Key Socio - Economic Indicators, 1998 - 2002

	1998	1999	2000	2001	2002
Population (million persons)	22.1	22.7	23.5	24.0	24.6
Labour Force (million persons)	8.8	9.2	9.6	9.5	9.8
Unemployment (as % of labour force)	3.2	3.4	3.1	3.6	3.5
Per Capita Income (RM)	12,135	12,304	13,333	12,855	13,683
Real GDP (RM billion)	182.2	193.3	209.5	210.6	219.3
Real GNP (RM billion)	172.8	179.7	190.5	193.0	202.1
% change real GDP	-7.4	6.1	8.3	0.3	4.1
<u>% Real GDP by Industrial Origin</u>					
Agriculture, forestry & fishery	9.6	9.1	8.6	8.5	8.4
Mining & quarrying	7.9	7.9	7.3	7.2	7.2
Manufacturing	27.9	29.4	32.0	30.1	30.1
Construction	4.0	3.6	3.3	3.4	3.3
Services	55.8	55.0	54.0	57.0	57.0
CPI (2000 = 100)	5.3	2.8	1.6	1.4	1.8
PPI (1989 = 100)	10.7	-3.3	3.1	-5.0	4.4
Merchandise balance (RM billion)	69.2	86.0	79.1	69.9	72.1
Services balance (RM billion)	-22.2	-10.7	-10.7	-8.4	-6.0
Current account balance (RM billion)	37.4	47.9	32.3	27.7	30.5
Current account balance as % of GNP	13.9	17.1	10.3	9.0	9.1
National Debt (RM billion)	163.0	161.6	160.9	173.4	185.6
External debt service ratio	6.7	6.1	5.4	6.8	6.7
Annual population growth rate	2.3	2.4	3.4	2.2	2.1
% Population below 15 years	34.0	33.5	34.1	33.8	33.5
<u>Life expectancy at birth (years)</u>					
Male	69.7	69.9	70.2	70.3	70.4
Female	74.7	74.9	75.1	75.2	75.3
Population per doctor	1,477	1,465	1,504	1,487	1,406
Enrolment rate at primary schools	95.4	96.0	96.8	97.2	97.9

Sources: Bank Negara Report on the Economy, Statistical Yearbook 2003

APPENDIX



Appendix

Appendix I: Subject Fields Used By Institute for Scientific Information (ISI)

The 105 Deluxe fields are subdivided as follow:

- Science and Technology – 82 fields
- Social Sciences – 12 fields
- Arts and Humanities – 10 fields
- Multidisciplinary – 1 field

STANDARD FIELDS	DELUXE FIELDS
Agricultural Sciences	Agricultural chemistry Agriculture/Agronomy Food Science/Nutrition
Astrophysics	Space Science
Biology & Biochemistry	Biochemistry & Biophysics Biology, General Biotechnology & Applied Microbiology Endocrinology, Nutrition & Metabolism Experimental Biology Physiology
Chemistry	Chemical Engineering Chemistry & Analysis Chemistry Inorganic & Nuclear Chemistry Organic Chemistry/ Polymer Science Physical Chemistry/ Chemical Physics Spectroscopy/ Instrumentation/ Analytical Science
Clinical Medicine	Anesthesia & Intensive Care Cardiovascular & Hematology Research Cardiovascular & Respiratory System Clinical Immunology & Infectious Disease Clinical Psychology & Psychiatry Dentistry/Oral Surgery & Medicine Dermatology Endocrinology, Metabolism & Nutrition Environmental Medicine & Public Health Gastroenterol and Hepatology General & Internal Medicine Health Care Science & Services Hematology Medical Research, Diagnosis & Treatment Medical Research, General Topics Medical Research, Organs & System Neurology Oncogenesis & Cancer Res Oncology Ophthalmology Orthopedics & Sports Med Otolaryngology Pediatrics Pharmacology/ Toxicology Radiology, Nuclear Medicine & Imaging Reproductive Medicine Research/Lab Medicine & Medical Technology Rheumatology Surgery Urology & Nephrology
Computer Science	Computer Science & Engineering Information Technology & Communications System
Ecology/ Environment	Environment/Ecology
Economics & Business	Economics Management

STANDARD FIELDS	DELUXE FIELDS
Education	Education
Engineering	Aerospace Engineering AI, Robotics & Automatic Control Civil Engineering Electrical & Electronics Engineering Engineering Mathematics Engineering Management/General Environmental Engineering/Energy Instrumentation/Measurement Mechanical Engineering Nuclear Engineering
Geoscience	Earth Science Geological, Petroleum & Mining Engineering
Immunology	Immunology
Law	Law
Materials Science	Materials Science & Engineering Metallurgy
Mathematics	Mathematics
Microbiology	Microbiology
Molecular Biology & Genetics	Cell & Developmental Biology Molecular Biology & Genetics
Multidisciplinary	Multidisciplinary
Neurosciences	Neurosciences & Behavior
Pharmacology	Pharmacology & Toxicology
Physics	Applied Physics/Condensed Matter/Materials Science Optics & Acoustics Physics
Plant & Animal Sciences	Animal & Plant Sciences Animal Sciences Aquatic Sciences Entomology/Pest Control Plant Sciences Veterinary Med/Animal Health
Psychology/ Psychiatry	Psychiatry Psychology
Social Sciences, General	Communication Environmental Studies, Geography & Development Library & Information Science Political Science & Public Administration Public Health & Health Care Science Rehabilitation Social Work & Social Policy Sociology & Anthropology
Arts & Humanities	Archaeology Art & Architecture Classical Studies General History Language & Linguistics Literature Performing Arts Philosophy Religion & Theology

Appendix II: Science and Technology Subject Fields Used by ISI

STANDARD FIELDS	DELUXE FIELDS
Agricultural Sciences	Agricultural chemistry Agriculture/Agronomy Food Science/Nutrition
Astrophysics	Space Science
Biology & Biochemistry	Biochemistry & Biophysics Biology, General Biotechnology & Applied Microbiology Endocrinology, Nutrition & Metabolism Experimental Biology Physiology
Chemistry	Chemical Engineering Chemistry & Analysis Chemistry Inorganic & Nuclear Chemistry Organic Chemistry/ Polymer Science Physical Chemistry/ Chemical Physics Spectroscopy/ Instrumentation/ Analytical Science
Clinical Medicine	Anesthesia & Intensive Care Cardiovascular & Hematology Research Cardiovascular & Respiratory System Clinical Immunology & Infectious Disease Clinical Psychology & Psychiatry Dentistry/Oral Surgery & Medicine Dermatology Endocrinology, Metabolism & Nutrition Environmental Medicine & Public Health Gastroenterol and Hepatology General & Internal Medicine Health Care Science & Services Hematology Medical Research, Diagnosis & Treatment Medical Research, General Topics Medical Research, Organs & System Neurology Oncogenesis & Cancer Res Oncology Ophthalmology Orthopedics & Sports Med Otolaryngology Pediatrics Pharmacology/ Toxicology

STANDARD FIELDS	DELUXE FIELDS
	Radiology, Nuclear Medicine & Imaging Reproductive Medicine Research/Lab Medicine & Medical Technology Rheumatology Surgery Urology & Nephrology
Computer Science	Computer Science & Engineering Information Technology & Communications System
Ecology/ Environment	Environment/Ecology
Engineering	Aerospace Engineering AI, Robotics & Automatic Control Civil Engineering Electrical & Electronics Engineering Engineering Mathematics Engineering Management/General Environmental Engineering/Energy Instrumentation/Measurement Mechanical Engineering Nuclear Engineering
Geoscience	Earth Science Geological, Petroleum & Mining Engineering
Immunology	Immunology
Materials Science	Materials Science & Engineering Metallurgy
Mathematics	Mathematics
Microbiology	Microbiology
Molecular Biology & Genetics	Cell & Developmental Biology Molecular Biology & Genetics
Neurosciences	Neurosciences & Behavior
Pharmacology	Pharmacology & Toxicology
Physics	Applied Physics/Condensed Matter/Materials Science Optics & Acoustics Physics
Plant & Animal Sciences	Animal & Plant Sciences Animal Sciences Aquatic Sciences Entomology/Pest Control Plant Sciences Veterinary Med/Animal Health
Psychology/ Psychiatry	Psychiatry Psychology

Appendix III: Government Support and Funding Agencies for Science and Technology

Grants/Schemes/Funding Agencies	Administered By
Industry R & D Grant Scheme (IGS)	Ministry of Science, Technology and Innovation
Intensification of Research in Priority Areas Program (IRPA)	
Multimedia Super Corridor (MSC) Research and Development Grant Scheme (MGS)	Multimedia Development Corporation Sdn Bhd
Commercialization of R & D Fund (CRDF)	Malaysian Technology Development Corporation (MTDC)
Technology Acquisition Fund (TAF)	
Technology Acquisition Fund for Women (TAF-W)	
Demonstrator Application Grant Scheme (DAGS)	MIMOS Berhad.
Upgrading Engineering Design	Small and Medium Industries Development Corporation (SMIDEC)
E-Manufacturing Grant	
RosettaNet Standard Implementation for SMEs	
Industrial Technical Assistance Fund (ITAF)	
Double Deduction	Inland Revenue Board

Appendix IV: Types of Patent According to US Patent and Trademark Office

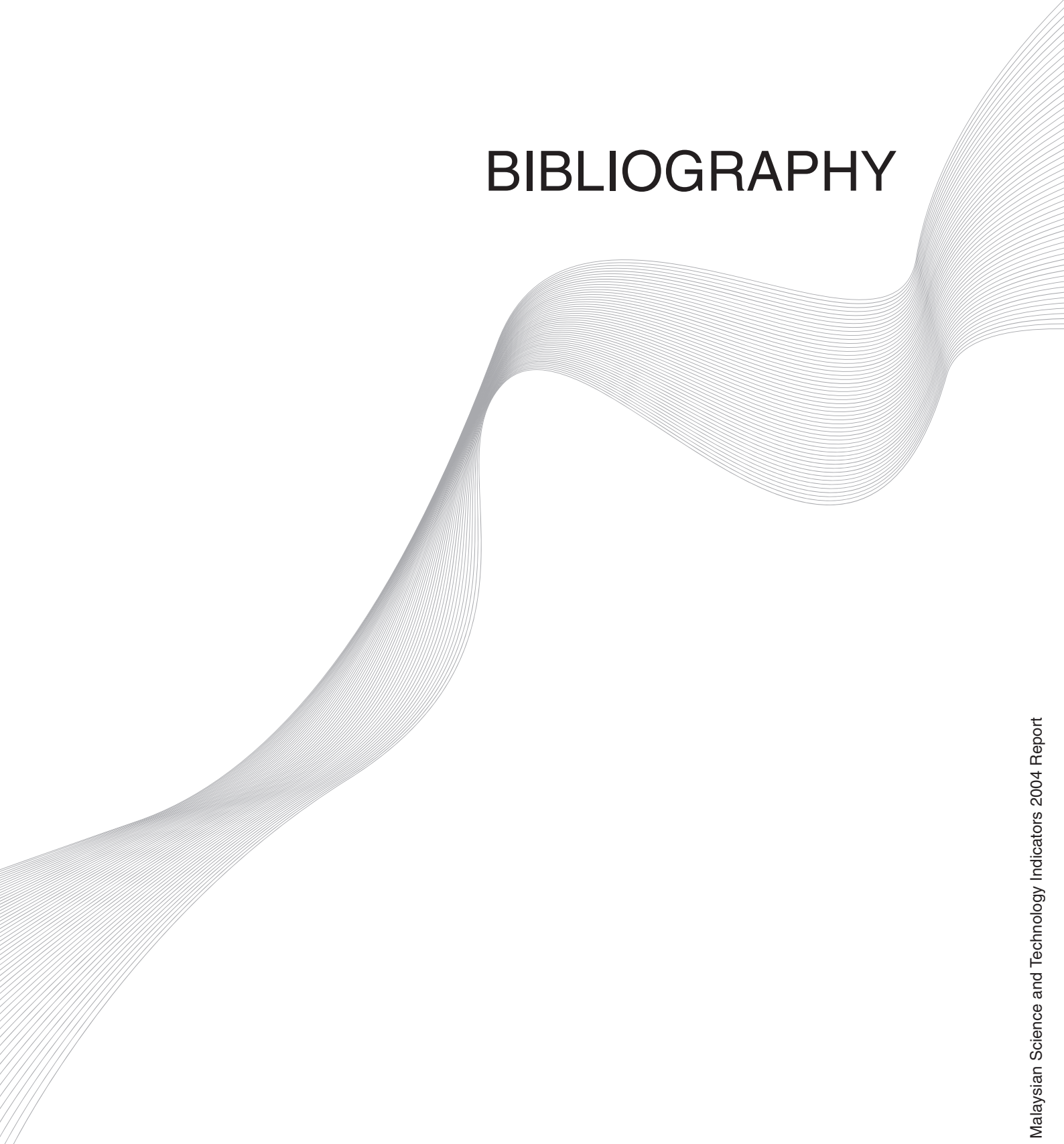
The U.S. Patent and Trademark Office (PTO) issues several different types of patent documents which offers different kinds of protection and covers different types of subject matter, as follows:

- **Utility Patent-** Issued for the invention of a new and useful process, machine, manufacture, or composition of matter, or a new and useful improvement thereof, it generally permits its owner to exclude others from making, using, or selling the invention for a period of up to twenty years from the date of patent application filing ++, subject to the payment of maintenance fees. Approximately 90% of the patent documents issued by the PTO in recent years have been utility patents, also referred to as “patents for invention.”
- **Design Patent-** Issued for a new, original, and ornamental design for an article of manufacture, it permits its owner to exclude others from making, using, or selling the design for a period of fourteen years from the date of patent grant. Design patents are not subject to the payment of maintenance fees.
- **Plant Patent-** Issued for a new and distinct, invented or discovered asexually reproduced plant including cultivated sports, mutants, hybrids, and newly found seedlings, other than a tuber propagated plant or a plant found in an uncultivated state, it permits its owner to exclude others from making, using, or selling the plant for a period of up to twenty years from the date of patent application filing ++. Plant patents are not subject to the payment of maintenance fees.

- Reissue Patent- Issued to correct an error in an already issued utility, design, or plant patent, it does not affect the period of protection offered by the original patent.
- Defensive Publication (DEF) - Issued instead of a regular utility, design, or plant patent, it offers limited protection, defensive in nature, to prevent others from patenting an invention, design, or plant. The Defensive Publication was replaced by the Statutory Invention Registration in 1985-86.
- Statutory Invention Registration (SIR) - This document replaced the Defensive Publication in 1985-86 and offers similar protection.

Note: (++) - Although, the length of utility and plant patent protection (patent term) was previously seventeen years from the date of patent grant, utility and plant patents filed after June 8, 1995 now have a patent term of up to twenty years from the date of filing of the earliest related patent application. Utility and plant patents which were applied for prior to June 8, 1995, and which were or will be in force after June 8, 1995, now have a patent term of seventeen years from the date of patent grant or twenty years from the date of filing of the earliest related patent application, whichever is longer. Utility patents are subject to the payment of periodic maintenance fees to keep the patent in force. Patent terms can be extended under some specific circumstances.

BIBLIOGRAPHY

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Bibliography

Eighth Malaysia Plan 2001-2005 (2001). Kuala Lumpur: Percetakan Nasional Malaysia Berhad *Economic Planning Unit, Prime Minister's Office*.

Ministry of Science, Technology and Environment, Malaysia. (1995). *1992 Malaysian Science and Technology Indicators Report*. Kuala Lumpur: Malaysian Science and Technology Centre.

_____. (1996). *1994 Malaysian Science and Technology Indicators Report*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

_____. (1996). *1994 National Survey of Research and Development*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

_____. (1997). *The Public Awareness of Science and Technology Malaysia 1996*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

_____. (1998a). *1996 Malaysian Science and Technology Indicators Report*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

_____. (1998b). *1996 National Survey of Research and Development*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

_____. (1999). *The Public Awareness of Science and Technology Malaysia 1998*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

_____. (2000a). *1998 Malaysian Science and Technology Indicators Report*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

_____. (2000b). *1998 National Survey of Research and Development*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

_____. (2001a). *2000 National Survey of Research and Development*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

_____. (2001b). *The Public Awareness of Science and Technology Malaysia 2000*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

_____. (2001c). *National Survey of Innovation 1997-1999*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

_____. (2002a). *The Public Awareness of Science and Technology Malaysia 2002*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

_____. (2002b). *National Survey of Innovation 2000-2001*. Kuala Lumpur: Malaysian Science and Technology Information Centre.

May, R. (1997). *The scientific wealth of nations*. Science, 275 (7), pp. 793-796.

National Science Foundation. (2002). *Science and Engineering Indicators 2002*.

OECD (2001). *OECD Science, Technology and Industry Scoreboard*. Paris: OECD.

Okubo, Yoshiko. (1997). *Bibliometric indicators and analysis of research systems: methods and examples*. Paris: OECD. (STI working papers 1997/1).

Pritchard, A. (1969). *Statistical bibliography or bibliometrics*, Journal of Documentation, 25(4), pp. 348-349

Szarina Abdullah ... et. al. (2003). *A bibliometric study of science and technology knowledge productivity in Malaysia: Interim Report*. Shah Alam: Bibliometrics Special Interest Group, Faculty of Information Studies, Universiti Teknologi MARA for The Ministry of Science, Technology and the Environment, Malaysia.

Tijssen, Robert J.W. and van Leeuwen, thed N. (2003). Bibliometric analyses of world science, Extended Technical Annex to chapter 5 of the 'Third European Report on S & T Indicators', Leiden: Centre for Science and Technology Studies (CWTS).

UNCTAD. (2001). *Human Development Report 2001*. New York: UNCTAD.

Weinstock, N. (1971). Citation indexes, in Kent, a. (Ed.). *Encyclopedia of Library and Information Sciences*, New York: Marcel Dekker, Vol. 5, pp.16-41.

World Bank. (2001). *World Development Report 2002*. Washington D.C.: World Bank.

Electronic sources:

94 brain-gain scientists have left country (September 21, 2004). *The Star Online*. Retrieved 8 September 8, 2004 from

<http://thestar.com.my/news/story.asp?file=/2004/9/21/parliament/8941698&sec=parliament>

Institute for Scientific Information (ISI). In-cites - new entrants to ISI Essential Science Indicators Ranking – December 2002. Retrieved from

<http://www.in-cites.com/newentrants/december2002.html>

Institute for Scientific Information (ISI). National Science Indicators (NSI) – Especially Prepared for MASTIC 1981-2002 [CD-ROM]

Institute of Scientific Information (ISI). National Citation Report (NCR) – Malaysia Especially Prepared for MASTIC 1981-2002

Institute for Management Development (IMD). *The World Competitiveness Year Book 2004*. [Online]. Retrieved from <http://www.imd.ch/wcy>

Ministry of Human Resources Malaysia. *Programme to Encourage Malaysian Citizens with Expertise Residing Overseas to Return to Malaysia*. Retrieved October 11, 2004 from <http://mohr.gov.my/mygoveg/bi/gpexpert.htm>

Moreira, C. F. (February 13, 2004). SchoolNet gets moving. *The Star Online*. Retrieved 8 October 2004 from

<http://startechcentral.com/tech/story.asp?file=/2004/2/13/technology/7316449&sec=technology>

Public Service Department Malaysia. *Garis Panduan Mengenai Pengambilan Saintis Warganegara Malaysia Di Luar Negeri Dan Saintis Asing*. Service Circular (3) 1995. Retrieved October 13, 2004 from

http://www.eghrmis.gov.my/wp_content2/pekeliling/PP95/PP95Bil03/PP95Bil03.htm

Yong, T.K. (August 5, 2001). Raising Perks for Returnees. *NSTP Advertisement Interactive Website*. Retrieved 8 October 2004 from <http://adtimes.nstp.com.my/jobstory/2001/aug5.htm>

