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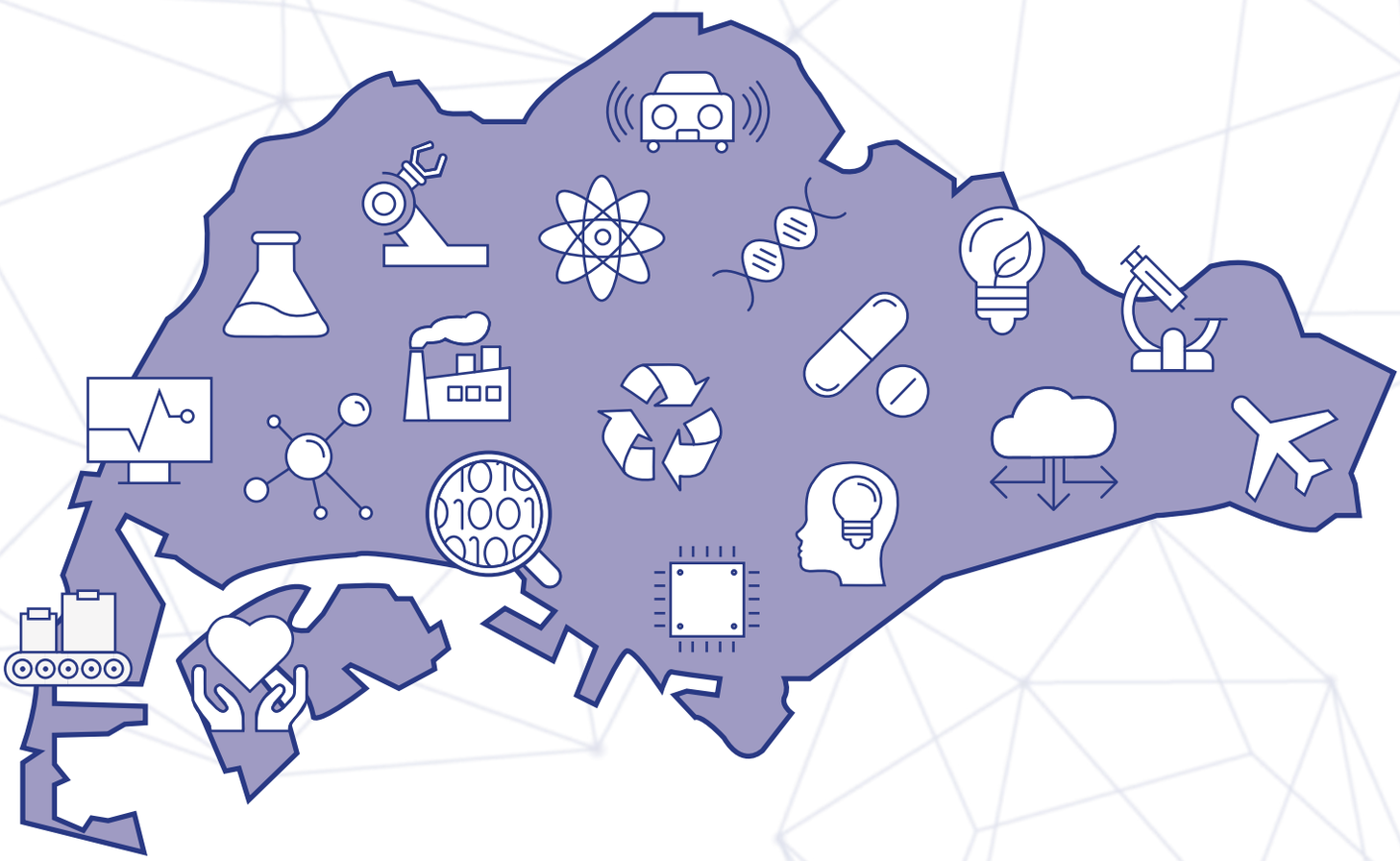
NATIONAL SURVEY OF RESEARCH, INNOVATION AND ENTERPRISE IN SINGAPORE 2021



NATIONAL RESEARCH FOUNDATION
PRIME MINISTER'S OFFICE
SINGAPORE

Agency for Science, Technology and Research
SINGAPORE

NATIONAL SURVEY OF RESEARCH, INNOVATION AND ENTERPRISE 2021

Expenditure on R&D rose in 2021...

All types of expenditure increased for private and public sector in 2021.

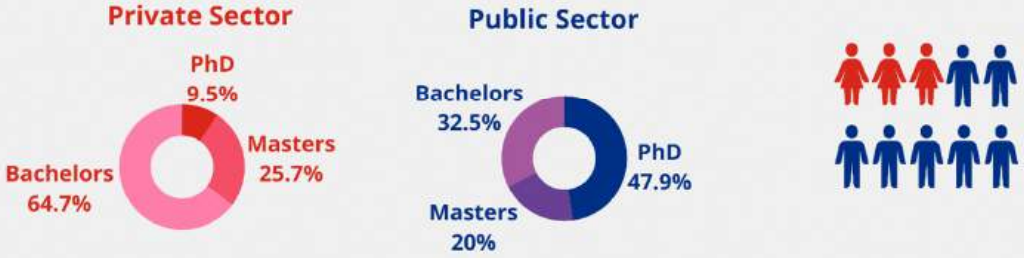
R&D-related Employment Up in 2021...

55,269 jobs* associated with R&D in 2021, up from 53,608 in 2020

	Private Sector			Public Sector		
	2020	2021	% Change	2020	2021	% Change
Researchers[1]	24,237	23,567	-2.8%	21,878	23,719	+8.4%
- Research Scientists and Engineers (RSE)[2]	22,219	21,573	-2.9%	16,609	18,144	+9.2%

Bulk of RSEs in Private Sector were bachelor's degree holders while there was higher proportion of PhD RSEs in the Public Sector in 2021

31.3% of all RSEs were females in 2021



* Includes researchers, technicians and other supporting staff.
[1]Comprises Research Scientists and Engineers, non-degree researchers and full-time postgraduate students.
[2]Refers to those who hold formal qualifications at university degree level, and excludes full-time postgraduate students.

CONTENTS

Introduction

Singapore's sustained investments in Research, Innovation and Enterprise (RIE) over the past three decades have built up a vibrant and diverse research and innovation ecosystem. This includes fostering close collaborations amongst companies, institutes of higher learning, research institutes as well as public agencies. These efforts will help reinforce Singapore's standing as a global innovation hub capable of leveraging R&D to address national needs and create economic value.

In 2021, Singapore's Gross Expenditure on R&D (GERD) increased by 7.4% to reach $11.2 billion from $10.4 billion in 2020, registering growth of 53.4% (or CAGR of 4.4%) between 2011 to 2021. Singapore's GERD as a percentage of GDP was 2.0% in 2021. The increase in GERD was due to the increase in both Business Expenditure on R&D (BERD), by 7.3% between 2020 and 2021, and the increase in Public Expenditure on R&D (PUBERD) by 7.5% over the same period. The BERD/PUBERD ratio in 2021 decreased to 1.73, from 1.74 in 2020.

R&D investments enable job creation. In 2021, a total of 55,269 jobs were associated with R&D activities. Among these, Research Scientists and Engineers (RSEs) accounted for the majority at 71.9%, or 39,717 jobs. The bulk of RSEs were Bachelor's degree holders (50.0%), followed by PhD (27.1%) and Master's degree holders (22.9%). The number of RSEs in the private sector decreased by 2.9% between 2020 and 2021, while the public sector saw an increase of 9.2%, bouncing back from the decline of 5.7% in 2020. Overall, the total number of RSEs grew by 2.3% in 2021.

The RIE survey data provides insights about Singapore's R&D ecosystem, from the expenditure of organisations to the impact on manpower. This survey would not be possible without the support of participating organisations in both the public and private sectors. We thank all participant organisations for their important contributions.

National Research Foundation,
Agency for Science, Technology and Research

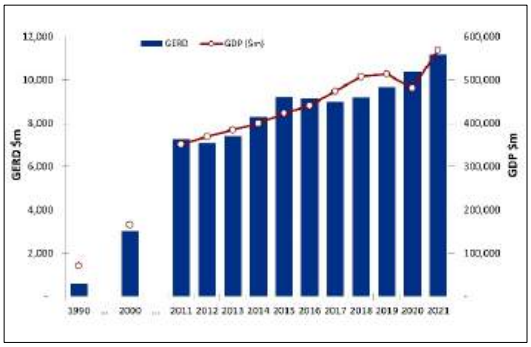
1. OVERVIEW OF R&D IN SINGAPORE

1.1. Gross Expenditure on R&D (GERD)

GERD in Singapore increased by 7.4% from $10.4 billion in 2020 to $11.2 billion in 2021. Singapore's GDP (at current market prices) increased by 19.5% from $476.4 billion to $569.4 billion[1] over the same period.

In 2011, GERD was $7.3 billion and GDP was $351.4 billion. The Compound Annual Growth Rate (CAGR) of GERD from 2011 to 2021 was 4.4%.

Fig.1.1 Gross Expenditure on R&D and GDP (1990-2021)

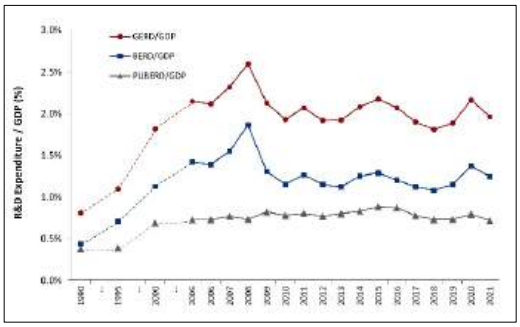


1.2. Ratio of Public Expenditure on R&D (PUBERD) to Business Expenditure on R&D (BERD)

Due to the strong GDP rebound post-COVID, GERD as a percentage of GDP decreased from 2.2% in 2020 to 2.0% in 2021. Of this, Business Expenditure on R&D (BERD) as a percentage of GDP decreased from 1.4% in 2020 to 1.2% in 2021, while Public Expenditure on R&D (PUBERD) as a percentage of GDP decreased from 0.8% in 2020 to 0.7% in 2021.

For every $1 spent on research in the public sector, $1.73 was spent by businesses in 2021.

Fig.1.2 Gross Expenditure, Business Expenditure and Public Expenditure on R&D as a percentage of GDP (1990-2021)

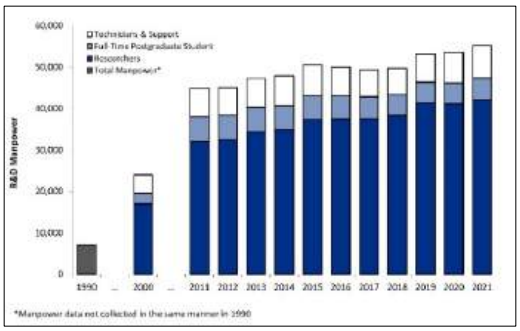


1.3. Manpower

Total R&D Manpower (including researchers, full-time postgraduate students, technicians and support staff) increased by 3.1% from 53,608 persons in 2020 to 55,269 persons in 2021. This represents a CAGR of 2.1% from a base of 44,846 persons in 2011.

The number of researchers (excluding full-time postgraduate students) increased by 2.1% from 41,165 in 2020 to 42,049 in 2021. The CAGR from 2011, with 32,016 researchers, to 2021 was 2.8%. The total number of researchers was 47,286 in 2021 – this includes full-time postgraduate students.

Fig.1.3 R&D Manpower (1990-2021)



[1] GDP figure is extracted from Department of Statistics in Jan 2024.

2. BUSINESS EXPENDITURE ON R&D (BERD)

2.1 Overview

In 2021, 979 private sector companies indicated that they performed R&D in Singapore. The total BERD of these companies amounted to $7.1 billion, corresponding to 1.2% of Singapore's GDP in 2021. This represents an increase of 7.3% compared to the BERD in 2020 at $6.6 billion. The CAGR from 2011 to 2021 was 4.8%, from a base of $4.4 billion in 2011.

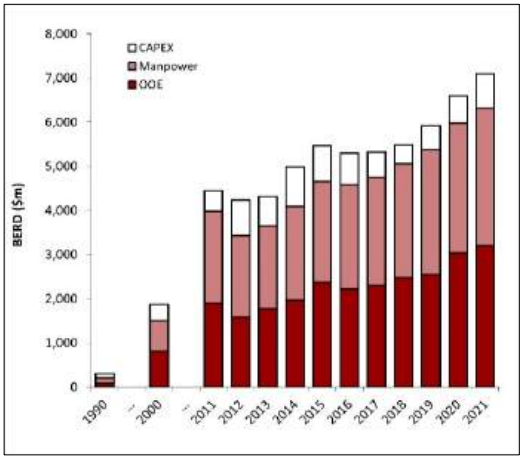
2.2 Type of Expenditure

Capital expenditure (CAPEX) increased by 25.4% from $617.5 million in 2020 to $774.4 million in 2021. From a base of $463.6 million in 2011, the CAGR for 2011 to 2021 was 5.3%.

Manpower expenditure increased by 5.9% to $3.1 billion in 2021 from $2.9 billion in 2020. From a base of $2.1 billion in 2011, the CAGR for 2011 to 2021 was 4.1%.

Other operating expenditure (OOE) rose by 5.4% to $3.2 billion in 2021 from $3.0 billion in 2020. From a base of $1.9 billion in 2011, the CAGR for 2011 to 2021 for OOE was 5.4%.

Fig.2.1 Business Expenditure on R&D by type of cost (1990-2021)



2.3 Type of R&D

The types of R&D conducted in private sector companies are classified into 3 categories.

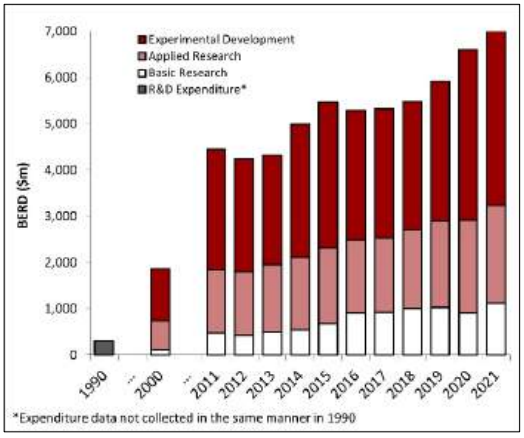
a) **Basic research** (both experimental or theoretical work undertaken without any particular application or use in view);
b) **Applied research** (original investigation directed primarily towards a specific practical aim or objective); and
c) **Experimental development** (systematic work directed to producing or improving substantially materials, products and devices; or installing new processes, systems and services).

Basic research expenditure in the private sector increased by 23.1% from $907.5 million in 2020 to $1.1 billion in 2021. From a base of $472.4 million in 2011, the CAGR for 2010 to 2020 was 9.0%.

Applied research by private sector companies increased by 6.3% from $2.0 billion in 2020 to $2.1 billion in 2021. This represents a CAGR of 4.5% from 2011 when it was $1.4 billion.

In 2021, business expenditure on experimental development rose by 4.0% from $3.7 billion in 2020 to $3.8 billion in 2021. CAGR for the period 2011 to 2021 was 4.0% as business expenditure on experimental development by private sector companies in 2011 was $2.6 billion.

Fig.2.2 Type of Business Expenditure on R&D (1990-2021)



2.4 Fields of Science and Technology

In the private sector, research expenditure in Electronics grew by 4.7% from $3.4 billion in 2020 to $3.5 billion in 2021. This represents a CAGR of 4.6% from 2011 when it was $2.6 billion.

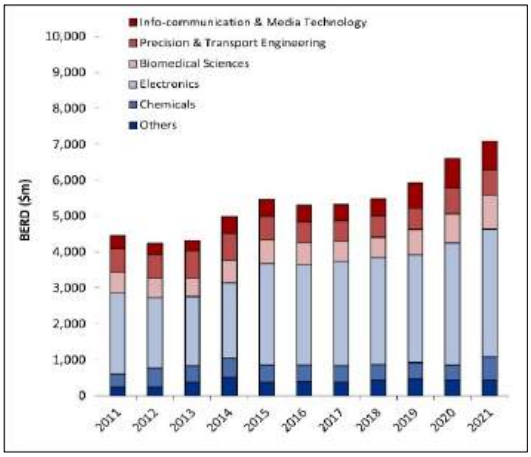
Research expenditure in Info-communication & Media Technology decreased by 3.3% from $819.0 million in 2020 to $792.1 million in 2021. This represents a CAGR of 8.2% from 2011 when it was $359.7 million.

Research expenditure on Biomedical Sciences increased by 15.1%[2] from $827.7 million in 2020 to $952.4 million in 2021. This represents a CAGR of 5.2% from 2011 when it was $573.6 million.

Spending in Chemicals research increased by 51.7% from $425.3 million in 2020 to $645.2 million in 2021. From a base of $354.1 million in 2011, the CAGR was positive at 6.2%.

Expenditure in Precision and Transport Engineering research increased by 0.1% from $710.4 million in 2020 to $711.0 million in 2021. Between 2011 and 2021, the CAGR was 0.8%, from a base of $654.7 million in 2011.

Fig.2.3 Business Expenditure on R&D by fields of science and technology (2011-2021)



The types of R&D conducted are classified by Fields of Science and Technology are as follows:

a) **Electronics**; Comprising: Electrical & Electronics Engineering, and Computer Engineering.
b) **Info-communication & Media Technology**; Comprising: Info-communication & Media Technology, and Computer & Related Sciences.
c) **Chemicals**; Comprising: Material Sciences & Chemical Engineering, and Chemical Sciences.
d) **Biomedical Sciences**; Comprising: Biomedical & Related Sciences, and Biomedical Engineering.
e) **Precision & Transport Engineering**; Comprising: Aeronautical Engineering, Civil & Architecture Engineering, Marine Engineering, Mechanical Engineering, and Metallurgy & Metal Engineering.
f) **Others**; Comprising: Agricultural Sciences, Food Sciences, Earth & Related Environmental Sciences, Environmental Engineering, Physical Sciences & Mathematics, Energy, and Other Areas.

[2] This sharp increase could in part be due to the R&D expenditures by companies during COVID-19.

3. PUBLIC EXPENDITURE ON R&D (PUBERD)

3.1 Overview

In 2021, 78 public institutions, including A*STAR research institutes, institutes of higher learning, academic medical centres, hospitals and other publicly-funded research organisations, indicated that they performed R&D in Singapore.

These organisations reported a total R&D expenditure of $4.1 billion in 2021, making up 0.7% of Singapore's GDP, a slight decrease from the 0.8% in 2020. This was due to faster growth seen in GDP relative to PUBERD. The total expenditure by public sector in 2021 was nevertheless higher than the $3.8 billion in 2020. From a base of $2.8 billion in 2011, the CAGR for 2011 to 2021 was 3.8%.

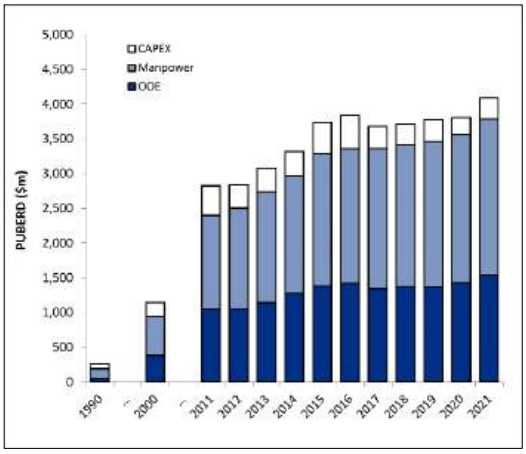
3.2 Type of Expenditure

Amongst public institutions, CAPEX increased by 25.0% from $244.4 million in 2020 to $305.2 million in 2021. From a CAPEX of $428.1 million in 2011, the CAGR for 2011 to 2021 for CAPEX decreased by 3.3%.

Manpower expenditure increased by 5.3% from $2.1 billion in 2020 to $2.2 billion in 2021. From a base of $1.4 billion in 2011, the CAGR for 2011 to 2021 for manpower expenditure was 5.2%.

OOE increased by 7.9% from $1.4 billion in 2020 to $1.5 billion in 2021. From a base of $1.0 billion in 2011, the CAGR for 2011 to 2021 for OOE was 4.0%.

Fig.3.1 Public Expenditure on R&D by type of cost (1990-2021)



3.3 Type of R&D

The types of R&D conducted in public sector research organisations are as follows:

a) **Pure basic research** (primarily focused on the advancement of knowledge, rather than to solve a specific problem or to seek long-term economic or social benefits);
b) **Strategic basic research** (carried out with the expectation that it will produce a broad base of knowledge likely to form the basis of the solution to current or future problems or possibilities);
c) **Applied research** (original investigation directed primarily towards a specific practical aim or objective); and
d) **Experimental development** (systematic work directed to producing or improving substantially materials, products and devices; or installing new processes, systems and services).

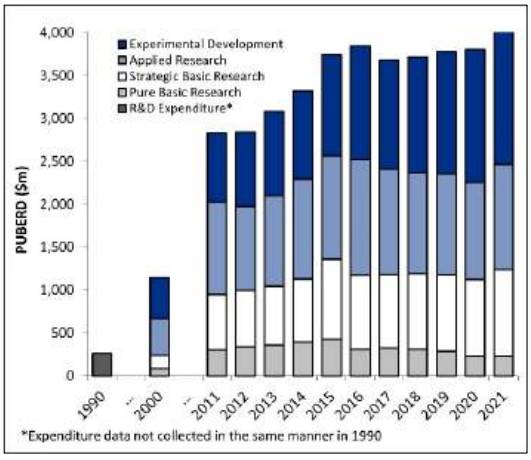
Pure basic research expenditure in public institutions decreased slightly by 0.2% from $229.1 million in 2020 to $228.6 million in 2021. From a base of $300.5 million in 2011, the CAGR for 2011 to 2021 showed a decline of 2.7%.

Strategic basic research expenditure in public institutions increased by 12.8% from $894.5 million in 2020 to $1.0 billion in 2021. This represents a CAGR of 4.5% from 2011 when it was $647.0 million. Together, pure basic research and strategic basic research registered a CAGR of 2.7% from 2011 to 2021.

Applied research expenditure in public institutions increased by 8.8% from $1.1 billion in 2020 to $1.2 billion in 2021. This represents a CAGR of 1.3% from 2011 when it was $1.1 billion.

Experimental development expenditure in public institutions increased by 4.6% from $1.5 billion in 2020 to $1.6 billion in 2021. This represents a CAGR of 7.4% from 2011 when it was $797.3 million.

Fig.3.2 Type of Public Expenditure on R&D (1990-2021)



3.4 Fields of Science & Technology

In public institutions, expenditure on R&D in Electronics declined by 7.6% from $658.5 million in 2020 to $608.6 million in 2021. This represents a CAGR of 2.7% from 2011 when it was $465.0 million.

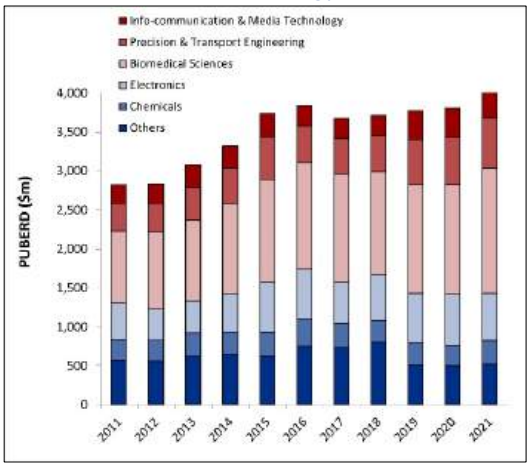
R&D expenditure on Info-communication & Media Technology increased by 9.9% from $372.9 million in 2020 to $409.8 million in 2021. This represents a CAGR of 5.2% from 2011 when it was $247.0 million.

Expenditure on R&D in Chemicals increased by 16.4% from $263.3 million in 2020 to $306.5 million in 2021. Between 2011 and 2021, the CAGR was 1.3%, from a base of $268.4 million in 2011.

Expenditure on R&D in Biomedical Sciences increased by 13.9%[3] from $1.4 billion in 2020 to $1.6 billion in 2021. This represents a CAGR of 5.7% from 2011 when it was $920.9 million.

The expenditure for Precision and Transport Engineering increased by 6.7% from $600.2 million in 2020 to $640.5 million in 2021. Between 2011 and 2021, the CAGR was 6.2%, from a base of $350.9 million in 2011.

Fig.3.3 Public Expenditure on R&D by fields of science and technology (2011-2021)



[3] This sharp increase could in part be due to the R&D expenditures by public agencies during COVID-19.

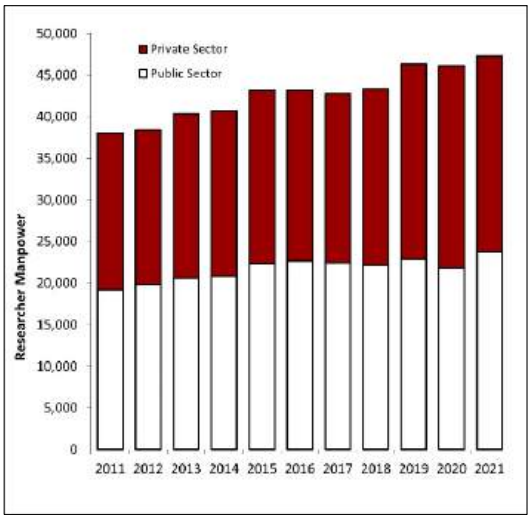
4. R&D TALENT

4.1 Total Researchers[4]

The total number of researchers (comprising Research Scientists and Engineers (RSEs), non-degree researchers and full-time postgraduate research students) increased by 2.5% from 46,115 in 2020 to 47,286 in 2021. This represents a CAGR of 2.2% from a base of 38,006 in 2011.

Researchers in the private sector fell by 2.8% from 24,237 in 2020 to 23,567 in 2021, while researchers in the public sector increased by 8.4% from 21,878 in 2020 to 23,719 in 2021. Nevertheless, between 2011 and 2021, both private and public sectors registered positive growth in researchers, with CAGR of 2.3% and 2.1% respectively.

Fig.4.1 Researcher Manpower (2011-2021)



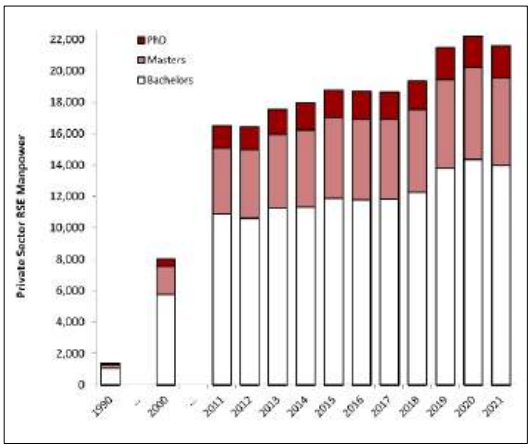
4.2 Total Research Scientists & Engineers

RSEs comprise researchers who hold formal qualifications at the university degree level. RSEs exclude full-time postgraduate research students.

In 2021, the number of RSEs grew by 2.3% from 38,828 in 2020 to 39,717 in 2021. This represents a CAGR of 3.0% from a base of 29,480 in 2011.

In the private sector, the number of PhD RSEs increased by 2.6% from 2,006 in 2020 to 2,058 in 2021. This represents a CAGR of 3.8% from 1,422 in 2011. RSEs with a Master's degree fell by 5.0% from 5,846 in 2020 to 5,553 in 2021. There was nevertheless a positive CAGR of 2.9% from 4,189 in 2011. The number of RSEs with a Bachelor's degree declined by 2.8% from 14,367 in 2020 to 13,962 in 2021. This represents a CAGR of 2.5% from 10,885 in 2011.

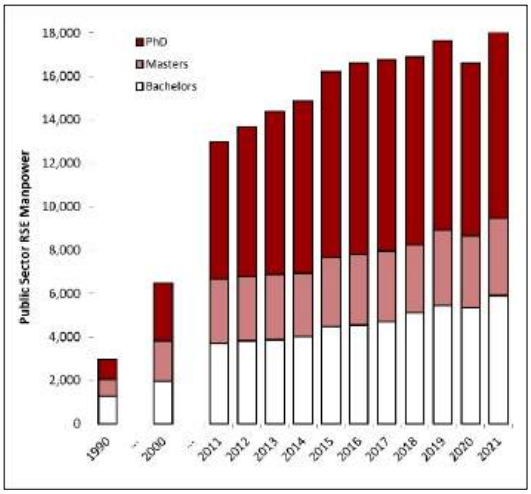
Fig.4.2 Private Sector Research Scientists & Engineers (1990-2021)



In the public sector, the number of PhD RSEs increased by 9.3% from 7,949 in 2020 to 8,689 in 2021. This represents a CAGR of 3.2%, from a base of 6,330 in 2011. RSEs with a Master's degree increased by 7.2% from 3,320 in 2020 to 3,560 in 2021. There was a CAGR growth of 1.9% from a base of 2,945 in 2011. RSEs with a Bachelor's degree increased by 10.4% from 5,340 in 2020 to 5,895 in 2021. The CAGR was 4.7% from a base of 3,709 in 2011.

[4] Data on all R&D manpower (including non-researchers) can be found in the manpower tables under the List of Tables appended at the end of the report.

Fig.4.3 Public Sector Research Scientists & Engineers (1990-2021)

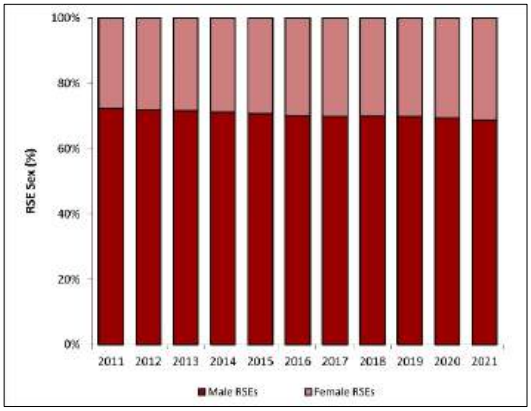


4.3 Profile of Research Scientists & Engineers

Sex

There were 12,435 female RSEs in 2021, making up 31.3% of all RSEs, higher than the 30.6% in 2020. This represents a CAGR of 4.3% from 8,137 female RSEs in 2011.

Fig.4.4 Sex of Research Scientists & Engineers (2011-2021)

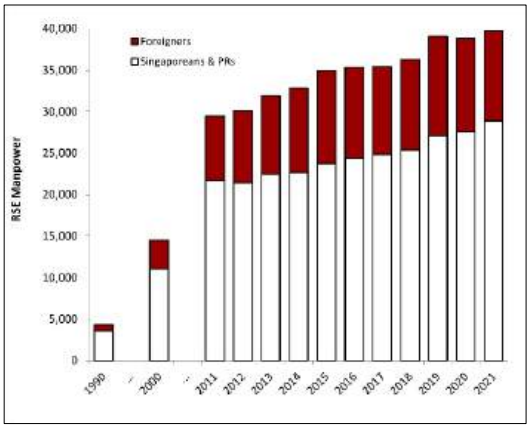


Citizenship

The number of Singaporean and Permanent Resident (PR) RSEs increased by 4.8% from 27,550 in 2020 to 28,859 in 2021. This represents a CAGR of 2.9% from a base of 21,701 RSEs in 2011.

The number of foreign RSEs continued to decrease from 11,949 in 2019, to 11,278 in 2020, and 10,858 in 2021, resulting in a 3.7% decline in 2021. Nevertheless, there was a CAGR of 3.4% from a base of 7,779 foreign RSEs in 2011.

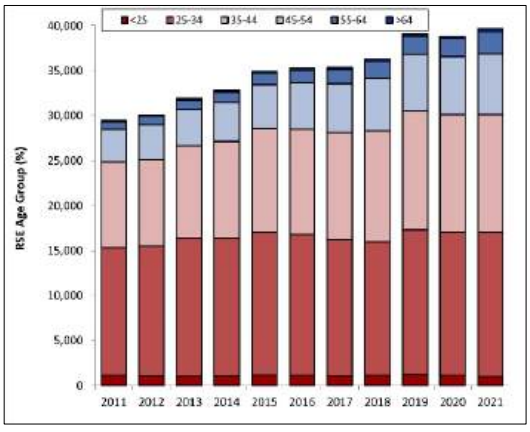
Fig.4.5 Citizenship of Research Scientists & Engineers (1990-2021)



Age-Bands

In 2021, 42.9% of all RSEs were under the age of 35 and 75.9% of all RSEs were under the age of 45. Compared to 2011, these proportions had fallen from 52.0% and 84.3% respectively, as there were now more RSEs in the higher age-bands.

Fig.4.6 Age-Bands of Research Scientists & Engineers (2011-2021)



5. PATENTS

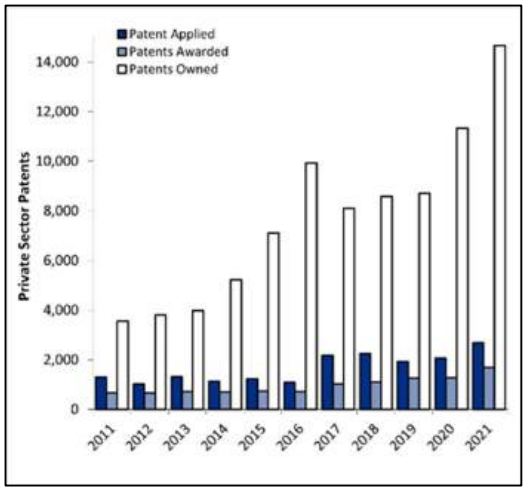
5.1 Patents Applied

In 2021, the total number of primary patent applications (first filings) as a result of R&D conducted in Singapore, stood at 3,643. This was an increase of 22.8% from the 2,967 patents filed in 2020, and a CAGR of 6.7% from the 1,913 patents filed in 2011.

In the private sector, 2,691 patents were filed in 2021, showing a 30.4% increase from the 2,063 patents filed in 2020, and a CAGR of 7.5% from the 1,303 patents filed in 2011.

In the public sector, the number of patent applications increased from 904 in 2020 to 952 in 2021. This represents an increase of 5.3%, and a CAGR of 4.6% from the 610 patents filed in 2011.

Fig.5.1 Patents Applied, Awarded and Owned in the Private Sector (2011-2021)

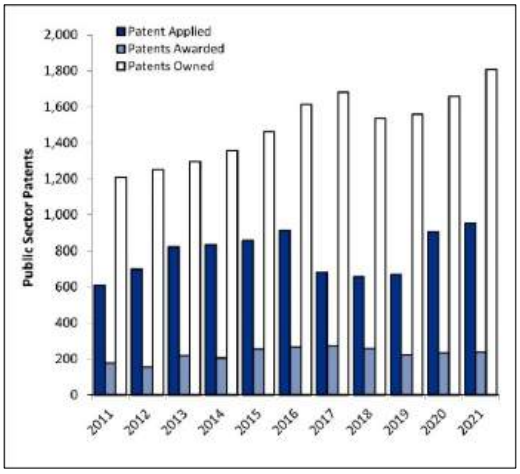


5.2 Patents Awarded

In 2021, the total number of patents awarded (first grants) as a result of R&D conducted in Singapore was 1,919. This represents an increase of 27.1% from 1,510 patents awarded in 2020 and a CAGR of 8.4% from the 855 patents awarded in 2011.

The number of patents awarded to private sector companies increased by 31.7% from 1,276 patents awarded in 2020 to 1,681 in 2021 and a CAGR of 9.5% from the 679 patents awarded in 2011. In the public sector, the number of patents awarded increased by 1.7% from 234 in 2020 to 238 in 2021, and a CAGR of 3.1% from the 167 patents awarded in 2011.

Fig.5.2 Patents Applied, Awarded and Owned in the Public Sector (2011-2021)



6. INTERNATIONAL COMPARISON OF R&D

6.1 Research Intensity in Selected Countries/Regions

According to OECD Main Science and Technology Indicators 2023/09, the United States of America remained the top R&D spender in 2021, with US$806 billion spent on research. China remained in second position, having spent US$667 billion, while Japan remained in third position having spent US$177 billion. Normalised as a percentage of GDP, GERD/GDP was 3.5% in the United States, 2.4% in China and 3.3% in Japan.

Singapore's GERD/GDP was 2.2% in 2020 and 2.0% in 2021 as GDP increased at a faster rate than GERD in 2021. The top 3 most research-intensive countries/regions in the world were Israel (5.6%), Republic of Korea (4.9%), and Taiwan (3.8%).

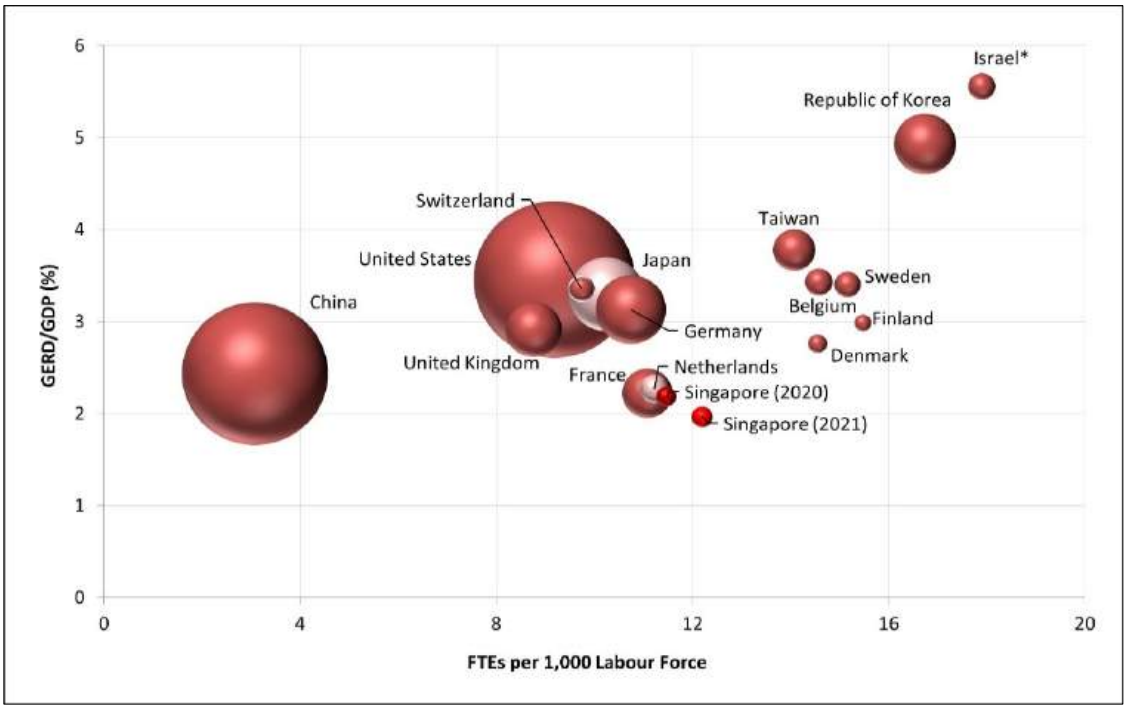
6.2 Researcher Intensity in Selected Countries/Regions

Researcher intensity is measured by Full-time Equivalence (FTEs) as a percentage of the labour force. Singapore's labour force decreased by 2.9% from 3.71 million in 2020 to 3.61 million in 2021. Researcher FTEs however rose slightly by 3.4% from 42,579 in 2020 to 44,007 in 2021.

Singapore's researcher intensity (FTEs/1,000 Labour Force) was 11.5 in 2020 and 12.2 in 2021. This places Singapore within the ranks of countries such as Netherlands (11.2) and France (11.1).

The top 3 countries in terms of researcher intensity in 2021 are Republic of Korea (16.7), Finland (15.5) and Sweden (15.2).

Fig.6.1 Comparison of Selected Countries/Regions by Research & Researcher Intensity (2021)



Bubble size indicates GERD.
**Researcher intensity for Israel is of 2012.*
Source: OECD, Main Science and Technology Indicators 2023/09

7. EXPLANATORY NOTES AND DEFINITIONS

7.1 DEFINITION OF R&D

7.1.1 Research and development (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of this stock of knowledge to devise new applications. R&D covers three activities: basic research, applied research and experimental development, which are defined and described in Section 7.5. The scope of the definition of R&D for this Survey extends to R&D in science and technology only and excludes the social sciences and humanities.

7.1.2 R&D is related to a number of other activities with a scientific and technological basis, which are often very closely linked to R&D through flows of information or in terms of operations, institutions and personnel. The basic criterion for distinguishing R&D from related activities is the presence of an appreciable element of novelty and the resolution of scientific or technological uncertainty, i.e. when the solution to a problem is not readily apparent to someone familiar with the basic stock of common knowledge and techniques for the area concerned. In particular, there is difficulty locating the cutoff point between experimental development and the related activities required to realise an innovation.

7.2 R&D MANPOWER

7.2.1 R&D manpower comprises all persons directly employed on R&D and those providing direct services. It includes persons who are mainly or partially engaged in R&D. It comprises the three occupation groups defined and described below: researchers; technicians; and other supporting staff.

7.2.2 Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, or in the management of the projects concerned. Managers and administrators engaged in the planning and management of the scientific and technical aspects of a researcher's work are categorised as researchers. Full-time postgraduate research students, at both the master degree and PhD level, are categorised as researchers.

7.2.3 Researchers are further sub-classified as follows:

(a) **Research scientists and engineers (RSEs)** comprise the researchers, excluding the full-time postgraduate research students, who hold formal qualifications at the university degree level. RSEs are classified into three subcategories according to the highest level of the formal qualifications: PhD; master degree; and bachelor degree.

(b) **Non-degree researchers** comprise the researchers, excluding the full-time postgraduate research students, who hold formal qualifications below the university degree level.

(c) **Full-time postgraduate research students (FPGRSs)**.

We define also TRSEs ("total" RSEs) to be the category comprising the RSEs and FPGRSs.

7.2.4 **Technicians** are persons whose main tasks require technical knowledge and experience in one or more fields of science and technology. They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers. The tasks of technicians include: preparing computer programmes; carrying out experiments, tests and analyses; preparing materials and equipment for experiments, tests and

analyses; and recording measurements, making calculations and preparing charts and graphs.

7.2.5 **Other supporting staff** comprise other persons who participate in or are directly associated with R&D projects. Managers and administrators dealing mainly with financial and personnel matters and general administration, skilled and unskilled craftsmen, and secretarial and clerical staff, are included in this heading, insofar as their activities are a direct service to R&D. Persons providing an indirect service should be excluded (but their wages and salaries should be included as an overhead costs when measuring expenditure on R&D).

7.2.6 The Survey's reporting convention for the headcount of those engaged in R&D is the number of persons as at the last day of the one-year reporting period.

7.2.7 One full-time equivalence (FTE) unit may be thought of as one person-year. A person who spends 30% of his time on R&D and the rest on other activities during the one-year reporting period should be considered as 0.3 FTE. If a full-time R&D worker is employed for only six months during the one-year reporting period, this results in a 0.5 FTE.

7.2.8 R&D manpower is also classified by the following:

(a) **Nationality**, categorised by "Singapore citizens and Singapore permanent residents" as well as "non-PR foreign citizens".

(b) **Age group**, categorised by the following: (i) under 25 years; (ii) 25-34 years; (iii) 35-44 years; (iv) 45-54 years; (v) 55-64 years; and (vi) above 64 years.

(c) **Sex**.

7.3. R&D EXPENDITURE

7.3.1 The (intramural) R&D expenditures for an organisation comprise all expenditures on R&D performed *within the organisation* during the reporting period. They include non-R&D expenditures made outside the organisation but in support of the R&D performed within the organisation. It excludes extramural R&D expenditures, which are the sums an organisation paid or committed to pay to another organisation for the performance of R&D (e.g., acquisition of R&D performed by others and grants given to others for performing R&D).

7.3.2 Intramural R&D expenditures comprise current and capital expenditures.

(a) **Current expenditures** comprise manpower and other operating expenditures:

(i) **Manpower expenditures** comprise annual wages and salaries and all associated expenditures for R&D manpower. The manpower expenditures on persons who provide an indirect service to R&D and are not categorized as R&D manpower are included as other operating expenditures on R&D and not as manpower expenditures on R&D.

(ii) **Other operating expenditures (OOE)** include non-capital purchases of materials, supplies and equipment to support R&D performed by the organisation. Administrative and other overhead expenditures are included and prorated if necessary. Expenditures on indirect services are included. Rents and fees associated with R&D are included.

(b) **Capital expenditures (CAPEX)** are the annual gross expenditures on fixed assets used in the R&D programmes of the organisation, i.e. on (i) land, buildings and other structures, and on (ii) vehicles, plant,

machinery and equipment. They are reported in full for the reporting period when they took place rather than registered as an element of depreciation.

7.3.3 Sources of R&D funds are reported by the performers of research. The surveyed organisation reports the sums which it received or will receive from various sources for the performance of (intramural) R&D during the one-year reporting period. Funds received for R&D performed during earlier periods or for R&D not yet started are excluded. The categories of sources of R&D funds are:

(a) Within Singapore:
  (i) Private sector;
  (ii) Government sector;
  (iii) Institutes of Higher Learning.

(b) Abroad:
  (i) Foreign-based companies;
  (ii) Foreign governments and international organisations.

7.3.4 All monetary amounts in this report are in Singapore dollars. Monetary amounts that are reported by survey respondents in foreign currency units are converted to Singapore dollars based on the average exchange rates for the relevant year, as published by the Monetary Authority of Singapore.

7.4. INSTITUTIONAL CLASSIFICATION

7.4.1 Sectors. The Survey classifies organisations into four sectors:

(a) **Private sector**. This comprises all business enterprises, excluding institutions of higher learning.

(b) **Government sector**. This comprises all government organisations, but excludes the public institutions of higher learning and the A*STAR research institutes, which are classified under separate sectors. It includes all government ministries and statutory boards.

(c) **Institutes of Higher Learning**. This comprises institutions of higher learning, including the universities and polytechnics.

(d) **Public research institutes**. This comprises the A*STAR research institutes.

7.4.2 Industrial classification. The enterprises in the private sector are further sub-classified into industry groups and subgroups according to their classification by the Singapore Standard Industrial Classification (SSIC) 2020.

7.4.3 The enterprises in the private sector are also sub-classified by ownership and size:

(a) A company with at least 30% local equity is classified as a local company, and with less than 30% local equity a foreign company.

(b) A local company is classified as a small/medium-sized enterprise (SME) if it satisfies the following criteria (following Enterprise Singapore), and a large enterprise (LE) otherwise:

  (i) Annual sales turnover of not more than $100 million; or
  (ii) Employment size of not more than 200 workers.

7.5. FUNCTIONAL DISTRIBUTION

7.5.1 Type of R&D. Three types of R&D are distinguished:

(a) **Basic research** is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.

The performer of the research may not know about actual applications when doing the research, and therefore does not have them in view: such research is basic according to the definition. Research that is undertaken with the goal of a broad range of applications in the future, but which does not have a particular use in view, is basic according to the definition.

Thus, two types of basic research are distinguished:

(i) **Pure basic research** is carried out primarily for the advancement of knowledge, rather than to solve a specific problem or to seek long-term economic or social benefits or to transfer the results to sectors responsible for their application.

(ii) **Strategic (or oriented) basic research** is carried out with the expectation that it will produce a broad base of knowledge likely to form the basis of the solution to recognised or expected, current or future problems or possibilities.

(b) **Applied research** is also original investigation undertaken in order to acquire new knowledge. However, it is directed primarily towards a specific practical aim or objective. Applied research is undertaken either to determine possible uses for the findings of basic research or to determine new methods or ways of achieving specific and predetermined objectives. It involves considering the available knowledge and its extension in order to solve particular problems. The results of applied research are intended primarily to be valid for a single or limited number of products, operations, methods or systems. Applied research gives operational form to ideas.

(c) **Experimental development** is systematic work, drawing on knowledge gained from research and practical experience, that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed.

7.5.2 Fields of science and technology (S&T). The areas of R&D are classified by the following S&T fields:

Natural sciences (excluding biological sciences)

- Computer and related sciences [computer programming, computer studies, electronic data processing, information sciences, system analysis, and areas related to software development]
- Physical sciences and mathematics [astronomy and space sciences, physics and related sciences]
- Chemical sciences [chemistry and related sciences]
- Earth and related environmental sciences [geology, geophysics, mineralogy, meteorology, physical geography and other geosciences, other atmospheric sciences including climate research, oceanography, vulcanology, palaeoecology and related sciences]

Engineering and technology

- Civil and architecture engineering [architecture engineering, building sciences and engineering, construction engineering, municipal and structural engineering]
- Mechanical engineering
- Metallurgy and metal engineering
- Aeronautical engineering
- Marine engineering
- Electrical and electronics engineering [electrical engineering, electronics, communication engineering and systems]
- Computer engineering [hardware only]

- Info-communication and media technology
- Materials science and chemical engineering
- Environmental engineering
- Biomedical engineering

Biomedical and related sciences

- Basic medicine [anatomy, cytology, physiology, pharmacy, pharmacology, toxicology, immunology and immunohaematology, pathology, neuroscience]
- Clinical medicine [anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology, oncology, geriatrics, cardiovascular, dermatology, urology, infectious diseases]
- Health sciences [public health services, social medicine, hygiene, nursing, epidemiology]
- Pharmaceutical sciences and manufacturing
- Biological sciences [biochemistry, biology, biophysics, genetics, microbiology, molecular biology, bioengineering, bioinformatics]
- Other related biomedical sciences

Agricultural sciences, food sciences [Agronomy, agrotechnology, animal husbandry, fisheries, forestry, horticulture, bacteriology related to animals, veterinary medicine, botany, zoology, food and other related sciences]

Energy
[Clean energy systems; solar energy; wind energy]

Other areas

7.6. OTHER DATA

7.6.1 The following R&D-related data are also collected by the Survey:

(a) **Patenting activities** arising from R&D performed in Singapore:

(i) Number of primary patent applications during the reporting period. Only first filings of patent applications are counted, and patent applications for the same invention in more than one country are entered as one.

(ii) Number of patent awards during the reporting period. Patent awards for the same invention in more than one country are entered as one.

(iii) Number of patents owned as at the last day of the calendar year.

(b) **Revenue data**:

(i) Licensing revenue from patents and new technologies developed in Singapore;

(ii) Sales revenue from commercialized products/processes attributed to R&D performed in Singapore.

7.6.2

(a) The following classification data are also collected in the Survey:

(i) Total number of employees;

(ii) Total sales revenue over the one-year reporting period;

(iii) Information on local and foreign equity in the company.

(b) The industrial classification of private sector enterprises by the SSIC 2020 is obtained from the Department of Statistics.

7.6.3 The convention for reporting data such as sales revenue may differ across organisations.

7.7 LIST OF ABBREVIATIONS:

BERD	Business Expenditure on R&D
CAPEX	Capital Expenditure
CAGR	Compound Annual Growth Rate
EDB	Economic Development Board
FPGRS	Full-time Postgraduate Research Student
FTE	Full-time Equivalence
GDP	Gross Domestic Product
GERD	Gross Expenditure on R&D
IPOS	Intellectual Property Office of Singapore
OOE	Other Operating Expenditure
PG	Post Graduate
PUBERD	Public Expenditure on R&D
RIE	Research, Innovation and Enterprise
R&D	Research & Development
RSE	Research Scientists and Engineers
SME	Small & Medium Enterprise
SSIC	Singapore Standard Industrial Classification
S&T	Science and Technology
UEN	Unique Entity Number

8. METHODOLOGY

8.1. METHODOLOGY

8.1.1 The National Survey of Research, Innovation and Enterprise (RIE) in Singapore is conducted under the Statistics Act 1973 (Chapter 317), which makes the submission of returns mandatory. Individual returns received are kept in confidence with the Statistics Act. The Act is available on the Singapore Department of Statistics' website (www.singstat.gov.sg).

8.1.2 The approach is to survey all organisations that are known to perform R&D. A register of R&D performing organisations is maintained. The Survey form is sent to the organisations on the register. The register comprises all organisations that had reported previously to the Survey that they performed R&D, after excluding those that subsequently reported that they did not perform R&D or ceased operations. The register is updated annually through a Preliminary Survey of organisations that are potentially performing R&D but are not on the register. The list of organisations surveyed in the Preliminary Survey is compiled annually from various sources, and includes all companies that are in receipt of government R&D grants.

8.1.3 From 2019, the register has expanded to include organisations that perform innovation activities (other than R&D). This is in line with the expansion of the survey to include returns on innovation activities performed by organisations in Singapore.

8.2. RESPONSES

8.2.1 The organisations that reported to the Survey that they performed innovation and/or R&D in 2021 comprised private sector enterprises, government organisations, institutions of higher learning and the public research institutes. A total of 979 private sector enterprises reported that they performed R&D in 2021.

8.2.2 Approximately 18,500 survey forms were sent out in the Preliminary Survey. Subsequently, close to 4,000 survey forms were sent out to private sector enterprises in the 2021 register of innovation and/or R&D-performing organisations, exceeding the 2020 figure by over a thousand. From these, nearly 1,900 private sector enterprises responded, out of which 1,510 (80%) reported that they performed innovation (including R&D) from 2019 to 2021, up from the 1,421 in the previous reference period. The remaining 386 (20%) reported that they did not perform innovation and/or R&D in 2021 or had ceased business operations.

8.2.3 In 2021, the top 150 private sector enterprises (by R&D expenditure in 2020) accounted for 80% ($5.7 billion) of private sector R&D expenditure. 146 (97%) reported that they performed R&D in 2021 and their returns were either reported under their own name or under a parent or subsidiary and 4 (3%) either reported that they did not perform R&D in 2021 or had ceased business operations or did not respond to us.

8.2.4 95% of all the government organisations, institutions of higher learning and public research institutes that were surveyed in 2021 responded.

8.2.5 The 2021 National RIE Survey publication continues to report the aggregated findings of organisations that perform in-house R&D. Findings of innovation activities performed by organisations in Singapore may be included in future editions of the publication.

8.3. CONVENTIONS

8.3.1 The reporting period of the Survey is one year in length. The actual period may

vary across Survey respondents but it would usually be the calendar or fiscal year.

8.4. HISTORICAL NOTES

8.4.1 The National Survey of R&D in Singapore was conducted by the Singapore Science Council on a triennial basis from 1978 to 1987. Since 1990, it has been conducted and published annually by the Agency for Science, Technology and Research (formerly the National Science and Technology Board). In 2019, the National Survey of R&D has been renamed the National Survey of Research, Innovation and Enterprise (RIE), which includes innovation as well.

8.4.2 Postgraduate research students (at the master degree and PhD levels) have been reported as R&D manpower only since the 2000 Survey. In the 2000 Survey, both full-time and part-time postgraduate research students were counted. Since the 2001 Survey, only full-time postgraduate research students (FPGRSs) have been included.

8.4.3 In 2000 and 2001, the Survey published data on patents applied and awarded that combined data from the Survey with data from the public databases of the Intellectual Property of Singapore (IPOS). Specifically, the published data combined the patenting data of the Survey respondents with the patenting data in the IPOS databases of locally-based companies (and individuals) that were not among the Survey's respondents. (The IPOS data contributed an additional 128 patents applied and 46 patents awarded in 2000, and an additional 193 patents applied and 51 patents awarded in 2001.) Since 2002, the Survey publishes only the patenting data of Survey respondents.

8.4.4 Since the 2002 Survey, (a) the industrial classification of enterprises in the private sector by industry groups was revised to ensure overall consistency of the classifications with SSIC 2000 and to align the definitions of the industry groups in the manufacturing industries with EDB's new definitions; (b) basic research in the private sector was not sub-classified into the subtypes of pure and strategic basic research; (c) "licensing revenue from acquired patents and new technologies" and "sales revenue from commercialised products and processes attributed to R&D performed in Singapore within the last 2 years" ceased to be published; (d) the Survey asked additionally for the age group and sex of R&D manpower to be reported; (e) the Survey included "computer engineering", "info-communication & media technology", "biological sciences", "basic medicine", "clinical medicine", "health sciences", "pharmaceutical sciences & manufacturing" and "other biomedical related sciences" as disaggregated options under the fields of science & technology category for both researchers and R&D expenditure; and (f) the Survey asked for the disaggregation of reported R&D expenditure in each field of science & technology by the type of R&D.

8.4.5 Prior to 2005, the classification of survey respondents from the private sector was based on the SSIC 2000. In 2005, it was updated to SSIC 2005, in 2010, to SSIC 2010, in 2015, to SSIC 2015, in 2017, to SSIC 2015 (version 2018), and in 2020, to SSIC 2020. In 2017, the aggregation of manufacturing activities into the EDB-defined manufacturing subsectors was also updated with EDB's revised classification. These revisions have some but limited impact on the comparability of the published R&D statistics in the 2017 survey report relative to those in the preceding survey reports.

8.4.6 Hitherto, organisations which were known to have performed R&D in the survey period, but which did not submit a survey return or submitted an incomplete survey return, have been excluded from the published survey results. With effect from

the 2006 survey report, such organisations would be captured in the published survey results through a mechanism of imputation, where this is feasible. The imputed data would be based on the previous year's survey returns and/or the current year's incomplete returns. The impact on the published statistics was marginal considering the survey already had a high response rate. Imputation was used for 7 (0.2%) of the 4,121 entities surveyed in 2021.

8.4.7 With effect from the 2007 Survey, an exercise would be undertaken on a yearly basis to update any changes made by the Department of Statistics to an organisation's Unique Entity Number (UEN) which could in turn impact its SSIC code. This is to capture any changes in the organisation's core activity so as to ensure that the organisation is placed in the correct industry classification.

8.4.8 With effect from the 2021 Survey, breakdowns for Capital Costs into the separate components "*Land, Building & Other Structures"*, and "*Vehicles, Plant, Machinery & Equipment"* are no longer collected to reduce respondent burden.

LIST OF TABLES

Table 1.1A R&D Manpower

Type of R&D Manpower	Private Sector	Government Sector	Institutes of Higher Learning	Public Research Institutes	Total
Researchers	23,567	4,265	15,310	4,144	47,286
RSEs#	21,573	4,059	10,100	3,985	39,717
PhD	2,058	712	5,797	2,180	10,747
Master	5,553	1,206	1,762	592	9,113
Bachelor	13,962	2,141	2,541	1,213	19,857
Postgrad students*	-	-	5,141	96	5,237
Non-Degree	1,994	206	69	63	2,332
Technicians	1,638	376	286	290	2,590
Other Supporting Staff	2,704	1,717	441	531	5,393
Total	27,909	6,358	16,037	4,965	55,269

* Similar to past years, postgraduate students at the Public Research Institutes are reported under Institutes of Higher Learning (IHL). Postgraduate students matriculated with overseas IHLs are reported under Public Research Institutes.

RSE is a definition used within Singapore context. It includes researchers with at least a degree. For more detailed definition regarding RSE, please see page 11 of explanatory notes.

Table 1.1B R&D Manpower (FTE)

Type of R&D Manpower	Private Sector	Government Sector	Institutes of Higher Learning	Public Research Institutes	Total
Researchers	22,546.52	3,068.63	14,351.47	4,040.25	44,006.87
RSEs#	20,634.46	2,903.33	9,153.36	3,881.25	36,572.40
PhD	2,006.19	595.61	5,246.53	2,111.40	9,959.73
Master	5,354.43	777.56	1,533.58	581.05	8,246.62
Bachelor	13,273.84	1,530.16	2,373.26	1,188.80	18,366.06
Postgrad students*	-	-	5,141.00	96.00	5,237.00
Non-Degree	1,912.06	165.30	57.10	63.00	2,197.46
Technicians	1,545.12	351.96	259.82	283.95	2,440.85
Other Supporting Staff	2,457.08	1,617.40	430.45	518.60	5,023.53
Total	26,548.72	5,037.99	15,041.74	4,842.80	51,471.25

Table 1.2 R&D Manpower by Nationality

Type of R&D Manpower	Private Sector		Government Sector		Institutes of Higher Learning		Public Research Institutes		Total	
	Singapore Citizens & Permanent Residents	Foreign Citizens	Singapore Citizens & Permanent Residents	Foreign Citizens	Singapore Citizens & Permanent Residents	Foreign Citizens	Singapore Citizens & Permanent Residents	Foreign Citizens	Singapore Citizens & Permanent Residents	Foreign Citizens
Researchers	17,600	5,967	4,075	190	7,522	7,788	3,285	859	32,482	14,804
RSEs[#]	15,878	5,695	3,882	177	5,885	4,215	3,214	771	28,859	10,858
PhD	1,497	561	641	71	2,771	3,026	1,581	599	6,490	4,257
Master	3,722	1,831	1,166	40	1,058	704	481	111	6,427	2,686
Bachelor	10,659	3,303	2,075	66	2,056	485	1,152	61	15,942	3,915
Postgrad students*	-	-	-	-	1,569	3,572	8	88	1,577	3,660
Master Level	-	-	-	-	151	270	4	9	155	279
PhD Level	-	-	-	-	1,418	3,302	4	79	1,422	3,381
Non-Degree	1,722	272	193	13	68	1	63	0	2,046	286
Technicians	1,088	550	340	36	273	13	279	11	1,980	610
Other Supporting Staff	2,001	703	1,667	50	426	15	523	8	4,617	776
Total	20,689	7,220	6,082	276	8,221	7,816	4,087	878	39,079	16,190

* Similar to past years, postgraduate students at the Public Research Institutes are reported under Institutes of Higher Learning (IHL). Postgraduate students matriculated with overseas IHLs are reported under Public Research Institutes.

[#] RSE is a definition used within Singapore context. It includes researchers with at least a degree. For more detailed definition regarding RSE, please see page 11 of explanatory notes.

Table 1.3 R&D Manpower by Age Group

Type of R&D Manpower	Private Sector						Government Sector						Institutes of Higher Learning						Public Research Institutes						Total					
	<25	25-34	35-44	45-54	55-64	>64	<25	25-34	35-44	45-54	55-64	>64	<25	25-34	35-44	45-54	55-64	>64	<25	25-34	35-44	45-54	55-64	>64	<25	25-34	35-44	45-54	55-64	>64
Researchers	572	8,540	8,423	4,602	1,333	97	108	1,511	1,333	924	344	45	1,594	8,600	2,775	1,328	786	227	136	1,715	1,369	555	321	48	2,410	20,366	13,900	7,409	2,784	417
RSEs#	432	8,056	7,882	4,053	1,079	71	98	1,475	1,295	842	306	43	354	4,906	2,564	1,279	775	222	122	1,602	1,351	544	318	48	1,006	16,039	13,092	6,718	2,478	384
PhD	0	542	955	389	158	14	0	129	297	189	84	13	1	2,296	1,855	886	567	192	0	660	924	371	191	34	1	3,627	4,031	1,835	1,000	253
Master	48	1,631	2,122	1,355	381	16	8	367	396	323	102	10	50	893	396	254	146	23	13	193	179	105	92	10	119	3,084	3,093	2,037	721	59
Bachelor	384	5,883	4,805	2,309	540	41	90	979	602	330	120	20	303	1,717	313	139	62	7	109	749	248	68	35	4	886	9,328	5,968	2,846	757	72
Postgrad students*	-	-	-	-	-	-	-	-	-	-	-	-	1,234	3,675	199	30	3	0	7	82	6	1	0	0	1,241	3,757	205	31	3	0
Non-Degree	140	484	541	549	254	26	10	36	38	82	38	2	6	19	12	19	8	5	7	31	12	10	3	0	163	570	603	660	303	33
Technicians	134	656	443	290	97	18	22	159	100	39	45	11	17	60	43	63	97	6	13	103	74	43	53	4	186	978	660	435	292	39
Other Supporting Staff	144	769	856	635	256	44	116	679	518	284	97	23	4	87	162	108	66	14	6	148	157	140	71	9	270	1,683	1,693	1,167	490	90
Total	850	9,965	9,722	5,527	1,686	159	246	2,349	1,951	1,247	486	79	1,615	8,747	2,980	1,499	949	247	155	1,966	1,600	738	445	61	2,866	23,027	16,253	9,011	3,566	546

* Similar to past years, postgraduate students at the Public Research Institutes are reported under Institutes of Higher Learning (IHL). Postgraduate students matriculated with overseas IHLs are reported under Public Research Institutes.

RSE is a definition used within Singapore context. It includes researchers with at least a degree. For more detailed definition regarding RSE, please see page 11 of explanatory notes.

Table 1.4 R&D Manpower by Sex

Type of R&D Manpower	Private Sector		Government Sector		Institutes of Higher Learning		Public Research Institutes		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Researchers	17,127	6,440	2,684	1,581	9,899	5,411	2,544	1,600	32,254	15,032
RSEs[#]	15,729	5,844	2,568	1,491	6,541	3,559	2,444	1,541	27,282	12,435
PhD	1,450	608	452	260	4,105	1,692	1,507	673	7,514	3,233
Master	4,166	1,387	773	433	1,075	687	356	236	6,370	2,743
Bachelor	10,113	3,849	1,343	798	1,361	1,180	581	632	13,398	6,459
Postgrad students*	-	-	-	-	3,314	1,827	58	38	3,372	1,865
Non-Degree	1,398	596	116	90	44	25	42	21	1,600	732
Technicians	1,049	589	165	211	165	121	142	148	1,521	1,069
Other Supporting Staff	1,421	1,283	380	1,337	165	276	219	312	2,185	3,208
Total	19,597	8,312	3,229	3,129	10,229	5,808	2,905	2,060	35,960	19,309

* Similar to past years, postgraduate students at the Public Research Institutes are reported under Institutes of Higher Learning (IHL). Postgraduate students matriculated with overseas IHLs are reported under Public Research Institutes.

[#] RSE is a definition used within Singapore context. It includes researchers with at least a degree. For more detailed definition regarding RSE, please see page 11 of explanatory notes.

Table 1.5 R&D Expenditure by Type of Costs

$ million

Type of Costs	Private Sector	Government Sector	Institutes of Higher Learning	Public Research Institutes	Total
Capital Costs	774.35	72.88	129.08	103.27	1,079.58
Manpower Costs	3,112.66	723.94	908.70	607.82	5,353.12
Researchers	2,771.59	566.52	829.18	524.49	4,691.78
RSEs	2,555.98	541.41	723.24	517.07	4,337.70
Postgrad students	-	-	102.64	1.48	104.12
Non-Degree	215.61	25.10	3.30	5.93	249.94
Technicians	120.32	29.20	11.81	32.24	193.57
Other Supporting Staff	220.75	128.23	67.71	51.10	467.79
Other Operating Costs	3,201.19	617.31	448.30	476.40	4,743.20
Total	7,088.20	1,414.13	1,486.08	1,187.49	11,175.90

Table 1.6 R&D Expenditure by Source of Funding

$ million

Source of Funding	Private Sector	Government Sector	Institutes of Higher Learning	Public Research Institutes	Total
Own Funds	6,245.82	213.20	189.93	26.83	6,675.78
Private Sector	60.64	38.23	108.00	10.28	217.15
Government Sector	237.02	1,134.29	1,154.59	1,140.85	3,666.75
Institutes of Higher Learning	0.46	12.89	10.48	1.35	25.18
Foreign-Based Companies	539.15	15.18	17.85	7.20	579.38
Foreign Governments & International Organisations	5.10	0.35	5.23	0.97	11.65
Total	7,088.19	1,414.14	1,486.08	1,187.48	11,175.89

Table 1.7 Patenting Indicators

Patenting Indicators	Private Sector	Government Sector	Institutes of Higher Learning	Public Research Institutes	Total
Patents Applied	2,691	83	710	159	3,643
Patents Awarded	1,681	34	133	71	1,919
Patents Owned (Cumulatively as at 31 Dec 2020)	14,622	287	1,144	376	16,429

Table 1.8 Revenue Indicators

$ million

Revenue Indicators	Private Sector	Government Sector	Institutes of Higher Learning	Public Research Institutes	Total
Licensing Revenue from Patents and New Technologies Developed in Singapore	244.34	2.99	7.25	12.83	267.41
Sales Revenue from Commercialised Products/Processes Attributed to R&D Performed in Singapore	26,748.55	1.35	20.56	90.23	26,860.69

Table 2.1 Researchers by Field of Science & Technology

Field of Science & Technology	Private Sector				Government Sector				Institutes of Higher Learning					Public Research Institutes					Total				
	PhD	Master	Bachelor	Non-Degree	PhD	Master	Bachelor	Non-Degree	PhD	Master	Bachelor	Postgrad Students	Non-Degree	PhD	Master	Bachelor	Postgrad Students	Non-Degree	PhD	Master	Bachelor	Postgrad Students	Non-Degree
Agricultural & Food Sciences	199	208	569	95	52	20	47	5	151	29	75	93	9	28	10	43	3	0	430	267	734	96	109
Biomedical & Related Sciences	404	257	764	72	347	459	830	91	1,879	455	891	1,018	6	855	164	567	31	12	3,485	1,335	3,052	1,049	181
Engineering & Technology	1,042	4,159	10,031	1,548	189	537	943	100	1,903	737	797	2,081	30	990	332	509	41	51	4,124	5,765	12,280	2,122	1,729
Natural Sciences (excluding Biological Sciences)	353	810	2,373	267	105	167	289	9	1,317	293	375	1,506	10	307	86	94	21	0	2,082	1,356	3,131	1,527	286
Energy & Other Areas	60	119	225	12	19	23	32	1	547	248	403	443	14	0	0	0	0	0	626	390	660	443	27
Total	2,058	5,553	13,962	1,994	712	1,206	2,141	206	5,797	1,762	2,541	5,141	69	2,180	592	1,213	96	63	10,747	9,113	19,857	5,237	2,332

Table 2.2 Private Sector Researchers by Enterprise Ownership/Size and Field of Science & Technology

Field of Science & Technology	Local Companies				Foreign Companies				Total			
	PhD	Master	Bachelor	Non-Degree	PhD	Master	Bachelor	Non-Degree	PhD	Master	Bachelor	Non-Degree
Agricultural & Food Sciences	91	38	156	33	108	170	413	62	199	208	569	95
Biomedical & Related Sciences	182	86	208	22	222	171	556	50	404	257	764	72
Engineering & Technology	265	986	3,126	571	777	3,173	6,905	977	1,042	4,159	10,031	1,548
Natural Sciences (excluding Biological Sciences)	89	469	1,540	137	264	341	833	130	353	810	2,373	267
Energy & Other Areas	19	39	86	9	41	80	139	3	60	119	225	12
Total	646	1,618	5,116	772	1,412	3,935	8,846	1,222	2,058	5,553	13,962	1,994

Table 2.3 R&D Expenditure by Type of R&D and Field of Science & Technology

$ million

Field of Science & Technology	Private Sector			Government Sector				Institutes of Higher Learning				Public Research Institutes				Total		
	Basic Research	Applied Research	Experimental Development	Pure Basic Research	Strategic Basic Research	Applied Research	Experimental Development	Pure Basic Research	Strategic Basic Research	Applied Research	Experimental Development	Pure Basic Research	Strategic Basic Research	Applied Research	Experimental Development	Basic Research	Applied Research	Experimental Development
Agricultural & Food Sciences	17.39	146.23	140.88	0.00	19.04	4.69	0.00	4.93	9.32	19.81	12.18	0.83	5.53	5.98	3.94	57.05	176.70	157.00
Biomedical & Related Sciences	154.15	183.09	524.73	15.28	46.00	204.82	205.52	52.08	299.83	136.59	40.96	11.10	133.80	194.98	149.05	712.25	719.47	920.26
Engineering & Technology	685.80	1,574.86	2,850.34	0.09	4.50	93.05	697.31	64.49	138.36	200.94	60.16	3.06	142.48	157.58	263.94	1,038.78	2,026.43	3,871.75
Natural Sciences (excluding Biological Sciences)	249.21	200.56	279.48	0.00	0.00	46.20	76.48	53.20	116.05	90.32	38.10	0.53	31.99	25.76	25.68	450.99	362.84	419.74
Energy & Other Areas	10.80	23.35	47.30	0.00	0.00	0.00	1.15	22.65	54.21	42.23	29.66	0.31	8.13	5.94	16.88	96.10	71.52	94.99
Total	1,117.37	2,128.09	3,842.74	15.37	69.55	348.76	980.46	197.35	617.78	489.88	181.07	15.83	321.93	390.24	459.49	2,355.18	3,356.97	5,463.75

Table 2.4 Private Sector R&D Expenditure by Enterprise Ownership/Size, Type of R&D and Field of Science & Technology

$ million

Field of Science & Technology	Local Companies			Foreign Companies			Total		
	Basic Research	Applied Research	Experimental Development	Basic Research	Applied Research	Experimental Development	Basic Research	Applied Research	Experimental Development
Agricultural & Food Sciences	14.74	21.91	15.85	2.66	124.32	125.03	17.39	146.23	140.88
Biomedical & Related Sciences	37.63	44.94	228.42	116.52	138.14	296.31	154.15	183.09	524.73
Engineering & Technology	68.95	297.98	519.35	616.85	1,276.89	2,331.00	685.80	1,574.86	2,850.34
Natural Sciences (excluding Biological Sciences)	115.33	64.30	132.21	133.88	136.26	147.27	249.21	200.56	279.48
Energy & Other Areas	1.57	5.85	22.11	9.23	17.50	25.19	10.80	23.35	47.30
Total	238.22	434.98	917.94	879.14	1,693.11	2,924.80	1,117.37	2,128.09	3,842.74

Table 3.1 Private Sector R&D Expenditure as Percentage of Total Sales Revenue by Enterprise Ownership/Size and Industrial Classification

Industrial Classification	Local Companies			Foreign Companies			Total		
	R&D Expenditure	Total Sales Revenue	R&D Expenditure as % of Total Sales Revenue	R&D Expenditure	Total Sales Revenue	R&D Expenditure as % of Total Sales Revenue	R&D Expenditure	Total Sales Revenue	R&D Expenditure as % of Total Sales Revenue
Primary Industries & Construction	31.65	2,270.26	1.39%	10.93	1,061.30	1.03%	42.58	3,331.56	1.28%
Manufacturing	504.03	25,158.47	2.00%	3,183.59	205,491.24	1.55%	3,687.62	230,649.71	1.60%
Biomedical Manufacturing	70.12	1,405.28	4.99%	200.18	16,928.39	1.18%	270.30	18,333.67	1.47%
Chemicals	20.31	3,450.56	0.59%	475.49	28,290.55	1.68%	495.80	31,741.11	1.56%
Electronics	81.02	8,513.08	0.95%	1,868.20	127,890.36	1.46%	1,949.22	136,403.44	1.43%
Precision Engineering	235.42	7,100.71	3.32%	410.00	18,317.44	2.24%	645.42	25,418.15	2.54%
Transport Engineering	83.90	2,931.71	2.86%	135.01	6,548.68	2.06%	218.91	9,480.39	2.31%
General Manufacturing	13.26	1,757.13	0.75%	94.71	7,515.83	1.26%	107.97	9,272.96	1.16%
Services	1,055.46	155,214.50	0.68%	2,302.54	268,342.76	0.86%	3,358.00	423,557.26	0.79%
R&D	385.68	195.61	197.17%	854.21	1,247.99	68.45%	1,239.89	1,443.60	85.89%
Financial Intermediation & Other Business Activities	339.92	66,394.17	0.51%	189.28	14,521.32	1.30%	529.20	80,915.49	0.65%
Information & Communications	197.41	6,856.55	2.88%	484.65	62,494.45	0.78%	682.06	69,351.00	0.98%
Wholesale & Retail Trade	105.55	73,141.63	0.14%	736.77	186,865.25	0.39%	842.32	260,006.88	0.32%
All Other Services[1]	26.90	8,626.54	0.31%	37.63	3,213.75	1.17%	64.53	11,840.29	0.55%
Total	1,591.14	182,643.23	0.87%	5,497.06	474,895.30	1.16%	7,088.20	657,538.53	1.08%

[1] Refers to industries in Education, Health & Social Services, Logistics & Other Services.

Table 3.2 Private Sector Patenting Indicators by Enterprise Ownership/Size and Industrial Classification

Industrial Classification	Local Companies			Foreign Companies			Total		
	Patents Applied	Patents Awarded	Patents Owned	Patents Applied	Patents Awarded	Patents Owned	Patents Applied	Patents Awarded	Patents Owned
Primary Industries & Construction	8	6	11	3	1	4	11	7	15
Manufacturing	106	73	1,715	428	169	4,500	534	242	6,215
Biomedical Manufacturing	22	6	431	49	13	34	71	19	465
Chemicals	2	0	1	27	0	14	29	0	15
Electronics	15	28	677	165	89	1,246	180	117	1,923
Precision Engineering	57	35	575	62	28	3,092	119	63	3,667
Transport Engineering	5	0	20	116	29	107	121	29	127
General Manufacturing	5	4	11	9	10	7	14	14	18
Services	305	340	2,759	1,841	1,092	5,633	2,146	1,432	8,392
R&D	113	273	1,746	224	94	1,287	337	367	3,033
Financial Intermediation & Other Business Activities	100	30	706	46	62	288	146	92	994
Information & Communications	80	31	95	352	29	158	432	60	253
Wholesale & Retail Trade	10	6	211	1,219	907	3,900	1,229	913	4,111
All Other Services[1]	2	0	1	0	0	0	2	0	1
Total	419	419	4,485	2,272	1,262	10,137	2,691	1,681	14,622

[1] Refers to industries in Education, Health & Social Services, Logistics & Other Services.

Table 3.3 Private Sector Licensing Revenue from Patents and New Technologies Developed in Singapore and Sales Revenue from Commercialised Products/Processes Attributed to R&D Performed in Singapore by Enterprise Ownership/Size and Industrial Classification

$ million

Industrial Classification	Local Companies		Foreign Companies		Total	
	Licensing Revenue	Sales Revenue	Licensing Revenue	Sales Revenue	Licensing Revenue	Sales Revenue
Primary Industries & Construction	0.00	40.62	0.20	0.23	0.20	40.85
Manufacturing	213.15	1,040.87	0.73	23,992.38	213.88	25,033.24
Biomedical Manufacturing	0.00	8.35	0.00	61.84	0.00	70.19
Chemicals	25.11	8.25	0.00	221.26	25.11	229.52
Electronics	0.00	156.05	0.62	21,870.97	0.62	22,027.03
Precision Engineering	0.41	144.16	0.11	1,544.27	0.52	1,688.44
Transport Engineering	0.00	589.69	0.00	269.53	0.00	859.22
General Manufacturing	187.63	134.36	0.00	24.49	187.63	158.85
Services	18.42	804.88	11.84	869.58	30.26	1,674.46
R&D	3.92	7.13	0.12	207.34	4.04	214.47
Financial Intermediation & Other Business Activities	0.27	47.24	1.44	0.40	1.71	47.64
Information & Communications	12.23	213.36	10.32	47.81	22.55	261.17
Wholesale & Retail Trade	2.00	536.08	0.05	588.20	2.05	1,124.27
All Other Services[1]	0.00	1.06	0.00	25.84	0.00	26.90
Total	231.56	1,886.36	12.77	24,862.19	244.34	26,748.55

[1] Refers to industries in Education, Health & Social Services, Logistics & Other Services.

Table 4.1 Private Sector Survey Respondents by Enterprise Ownership/Size and Industrial Classification

Industrial Classification	Local Companies	Foreign Companies					Total
		USA	Europe	East Asia[1]	Asean (excl. S'pore)	Others	
Primary Industries & Construction	21	0	1	2	0	3	27
Manufacturing	155	37	47	41	2	14	296
Biomedical Manufacturing	19	5	9	2	0	1	36
Chemicals	20	5	11	8	0	3	47
Electronics	19	10	10	9	1	4	53
Precision Engineering	54	12	11	14	0	3	94
Transport Engineering	14	3	2	3	0	2	24
General Manufacturing	29	2	4	5	1	1	42
Services	425	38	88	62	2	41	656
R&D	100	13	10	18	0	8	149
Financial Intermediation & Other Business Activities	103	8	17	11	0	11	150
Information & Communications	162	10	18	6	1	15	212
Wholesale & Retail Trade	41	6	40	26	0	7	120
All Other Services[2]	19	1	3	1	1	0	25
Total	601	75	136	105	4	58	979

[1] East Asia comprises of Japan, Republic of Korea, China (incl. HK) & Taiwan.

[2] Refers to industries in Education, Health & Social Services, Logistics & Other Services.

Table 4.2 Private Sector Survey Respondents by Bands of R&D Expenditure and Industrial Classification

Industrial Classification	$200,000 & below	$200,001 - $500,000	$500,001 - $1,000,000	$1,000,001 - $2,000,000	$2,000,001 - $5,000,000	$5,000,001 - $10,000,000	$10,000,001 - $15,000,000	$15,000,001 - $20,000,000	$20,000,001 - $30,000,000	$30,000,001 & Above	Total
Primary Industries & Construction	12	5	4	0	4	1	0	1	0	0	27
Manufacturing	58	50	39	31	33	20	18	13	10	24	296
Biomedical Manufacturing	4	8	3	3	5	5	3	0	2	3	36
Chemicals	11	12	7	2	4	2	2	3	2	2	47
Electronics	4	4	6	5	9	5	2	4	1	13	53
Precision Engineering	21	12	15	12	12	6	9	2	1	4	94
Transport Engineering	1	4	4	4	2	1	2	2	2	2	24
General Manufacturing	17	10	4	5	1	1	0	2	2	0	42
Services	196	116	83	69	81	53	9	8	14	27	656
R&D	40	29	12	18	16	16	1	2	4	11	149
Financial Intermediation & Other Business Activities	43	27	22	20	14	12	4	1	3	4	150
Information & Communications	73	44	34	17	26	9	1	1	4	3	212
Wholesale & Retail Trade	30	12	12	14	20	15	3	3	2	9	120
All Other Services[1]	10	4	3	0	5	1	0	1	1	0	25
Total	266	171	126	100	118	74	27	22	24	51	979

[1] Refers to industries in Education, Health & Social Services, Logistics & Other Services.

Table 4.3 Private Sector Survey Respondents by Bands of R&D Expenditure and R&D Manpower

No. of R&D Manpower	$200,000 & below	$200,001 - $500,000	$500,001 - $1,000,000	$1,000,001 - $2,000,000	$2,000,001 - $5,000,000	$5,000,001 - $10,000,000	$10,000,001 - $15,000,000	$15,000,001 - $20,000,000	$20,000,001 - $30,000,000	$30,000,001 & Above	Total
5 and Below	250	112	41	17	11	1	0	1	2	1	436
6 - 10	15	41	50	29	12	9	3	0	0	1	160
11 - 20	1	16	29	37	40	12	2	0	0	1	138
21 - 40	0	2	4	16	48	30	4	0	1	2	107
41 - 60	0	0	0	0	5	11	5	4	2	5	32
61 - 80	0	0	0	1	2	5	4	6	6	2	26
81 - 100	0	0	0	0	0	2	2	6	3	4	17
101 and Above	0	0	2	0	0	4	7	5	10	35	63
Total	266	171	126	100	118	74	27	22	24	51	979

Table 5.1 - Time Series of Some Key Indicators

Year	RSEs	Private Sector RSEs	PhD RSEs	PG Students	RSEs per 10k Labour Force	RSEs + PG Students per 10k Labour Force	Total R&D Expenditure ($m)	Private Sector R&D Expenditure ($m)	Private Sector R&D Expenditure as % of Total R&D Expenditure	Total R&D Expenditure as % of GDP	Private Sector R&D Expenditure as % of GDP
1990	4,329	1,363	970	-	27.7	-	571.70	309.50	54.14%	0.81%	0.44%
1991	5,218	2,315	1,184	-	31.2	-	756.80	442.00	58.40%	0.96%	0.56%
1992	6,454	3,187	1,424	-	37.2	-	949.54	577.62	60.83%	1.12%	0.68%
1993	6,629	3,248	1,630	-	37.6	-	997.93	618.58	61.99%	1.02%	0.63%
1994	7,086	3,561	1,724	-	38.5	-	1,174.98	736.23	62.66%	1.04%	0.65%
1995	8,340	4,163	1,887	-	47.7	-	1,366.56	881.37	64.50%	1.10%	0.71%
1996	10,153	5,085	2,237	-	50.1	-	1,792.14	1,133.42	63.24%	1.32%	0.83%
1997	11,302	5,792	2,485	-	53.4	-	2,104.56	1,314.52	62.46%	1.42%	0.88%
1998	12,655	6,573	2,733	-	57.8	-	2,492.26	1,536.10	61.63%	1.74%	1.07%
1999	13,817	7,502	3,054	-	62.6	-	2,656.30	1,670.86	62.90%	1.82%	1.14%
2000	14,483	7,997	3,111	2,570	66.1	77.8	3,009.52	1,866.05	62.00%	1.82%	1.13%
2001	15,366	8,389	3,347	3,211	65.9	79.7	3,232.68	2,045.02	63.26%	2.01%	1.27%
2002	15,654	8,598	3,639	3,723	67.5	83.5	3,368.34	2,055.01	61.01%	2.03%	1.24%
2003	17,074	9,827	3,791	4,065	73.8	91.4	3,396.90	2,053.62	60.46%	2.00%	1.21%
2004	18,935	11,596	4,063	3,705	80.9	96.7	4,041.47	2,569.56	63.58%	2.08%	1.32%
2005	21,338	13,217	4,575	3,718	90.1	105.8	4,569.41	3,018.54	66.06%	2.15%	1.42%
2006	22,675	13,893	5,005	3,761	87.4	101.9	4,998.45	3,281.74	65.66%	2.12%	1.39%
2007	24,506	14,921	5,637	4,094	90.4	105.5	6,326.20	4,222.10	66.74%	2.32%	1.55%
2008	25,744	15,348	6,147	4,605	87.6	103.2	7,113.54	5,105.45	71.77%	2.60%	1.86%
2009	26,608	15,060	6,751	5,295	87.8	105.3	6,009.08	3,689.06	61.39%	2.13%	1.31%
2010	28,296	15,609	7,477	5,760	90.2	108.6	6,308.04	3,761.11	59.62%	1.93%	1.15%
2011	29,480	16,496	7,752	5,990	91.1	109.6	7,271.73	4,446.29	61.14%	2.07%	1.27%
2012	30,105	16,422	8,365	5,924	89.6	107.2	7,074.25	4,238.01	59.91%	1.92%	1.15%
2013	31,924	17,526	9,109	6,012	92.7	110.2	7,393.51	4,315.42	58.37%	1.92%	1.12%
2014	32,816	17,967	9,648	5,800	92.9	109.4	8,307.22	4,989.14	60.06%	2.08%	1.25%
2015	34,972	18,761	10,299	5,862	96.9	113.1	9,207.58	5,469.39	59.40%	2.17%	1.29%
2016	35,289	18,686	10,603	5,734	96.1	111.7	9,136.46	5,295.59	57.96%	2.07%	1.20%
2017	35,389	18,625	10,540	5,367	96.8	111.4	9,002.13	5,325.15	59.15%	1.90%	1.12%
2018	36,264	19,368	10,474	4,955	98.7	112.1	9,198.76	5,484.22	59.62%	1.81%	1.08%
2019	39,082	21,466	10,692	4,931	104.4	117.6	9,690.45	5,916.67	61.06%	1.89%	1.15%
2020	38,828	22,219	9,955	4,950	104.5	117.9	10,405.17	6,602.90	63.46%	2.16%	1.37%
2021	39,717	21,573	10,747	5,237	110.1	124.6	11,175.89	7,088.19	63.42%	1.96%	1.24%

Table 5.1 - Time Series of Some Key Indicators (Continued)

Year	Patents Applied	Patents Awarded	Patents Owned	Licensing Revenue from Patents and New Technologies Developed in Singapore ($m)	Sales Revenue from Commercialised Products/Processes Attributed to R&D Performed in Singapore ($m)	Private Sector Survey Respondents	Labour Force[1] ('000)	GDP[2] ($m)
1990	-	-	-	-	-	266	1,562.8	70,492.3
1991	-	-	-	-	-	311	1,673.7	78,542.8
1992	-	20	96	38.45	-	331	1,733.6	84,920.2
1993	142	52	200	41.22	-	410	1,762.7	97,923.1
1994	263	58	204	52.80	-	427	1,842.2	112,555.4
1995	242	51	256	111.41	-	440	1,749.3	124,463.3
1996	316	91	614	27.34	6,381.02	496	2,024.9	135,777.2
1997	490	132	831	26.61	9,647.26	508	2,116.0	148,664.4
1998	579	136	847	50.97	13,369.92	571	2,187.9	143,474.9
1999	673	161	1,077	671.89	10,663.94	593	2,208.7	146,252.5
2000	774	239	1,268	74.63	15,577.77	539	2,192.3	165,632.4
2001	903	410	1,456	55.17	16,659.52	513	2,330.5	160,885.6
2002	936	451	1,739	87.50	11,445.60	519	2,320.6	165,698.1
2003	1,001	460	2,314	132.37	10,360.46	617	2,312.3	170,117.9
2004	1,257	599	2,570	82.70	12,068.56	765	2,341.9	194,433.0
2005	1,594	877	3,475	93.66	13,508.99	900	2,367.3	212,723.0
2006	2,036	933	4,717	139.15	25,678.32	897	2,594.1	236,158.8
2007	1,727	953	5,786	127.88	16,385.51	992	2,710.3	272,697.6
2008	1,581	730	5,455	42.43	21,548.76	887	2,939.9	273,941.6
2009	1,562	747	6,061	31.80	12,299.85	851	3,030.0	282,394.5
2010	1,762	653	5,450	34.69	10,908.47	797	3,135.9	326,980.1
2011	1,913	855	4,763	95.63	13,478.21	802	3,237.1	351,367.9
2012	1,722	817	5,048	1,358.06	21,297.28	695	3,361.8	368,770.5
2013	2,144	934	5,275	1,458.02	22,308.06	809	3,443.7	384,870.3
2014	1,965	911	6,579	475.60	25,237.34	880	3,530.8	398,947.9
2015	2,090	988	8,575	322.55	23,227.05	806	3,610.6	423,444.1
2016	1,997	988	11,534	298.45	29,318.35	772	3,672.8	440,754.7
2017	2,852	1,290	9,784	295.94	26,314.41	849	3,657.0	474,034.1
2018	2,896	1,356	10,114	280.76	31,807.62	855	3,675.6	508,337.4
2019	2,594	1,478	10,253	270.99	29,301.87	1,058	3,742.5	514,066.0
2020	2,967	1,510	12,985	275.21	30,840.66	980	3,713.9	480,691.2
2021	3,643	1,919	16,429	267.41	26,860.69	979	3,607.6	569,364.2*

[1]Source - Ministry of Manpower and Singapore Department of Statistics
[2]Source - Singapore Department of Statistics
*Figure correct as at Jan 2024.