

NATIONAL SURVEY

of Research,
Innovation
and Enterprise
in Singapore

2019



NATIONAL
RESEARCH
FOUNDATION



Agency for
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and Research
SINGAPORE

NATIONAL SURVEY OF RIE IN SINGAPORE 2019

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Introduction

Singapore has built up a vibrant research and innovation ecosystem through the years. In recent times, a stronger emphasis has been placed on initiatives to strengthen innovation capabilities in companies and public agencies, together with academia and the research institutes. These efforts help to position Singapore as a global innovation hub, as well as to better equip Singapore in tackling challenges for the future. To recognise the importance of all these activities in Singapore's RIE journey, the National Survey of Research & Development (R&D) has hence been renamed the National Survey of Research, Innovation and Enterprise (RIE).

In 2019, Singapore's Gross Expenditure on R&D (GERD) increased by 5.0% to reach \$9.7 billion from \$9.2 billion in 2018. Singapore's GERD as a percentage of GDP was 1.9% in 2019. The increase in GERD was due to both an increase in the Business Expenditure on R&D (BERD), which rose 7.3% in 2019 from 2018, and Public Expenditure on R&D (PUBERD), which showed a smaller increase of 1.6%. As a result, the BERD/PUBERD ratio in 2019 increased to 1.56, from 1.48 in 2018.

R&D investments enable job creation. In 2019, a total of 52,989 jobs were associated with R&D activities. Amongst these, RSEs (Research Scientists and Engineers) accounted for the majority at 73%, or 38,887 jobs. The bulk of RSEs were Bachelor's degree holders (almost 50%), followed by PhD (about 30%) and Master's degree holders (about 20%). The total number of RSEs continued to grow, with both the private and public sectors contributing to an increase in 7.2% in 2019 over 2018.

This survey would not be possible without the support of participating organisations in both the public and private sectors. We thank you for your important contributions, and look forward to continuing our work together to advance Singapore's Research, Innovation and Enterprise ecosystem, which will be a crucial differentiator in driving our economic strategy and securing Singapore's future.

*National Research Foundation,
Agency for Science, Technology and Research*

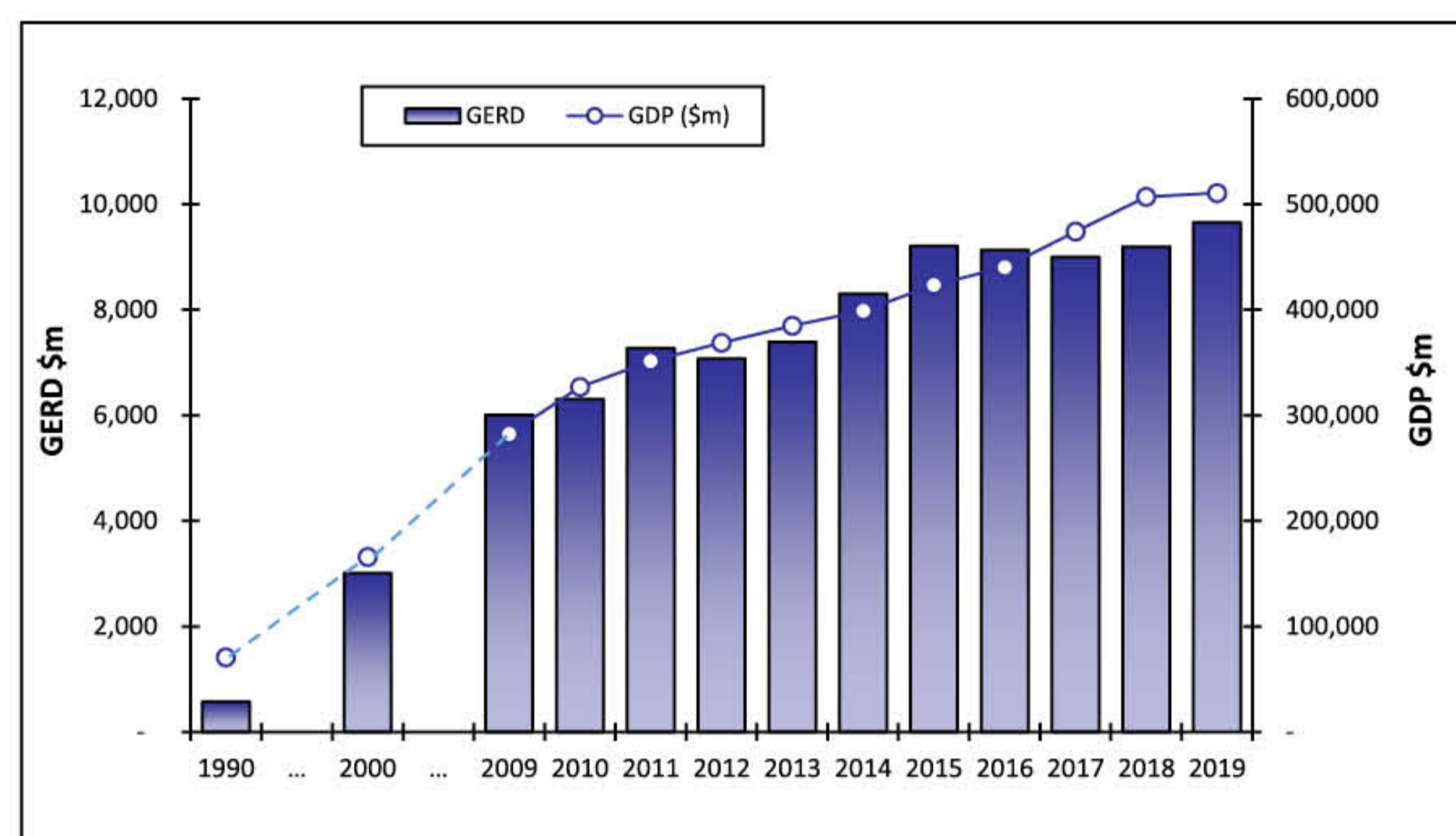
1. OVERVIEW OF R&D IN SINGAPORE

1.1. Gross Expenditure on R&D (GERD)

GERD in Singapore increased by 5.0% from \$9.2 billion in 2018 to \$9.7 billion in 2019. In the same period, Singapore's GDP (at current market prices) increased by 0.7% from \$507.1 billion to \$510.7 billion.

In 2009, GERD was \$6.0 billion and GDP was \$282.4 billion. The Compound Annual Growth Rate (CAGR) of GERD over the past decade (from 2009 to 2019) was 4.9%.

Fig.1.1 Gross Expenditure on R&D and GDP (1990-2019)

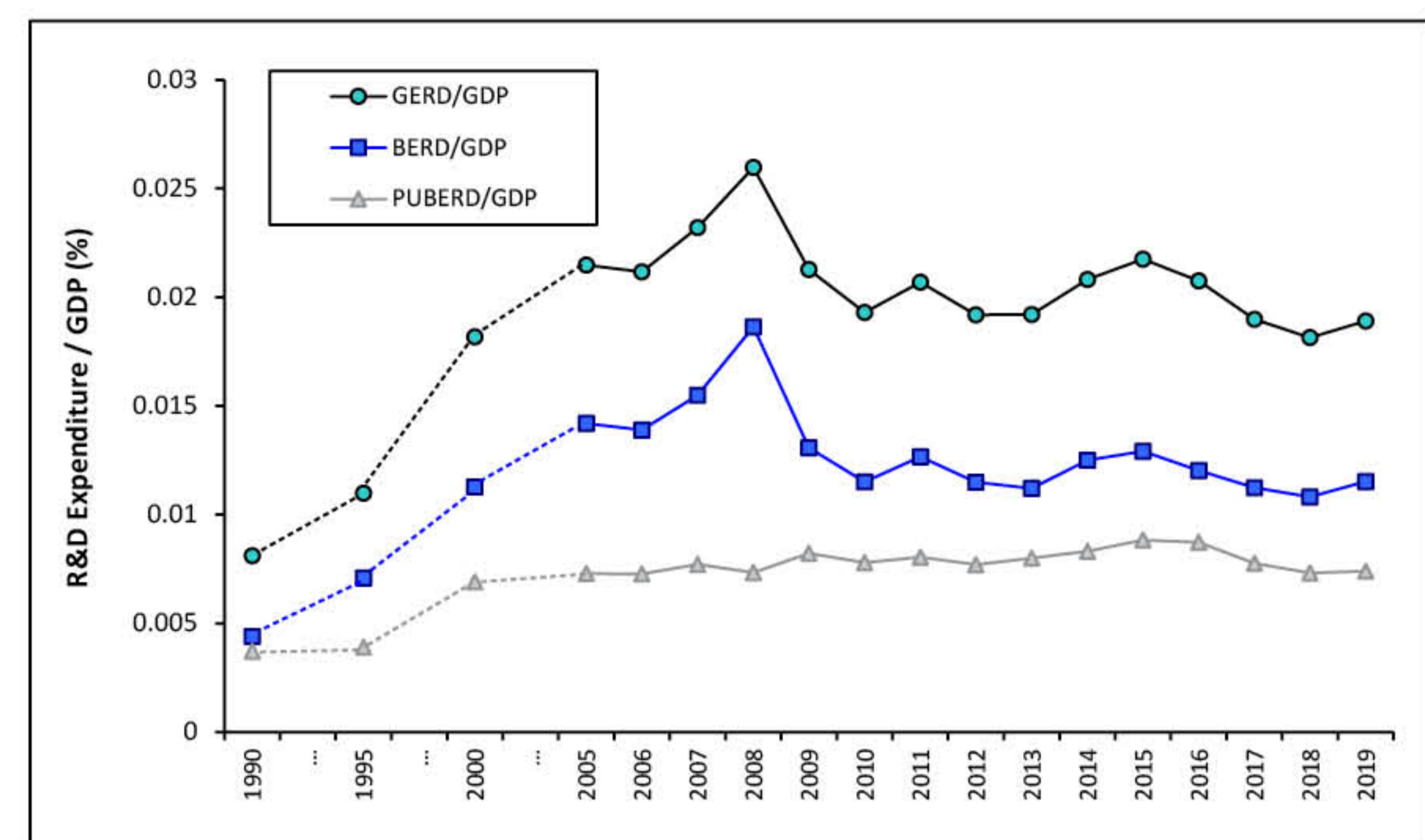


1.2 Ratio of Public Expenditure on R&D (PUBERD) to Business Expenditure on R&D (BERD)

GERD as a percentage of GDP increased from 1.8% in 2018 to 1.9% in 2019. Of this, Business Expenditure on R&D (BERD) as a percentage of GDP increased from 1.1% in 2018 to 1.2% in 2019, while Public Expenditure on R&D (PUBERD) as a percentage of GDP remained constant at 0.7%.

For every \$1 spent on research in the public sector, \$1.56 was spent in businesses in 2019.

Fig.1.2 Gross Expenditure, Business Expenditure and Public Expenditure on R&D as a percentage of GDP (1990-2019)

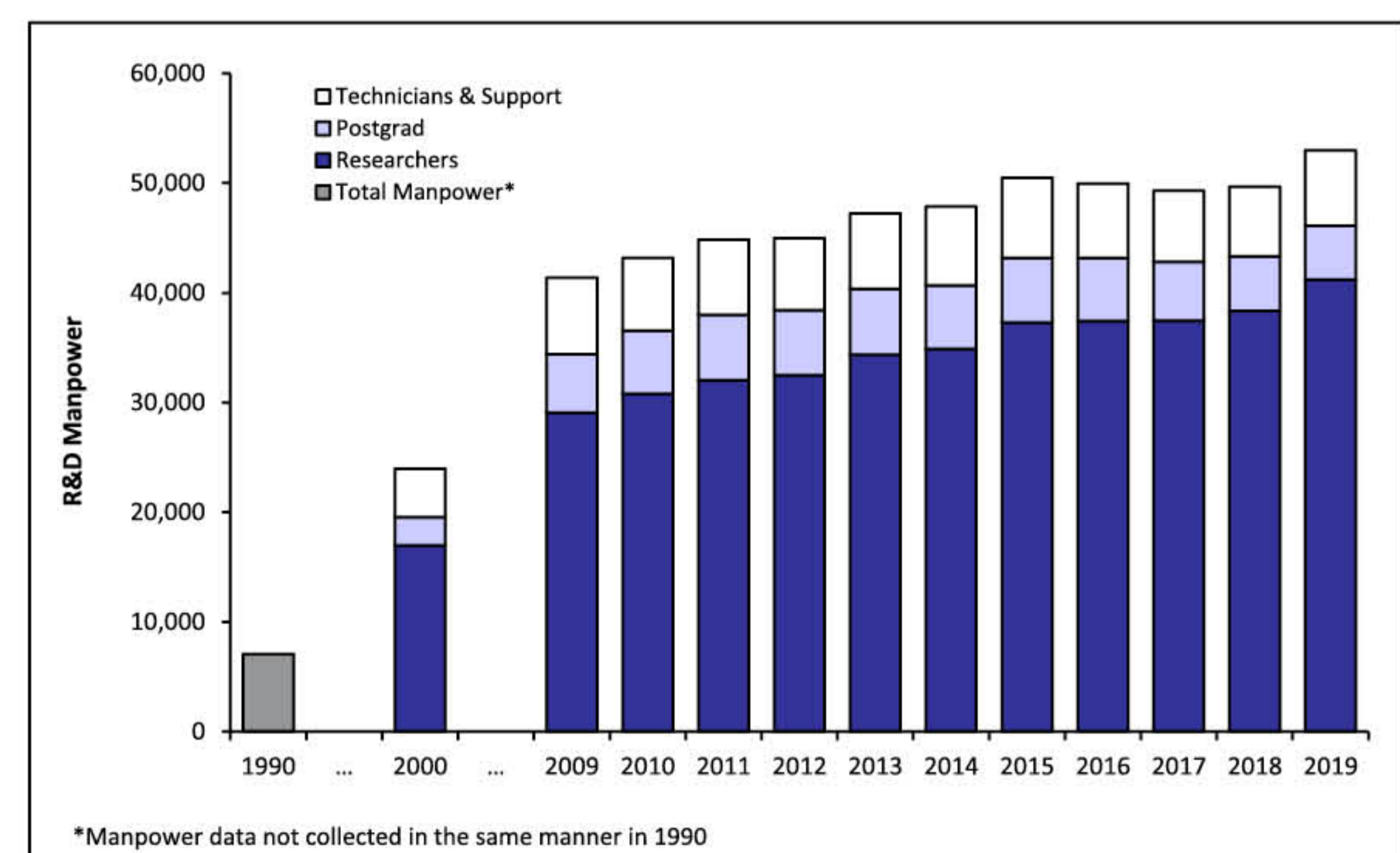


1.3 Manpower

Total R&D Manpower (including researchers, postgraduate students, technicians and support staff) increased by 6.6% from 49,701 persons in 2018 to 52,989 persons in 2019. This represents a CAGR of 2.5% from a base of 41,384 persons in 2009.

The number of researchers (excluding postgraduate students) increased by 7.3% from 38,374 in 2018 to 41,194 in 2019. The CAGR from 2009, with 29,089 researchers, to 2019 was 3.5%. Including postgraduate students, the total number of researchers was 46,125 in 2019.

Fig.1.3 R&D Manpower (1990-2019)



2. BUSINESS EXPENDITURE ON R&D (BERD)

2.1 Overview

In 2019, 1,052 private sector companies indicated that they performed R&D in Singapore. The total BERD of these companies amounted to \$5.9 billion, corresponding to 1.2% of Singapore's GDP in 2019. This represents an increase of 7.3% compared to the BERD in 2018 at \$5.5 billion. The CAGR from 2009-2019 was 4.8%, from a base of \$3.7 billion in 2009.

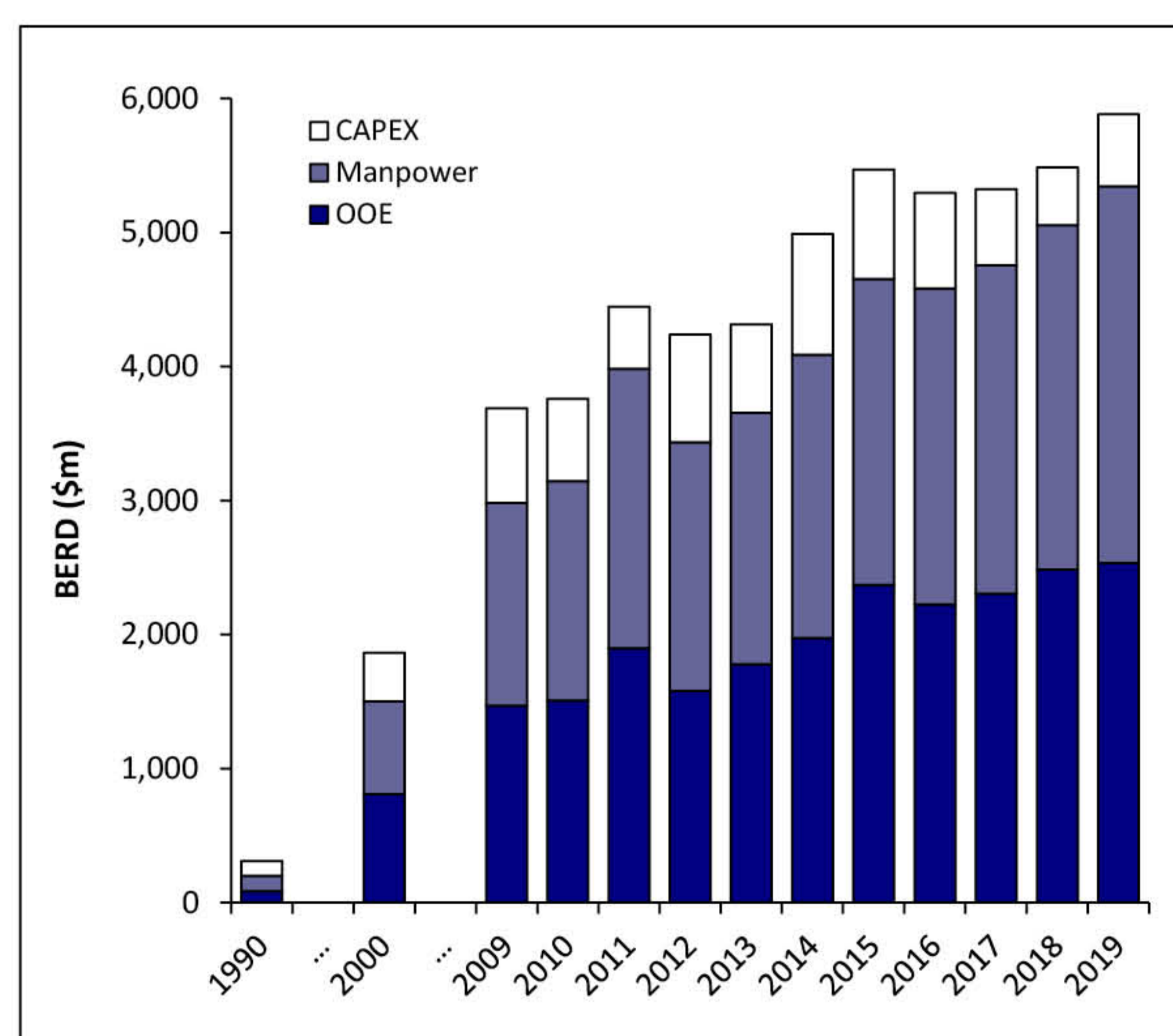
2.2 Type of Expenditure

Capital expenditure (CAPEX) increased by 25.2% to \$537.8 million in 2019 from \$429.5 million in 2018. From a base of \$708.0 billion in 2009, the CAGR for 2009-2019 was -2.7%.

Manpower expenditure increased by 9.4% to \$2.8 billion in 2019 from \$2.6 billion in 2018. From a base of \$1.5 billion in 2009, the CAGR for 2009-2019 was 6.4%.

Other operating expenditure (OOE) rose by 1.9% to \$2.53 billion in 2019 from \$2.49 billion in 2018. From a base of \$1.5 billion in 2009, the CAGR for 2009-2019 for OOE was 5.6%.

Fig.2.1 Business Expenditure on R&D by type of cost (1990-2019)



2.3 Type of R&D

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

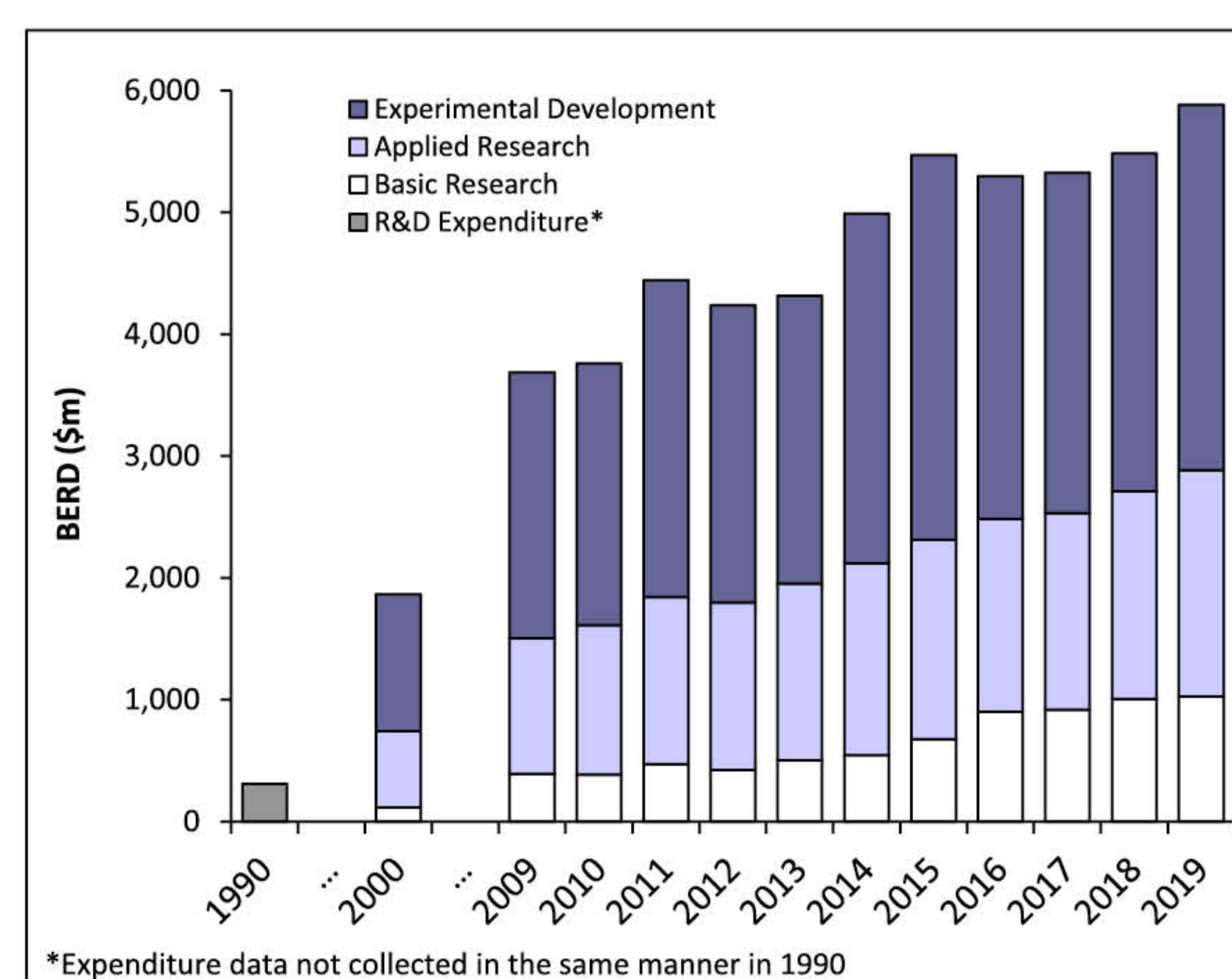
- Basic research (both experimental or theoretical work undertaken without any particular application or use in view);
- Applied research (original investigation directed primarily towards a specific practical aim or objective); and
- Experimental development (systematic work directed to producing or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

Basic research expenditure in the private sector increased by 1.8% from \$1.01 billion in 2018 to \$1.03 billion in 2019. This represents a CAGR of 10.1% from 2009 when it was \$392.7 million.

Applied research by private sector companies increased by 9.1% from \$1.7 billion in 2018 to \$1.9 billion in 2019. This represents a CAGR of 5.3% from 2009 when it was \$1.1 billion.

In 2019, business expenditure on experimental development rose by 8.1% from \$2.8 billion in 2018 to \$3.0 billion in 2019. CAGR for the period 2009 to 2019 was 3.2% as business expenditure on experimental development by private sector companies in 2009 was \$2.2 billion.

Fig.2.2 Type of Business Expenditure on R&D (1990-2019)



2.4 Fields of Science & Technology

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

- a) Electronics; Comprising: Electrical & Electronics Engineering, and Computer Engineering.
- b) Infocomms and Media (ICM); 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.

In the private sector, research expenditure in Electronics grew by 1.0% from \$2.95 billion in 2018 to \$2.98 billion in 2019. This was a CAGR of 4.6% from 2009 when it was \$1.9 billion.

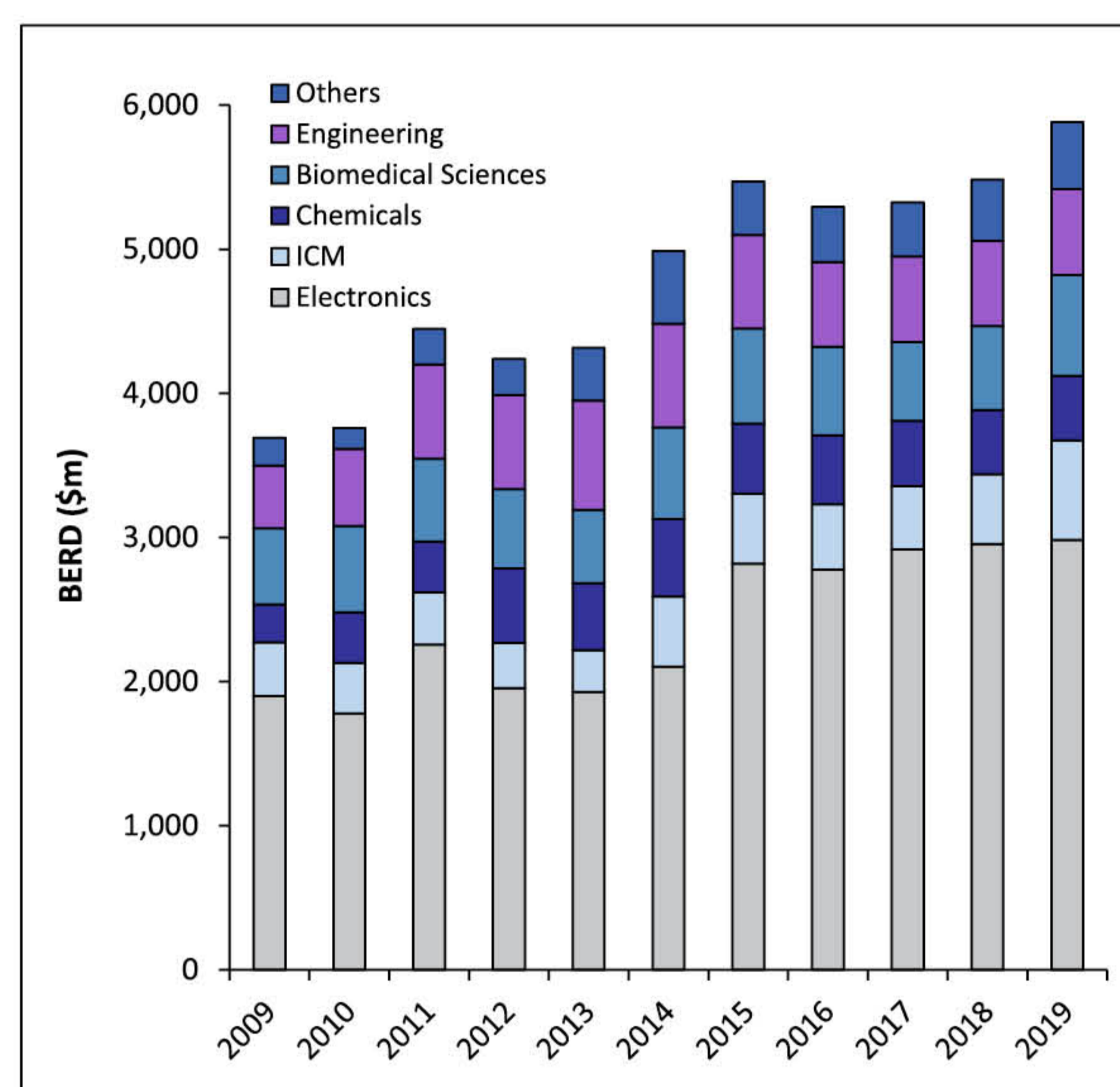
Research expenditure in ICM grew by 42.5% from \$483.6 million in 2018 to \$689.1 million in 2019. This was a CAGR of 6.3% from 2009 when it was \$375.5 million.

Research expenditure on Biomedical Sciences increased by 20.2% from \$581.3 million in 2018 to \$698.7 million in 2019. This was a CAGR of 2.8% from 2009 when it was \$528.2 million.

Spending in Chemicals research increased slightly by 0.3% from \$447.2 million in 2018 to \$448.6 million in 2019. From a base of \$261.4 million in 2009, the CAGR was 5.5%.

Expenditure in Precision and Transport Engineering research increased by 1.4% from \$589.9 million in 2018 to \$598.0 million in 2019. Between 2009 and 2019, the CAGR was 3.2%, from a base of \$434.9 million in 2009.

Fig.2.3 Business Expenditure on R&D by fields of science and technology (2009-2019)



3. PUBLIC EXPENDITURE ON R&D (PUBERD)

3.1 Overview

In 2019, 82 public institutions, including A*STAR research institutes, institutes of higher learning, hospitals and other publicly-funded research organisations, indicated that they performed R&D in Singapore.

These organisations reported a total R&D expenditure of \$3.8 billion in 2019. This was an increase of 1.6% from \$3.7 billion in 2018. From a base of \$2.3 billion in 2009, the CAGR for 2009-2019 was 5.0%.

Expenditure in public organisations as a proportion of GDP remained constant at 0.7%.

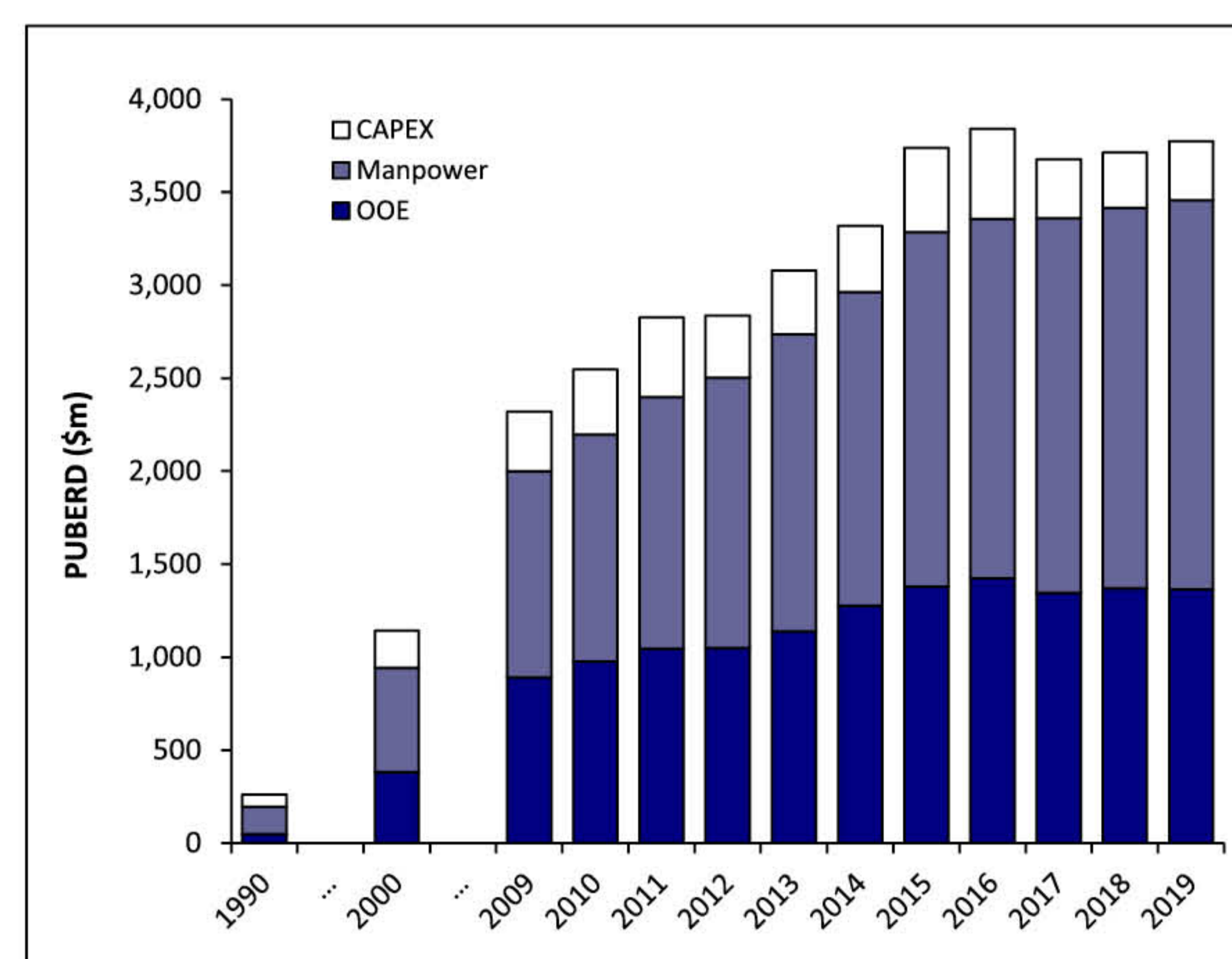
3.2 Type of Expenditure

Amongst public institutions, CAPEX increased by 6.3% from \$298.1 million in 2018 to \$316.9 million in 2019. From a CAPEX of \$322.1 million in 2009, the CAGR for 2009-2019 for CAPEX was a small decrease of 0.2%.

Manpower expenditure increased by 2.2% from \$2.0 billion in 2018 to \$2.1 billion in 2019. From a base of \$1.1 billion in 2009, the CAGR for 2009-2019 for manpower expenditure was 6.6%.

OOE declined by 0.4% from \$1.37 billion in 2018 to \$1.36 billion in 2019. From a base of \$889.7 million in 2009, the CAGR for 2009-2019 for OOE was 4.4%.

Fig.3.1 Public Expenditure on R&D by type of cost (1990-2019)



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).

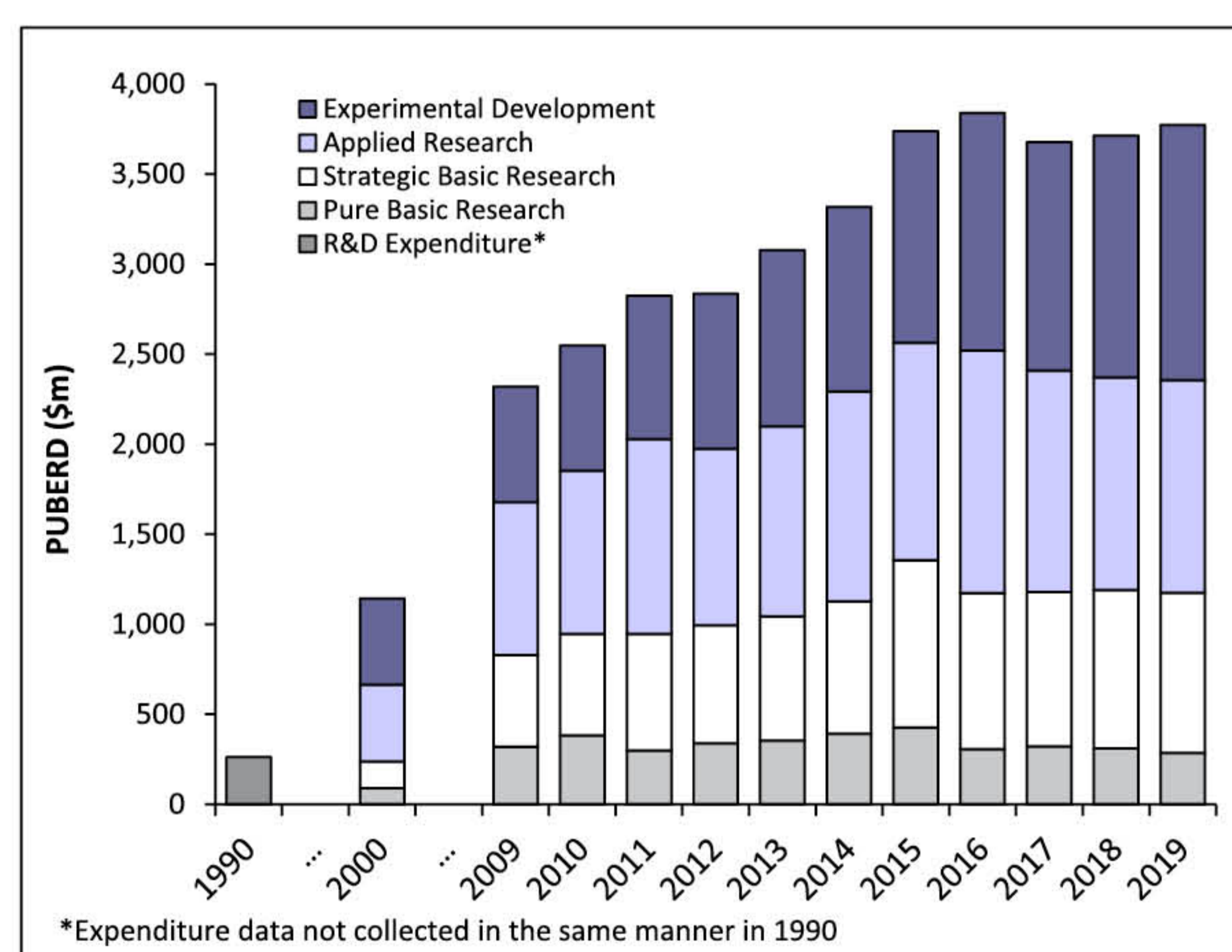
Pure basic research expenditure in public institutions decreased by 7.3% from \$310.0 million in 2018 to \$287.3 million in 2019. From a base of \$319.5 million in 2009, the CAGR for 2009-2019 showed a decrease at 1.1%.

Strategic basic research expenditure in public institutions increased by 0.8% from \$882.0 million in 2018 to \$889.1 million in 2019. This represents a CAGR of 5.7% from 2009 when it was \$509.7 million.

Applied research expenditure in public institutions was similar, at \$1.2 billion in both 2018 and 2019. This represents a CAGR of 3.3% from 2009 when it was \$850.6 million.

Experimental development expenditure in public institutions increased by 5.5% from \$1.3 billion in 2018 to \$1.4 billion in 2019. This represents a CAGR of 8.3% from 2009 when it was \$640.2 million.

Fig.3.2 Type of Public Expenditure on R&D (1990-2019)



3.4 Fields of Science & Technology

This section shows a breakdown by Fields of Science and Technology as follows:

- a) Electronics;
- b) ICM;
- c) Chemicals;
- d) Biomedical Sciences;
- e) Precision & Transport Engineering; and
- f) Others.

In public institutions, expenditure on R&D in Electronics increased by 7.0% from \$594.0 million in 2018 to \$635.3 million in 2019. This was a CAGR of 6.3% from 2009 when it was \$346.5 million.

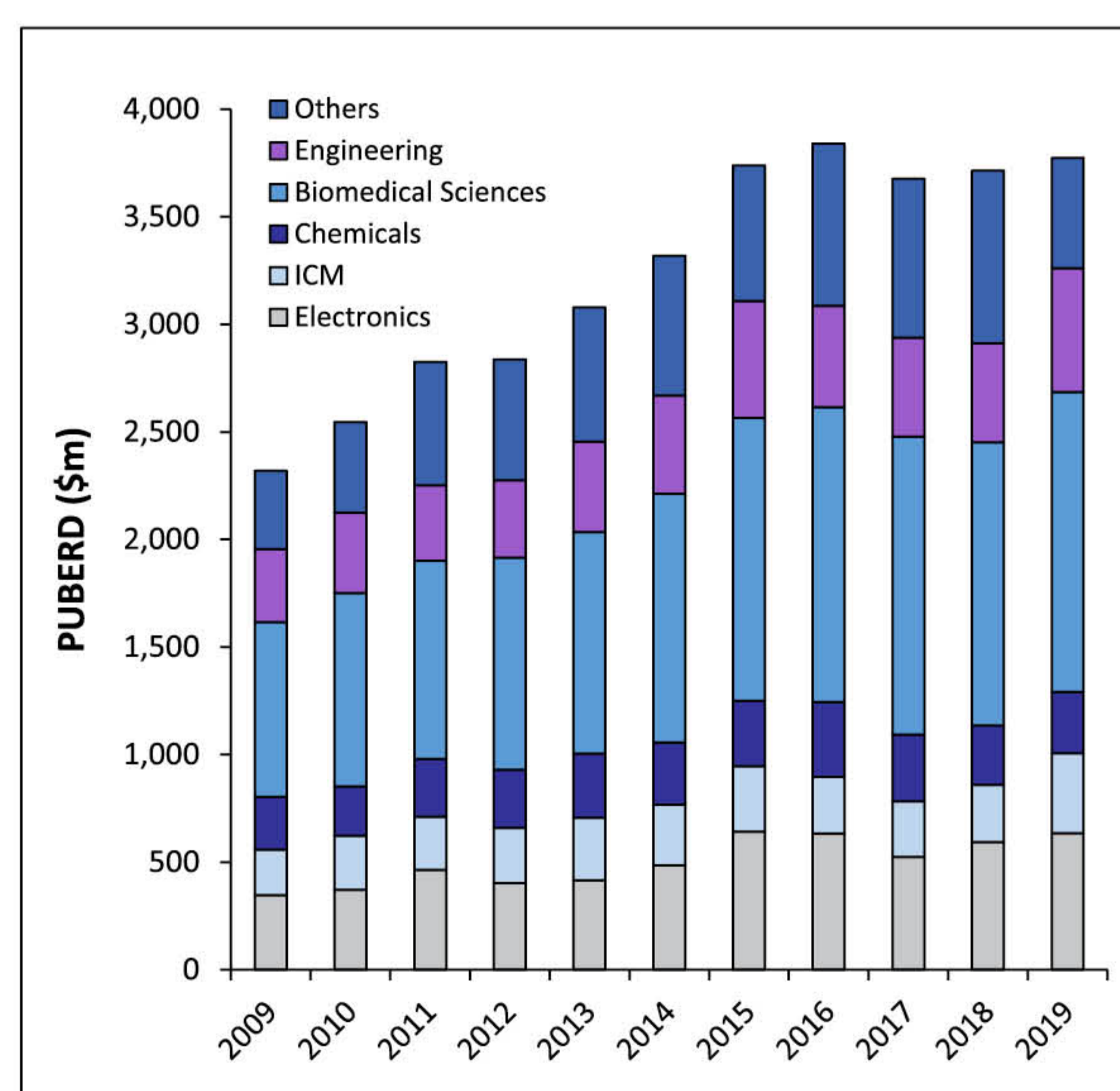
R&D expenditure on ICM increased by 39.4% from \$265.6 million in 2018 to \$370.3 million in 2019. This was a CAGR of 5.7% from 2009 when it was \$212.6 million.

Expenditure on R&D in Chemicals increased by 3.5% from \$276.3 million in 2018 to \$286.1 million in 2019. Between 2009 and 2019, the CAGR was 1.6%, from a base of \$244.5 million in 2009.

Expenditure on R&D in Biomedical Sciences increased by 5.8% from \$1.3 billion in 2018 to \$1.4 billion in 2019.

The expenditure for Precision and Transport Engineering also increased by 25.8% from \$458.9 million in 2018 to \$577.3 million in 2019. Between 2009 and 2019, the CAGRs were both 5.5%, from a base of \$812.9 million and \$338.5 million in 2009 respectively.

Fig.3.3 Public Expenditure on R&D by fields of science and technology (2009-2019)



4. R&D TALENT

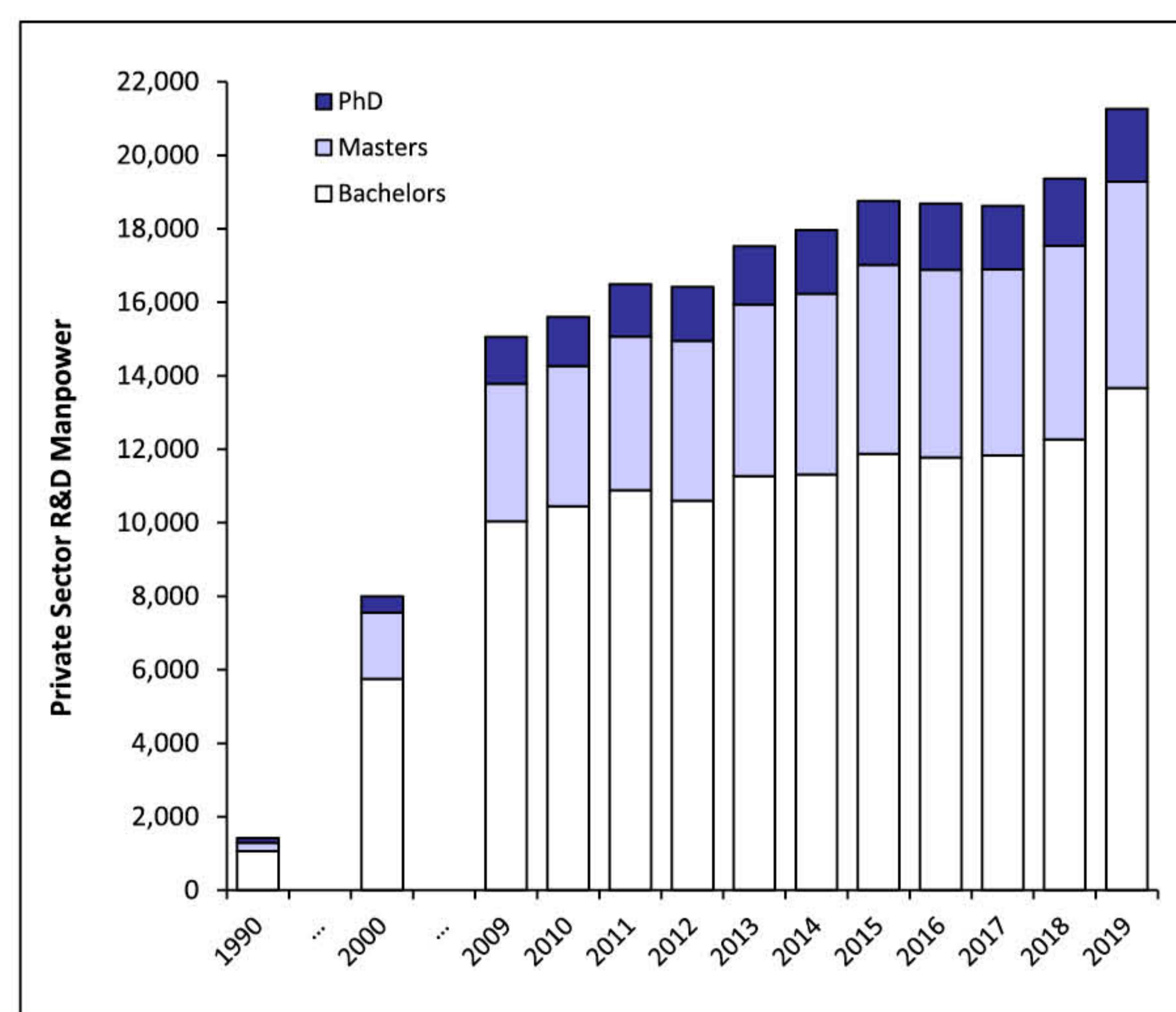
4.1 Total Research Scientists & Engineers

Research Scientists and Engineers (RSEs) comprise researchers who hold formal qualifications at the university degree level. RSEs exclude full-time postgraduate research students.

In 2019, the number of RSEs grew by 7.2% from 36,264 in 2018 to 38,887 in 2019. This represents a CAGR of 3.9% from a base of 26,608 in 2009.

In the private sector, the number of PhD RSEs rose by 8.3% from 1,834 in 2018 to 1,987 in 2019. This was a CAGR of 4.6% from 1,267 PhD RSEs in 2009. RSEs with a Master's degree increased by 6.6% from 5,263 in 2018 to 5,611 in 2019. This was a CAGR of 4.1% from 3,750 RSEs with Master's degrees in 2009. The number of RSEs with a Bachelor's degree also increased by 11.4% from 12,271 in 2018 to 13,673 in 2019. This was a CAGR of 3.1% from 10,043 RSEs with Bachelor's degrees in 2009.

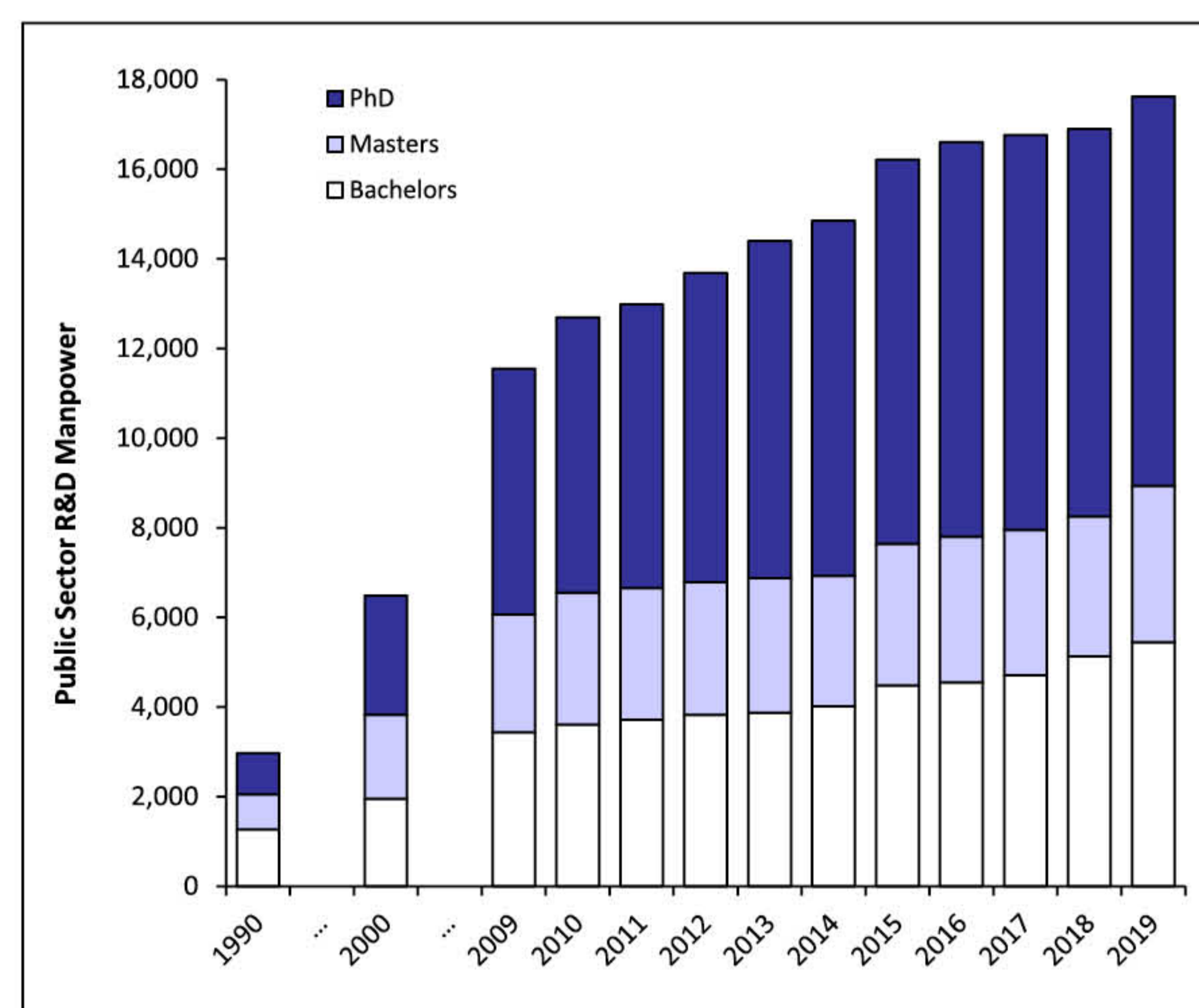
Fig.4.1 Private Sector Research Scientists & Engineers (1990-2019)



In the public sector, the number of PhD RSEs increased slightly by 0.5% from 8,640 in 2018 to 8,682 in 2019. However, between 2009 and 2019, the CAGR was 4.7%, from a base of 5,484 in 2009. RSEs with a Master's degree increased

by 11.5% from 3,128 in 2018 to 3,488 in 2019. There was an overall CAGR growth of 2.9% from a base of 2,631 in 2009. RSEs with a Bachelor's degree grew by 6.2% from 5,128 in 2018 to 5,446 in 2019. The CAGR was 4.7% from a base of 3,433 in 2009.

Fig.4.2 Public Sector Research Scientists & Engineers (1990-2019)

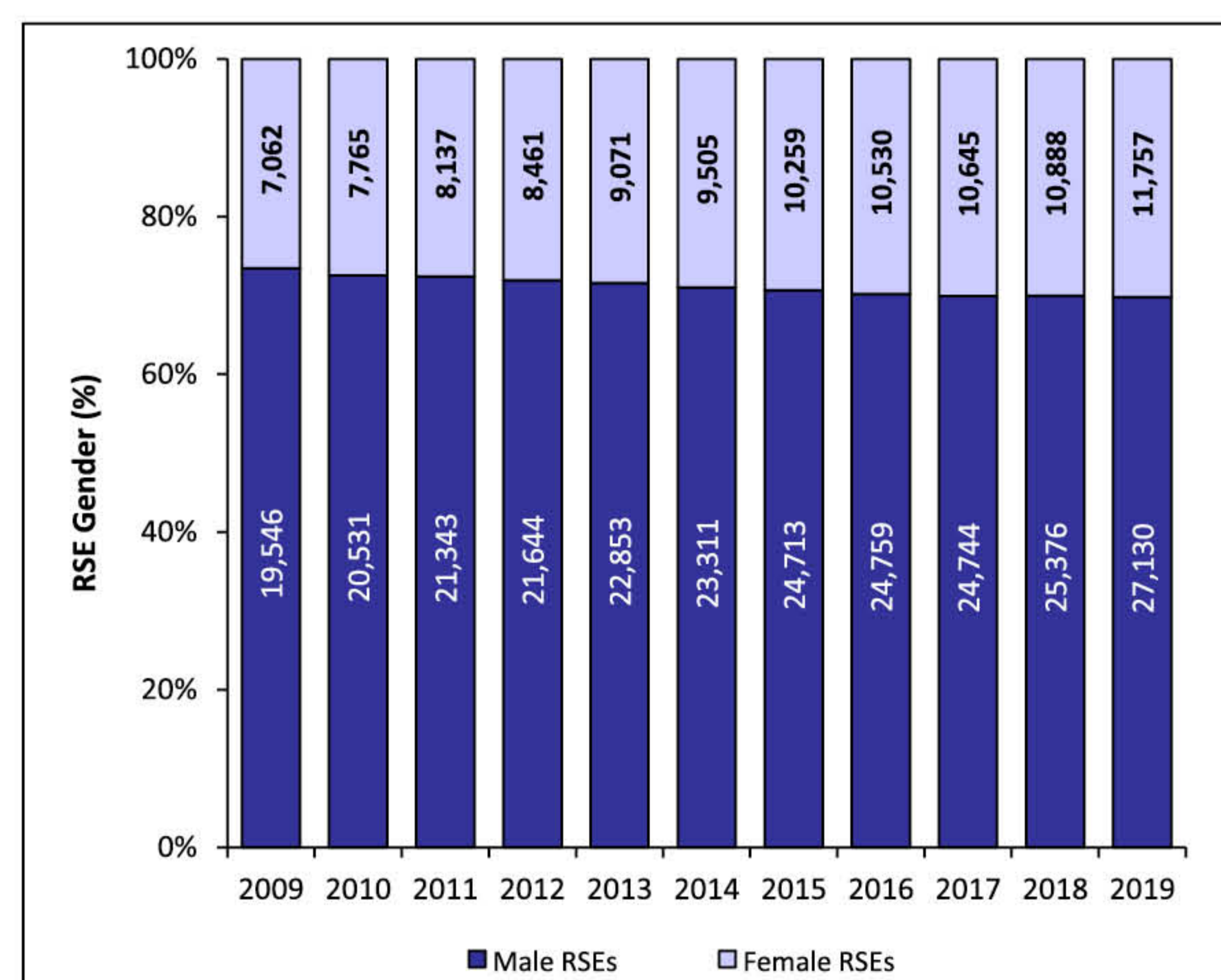


4.2 Profile of Research Scientists & Engineers

Gender

In 2019, females, at 11,757 made up 30.2% of all RSEs, similar to the 30.0% in 2018 but higher than the 26.5% in 2009. This was a CAGR of 5.2% from 7,062 female RSEs in 2009.

Fig.4.3 Gender of Research Scientists & Engineers (2009-2019)

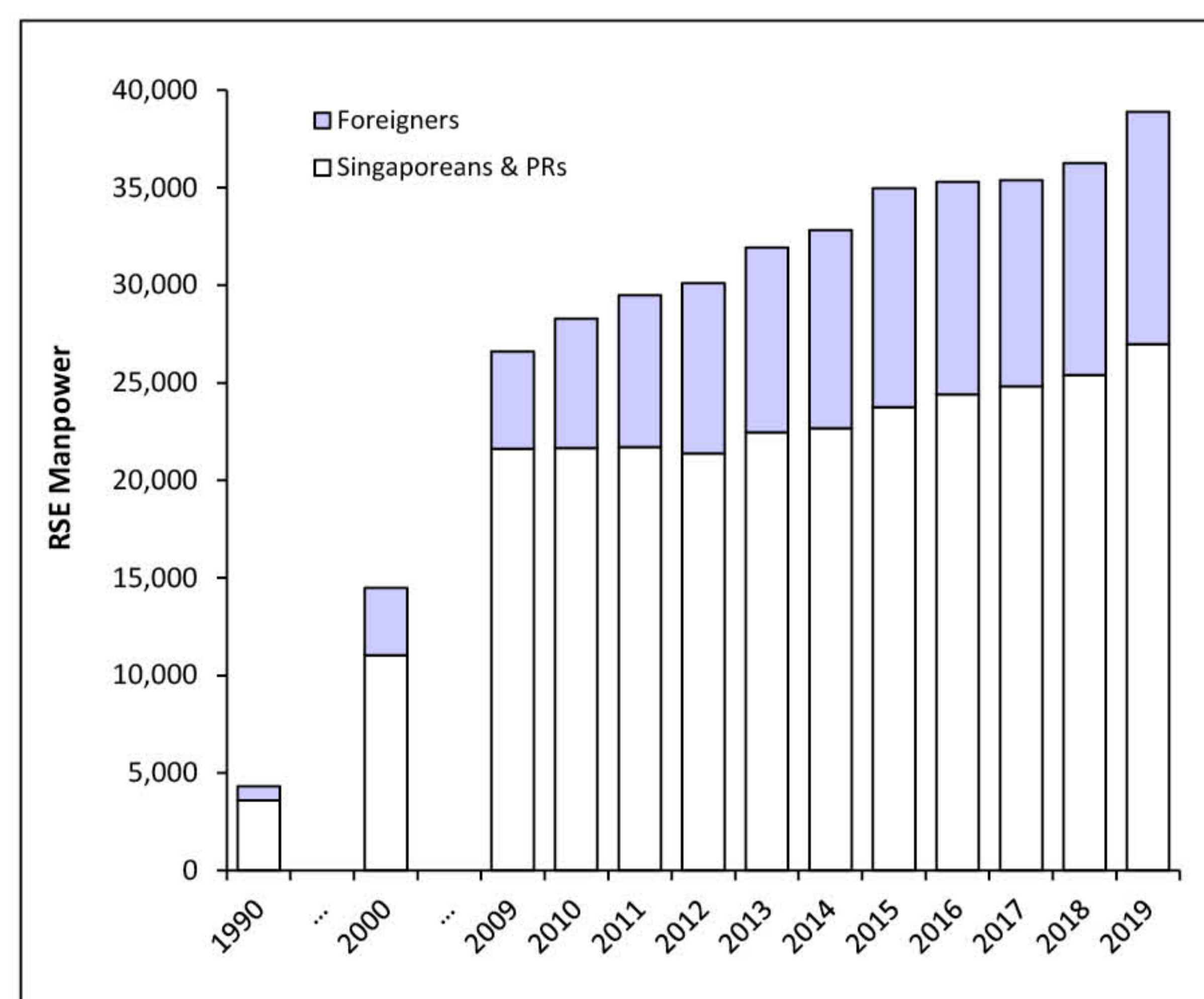


Citizenship

The number of Singaporean and Permanent Resident (PR) RSEs increased by 6.3% from 25,387 in 2018 to 26,979 in 2019. This represents a CAGR of 2.2% from a base of 21,630 RSEs in 2009.

The number of non-resident foreign RSEs increased by 9.5% from 10,877 in 2018 to 11,908 in 2019. This represents a CAGR of 9.1% from a base of 4,978 foreign RSEs in 2009.

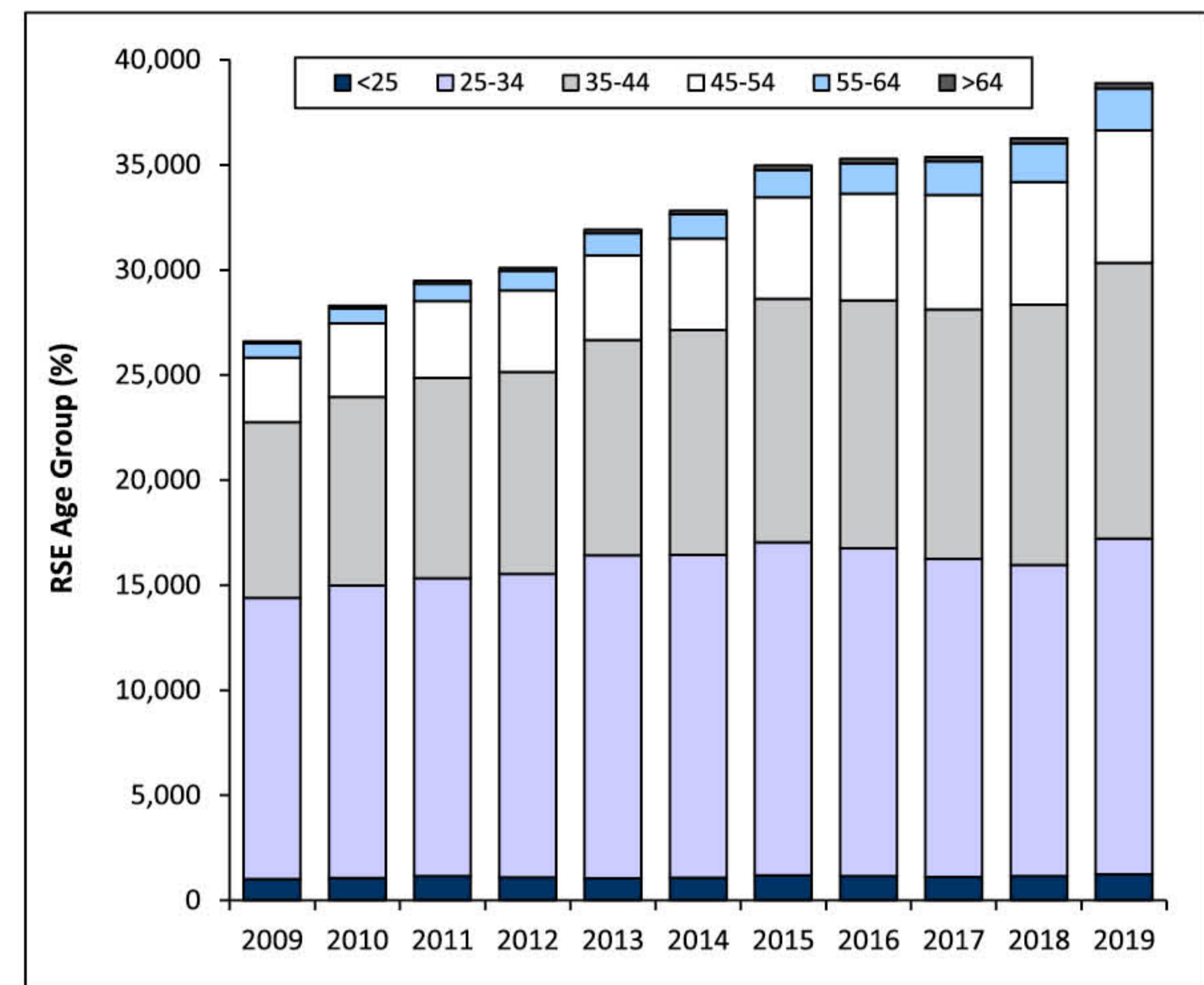
Fig.4.4 Citizenship of Research Scientists & Engineers (1990-2019)



Age-Bands

In 2019, 44.3% of all RSEs were under the age of 35 and 78.0% of all RSEs were under the age of 45. Compared to 2009, these proportions had fallen from 54.1% and 85.5% respectively, as there were now more RSEs in the higher age-bands.

Fig.4.5 Age-Bands of Research Scientists & Engineers (2009-2019)



5. PATENTS

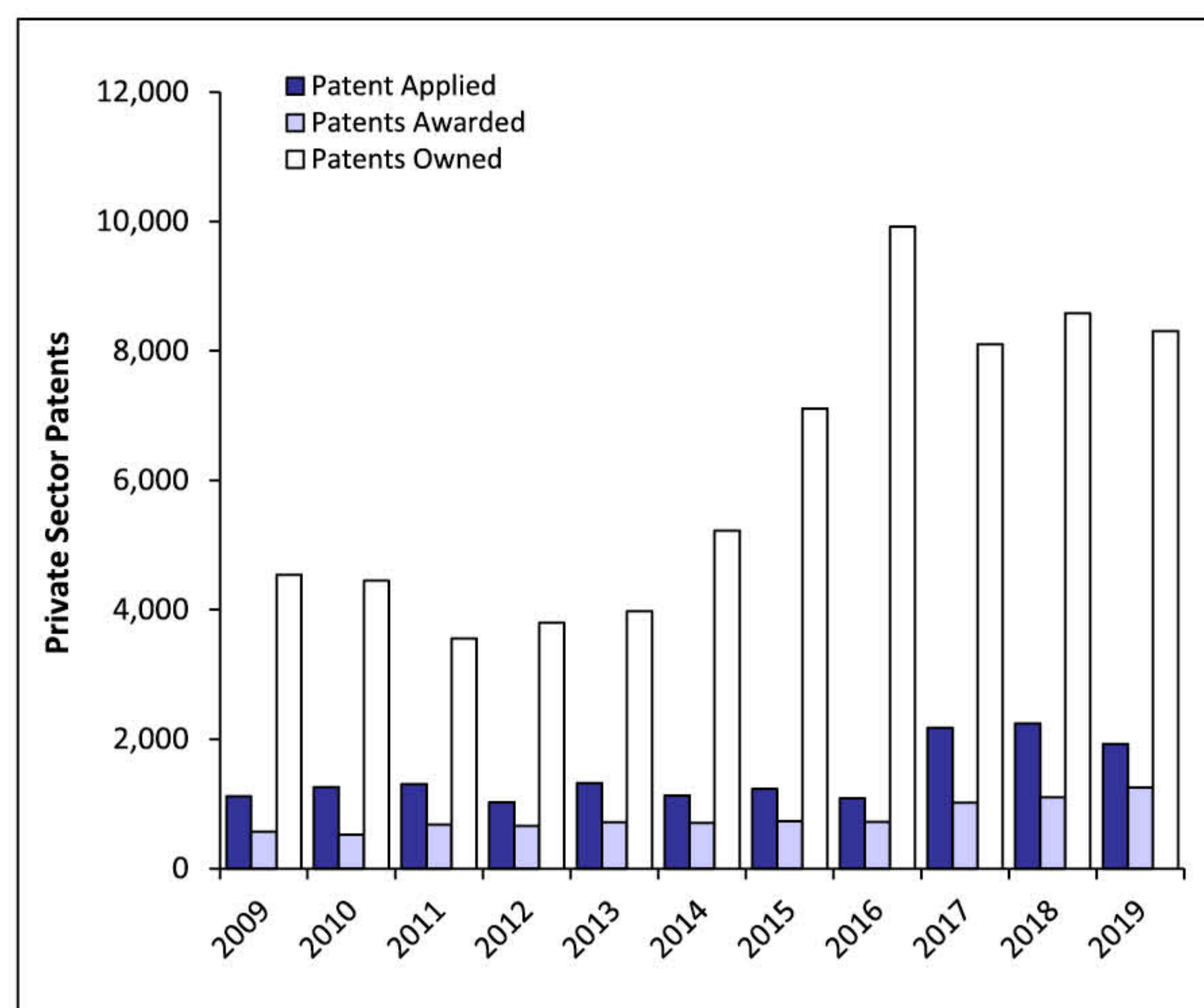
5.1 Patents Applied

In 2019, the total number of primary patent applications (first filings) as a result of R&D conducted in Singapore, stood at 2,592. This represents a decrease of 10.5% from 2,896 patents filed in 2018, and a CAGR of 5.2% from the 1,562 patents filed in 2009.

In the private sector, 1,923 patents were filed in 2019, showing a 14.2% decrease from the 2,241 patents filed in 2018, and a CAGR of 5.6% from the 1,117 patents filed in 2009.

In the public sector, the number of patent applications increased slightly from 655 in 2018 to 669 in 2019. This represents an increase of 2.1%, but a CAGR of 4.2% from the 445 patents filed in 2009.

Fig.5.1 Patents Applied, Awarded and Owned in the Private Sector (2009-2019)

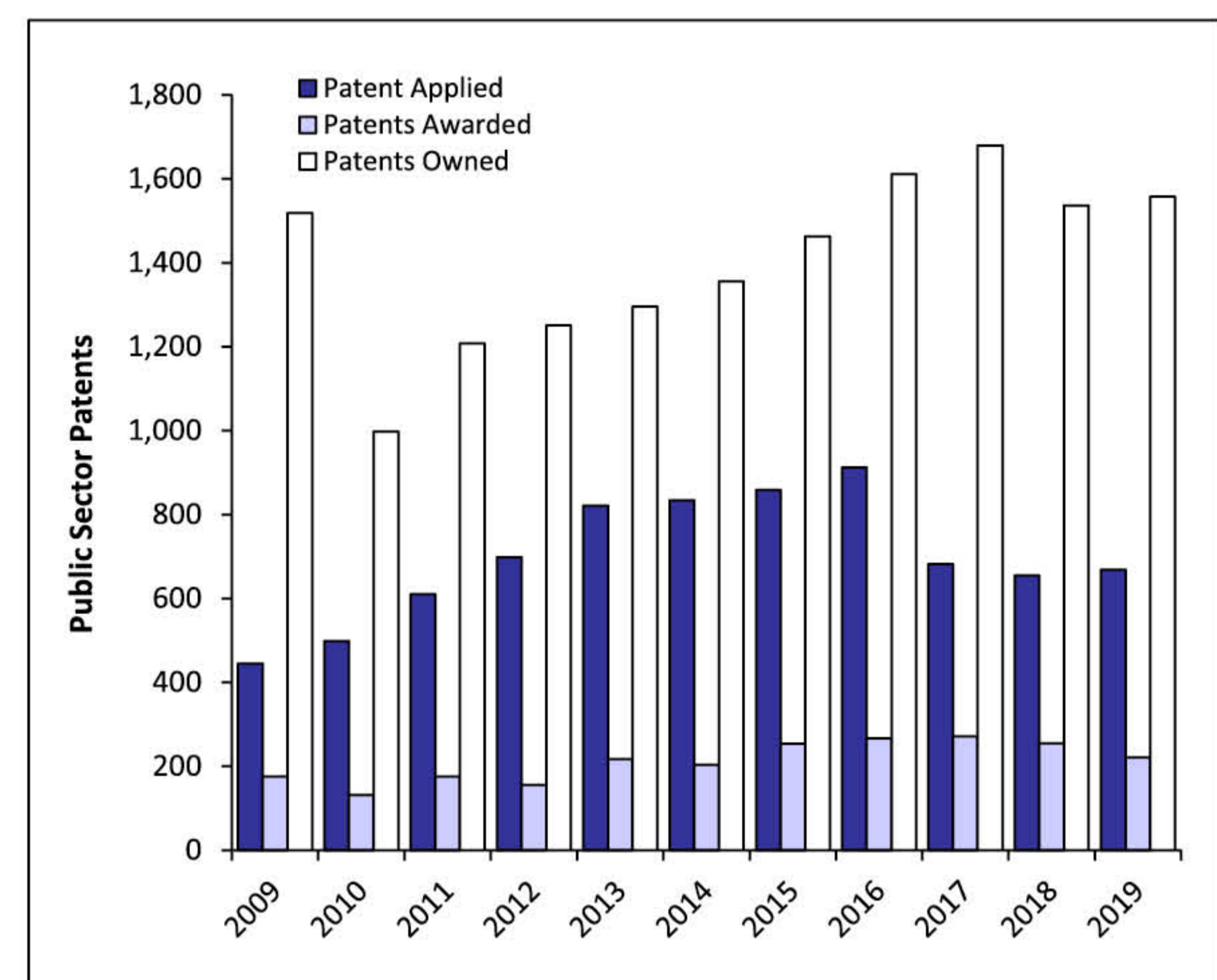


5.2 Patents Awarded

In 2019, the total number of patents awarded (first grants) as a result of R&D conducted in Singapore was 1,476. This represents an increase of 8.8% from 1,356 patents awarded in 2018 and a CAGR of 7.0% from the 747 patents awarded in 2009.

The number of patents awarded to private sector companies increased by 14.0% from 1,101 patents awarded in 2018 to 1,255 in 2019 and a CAGR of 8.2% from the 571 patents awarded in 2009. In the public sector, the number of patents awarded decreased by 13.3% from 255 in 2018 to 221 in 2019, but showed a CAGR of 2.3% from the 176 patents awarded in 2009.

Fig.5.2 Patents Applied, Awarded and Owned in the Public Sector (2009-2019)



6. INTERNATIONAL COMPARISON OF R&D

6.1 Research Intensity in Selected Countries

According to OECD Main Science and Technology Indicators 2020/02, the United States of America remained the top R&D spender, with US\$657 billion spent on research. China claimed second position in 2019, having spent US\$526 billion, while Japan in third position spent US\$173 billion. Normalised as a percentage of GDP, GERD/GDP was 3.1% in the United States, 2.2% in China and 3.2% in Japan.

Singapore's GERD/GDP was 1.8% in 2018 and 1.9% in 2019. The top 5 most research-intensive countries in the world were Israel (4.9%), Korea (4.6%), Taiwan (3.5%), Sweden (3.4%) and Japan (3.2%).

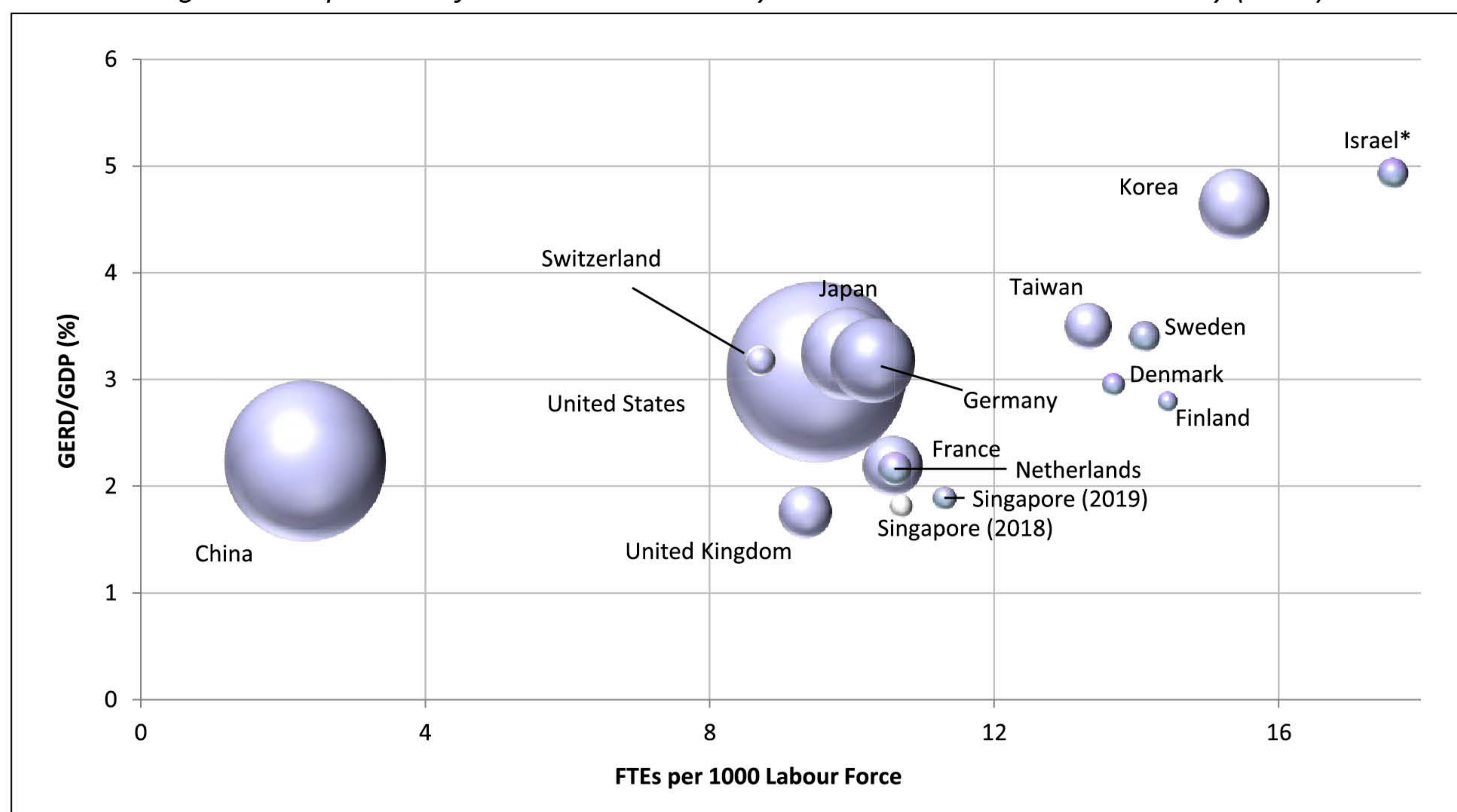
6.2 Researcher Intensity in Selected Countries

Researcher intensity is measured by Full-time Equivalence (FTEs) as a percentage of the labour force. Singapore's labour force increased by 1.8% from 3.68 million in 2018 to 3.74 million in 2019. Researcher FTEs rose by 7.6% from 39,293 in 2018 to 42,295 in 2019.

Singapore's researcher intensity (FTEs/1,000 Labour Force) was 10.7 in 2018 and 11.3 in 2019. This places Singapore within the ranks of countries such as Netherlands (10.6), France (10.3) and Japan (9.9).

The top 3 countries in terms of researcher intensity in 2018 are Israel (17.6), Korea (15.4) and Finland (14.4).

Fig. 6.1 Comparison of Selected Countries by Research & Researcher Intensity (2019)



Bubble size indicates GERD.

*Researcher intensity for Israel is of 2012.

Source: OECD, Main Science and Technology Indicators 2020/02

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 below. The scope of the definition of R&D for the 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
- c) postgraduate research students, who hold formal qualifications below the university degree level.
- d) 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) Gender.

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 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, where the latter includes 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) 2015 (Version 2018).

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 For enterprises in the private sector,

- a) The following classification data are also collected in the Survey:
 - i) Total number of employees;
 - ii) Total fixed assets;
 - iii) Total sales revenue over the one-year reporting period;
 - iv) Information on local and foreign equity in the company.
- b) The industrial classification of private sector enterprises by the SSIC 2015 (Version 2018) 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
BMS	Biomedical Sciences
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
ICM	Info-communication & Media Technology
IPOS	Intellectual Property Office of Singapore
LE	Large Enterprise
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 (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 In 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 2019 comprised private sector enterprises, government organisations, institutions of higher learning and the public research institutes. A total of 1,052 private sector enterprises reported that they performed R&D in 2019.

8.2.2 15,375 survey forms were sent out in the Preliminary Survey. Subsequently, 2,394 survey forms were sent out to private sector enterprises

in the 2019 register of innovation and/or R&D-performing organisations. From these, 1,337 private sector enterprises (55.8%) reported that they performed innovation activities (including R&D) from 2017 to 2019, 303 (12.7%) reported that they did not perform innovation and/or R&D in 2019 or had ceased business operations, and 754 (31.5%) did not respond or provided incomplete / late submissions.

8.2.3 In 2019, the top 150 private sector enterprises (by R&D expenditure in 2018) accounted for 81% (\$4.8 billion) of private sector R&D expenditure. 149 (99%) reported that they performed R&D in 2019 and their returns were either reported under their own name or under a parent or subsidiary and 1 (1%) reported that they did not perform R&D in 2019 or had ceased business operations.

8.2.4 99% of all the government organisations, institutions of higher learning and public research institutes that were surveyed in 2019 responded.

8.2.5 The 2019 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 gender of R&D manpower to be reported; (e) the Survey included "computer engineering", "information & 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 Singapore Standard Industrial Classification (SSIC) 2000. In 2005, it was updated to SSIC 2005, in 2010, to SSIC 2010, in 2015, to SSIC 2015, and in 2017, to SSIC 2015 (version 2018). 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 11 (0.4%) of the 2,510 entities surveyed in 2019.

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.

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Table 1.1A R&D Manpower

Type of R&D Manpower	Private Sector	Government Sector	Institutes of Higher Learning	Public Research Institutes	Total
Researchers	23,272	3,808	15,316	3,729	46,125
RSEs#	21,271	3,648	10,282	3,686	38,887
PhD	1,987	672	5,911	2,099	10,669
Master	5,611	1,130	1,830	528	9,099
Bachelor	13,673	1,846	2,541	1,059	19,119
Postgrad students*	-	-	4,931	-	4,931
Non-Degree	2,001	160	103	43	2,307
Technicians	1,489	386	243	282	2,400
Other Supporting Staff	2,077	1,527	522	338	4,464
Total	26,838	5,721	16,081	4,349	52,989

* Local postgraduate students at the Public Research Institutes are reported under Institutes of Higher Learning.

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	22,072.1	2,603.8	13,988.8	3,630.7	42,295.4
RSEs	20,238.8	2,478.1	8,970.6	3,587.7	35,275.2
PhD	1,912.0	553.6	4,955.0	2,029.6	9,450.1
Master	5,356.4	711.6	1,614.6	518.7	8,201.2
Bachelor	12,970.3	1,212.9	2,401.1	1,039.5	17,623.8
Postgrad students*	-	-	4,931.0	-	4,931.0
Non-Degree	1,833.3	125.7	87.3	43.0	2,089.3
Technicians	1,349.7	350.7	223.4	273.5	2,197.3
Other Supporting Staff	1,775.2	1,412.3	505.7	326.7	4,019.8
Total	25,196.9	4,366.7	14,718.0	4,230.9	48,512.5

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			
	<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	16,877	6,395	3,610	198	6,934	8,382	3,023	706	30,444	15,681								
RSEs	15,186	6,085	3,453	195	5,360	4,922	2,980	706	26,979	11,908								
PhD	1,402	585	584	88	2,570	3,341	1,535	564	6,091	4,578								
Master	3,624	1,987	1,080	50	941	889	431	97	6,076	3,023								
Bachelor	10,160	3,513	1,789	57	1,849	692	1,014	45	14,812	4,307								
Postgrad students*	-	-	-	-	1,482	3,449	-	-	1,482	3,449								
Master Level	-	-	-	-	169	171	-	-	169	171								
PhD Level	-	-	-	-	1,313	3,278	-	-	1,313	3,278								
Non-Degree	1,691	310	157	3	92	11	43	-	1,983	324								
Technicians	1,055	434	349	37	226	17	267	15	1,897	503								
Other Supporting Staff	1,564	513	1,471	56	499	23	337	1	3,871	593								
Total	19,496	7,342	5,430	291	7,659	8,422	3,627	722	36,212	16,777								

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					
	Singapore Citizens & Permanent Residents		Foreign Citizens		Total		Singapore Citizens & Permanent Residents		Foreign Citizens		Total		Singapore Citizens & Permanent Residents		Foreign Citizens		Total		Singapore Citizens & Permanent Residents		Foreign Citizens		Total		Singapore Citizens & Permanent Residents		Foreign Citizens		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	701	8,353	8,649	4,380	1,098	91	92	1,326	1,237	816	289	48	1,262	9,240	2,768	1,209	694	143	100	1,511	1,275	597	229	17	2,155	20,430	13,929	7,002	2,310	299
RSEs	574	7,896	8,121	3,787	833	60	80	1,312	1,204	749	261	42	486	5,278	2,531	1,170	676	141	98	1,499	1,258	587	227	17	1,238	15,985	13,114	6,293	1,997	260
PhD	6	562	896	376	130	17	0	124	302	167	69	10	2	2,667	1,874	775	489	104	0	670	881	401	134	13	8	4,023	3,953	1,719	822	144
Master	98	1,726	2,248	1,264	266	9	6	370	366	285	93	10	78	946	398	264	121	23	8	178	159	111	71	1	190	3,220	3,171	1,924	551	43
Bachelor	470	5,608	4,977	2,147	437	34	74	818	536	297	99	22	406	1,665	259	131	66	14	90	651	218	75	22	3	1,040	8,742	5,990	2,650	624	73
Postgrad students*	0	0	0	0	0	0	0	0	0	0	0	0	747	3,941	214	25	3	1	0	0	0	0	0	0	747	3,941	214	25	3	1
Non-Degree	127	457	528	593	265	31	12	14	33	67	28	6	29	21	23	14	15	1	2	12	17	10	2	0	170	504	601	684	310	38
Technicians	124	587	395	263	104	16	28	176	94	38	43	7	12	62	39	44	81	5	23	97	57	54	47	4	187	922	585	399	275	32
Other Supporting Staff	97	631	628	485	200	36	99	622	446	242	86	32	4	137	151	113	105	12	8	80	91	96	54	9	208	1,470	1,316	936	445	89
Total	922	9,571	9,672	5,128	1,402	143	219	2,124	1,777	1,096	418	87	1,278	9,439	2,958	1,366	880	160	131	1,688	1,423	747	330	30	2,550	22,822	15,830	8,337	3,030	420

Table 1.4 R&D Manpower by Gender

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	17,186	6,086	2,426	1,382	10,038	5,278	2,291	1,438	31,941	14,184
RSEs	15,727	5,544	2,332	1,316	6,796	3,486	2,275	1,411	27,130	11,757
PhD	1,472	515	428	244	4,227	1,684	1,435	664	7,562	3,107
Master	4,321	1,290	737	393	1,135	695	326	202	6,519	2,580
Bachelor	9,934	3,739	1,167	679	1,434	1,107	514	545	13,049	6,070
Postgrad students*	0	0	0	0	3,189	1,742	0	0	3,189	1,742
Non-Degree	1,459	542	94	66	53	50	16	27	1,622	685
Technicians	931	558	172	214	150	93	155	127	1,408	992
Other Supporting Staff	969	1,108	336	1,191	224	298	105	233	1,634	2,830
Total	19,086	7,752	2,934	2,787	10,412	5,669	2,551	1,798	34,983	18,006

Table 1.5 R&D Expenditure by Type of Costs

Type of Costs	Private Sector		Government Sector		Institutes of Higher Learning		Public Research Institutes		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Capital Costs			537.78	64.14			138.36	114.46		854.72
Land, Buildings & Other Structures			52.34	24.95			2.90	5.98		86.17
Vehicles, Plant, Machinery & Equipment			485.44	39.19			135.45	108.48		768.56
Manpower Costs			2,810.96	580.52			1,000.83	511.27		4,903.57
Researchers			2,516.64	455.47			923.67	445.71		4,341.49
RSEs			2,330.82	437.46			798.44	431.44		3,998.16
Postgrad students			0	0			119.91	0		119.91
Non-Degree			185.82	18.01			5.31	14.27		223.42
Technicians			102.55	24.82			9.51	30.07		166.94
Other Supporting Staff			191.77	100.23			67.65	35.49		395.13
Other Operating Costs			2,533.70	466.24			459.36	438.62		3,897.91
Total			5,882.43	1,110.89			1,598.54	1,064.34		9,656.21

\$ million

Table 1.6 R&D Expenditure by Source of Funding

Source of Funding	Private Sector	Government Sector	Institutes of Higher Learning	Public Research Institutes	Total
Own Funds	5,004.55	159.99	216.08	62.56	5,443.18
Private Sector	160.00	36.96	98.66	38.11	333.73
Government Sector	264.96	891.76	1,257.17	956.76	3,370.64
Institutes of Higher Learning	0.55	9.19	4.43	0.47	14.64
Foreign-Based Companies	450.48	12.89	16.04	5.64	485.05
Foreign Governments & International Organisations	1.89	0.10	6.16	0.81	8.96
Total	5,882.43	1,110.89	1,598.54	1,064.34	9,656.21

\$ million

Table 1.7 Patenting Indicators

Patenting Indicators	Private Sector	Government Sector	Institutes of Higher Learning	Public Research Institutes	Total
Patents Applied	1,923	70	465	134	2,592
Patents Awarded	1,255	20	134	67	1,476
Patents Owned (Cumulatively as at 31 Dec 2020)	8,307	126	817	615	9,865

Table 1.8 Revenue Indicators

Revenue Indicators	Private Sector	Government Sector	Institutes of Higher Learning	Public Research Institutes	Total
Licensing Revenue from Patents and New Technologies Developed in Singapore	258.92	3.46	5.48	3.13	270.99
Sales Revenue from Commercialised Products/Processes Attributed to R&D Performed in Singapore	29,269.11	0.29	11.98	20.50	29,301.87

\$ million

Table 2.1A 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	Non-Degree	Postgrad Students	Bachelor	Master	PhD	Non-Degree	Postgrad Students	Bachelor	Master	PhD	Non-Degree
	Agricultural & Food Sciences	166	164	579	105	37	25	50	6	143	28	57	67	9	5	2	3	0	351	219	689	67
Biomedical & Related Sciences	311	217	587	42	339	407	743	49	1,646	411	898	1,013	25	848	134	493	11	3,144	1,169	2,721	1,013	127
Engineering & Technology	1,177	4,167	9,952	1,519	221	563	898	103	2,145	849	775	2,107	37	942	304	496	32	4,485	5,883	12,121	2,107	1,691
Natural Sciences (excluding Biological Sciences)	298	942	2,329	239	74	133	151	2	1,310	308	436	1,368	11	291	88	60	0	1,973	1,471	2,976	1,368	252
Energy & Other Areas	35	121	226	96	1	2	4	0	667	234	375	376	21	13	0	7	0	716	357	612	376	117
Total	1,987	5,611	13,673	2,001	672	1,130	1,846	160	5,911	1,830	2,541	4,931	103	2,099	528	1,059	43	10,669	9,099	19,119	4,931	2,307

Table 2.1B Researchers (FTE) 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	Non-Degree	Postgrad Students	Bachelor	Master	PhD	Non-Degree	Postgrad Students	Bachelor	Master	PhD	Non-Degree
	Agricultural & Food Sciences	159.2	156.0	553.0	99.6	33.6	20.1	30.5	2.0	123.7	18.9	54.1	67.0	9.0	4.0	1.5	2.7	-	320.5	196.5	640.2	67.0
Biomedical & Related Sciences	294.3	210.9	563.2	40.7	288.6	194.0	420.6	41.3	1,302.1	366.0	857.2	1,013.0	23.0	823.8	131.4	479.5	11.0	2,708.8	902.4	2,320.5	1,013.0	116.0
Engineering & Technology	1,138.1	4,019.1	9,527.3	1,416.8	167.0	392.0	635.5	80.6	1,858.8	722.6	703.9	2,107.0	26.6	897.8	296.7	488.8	32.0	4,061.7	5,430.4	11,355.6	2,107.0	1,555.9
Natural Sciences (excluding Biological Sciences)	286.1	854.9	2,110.6	186.3	63.3	103.4	122.2	1.8	1,068.6	283.6	420.2	1,368.0	10.3	290.3	88.5	61.7	-	1,708.4	1,330.3	2,714.8	1,368.0	198.5
Energy & Other Areas	34.3	115.6	216.2	89.9	1.0	2.0	4.0	-	601.7	223.5	365.7	376.0	18.4	13.6	0.6	6.9	-	650.7	341.6	592.8	376.0	108.3
Total	1,912.0	5,356.4	12,970.3	1,833.3	553.6	711.6	1,212.9	125.7	4,955.0	1,614.6	2,401.1	4,931.0	87.3	2,029.6	518.7	1,039.5	43.0	9,450.1	8,201.2	17,623.8	4,931.0	2,089.3

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

Field of Science & Technology	Local Companies					Foreign Companies					Total			
	PhD	Master	Bachelor	Non-Degree		PhD	Master	Bachelor	Non-Degree					
Agricultural & Food Sciences	67	29	166	47		99	135	413	58		166	164	579	105
Biomedical & Related Sciences	153	76	174	15		158	141	413	27		311	217	587	42
Engineering & Technology	343	1,371	4,055	633		834	2,796	5,897	886		1,177	4,167	9,952	1,519
Natural Sciences (excluding Biological Sciences)	82	409	950	76		216	533	1,379	163		298	942	2,329	239
Energy & Other Areas	21	61	88	80		14	60	138	16		35	121	226	96
Total	666	1,946	5,433	851		1,321	3,665	8,240	1,150		1,987	5,611	13,673	2,001

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

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	Applied Research	Strategic Basic Research	Applied Research	Experimental Development			
Agricultural & Food Sciences	28.33	125.95	131.69	0.00	0.00	18.39	4.82	0.00	5.44	6.14	14.98	11.64	0.00	0.53	1.25	0.00	58.82	147.01	143.33
Biomedical & Related Sciences	107.91	156.26	315.30	15.20	18.84	167.18	161.83	161.83	69.44	234.24	139.65	59.04	19.77	100.69	183.67	116.09	566.08	646.76	652.26
Engineering & Technology	683.69	1,244.14	2,334.61	0.00	2.70	82.38	563.85	563.85	86.33	166.44	207.81	82.13	3.53	117.57	178.37	266.38	1,060.26	1,712.70	3,246.98
Natural Sciences (excluding Biological Sciences)	200.91	289.93	172.04	0.00	0.00	0.00	27.35	45.14	57.34	134.07	99.40	42.07	1.38	18.22	21.30	31.77	411.92	437.98	291.02
Energy & Other Areas	6.86	40.60	44.21	0.00	0.00	0.00	0.00	3.22	28.91	70.52	49.66	33.28	0.00	0.75	1.40	1.69	107.04	91.65	82.39
Total	1,027.69	1,856.89	2,997.84	15.20	39.93	281.72	774.04	774.04	247.46	611.41	511.50	228.17	24.68	237.75	385.98	415.93	2,204.13	3,036.09	4,415.99

\$ million

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

Field of Science & Technology	Local Companies				Foreign Companies				Total
	Basic Research	Applied Research	Development	Experimental	Basic Research	Applied Research	Development	Experimental	
Agricultural & Food Sciences	14.05	11.59	11.09	14.27	114.37	120.60	28.33	125.95	131.69
Biomedical & Related Sciences	34.06	33.81	144.27	73.84	122.45	171.03	107.91	156.26	315.30
Engineering & Technology	88.74	406.09	531.11	594.95	838.06	1,803.50	683.69	1,244.14	2,334.61
Natural Sciences (excluding Biological Sciences)	72.64	32.73	72.09	128.27	257.20	99.95	200.91	289.93	172.04
Energy & Other Areas	5.70	16.95	24.81	1.16	23.64	19.40	6.86	40.60	44.21
Total	215.20	501.17	783.37	812.49	1,355.72	2,214.47	1,027.69	1,856.89	2,997.84

\$ million

Table 3.1 Private Sector R&D Expenditure as Percentage of Total Sales Revenue by Enterprise Ownership 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	R&D Expenditure as % of Total Sales Revenue
Primary Industries & Construction	33.70	1,494.91	2.25%	4.11	3.17	129.69%	37.81	1,498.07	2.52%	2.52%
Manufacturing	475.95	39,472.52	1.21%	2,496.30	162,063.80	1.54%	2,972.25	201,536.32	1.47%	1.47%
Biomedical Manufacturing	53.67	1,099.56	4.88%	142.98	13,454.69	1.06%	196.65	14,554.25	1.35%	1.35%
Chemicals	18.48	6,586.88	0.28%	282.28	29,114.42	0.97%	300.76	35,701.30	0.84%	0.84%
Electronics	90.60	21,115.99	0.43%	1,504.79	95,461.75	1.58%	1,595.39	116,577.74	1.37%	1.37%
Precision Engineering	197.24	5,518.19	3.57%	331.15	10,354.71	3.20%	528.39	15,872.90	3.33%	3.33%
Transport Engineering	98.62	3,413.06	2.89%	128.06	7,015.12	1.83%	226.68	10,428.18	2.17%	2.17%
General Manufacturing	17.35	1,738.83	1.00%	107.03	6,663.12	1.61%	124.38	8,401.94	1.48%	1.48%
Services	990.09	42,768.17	2.32%	1,882.28	157,501.37	1.20%	2,872.37	200,269.54	1.43%	1.43%
R&D	314.91	170.40	184.81%	728.69	1,023.82	71.17%	1,043.59	1,194.22	87.39%	87.39%
Financial Intermediation & Other Business Activities	380.67	28,893.72	1.32%	138.71	10,036.93	1.38%	519.38	38,930.65	1.33%	1.33%
Information & Communications	130.76	2,348.32	5.57%	196.19	3,527.44	5.56%	326.95	5,875.76	5.56%	5.56%
Wholesale & Retail Trade	145.41	7,317.28	1.99%	801.39	141,980.61	0.56%	946.80	149,297.89	0.63%	0.63%
Education, Health & Social Services, Logistics & Other Services	18.34	4,038.45	0.45%	17.30	932.57	1.86%	35.64	4,971.03	0.72%	0.72%
Total	1,499.74	83,735.59	1.79%	4,382.69	319,568.34	1.37%	5,882.43	403,303.93	1.46%	1.46%

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 and Industrial Classification

\$ million

Industrial Classification	Local Companies		Foreign Companies		Total
	Licensing Revenue	Sales Revenue	Licensing Revenue	Sales Revenue	
Primary Industries & Construction	2.26	38.23	0.00	0.00	38.23
Manufacturing	234.38	3,086.79	0.83	18,536.08	21,622.87
Biomedical Manufacturing	0.00	6.73	0.00	189.39	196.12
Chemicals	0.00	1,495.91	0.00	283.92	1,779.83
Electronics	0.00	214.58	0.83	16,585.89	16,800.46
Precision Engineering	12.49	598.18	0.00	1,202.06	1,800.24
Transport Engineering	0.02	513.25	0.00	159.87	673.12
General Manufacturing	221.87	258.15	0.00	114.95	373.10
Services	7.58	5,097.65	13.86	2,510.36	7,608.01
R&D	0.42	9.72	0.76	192.74	202.46
Financial Intermediation & Other Business Activities	0.89	4,474.86	0.00	38.10	4,512.96
Information & Communications	2.95	389.29	12.95	35.19	424.48
Wholesale & Retail Trade	0.00	207.55	0.16	2,242.74	2,450.30
Education, Health & Social Services, Logistics & Other Services	3.32	16.22	0.00	1.58	17.80
Total	244.22	8,222.67	14.70	21,046.44	29,269.11

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

Industrial Classification	Foreign Companies							Total
	Local Companies	USA	Europe	East Asia ¹	Asean (excl. Spore)	Others		
Primary Industries & Construction	26	0	0	1	0	1	28	
Manufacturing	185	37	55	45	1	14	337	
Biomedical Manufacturing	17	5	11	2	0	1	36	
Chemicals	20	6	11	10	0	3	50	
Electronics	26	10	13	9	1	5	64	
Precision Engineering	69	11	10	15	0	2	107	
Transport Engineering	15	3	5	3	0	2	28	
General Manufacturing	38	2	5	6	0	1	52	
Services	440	38	103	63	3	40	687	
R&D	119	17	16	18	0	7	177	
Financial Intermediation & Other Business Activities	85	7	20	11	1	7	131	
Information & Communications	154	7	19	6	1	16	203	
Wholesale & Retail Trade	63	6	44	27	1	9	150	
Education, Health & Social Services, Logistics & Other Services	19	1	4	1	0	1	26	
Total	651	75	158	109	4	55	1,052	

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

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	14	7	1	1	4	0	0	1	0	0	28
Manufacturing	91	50	36	39	40	26	17	8	10	20	337
Biomedical Manufacturing	8	3	4	4	8	3	2	1	2	1	36
Chemicals	13	10	9	5	4	2	2	3	1	1	50
Electronics	6	8	3	11	5	10	6	2	1	12	64
Precision Engineering	31	19	15	10	13	7	5	2	1	4	107
Transport Engineering	8	1	1	3	6	4	2	0	1	2	28
General Manufacturing	25	9	4	6	4	0	0	0	4	0	52
Services	219	122	97	78	65	46	17	9	9	25	687
R&D	50	26	31	20	20	10	3	3	4	10	177
Financial Intermediation & Other Business Activities	40	25	16	16	11	10	4	3	2	4	131
Information & Communications	82	45	32	17	13	6	5	1	0	2	203
Wholesale & Retail Trade	37	21	16	20	19	18	5	2	3	9	150
Education, Health & Social Services, Logistics & Other Services	10	5	2	5	2	2	0	0	0	0	26
Total	324	179	134	118	109	72	34	18	19	45	1,052

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	298	120	58	16	7	0	2	0	0	0	501
6 - 10	18	47	51	42	13	2	0	0	1	0	174
11 - 20	6	8	22	37	42	11	3	0	0	1	130
21 - 40	2	3	3	20	37	27	3	2	0	5	102
41 - 60	0	0	0	3	5	20	11	3	2	1	45
61 - 80	0	0	0	0	3	5	4	4	6	2	24
81 - 100	0	0	0	0	0	5	5	5	6	5	26
101 and Above	0	1	0	0	2	2	6	4	4	31	50
Total	324	179	134	118	109	72	34	18	19	45	1,052

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%	2.02%	1.28%
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	38,887	21,271	10,669	4,931	103.9	117.1	9,656.21	5,882.43	60.92%	1.89%	1.15%

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	913	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
2006	2,036	933	4,717	139.15	25,678.32	897	2,594.1	236,159
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	282,395
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	440,372.2
2017	2,852	1,290	9,784	295.94	26,314.41	849	3,657.0	474,115.1
2018	2,896	1,356	10,114	280.76	31,807.62	855	3,675.6	507,123.9
2019	2,592	1,476	9,865	270.99	29,301.87	1,052	3,742.5	510,737.8

¹Source - Ministry of Manpower and Singapore Department of Statistics (Last updated 15 Mar 2021)

²Source - Singapore Department of Statistics (Last updated 15 Feb 2021)

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