Submission to the Consultation Process on the Successor to the Strategy for Science, Technology and Innovation 2006-2013

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In this short submission, I will comment on two points that I believe are of great importance when considering the successor to the Strategy for Science, Technology and Innovation 2006-2013 and that need to be urgently addressed by the government. These are i) the position of the Chief Scientific Adviser and ii) funding for basic research, or research for knowledge (pillar 8 of the consultation document).

1. Chief Scientific Adviser

According to the consultation paper (page 69) "the post of Chief Scientific Adviser (CSA) to the Government was established in 2004 to provide the Government with independent, expert advice on issues related to public science policy."

The position of the CSA is currently held by the Director General of Science Foundation Ireland (SFI). Because the Director General of SFI is a government employee and receives directives from the government, he, by definition, will not be able to provide truly independent advice.

However, Ireland needs a fully independent CSA who should be an eminent and research-active scientist and a member of the research community of the country. The appointment of the CSA is an important opportunity for the government to engage with the scientific community. Selection of a new CSA could be facilitated, for example, by the Royal Irish Academy.

2. Funding of basic research, or research for knowledge

The need to strongly support not only applied research but also basic research in Ireland has been recently highlighted in an open letter to the government signed by over 1,000 scientists (see *www.irishscientists.org*). However, in this letter, no suggestion on the level of funding for basic and applied research has been made. I would like to comment on this by reminding the interdepartmental committee of the excellent speech given by the president of the European Research Council (ERC), Prof. Jean-Pierre Bourguignon, in the Royal Irish Academy on 17 November 2014. In his speech (see enclosed text), Prof. Bourguignon states that "*on average most countries allocate around 20% of their national funding to basic research*". Please note that Prof. Bourguignon did not refer to 'oriented basic research' here, but to curiosity-driven research.

Countries with very ambitious research and development programs tend to invest more than the 20% mentioned by Prof. Bourguignon. For example, Austria, a relatively small EU member country, spent in 2014 32.4% of its national funding on research for knowledge ('Foerderung der allgemeinen Erweiterung des Wissens' in the enclosed table).

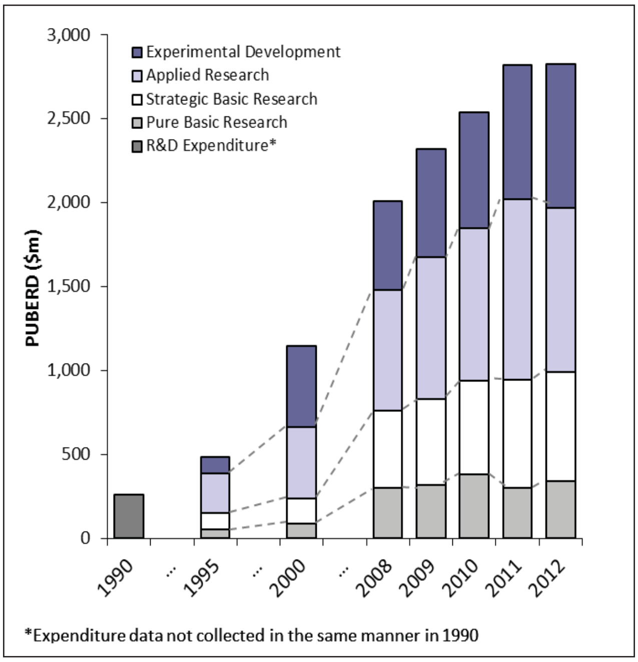
An interesting example, that I believe represents best practice internationally, is Singapore. Although a city state, it has a population similar to that of Ireland, and has an open and export-driven economy.

Singapore supports four different types of research. According to the National Survey of R&D for 2012 (enclosed) these are:

a) Pure Basic research (without seeking long-term economic or social benefits or making any effort to apply the results to practical problem);
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 that is directed to producing or improving substantially materials, products and devices; or installing new processes, systems and services)

The following graph shows that the total expenditure and a breakdown for each funding category:

Fig.3.2 Type of Public Expenditure on R&D (1990-2012)



Pure basic and strategic basic research together account for about one-third of the total research expenditure in Singapore.

I believe that Ireland should follow a similar distribution key, i.e. invest about 70% of research expenditure in applied research and 30% in basic research. Please note that the investment strategy used in Singapore allows for some prioritization of basic research in that strategic basic research can be targeted towards areas that are more likely of economic relevance. However, these areas are broadly defined so that they are not overly exclusive. Furthermore, strategy basic research is defined as research for knowledge and is thus not equivalent to 'oriented basic research'.

As I had mentioned above, I believe that what is done in Singapore represents best practice internationally and I urge the government to adopt a similar research funding model. After all, we should not try 'to reinvent the wheel'. Instead, we should look at what works for other countries (especially small countries with open and export-driven economies) and copy their successful model.

Enclosed:

- Text of speech of ERC president Prof. Jean-Pierre Bourguignon in the Royal Irish Academy on 17 November 2014

- Federal research expenditure in Austria 2010-2014

- Singapore National Survey of R&D for 2012

Acadamh Ríoga na hÉireann
Royal Irish Academy

European Research Council
Established by the European Commission

<u>Fostering Research in Europe</u>

<u>Viewed from the European Research Council with Ireland in Mind</u>

Dublin, 17 November 2014
Jean-Pierre Bourguignon,

President of the European Research Council

Distinguished guests, dear colleagues,

Ladies and Gentlemen,

I would first like to thank the President of the Royal Irish Academy, Professor Mary E. Daly, and Professor Nicholas Canny, one of my colleagues at the ERC Scientific Council, for their invitation to speak to you here today. It is a great pleasure for me to address you at this dedicated event.

And it is appropriate that the event be held here at the Royal Irish Academy. The Academy's leading role in promoting Irish science and culture - both here and abroad - is well recognised.

I know also how previous debates held here have been very influential in shaping public policy. So I feel a certain sense of responsibility. And I hope that this keynote address will touch points that you will consider relevant.

Because I want to discuss what I believe is a fundamental issue, namely: how should research and innovation be funded? Are the different ways of approaching this issue having some secondary effects that could counter their primary effects?

I think that all of us would agree that science has been one of the most formidable human adventure, with deep impact on the way we think, on the way our societies have evolved, and even on the way our daily lives develop. More and more often, in recent years, innovation and economic growth have been presented as closely linked – there is actually ample evidence to this effect – and the question of the involvement of researchers in the further link between scientific developments and innovation has become centre stage.

But many questions remain: What is the balance between supporting “blue sky” research and near-market development? What is the proper role of the public and the private sectors? Should smaller countries follow different policies from larger countries? To use the Brussels jargon - what is the right “policy mix”? I am personally even more worried by yet another question: How do we ensure that young people with the appropriate potential do not turn away from research careers?

The Minister has set out very eloquently just before me the current policy in Ireland. It is of course not my intention to comment in detail on the specific policies adopted here. However it is my intention to set out some basic principles. Principles which, I think, have a broad if not universal relevance.

The European Research Council operates according to simple principles. The ERC supports scientists from anywhere in the world, of any age and from any field of research - including the social sciences and humanities – with no predetermined targets or quotas. The ERC provides substantial, long-term funding, up to 3.5 million euros, to projects that may take up to five years under the leadership of a researcher, who can propose the organisation of the work towards the goal to her or his choice. The only conditions are that ERC funded researchers must spend at least 50% of their working time in an institution based in Europe. They must also be willing to be adventurous and to take risks in their research.

And this, with the involvement of evaluators of the highest possible calibre with the right mix of profiles, to me is the real value of ERC funding. Long term funding frees researchers from having to focus on short-term, if not immediate, impact, from thinking of having out the next publication before the full story is known, from getting distracted from the work developing by the need to write the next grant application. It allows researchers to really focus on the core of their research. In this way we hope that their work can lead to genuinely new knowledge, and, in some cases, even to radical breakthroughs.

I do not pretend that this vision of how to fund research is a new one. People who set up the ERC do not claim to have invented a new model. In fact numerous members of the European scientific community – I was one of them – campaigned long and hard to obtain from the European Commission that a scheme like ERC, that can finally rely on tried and trusted principles, be put in place. This required proper legislative changes, but, after those changes were made in the context of the Lisbon Treaty, one had to come up with a precise scheme and the right group of people to get everything up and running.

For example, the predecessor of what is today the Max Planck Society in Germany, was set up in 1911 according to the “Harnack Principle”. Alfred von Harnack, the first President of the Kaiser Wilhelm Society, advocated the right of researchers to work independently of government or private requirements and unencumbered by bureaucracy. And to this day Max Planck Institutes are following this principle: They are built up solely around some of the world's leading researchers, who themselves define their research subjects and are given the best working conditions, as well as free reign in selecting their staff.

In 1918 Richard Burdon Haldane chaired a committee which produced a report recommending that general research should be under the control of autonomous Research Councils. These would be free from political and administrative pressures that might discourage or biase research in certain areas. The principle of the autonomy of the research councils is now referred to as the “Haldane Principle”. The first research council to be created as a result of the Haldane Report was the Medical Research Council.

In 1939, Abraham Flexner wrote a famous manifesto with the title *"The usefulness of useless knowledge"*. It was the blueprint for establishing the Institute for Advanced Study in Princeton, later home to Einstein, Gödel, von Neumann, Oppenheimer and many others.

And after the Second World War, Vannevar Bush made similar arguments in "*Science, The Endless Frontier"*, his 1945 report to the President of the United States. This called for an expansion of government support for science, and the creation of the National Science Foundation. Famously he stated: *"Scientific progress on a broad front results from the free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown. Freedom of inquiry must be preserved under any plan for Government support of science."*
I don't wish to argue that there is a consensus on how what is the best way to fund research. Far from it. There has always been competing visions. The Haldane principle has remained enshrined in British Government policy, but has been criticised and altered over the years. In 1939 J.D. Bernal argued that social good was more important than researchers' freedom in deciding the direction of research. Solly Zuckerman criticised the principle in 1971 for its artificial separation of basic and applied science. To him this led to the elevation of the status of the former.

During the 1960s and the 1970s, there was a growing feeling that science could not just be left to scientists. Science, and especially technology, should be harnessed to societal needs.

This led to the creation of innovation agencies, innovation-focused industry policies and other new ideas, such as *grands projets,* aiming to shift attention towards fostering innovation as well as fulfilling societal needs.

The OECD was instrumental in this shift: In 1963, a working group led by Christopher Freeman (a great admirer of JD Bernal and who later founded the Science Policy Research Unit at Sussex University) produced the Frascati Manual, which defined how to collect R&D statistics.

The same year, the OECD organised the first international meeting of ministers of science; Two years later, it established a committee and an internal department for science policy, led by Jean-Jacques Salomon. This promoted the idea of the existence of a 'technology gap' between the USA and the rest of the world. This gap justified the need for science policy.

The 'OECD line' came to be that:

1. Research should help reach national, politically-determined goals.

2. Research should be planned and organised to that end.

3. Research should be more interdisciplinary, in order to solve real-world problems.

4. The universities were rigid, organised by discipline and unable to change themselves. They should be 'reorganised' in order to contribute more to the solution of societal problems and to reach national goals.

The increasing state R&D budgets of the time had high mission content. And new terminologies such as 'strategic research' and 'targeted research' began to emerge.

Alongside this increased emphasis on the utility of research, the 1960s saw the emergence of active "industrial policies". Governments, especially those of the UK and France, attempted to create national champions in industries deemed essential to the health of the national economy and defense. Among the favoured sectors were high-technology industries such as aerospace and computers. Again part of the motivation was to narrow the "technology gap" between Europe and the US. There was also a widely held belief in scale as the key to international competitiveness.

These developments have continued. Ben Martin, the highly respected expert in "Science policy and innovation studies" from SPRU, has summarised what has been learned in fifty years of innovation policy: Policymakers have not been short of advice on how best to enhance the impact of technological research through prioritisation of research areas. And today policymakers are being asked by the European Commission to pursue Smart Specialisation and Key Enabling Technologies.

But the approach of Bush has never gone away. Countries have continued to fund basic or blue sky or curiosity driven research throughout this period as ERC does it today (on average most countries allocate around 20% of their national funding to basic research).

Because the fact is that, despite fifty years of innovation studies, the best form of intervention is still not clear.

Martin concludes that we have achieved a greater understanding of the complexity of the innovation system. But he admits that this makes it harder to give clear recommendations to policymakers.

And the disadvantages of a top-down approach have become more apparent.

With some exceptions the industrial policy of the 60s and 70s was generally not as successful as its advocates wanted it to be. Policy-makers tended to overrate the risks and costs of market failures. And to underestimate the risks associated with government failures.

From the 1980s on there was a shift towards horizontal, non-selective policies aimed at improving the environment for all firms. Both at the national and at the European level (through the Single Market Programmes), more emphasis was placed on competition. The ability of governments to support their industries was curtailed. And previously protected sectors such as telecommunications and electricity were partially liberalised.

At the same time new institutions were established: The Framework Programme and Eureka were set up to promote intra-European cooperation in research.

The surge in US productivity growth from the mid-1990s, linked to the rapid application of information technology, led European governments to encourage the growth of entrepreneurial high-technology firms on the American model.

By the early 2000s some progress had been made. But there was still a wide productivity gap with the US. And in several high-technology sectors, such as information technology and biotechnology, European firms were lagging behind their American counterparts with the notable exception of the aerospace industry, through Airbus. There was also a growing concern about de-industrialisation. Especially with the shift of manufacturing to China and other emerging economies.

These changes were reflected in government policies to support research and innovation. At the EU level for example, there was more emphasis on "excellence" and creating a European Research Area. Such approaches were also taken by some national governments, e.g. in Denmark and in Germany, which established "Centres of excellence".

However, the financial crisis of 2008-09 led to another shift. Governments again provided short-term help to ailing industries such as the car manufacturers or the banking sector. But they also began to consider whether a more active industrial policy might be needed in the longer term. Some economists argued for a revival of sector-based policies in a form that would avoid the mistakes of the past.

So where does that leave us? Are there some basic weaknesses in the analyses put forward? Is the situation in Europe homogeneous enough that a uniform policy can work?

We can see that research and innovation policy, including industrial policy, has gone through several cycles.

Different national models have also come and gone. Over the years policymakers have been told to look to the Soviet Union, to the US, to Japan, to Finland, and now to Korea.

But there does seem to be one thing on which everyone does agree. That is, basic research is a classic public good in economic terms. The output of basic research is 'non-rival'. This means that many people can consume it at the same time without it being used up. And it is 'non-excludable'. This means that it is hard to stop people getting access to it. Actually, there are going on considerable access to give to it more Open Access. Therefore, the private sector will be very reluctant to spend adequate amounts to basic research, leaving it to the state to fund it.

The fact is that the ERC plays that one role in the research eco-system which we are sure makes it necessary for States to fund it.

This was very well formulated by the Irish former Commissioner Geoghegan-Quinn when she spoke here at the RIA in November 2012. She said that ***"…intellectual inquiry is a valuable and worthwhile pursuit in itself. Science satisfies our need to understand the world around us, to understand the great variety of life on earth, and to understand ourselves."***

And it is always worth repeating the testimony of Robert R. Wilson before the US Congress in 1969. The discussion was about the value of building an accelerator at Fermi's lab. He was asked whether the accelerator would help US defence and security. His reply was: ***"…it has nothing to do directly with defending our country except to help make it worth defending."***

Yet, even though I believe that the points made by the previous prestigious persons I just quoted are indeed true, it is not the only reason why basic research must be funded. It is simply a fact that frontier research can lead to tremendous economic rewards, by giving rise for example to completely new economic sectors, to many important new products, to major industrial developments, affecting the computer industry as well as pharmaceuticals. Many critical new steps have their origins in publicly funded research conducted at universities and research institutions; many of the commercially successful inventions we now take for granted and which have driven economic growth come from research conducted with no commercial purpose.

Think of Google: at its base is a piece of pure science, i.e. an imaginative algorithm (by the way, it has taken scientists some time to realize how powerful that algorithm can be to prove theorems). The software “Page Rank”, developed by Sergei Brin and Larry Page, came from a project produced with the help of funding from the NSF. The grant, covering several other things, was worth 4.5 million dollars. Google is now worth nearly 400 billion dollars!.

The link between curiosity driven research and applications is not new. Take the members of the UK’s Royal Society in the 17th century. They investigated such esoteric phenomena as magnetism, optics, universal gravitation and the motion of heavenly bodies. But it was obvious to them that this would lead to practical use in instrumentation in watches and engines, indispensable for carrying out trade on land and across the oceans. It went much further as it laid the basis for the industrial age.

Vannevar Bush was no ivory tower academic. He led six thousand American scientists in the U.S. Office of Scientific Research and Development (OSRD) during World War II. This was the body through which almost all US wartime military R&D was carried out, including the first phases of the Manhattan Project. He also later founded Raytheon, a major US defence contractor to this day. So this was somebody that was intensely interested in getting practical results. Yet he understood that allowing freedom to scientists, targeting in piority the brightest, was a way to get these results.

Bottom-up, curiosity driven ERC funded research is starting to produce results. Since 2007, over 4 300 research projects have been funded in some 600 distinct institutions in 30 countries. Some 20 000 PhDs and post-docs have been employed on ERC teams.

The direct output of the ERC is the science it funds. The publication of the results of research is an essential part of the scientific method. Scientific publications report the findings of original experimental and theoretical work in appropriate scientific journals as well as the methodologies that led to the results.

The expert judgment of scientists in the field is necessary to properly assess the scientific importance of a particular publication. And even then the significance of some papers can be missed for many years. Nevertheless, if we look at the 30 000 articles, that came out of the research projects funded by ERC, then **12%** of the articles published between 2008 - 2010 were in the **top 1%** most cited articles in the world in 2012. This is impressive given that by definition only 1% of articles can be in the top 1%, and less than 1% of articles with an EU author are in the top 1% on average.

So thee are very encouraging early signs that the ERC has already supported some of the most significant research worldwide in the last few years.

But let me be clear again. I do not claim that science leads directly to economic growth. With Google the science part was not enough. a lot of work and entrepreneurial spirit had to be mobilized to make this huge step. The most obvious one is the economic model which leads to one of the wealthiest companies of the world when the use of its products is free to the huge majority of its users. It took an entrepreneurial vision, the development of a business model, venture capital and many talented people to turn that algorithm into one of the world’s biggest, most profitable businesses.

Of course the innovation process is a complicated one, with many linkages and feedback mechanisms. And it needs to be understood at a systemic level. It is also increasingly global. Innovation does not follow a neat linear model in which "an innovation" follows directly and rapidly from "a research project". And there is no way to constrain the benefits in the same geographical location as the research takes place.

To explain this I think it is very important to understand something about research. And that is for every breakthrough there are many more results which are only of interest to scientists in the same field. And even more results that are what we could politely call “for the record”, but one must be very careful that "results for the record" may turn to highly relevant ones when looked at from a different angle or in combination with others.

A significant proportion of all research papers are never cited. This does not mean this research should not have been done. It is simply that for any real research project the outcome is by definition unknown, or it is not really research. Even if lots of research produces little impact, some research produces immense impact. And we do not know which is which beforehand.

Furthermore, I would argue that what is true of research is also true for the applications of research. One should not think that investing in applied research is a surer thing while investing in basic research would be risky and uncertain. It is very difficult to predict from where a truly important new development will come. Even experienced and successful venture capitalists hope to succeed with only a small percentage of their investments, and many of them are real bets. The best ones are very conscious of that, and this is precisely why they diversify their investments.

Many of the building blocks of the computer age: Turing machines, programming languages, even the internet itself, can be traced back to genuinely new ideas conceived in the academic world. This being said, I don't think anyone predicted the massively interconnected world in which we live today. Smart phones, tablets, soon watches and countless applications that have radically altered the way information is produced, accessed and processed, pass through cyberspace and interact with people anywhere around the globe with a formidable transforming effect on the way industry is organized, without even pointing to completely new areas. Investors now talk about "Industry 4.0".

Nobody asked for this. But these technologies meet deep human needs that have been long thought after. These domains have seen the creation of multi-billion euro companies from nothing. They have radically changed the way we work and play. And we are only beginning to see the effects of these technologies in our daily lives.

The link between intellectual creativity and innovation requires some deeper thinking. It is a critical relationship which cannot be judged merely in terms of patents and statistics.

To achieve such great innovations with lasting impacts on our societies, we need further developments in basic scientific research. Only led by the principles of academic curiosity and scientific excellence can we hope to discover the unexpected. We must invest in understandings before we can expect tangible applications.

In my experience the more visionary private sector leaders do very much understand the importance of government support for fundamental research. They understand the wider benefits of excellent science I mentioned above, in particular high tech companies need highly skilled, trained and versatile people. The added value of well trained, well motivated and ambitious people can never be stressed enough when the focus is often too much on amounts, on processes and on structures. There are indeed more or less proper environments for researchers to develop their projects, but the key issue is to challenge them to deliver the most ambitious projects they can think of. This is precisely what ERC does through a totally "bottom-up" approach. It has organized itself to be ready to appropriately evaluate projects of all kinds submitted by researchers. This is a real challenge, that actually turns out to be also one of the reasons why ERC has been able to attract an exceptional group of evaluators because they see this hard work as a formidable intellectual adventure.

Unfortunately, I speak to you today at a time when several governments have taken the decision to cut many areas of government spending. The cuts applied to the research budget have been particularly severe in the countries the most hit by the crisis such as Spain, with annual average decreases of -9.1% from 2008 – 2012[1]. Public R&D investments in Spain have returned to the levels of 2005-2006.

Faced with overall cuts I can see the temptation to cut basic research funding first as something whose return cannot be easily claimed in the short term when political leaders are under pressure to deliver results precisely in the short term. It appears to them easier to decide to fund technology X or solving problem Y than to say we are funding new knowledge and counting, on the basis of past experience in many different settings, for something to come out of it soon, or even not so soon.

But if we look at the most successful regions and countries of the world in terms of innovation, we see that their achievements are without exception built on a bedrock of excellent basic research.

This approach produces not only new knowledge, but also highly skilled researchers, access to international networks, new technologies and spin-off companies.

This is even more true as a country or region moves closer to the technological frontier. When countries are at certain stages of development they can enjoy "catch-up" growth simply by adopting existing technologies. This becomes increasingly difficult as economies mature. Europe has recognised this with the so called "Europe 2020 Policy" which makes research and innovation central to achieving its future goals.

I think that there is one particularly pernicious effect of such cuts: it seems that, unfortunately, their effect seems to fall disproportionately on the young ones, including in research. It is particularly important to continue to provide opportunities to young researchers to establish themselves as independent actors with adequate means to develop their own project. We must make sure that the most original and high calibre young researchers see a future for them here in Europe. At this moment data on researchers employment in Europe are vey shaky, with in particular very little visibility on the proportion between stable and unstable jobs. It is clear that the latter have grown very considerable in all countries and in particular in some disciplines where young researchers see with considerable apprehension the possibility of a career being postponed again and again. European research funding bodies such as the ERC cannot act as a substitute for national research funding. This is first and above all because the ERC's budget, for example, amounts to only 2% of EU public expenditure on R&D. The responsibility to support the potential of human curiosity rests equally with national and regional governments as well as with charitable foundations.

In the past couple of decades, Ireland has made significant advances in its research and development investment and has rapidly caught up with other European Union member states. Ireland's top academic institutions are able to attract high-level researchers, who are drawn by quality scientific equipment and infrastructures and the prospect of working with excellent colleagues and students. In 2003 Ireland was ranked 36th in the world for quality of scientific research output, but by 2010 the ranking was 20th. From 2000 to 2008 total spend on publicly-funded R&D in Ireland more than tripled (from €290 million in 2000 to 938 million in 2008). But thee has been a pick in 2008 in government funding for research in Ireland that has gone in 2013 to its 2006 level. In

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[1] European Commission - *"Research and innovation as sources of renewed growth"* June 2014: http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2013/research-and-innovation-as-sources-of-renewed-growth-com-2014-339-final.pdf

such circumstances it is not inappropriate for policy-makers to determine research funding priorities. But the fundamental argument of this keynote address has been that, in all research systems, it is essential that a significant proportion of funding is designated to exploratory, curiosity-driven research, thus offering some perspective to their brightest talents.

So my message to you today is simple. Ireland has made great strides. You have been through some very dark days. But I have every confidence that you will emerge even stronger than in the past if you do not neglect the foundations for future, sustainable growth.

If science is to make truly influential innovations, funding cannot be short-sighted. To maintain a healthy research ecosystem, it is right to invest substantially in long-term curiosity-driven research as well as in more targeted endeavours.

Ausgaben des Bundes 2010 bis 2014 für Forschung und Forschungsförderung nach sozio-ökonomischen Zielsetzungen
Auswertungen der Beilagen T (Teil a und Teil b) der Amtsbehelfe/Arbeitsbehelfe zu den Bundesfinanzgesetzen

Berichtsjahre		Ausgaben des Bundes für F&E insgesamt	Davon für												
			Förderung der Erforschung der Erde, der Meere, der Atmosphäre und des Weltraumes	Förderung der Land- und Forstwirtschaft	Förderung von Handel, Gewerbe und Industrie	Förderung der Erzeugung, Speicherung und Verteilung von Energie	Förderung des Transport-, Verkehrs- und Nachrichtenwesens	Förderung des Unterrichts- und Bildungswesens	Förderung des Gesundheitswesens	Förderung der sozialen und sozioökonomischen Entwicklung	Förderung des Umweltschutzes	Förderung der Stadt- und Raumplanung	Förderung der Landesverteidigung	Förderung anderer Zielsetzungen	Förderung der allgemeinen Erweiterung des Wissens
2010 [1])	in 1.000 €	**2.269.986**	103.791	67.621	587.124	39.977	56.969	50.648	472.455	99.798	67.114	12.792	123	-	711.574
	in %	**100,0**	4,6	3,0	25,9	1,8	2,5	2,2	20,8	4,4	3,0	0,6	0,0	-	31,2
2011 [2])	in 1.000 €	**2.428.143**	107.277	63.063	613.692	41.294	54.043	59.479	510.359	115.792	77.578	20.170	99	-	765.297
	in %	**100,0**	4,4	2,6	25,3	1,7	2,2	2,4	21,0	4,8	3,2	0,8	0,0	-	31,6
2012 [3])	in 1.000 €	**2.452.955**	103.432	60.609	607.920	55.396	47.934	65.537	499.833	121.570	86.776	20.338	120	-	783.490
	in %	**100,0**	4,2	2,5	24,8	2,3	2,0	2,7	20,4	5,0	3,5	0,8	0,0	-	31,8
2013 [4])	in 1.000 €	**2.621.249**	110.007	64.125	671.784	65.658	51.670	64.969	530.822	130.378	92.089	22.229	90	-	817.428
	in %	**100,0**	4,2	2,4	25,6	2,5	2,0	2,5	20,3	5,0	3,5	0,8	0,0	-	31,2
2014 [4])	in 1.000 €	**2.740.766**	113.042	76.931	679.570	62.414	51.336	75.282	555.032	129.496	88.785	21.707	83	-	887.088
	in %	**100,0**	4,1	2,8	24,8	2,3	1,9	2,7	20,3	4,7	3,2	0,8	0,0	-	32,4

Q: STATISTIK AUSTRIA, F&E-Jahresauswertungen. Erstellt am 06.06.2014. 1) Beilage T des Arbeitsbehelfes zum BFG 2012, Erfolg. - 2) Beilage T des Arbeitsbehelfes zum BFG 2013 (Finanzierungsvoranschlag), Erfolg. Revidierte Daten. - 3) Beilage T des Arbeitsbehelfes zum BFG 2014 (Finanzierungsvoranschlag), Erfolg. - 4) Beilage T des Arbeitsbehelfes zum BFG 2014 (Finanzierungsvoranschlag), Bundesvoranschlag.

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NATIONAL SURVEY OF RESEARCH AND DEVELOPMENT IN SINGAPORE 2012

NATIONAL SURVEY OF R&D IN SINGAPORE 2012

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Foreword

As Singapore matures as a knowledge-based economy, there needs to be a sustained investment in R&D and a continued supply of high-value researchers to meet the growing demand.

Singapore's Research, Innovation & Enterprise (RIE) 2015 plan targets to develop Singapore into one of the world's leading research-intensive, innovative and entrepreneurial economies. Developing deep R&D capabilities continues to remain a key priority for Singapore.

Investment in R&D continues to create high-value jobs in Singapore. The number of R&D jobs in Singapore reached a new high of 39,077 in 2012. This comprises Research Scientists and Engineers (RSEs), non-degree researchers, technicians and other supporting staff. Of the RSEs, the year-on-year growth in employment of higher-skilled RSEs was most significant – RSEs with PhDs grew by 7.9% to 7,754 and RSEs with Masters increased by 2.6% to 7,319.

In 2012, Gross Expenditure on R&D (GERD) was $7.2 billion, or 2.1% of GDP. The Compound Annual Growth Rate (CAGR) over the past 10 years (2002-2012) was 7.8%.

The Singapore government remains committed to research, innovation and enterprise. Over the past 10 years, Public Expenditure on R&D (PUBERD) has generally continued to increase, reaching $2.8 billion in 2012, or 0.8% of Singapore's GDP.

Nominal GDP growth slowed to 3.4% in 2012, from 5.8% in 2011, mainly due to weakness in externally-oriented sectors. Economic growth is likely to remain subdued. Against this macroeconomic backdrop, Business Expenditure on R&D (BERD) held steady at $4.4 billion, or 1.3% of GDP.

R&D spending by local private companies increased by $180 million to $1.3 billion in 2012. This reflects the increasing propensity of local companies to undertake R&D and innovation activities to improve their business, and the raising of the local innovation capacity in Singapore.

This survey will not be possible without the continued support of all organisations which participated in the survey. I would like to thank you for your invaluable contribution, and we look forward to working together to create an Innovation Economy.

Dr Raj Thampuran
Managing Director,
Agency for Science,
Technology and Research Singapore

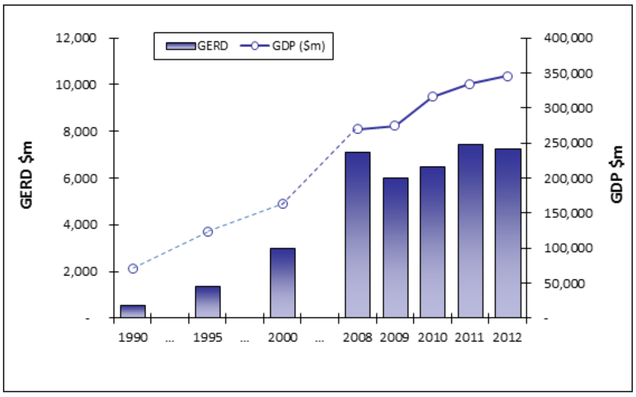
1. OVERVIEW OF R&D IN SINGAPORE

1.1 Gross Expenditure on R&D (GERD)

GERD in Singapore decreased slightly from $7.4 billion in 2011 to $7.2 billion in 2012. In the same period, Singapore's GDP (at current market prices) increased by 3.4% from $334.1 billion in 2011 to $345.6 billion in 2012.

In 2002, GERD was $3.4 billion and GDP stood at $162.3 billion. The Compound Annual Growth Rate (CAGR) of GERD from 2002 to 2012 was 7.8%.

Fig.1.1 Gross Expenditure on R&D and GDP growth (1990-2012)

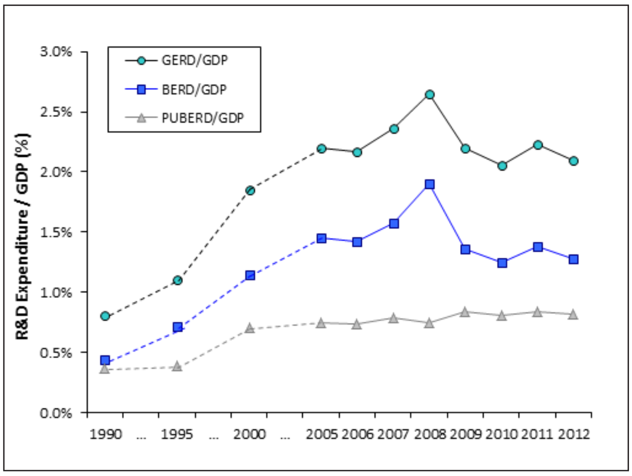


1.2 Ratio of Public Expenditure on R&D (PUBERD) to Business Expenditure on R&D (BERD)

GERD as a percentage of GDP remained stable at 2.2% in 2011 and 2.1% in 2012. Similarly, Business Expenditure on R&D (BERD) as a percentage of GDP remained stable at 1.4% in 2011 and 1.3% in 2012. Public Expenditure on R&D (PUBERD) as a percentage of GDP stood at 0.8% in 2011 and 2012.

For every $1 spent in research from public sources, $1.56 was spent by businesses in 2012.

Fig.1.2 Gross Expenditure, Business Expenditure and Public Expenditure on R&D as a percentage of GDP (1990-2012)

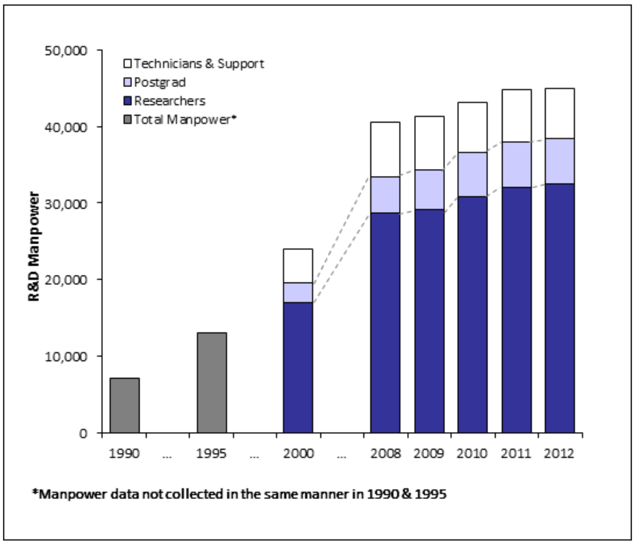


1.3 Manpower

Total R&D Manpower (including researchers, postgraduate students, technicians and support staff) grew by 0.3% from 44,855 persons in 2011 to 45,001 persons in 2012. This represents a CAGR of 5.3% from a base of 26,824 persons in 2002.

The number of researchers (excluding postgraduate students) rose by 1.5% from 32,023 in 2011 to 32,508 in 2012. The CAGR from 2002, with 17,808 researchers, to 2012 is 6.2%.

Fig.1.3 R&D Manpower (1990-2012)



2. BUSINESS EXPENDITURE ON R&D (BERD)

2.1 Overview

In 2012, 699 private sector companies indicated that they performed R&D in Singapore. The total BERD of these companies amounted to $4.4 billion, corresponding to 1.3% of Singapore's GDP in 2012. This represents a 4.6% decline compared to the BERD in 2011 at $4.6 billion. The CAGR from 2002-2012 was 7.8%.

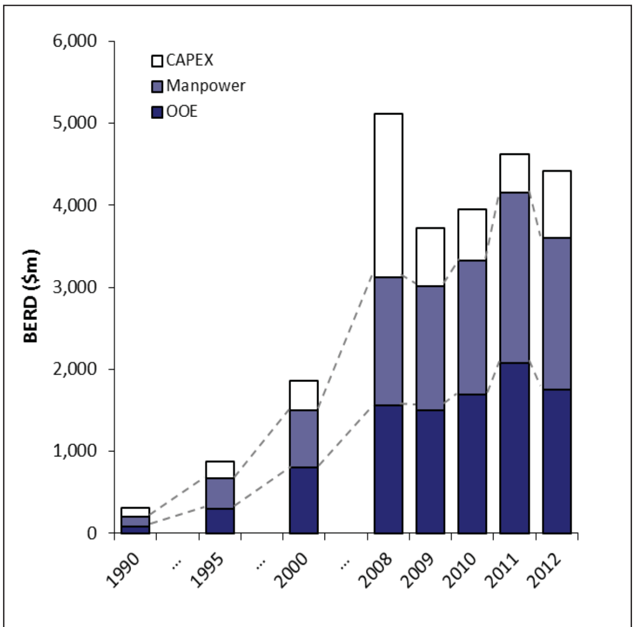
2.2 Type of Expenditure

Capital expenditure (CAPEX) grew by 72.8% to $807.9 million in 2012 from $467.7 million in 2011. CAPEX in 2002 was $414.6 million and CAGR for 2002-2012 was 6.9%.

On the other hand, manpower expenditure contracted 10.9% from $2.1 billion in 2011 to $1.9 billion in 2012. From a base of $791.4 million in 2002, the CAGR for 2002-2012 for manpower expenditure was 8.9%.

Other operating expenditure (OOE) also contracted by 15.7% from $2.1 billion in 2011 to $1.7 billion in 2012. From a base of $885.4 million in 2002, the CAGR for 2002-2012 for OOE was 7.0%.

Fig.2.1 Business Expenditure on R&D by type of cost (1990-2012)



2.3 Type of R&D

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

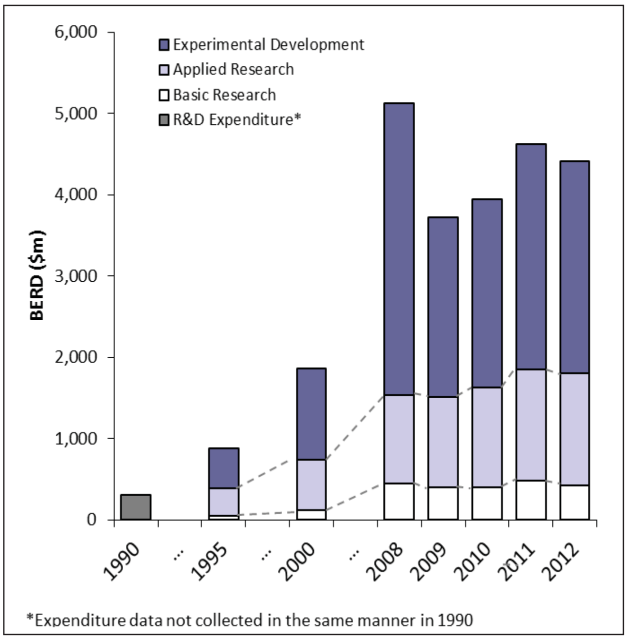
a) Basic research (experimental or theoretical work undertaken without any particular application or use in view);
b) Applied research (original investigation directed primarily towards a specific practical aim or objective); and
c) Experimental development (systematic work that is directed to producing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

Basic research expenditure decreased by 10.1% from $478.0 million in 2011 to $429.5 million in 2012. This represents a CAGR of 16.6% from 2002 when business expenditure on basic research was $92.1 million.

Applied research remained stable at $1.4 billion in 2011 and 2012. This represents a CAGR of 7.2% from 2002 when business expenditure on applied research was $689.2 million.

In 2012, experimental development contracted by 6.1% from $2.8 billion in 2011 to $2.6 billion in 2012. This represents a CAGR of 7.1% from 2002 when business expenditure on experimental development was $1.3 billion.

Fig.2.2 Type of Business Expenditure on R&D (1990-2012)



2.4 Fields of Science & Technology

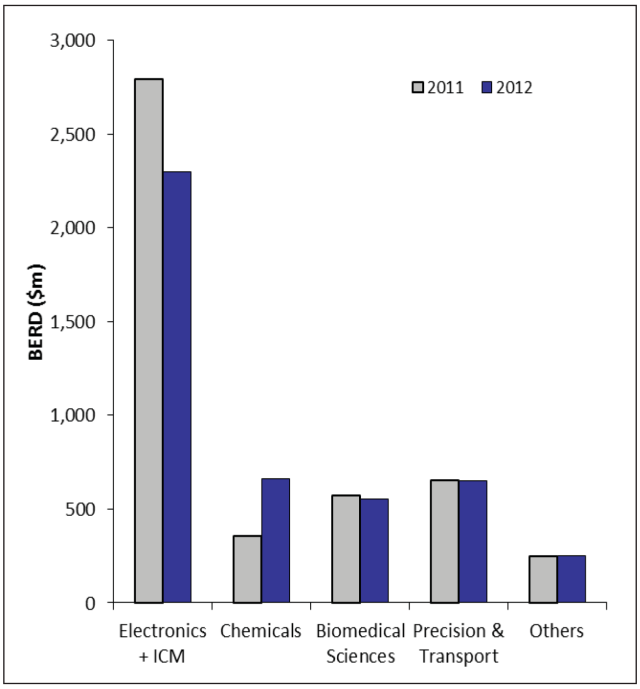
This section shows an alternative classification by Fields of Science and Technology as follows:

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

In the private sector, research expenditure in Electronics and ICM declined by 17.8% from $2.8 billion in 2011 to $2.3 billion in 2012. In contrast, Chemicals saw robust growth of 85.7% from $357.8 million in 2011 to $664.5 million in 2012.

Biomedical Sciences saw a contraction of 3.7% from $573.8 million in 2011 to $552.6 million in 2012. Expenditure in Precision and Transport Engineering research decreased slightly by 0.7% from $655.3 million in 2011 to $650.7 million in 2012.

Fig.2.3 Business Expenditure on R&D by fields of science and technology (2011-2012)



3. PUBLIC EXPENDITURE ON R&D (PUBERD)

3.1 Overview

In 2012, 63 public institutions including A*STAR research institutes, institutes of higher learning, hospitals and other public funded research organisations were surveyed.

These organisations reported a total expenditure of $2.83 billion in 2012. This represents a growth of 0.3% from $2.82 billion in 2011 and a CAGR of 8.0% from $1.3 billion in 2002.

Expenditure of public organisations as a proportion of GDP remained stable at 0.8% of GDP in 2011 and 2012.

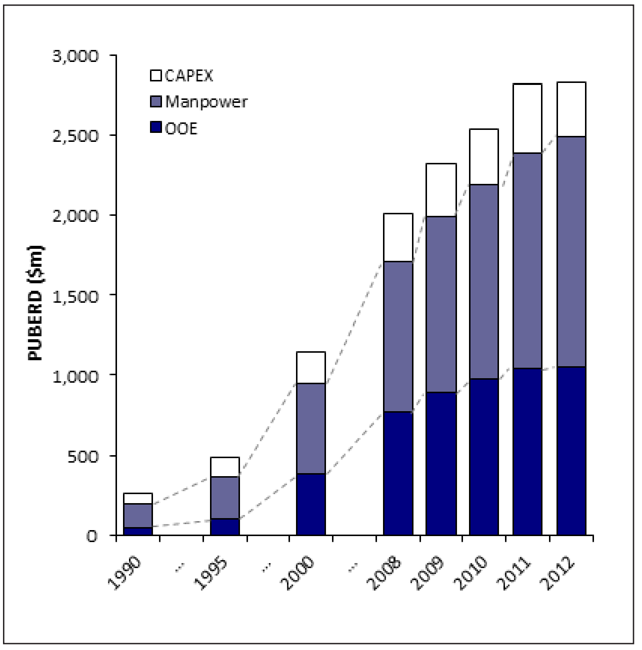
3.2 Type of Expenditure

Amongst public institutions, capital expenditure (CAPEX) declined by 22.1% from $428.0 million in 2011 to $333.3 million in 2012. CAPEX in 2002 was $243.7 million and CAGR for 2002-2012 was 3.2%.

Conversely, Manpower expenditure grew year-on-year by 7.4% from $1.3 billion in 2011 to $1.4 billion in 2012. From a base of $656.7 million in 2002, the CAGR for 2002-2012 for manpower expenditure was 8.2%.

OOE remained stable at $1.0 billion in 2011 and 2012. From a base of $412.9 million in 2002, the CAGR for 2002-2012 for OOE was 9.8%.

Fig.3.1 Public Expenditure on R&D by type of cost (1990-2012)



3.3 Type of R&D

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

a) Pure Basic research (without seeking long-term economic or social benefits or making any effort to apply the results to practical problem);
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 that is directed to producing or improving substantially materials, products and devices; or installing new processes, systems and services)

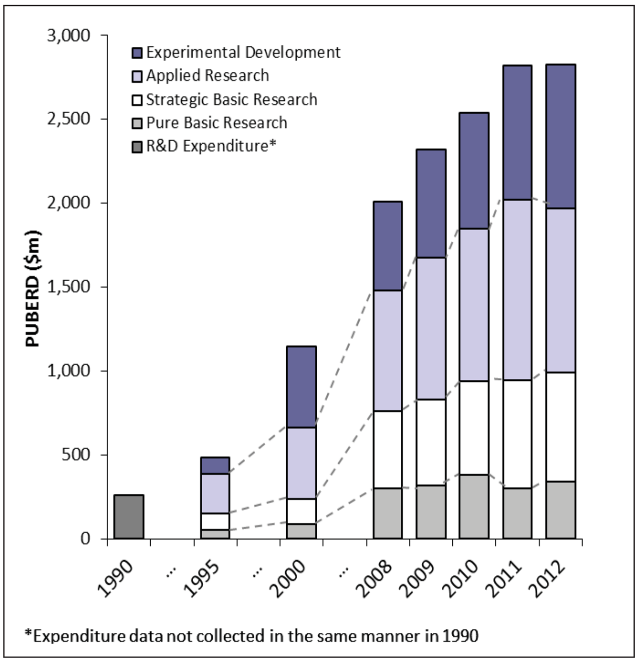
Pure basic research expenditure in public institutes grew 13.0% from $299.3 million in 2011 to $338.2 million in 2012. This represents a CAGR of 6.0% from 2002 when public expenditure on pure basic research was $188.7 million.

Strategic basic research grew by 1.1% from $642.6 million in 2011 to $650.0 million in 2012. This represents a CAGR of 10.3% from 2002 when public expenditure on strategic basic research was $243.8 million.

Applied research experienced a decline of 9.4% from $1,081.8 million in 2011 to $980.2 million in 2012. This represents a CAGR of 7.1% from 2002 when public expenditure on applied research was $493.8 million.

Experimental Development exhibited growth of 8.1% from $796.6 million in 2011 to $861.2 million in 2012. This represents a CAGR of 8.3% from 2002 when public expenditure on experimental development was $387.0 million.

Fig.3.2 Type of Public Expenditure on R&D (1990-2012)



3.4 Fields of Science & Technology

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

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

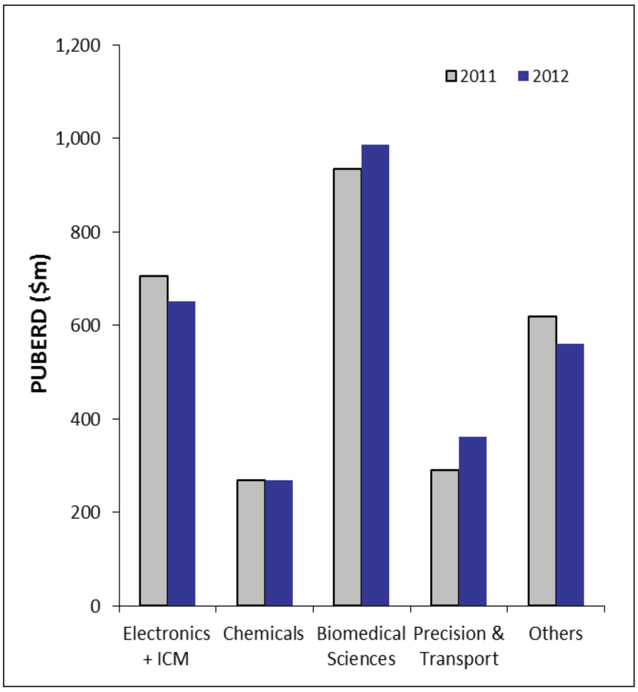
Research in Electronics and ICM contracted 7.6% from $705.8 million in 2011 to $652.5 million in 2012.

Chemicals grew slightly by 0.2% from $268.4 million in 2011 to $269.0 million in 2012.

Biomedical Sciences saw a growth of 5.6% from $935.2 million in 2011 to $987.1 million in 2012.

Precision and Transport Engineering increased by 24.0% from $290.8 million in 2011 to $360.7 million in 2012.

Fig.3.3 Public Expenditure on R&D by fields of science and technology (2011-2012)



4. R&D TALENT

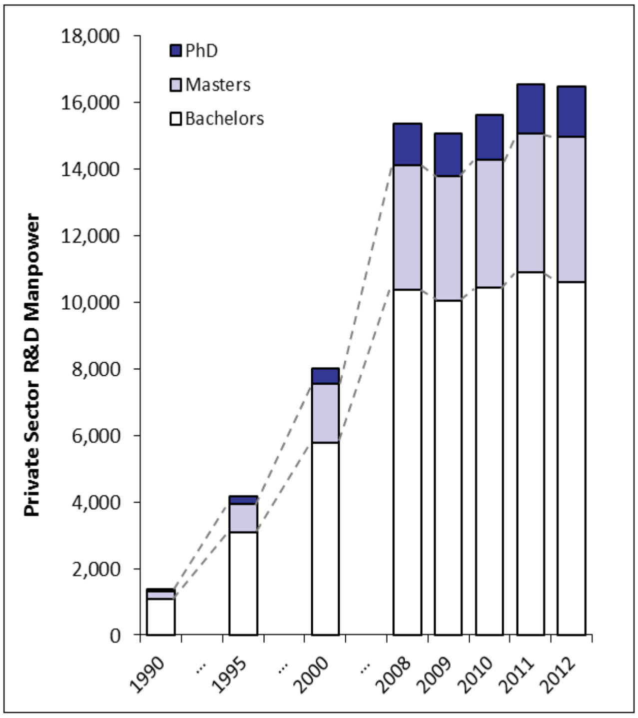
4.1 Total Research Scientists & Engineers

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

In 2012, the number of RSEs grew by 2.1% from 29,482 in 2011 to 30,109 in 2012. This represents a CAGR of 6.8% from a base of 15,654 in 2002.

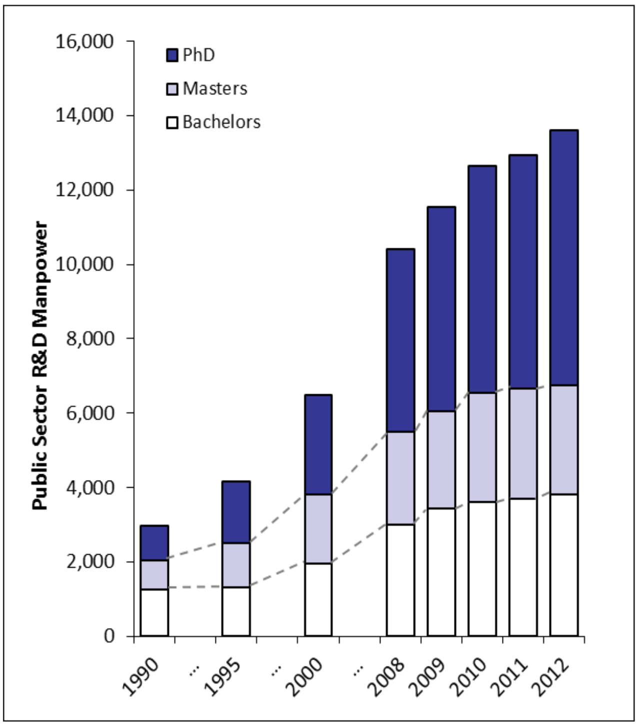
In the private sector, the number of PhD RSEs grew by 3.4% from 1,460 in 2011 to 1,509 in 2012. This represents a CAGR of 10.7% from 547 PhD RSEs in 2002. The number of RSEs with a Master's degree grew 4.2% from 4,189 in 2011 to 4,367 in 2012. This represents a CAGR of 8.3% from 1,971 RSEs with Master's degrees in 2002. The number of RSEs with a Bachelor's degree decreased between 2011 and 2012, falling by 2.5% from 10,886 in 2011 to 10,616 in 2012. This represents a CAGR of 5.7% from 6,080 RSEs with Bachelor's degrees in 2002.

Fig.4.1 Private Sector Research Scientists & Engineers (1990-2012)



In the public sector, the number of PhD RSEs grew by 9.0% from 6,294 in 2011 to 6,858 in 2012. This represents a CAGR of 8.3% from 3,092 PhD RSEs in 2002. RSEs with a Master's degree remained mainly unchanged from 2,945 in 2011 to 2,952 in 2012. This represents a CAGR of 4.1% from 1,975 RSEs with Master's degrees in 2002. RSEs with a Bachelor's degree grew by 2.7% from 3,708 in 2011 to 3,807 in 2012. The CAGR was 6.7% from a base of 1,989 Bachelor degree holding RSEs in 2002.

Fig.4.2 Public Sector Research Scientists & Engineers (1990-2012)

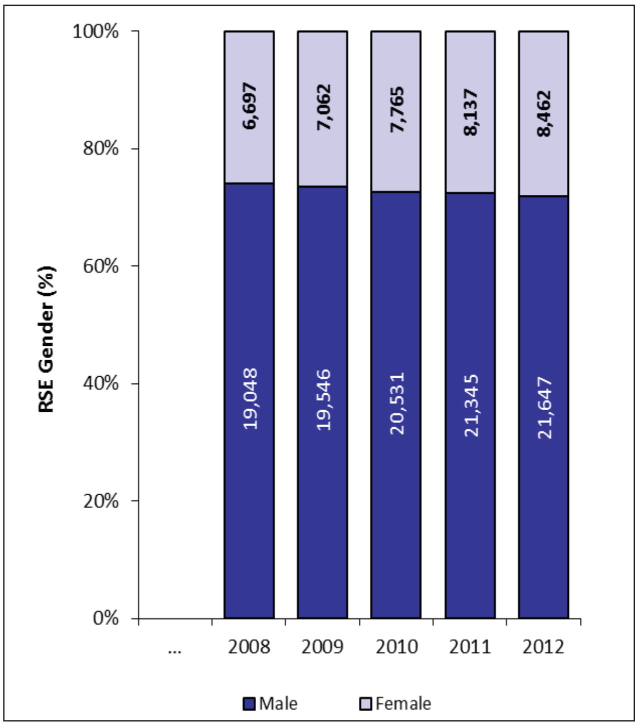


4.2 Gender of Research Scientists & Engineers

In 2012, females made up 28.1% of all RSEs, up from 27.6% in 2011, following the trend of increasing proportion of female RSEs (Fig 4.3).

a) Between 2008 and 2009, the number of male RSEs grew by 2.6% and female RSEs grew by 5.5%.
b) Between 2009 and 2010, the number of male RSEs grew by 5.0% and female RSEs grew by 10.0%.
c) Between 2010 and 2011, the number of male RSEs grew by 4.0% and female RSEs grew by 4.8%.
d) Between 2011 and 2012, the number of male RSEs grew by 1.4% and female RSEs grew by 4.0%.

Fig.4.3 Gender of Research Scientists & Engineers (2008-2012)

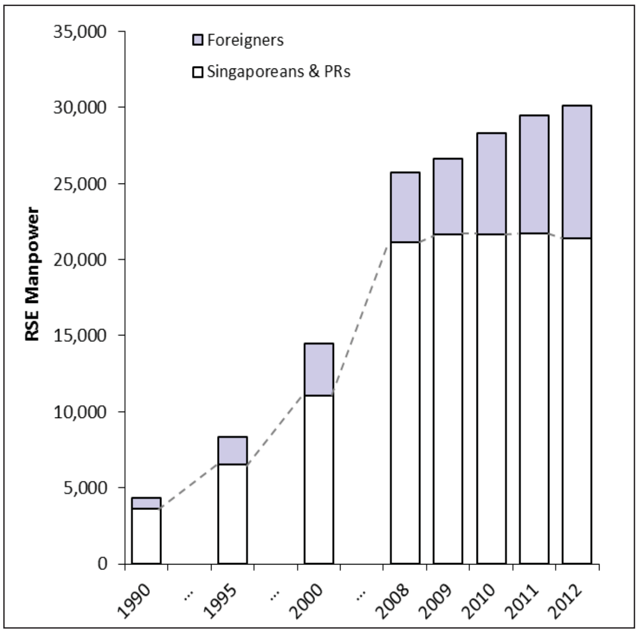


4.3 Citizenship of Research Scientists & Engineers

The number of Singaporean and Permanent Resident (PR) RSEs declined by 1.5% from 21,702 in 2011 to 21,380 in 2012. This represents a CAGR of 5.4% from a base of 12,680 RSEs in 2002.

In contrast, the number of non-PR foreign RSEs grew 12.2% from 7,780 in 2011 to 8,729 in 2012. This represents a CAGR of 11.4% from a base of 2,974 foreign RSEs in 2002.

Fig.4.4 Citizenship of Research Scientists & Engineers (1990-2012)



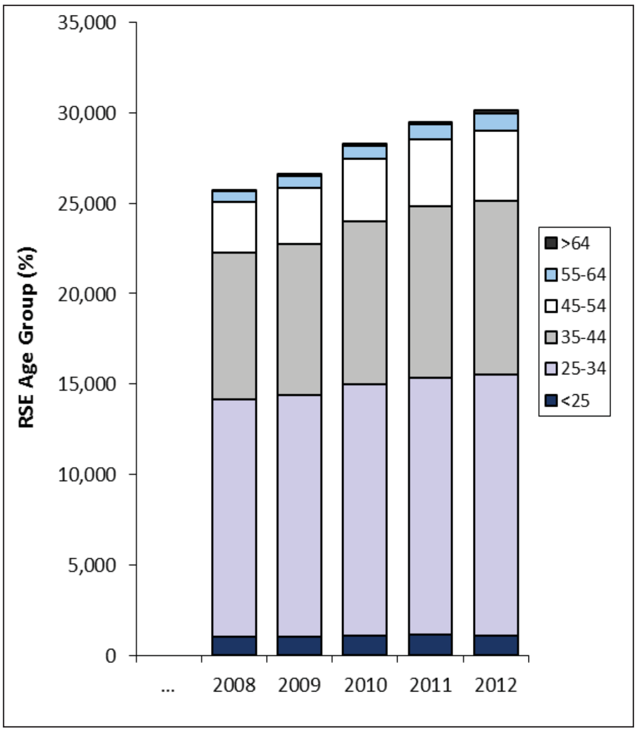
4.4 Age-Bands of Research Scientists & Engineers

In 2012, 51.6% of all RSEs were under the age of 35 and 83.5% of all RSEs were under the age of 45.

Between 2011 and 2012 the growth rates by the respective age bands were as follows:

- The number of RSEs 25 years of age declined by 4.2%.
- The number of RSEs between 25 and 34 years of age grew by 1.8%.
- The number of RSEs between 35 and 44 years of age grew by 0.8%.
- The number of RSEs between 45 and 54 years of age grew by 5.9%.
- The number of RSEs between 55 and 64 years of age grew by 13.9%.
- The number of RSEs over 64 years of age grew by 5.5%.

Fig.4.5 Age-Bands of Research Scientists & Engineers (2008-2012)



5. PATENTS

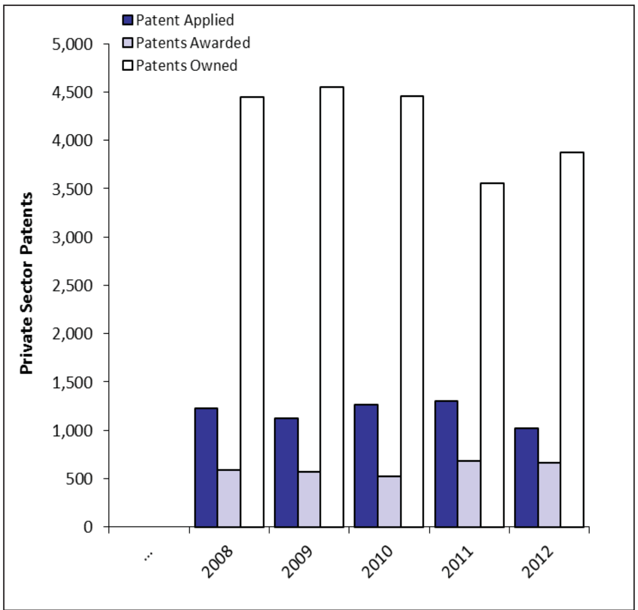
5.1 Patents Applied

In 2012, the total number of primary patent applications (first filings) as a result of R&D conducted in Singapore, stood at 1,722. This represents a decrease of 10.0% from 1,913 patents filed in 2011 and a CAGR of 6.3% from 936 patents filed in 2002.

In the private sector, 1,024 patents were filed in 2012, representing a 21.5% decrease over 1,305 patents filed in 2011.

In the public sector, patent applications continued to grow, increasing from 608 in 2011 to 698 in 2012. This represents a year-on-year growth of 14.8%.

Fig.5.1 Patents Applied, Awarded and Owned in the Private Sector (2008-2012)

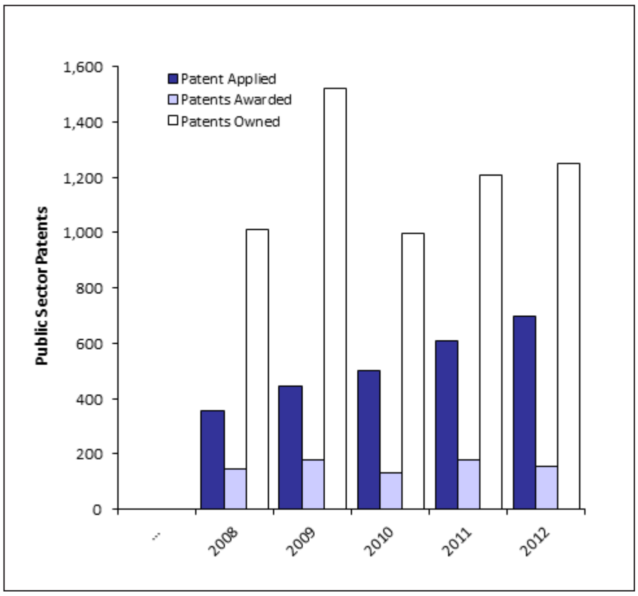


5.2 Patents Awarded

In 2012, the total number of patents awarded (first grants) as a result of R&D conducted in Singapore was 820. This represents a decrease of 4.1% from 855 patents awarded in 2011 and a CAGR of 6.2% from 451 patents awarded in 2002.

Patents awarded to private sector companies declined 2.1% year-on year, from 679 patents awarded in 2011 to 665 in 2012. In the public sector, patents awarded also declined by 11.9% from 176 in 2011 to 155 in 2012.

Fig.5.2 Patents Applied, Awarded and Owned in the Public Sector (2008-2012)



6. INTERNATIONAL COMPARISONS OF R&D

6.1 Research Intensity in Selected Countries

According to OECD Main Science and Technology Indicators 2013/01, the United States of America remains the top R&D spender in 2011, with US$415 billion spent on research. China claimed second position in 2011, having spent US$208 billion, while Japan in third position spent US$147 billion. Normalised as a percentage of GDP, GERD/GDP was 2.8% in the United States, 1.8% in China and 3.4% in Japan.

Singapore's GERD/GDP was 2.2% in 2011 and 2.1% in 2012. This puts Singapore in the league of research-intensive countries such as Denmark (3.1%), Taiwan (3.0%), Germany (2.9%), Switzerland (2.9%), Austria (2.8%), United States (2.8%), France (2.2%) and Belgium (2.0%).

The top 5 most research-intensive countries in the world were Israel (4.4%), Korea (4.0%), Finland (3.8%), Japan (3.4%), and Sweden (3.4%).

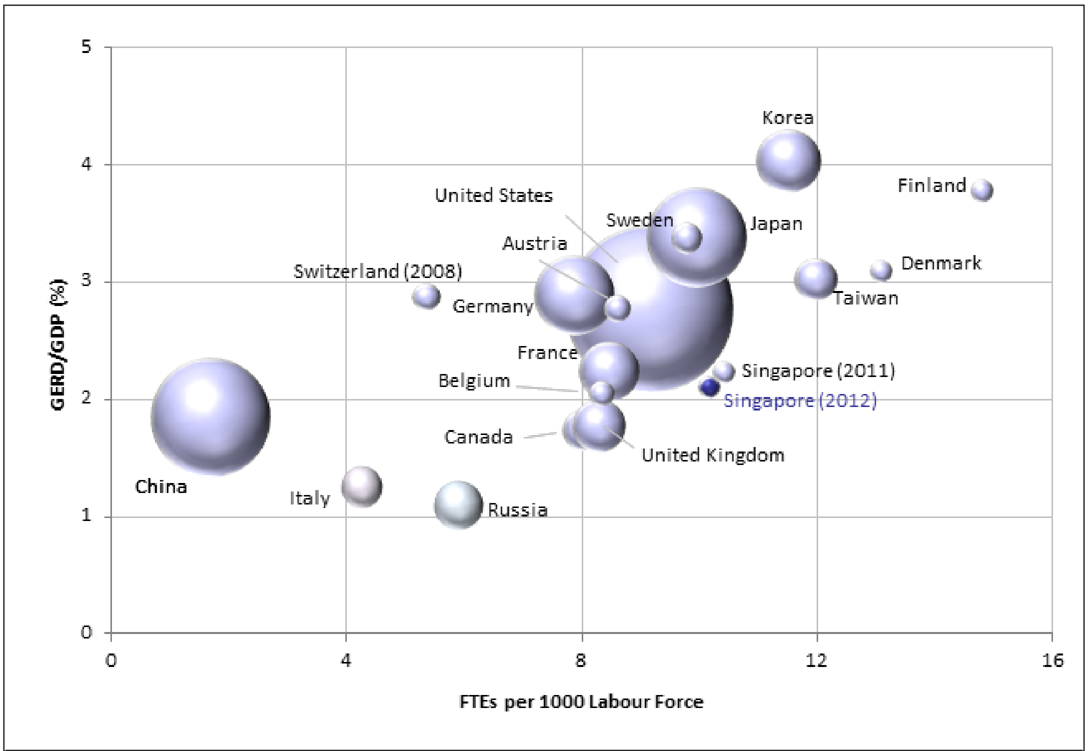
6.2 Researcher Intensity in Selected Countries

Researcher intensity is measured by Full-time Equivalence (FTEs) as a percentage of the labour force. Singapore's Labour Force grew by 3.9% from 3.2 million in 2011 to 3.4 million in 2012. Researcher FTEs also grew slightly by 1.3% from 33,178.4 in 2011 to 34,141.0 in 2012.

Singapore's researcher intensity (FTEs/ 1,000 Labour Force) was 10.4 in 2011 and 10.2 in 2012. This places Singapore together with countries such as Taiwan (12.0), Korea (11.5), Norway (10.4), Japan (10.0), Sweden (9.8), and the United States (9.1 in 2007).

The top 2 countries in terms of researcher intensity in 2011 (FTEs/ 1,000 Labour Force), were Finland (14.8) and Denmark (13.1).

Fig.6.1 Comparison of Selected Countries by Research & Researcher Intensity (2011)



Bubble size indicates GERD in 2011 unless otherwise stated.
Source : OECD, Main Science and Technology Indicators 2013/1

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 fulltime 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) 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 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 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) Higher education sector.

(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 in the Economic Survey 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 education.

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

(c) Higher education sector. This comprises institutions of higher education, 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) 2010. The industry groups and subgroups used in the report are shown in Table 1:

Table 1. Industry Groups and Subgroups by Singapore Standard Industrial Classification (SSIC) 2010

SSIC 2010	
Primary Industries & Construction	**SSIC2010**
Agriculture & Fishing	01-03
Mining & Quarrying, Energy & Water	08-09, 35-38
Construction	41-43
Manufacturing	
Biomedical Mfg	
Pharmaceuticals	21
Medical Technology	2660, 3250
Electronics	
Semiconductor	2611
Computer Peripherals	26124-26125, 26204
Data Storage	26202-26203, 26801
Infocomms & Consumer Electronics	26201, 26205, 26209, 263-264
Electronics Modules & Components	26121-26123, 26126-26127, 26129
Chemicals	
Petroleum	19
Petrochemicals	2013
Specialties	2011-2012, 2021-2022, 2024, 2029
Other Chemicals	17092, 2023, 203, 22213, 231, 23999
Precision Engineering	
Machinery & Systems	2513, 2651, 27102-27104, 27109, 2811, 2812, 2815, 2816, 28191- 28193, 28195-28196, 28199, 2821, 28221-28222, 28224, 28229, 28243, 28249, 2825, 2826, 28273-28274, 2829, 283
Precision Modules & Components	22191-22193, 22199, 22211, 22214-22216, 22218-22220, 25113, 2591-2594, 25951, 25959, 25993, 25995, 25997-25999, 26128, 2652, 2670, 2732, 2733, 2814, 28223, 28271-28272
Transport Engineering	
Marine & Offshore Engrg	28241-28242, 301
Aerospace	303
Land	22121, 252, 291-293, 302, 304, 309
General Mfg Industries	
Food, Beverages & Tobacco	10-12
Printing & Recorded Media	18
Other Mfg Industries	13-16, 1701-1702, 17091, 17093-17099, 22119, 22122, 22194, 22212, 22217, 2391-2396, 23991-23995, 24, 25111-25112, 25114-25119, 2512, 25952, 25991-25992, 25994, 25996, 26802, 272, 274-279, 2817, 28194, 31, 321-324, 329
Services	
R&D	
Biotech, life, medical sciences & Medtech	72101, 72107
Electronics	72102
Chemicals	72103
Engineering	72104
IT	72105
Environment and Clean technologies	72106
Other Natural Sciences	72109
Information and Communications	58-63
Logistics	49-53
Financial Intermediation & Other Business Activities	
Finance & Insurance	64-66
Engineering, Scientific and Technical Activities	71, 7411, 74904, 74905
Other Business Activities	69-70, 73, 7419, 742, 74901-74903, 74906-74909, 75, 77-82
Wholesale and Retail Trade	46-47
Education, Health and Social Work	85-88
Other Services	37-38, 55-56, 68, 84, 90-97,99

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 SPRING 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 for the advancement of knowledge, without seeking long-term economic or social benefits or making any effort to apply the results to practical problems 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). For the 2012 Survey, the areas of R&D were 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
- 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 and 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 2010 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
CR: Company Registration
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
RSE: Research Scientists and Engineers
SME: Small & Medium Enterprise
SSIC: Singapore Standard Industrial Classification
S&T: Science and Technology

8. METHODOLOGY

8.1. METHODOLOGY

8.1.1 The National Survey of R&D in Singapore 2012 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 in 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.

8.2. RESPONSES

8.2.1 The organisations that reported to the Survey that they performed R&D in 2012 comprised private sector enterprises, government organisations, institutions of higher education and the public research institutes. A total of 699 private sector enterprises reported that they performed R&D in 2012.

8.2.2 1,358 survey forms were sent out to private sector enterprises in the 2012 register of R&D-performing organisations. From these, 699 private sector enterprises (51%) reported that they performed R&D in 2012, 368 (27%) reported that they did not perform R&D in 2012 or had ceased business operations, and 247 (18%) did not respond or provided incomplete / late submissions. The remaining 44 (3%) submitted their returns under a parent or subsidiary or were duplicated in the register.

8.2.3 The private sector enterprises in the register of R&D-performing organisations included the 804 enterprises that reported that they performed R&D in 2012. Of these, 637 (79%) reported that they performed R&D in 2012, 78 (10%) reported that they did not perform R&D in 2012 or had ceased business operations. 84 (10%) did not respond or provided incomplete / late submissions to the 2012 Survey. The remaining 5 enterprises submitted their returns under a parent or subsidiary. The 78 enterprises that did not respond or provided incomplete / late submissions accounted for 1.2% ($55.1 million of $4.6 billion) of R&D expenditure of private sector enterprises in 2011.

8.2.4 In 2012, the top 150 private sector enterprises (by R&D expenditure in 2011) accounted for 81% ($3.8 billion) of private sector R&D expenditure. 142 (95%) reported that they performed R&D in 2012 and their returns were either reported under their own name or under a parent or subsidiary and 8 (5%) reported that they did not perform R&D in 2012 or had ceased business operations.

8.2.5 100% of all the government organisations, institutions of higher education and public research institutes that were surveyed in 2012 responded.

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).

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 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", "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 Singapore Standard Industrial Classification (SSIC) 2000. In 2005, it was updated to SSIC 2005, and in 2010, to the latest edition, SSIC 2010. In 2010, 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 2010 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 of the 699 private sector R&D performing organisations captured in 2012.

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 Company Registration (CR) number and 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.

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Profile of Survey Respondents

Time Series

Table 1.1A R&D Manpower

Type of R&D Manpower	Private Sector	Government Sector	Higher Education Sector	Public Research Institutes	Total
Researchers	18,657	2,401	13,781	3,593	38,432
RSEs#	16,492	2,320	7,759	3,538	30,109
PhD	1,509	424	4,347	2,087	8,367
Master	4,367	801	1,572	579	7,319
Bachelor	10,616	1,095	1,840	872	14,423
Postgrad students*	-	-	5,924	-	5,924
Non-Degree	2,165	81	98	55	2,399
Technicians	1,551	448	600	423	3,022
Other Supporting Staff	1,788	957	542	260	3,547
Total	21,996	3,806	14,923	4,276	45,001

Table 1.1B R&D Manpower (FTE)

Type of R&D Manpower	Private Sector	Government Sector	Higher Education Sector	Public Research Institutes	Total
Researchers	17,288.9	1,755.7	11,720.9	3,375.5	34,141.0
RSEs#	15,385.7	1,697.6	5,742.5	3,320.5	26,146.2
PhD	1,460.0	332.4	2,962.0	1,961.6	6,716.0
Master	4,165.5	533.8	1,181.8	534.5	6,415.6
Bachelor	9,760.2	831.4	1,598.6	824.4	13,014.6
Postgrad students*	-	-	5,924.0	-	5,924.0
Non-Degree	1,903.3	58.1	54.4	55.0	2,070.8
Technicians	1,411.3	394.6	288.6	355.6	2,450.1
Other Supporting Staff	1,503.5	852.9	294.8	216.8	2,867.8
Total	20,203.7	3,003.2	12,304.2	3,947.9	39,459.0

* Local postgraduate students at the Public Research Institutes are reported under the Higher Education Sector.
# 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 12 of explanatory notes.

Table 1.2 R&D Manpower by Nationality

Type of R&D Manpower	Private Sector		Government Sector		Higher Education Sector		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	14,231	4,426	2,236	165	5,695	8,086	2,774	819	24,936	13,496
RSEs#	12,296	4,196	2,156	164	4,208	3,551	2,720	818	21,380	8,729
PhD	993	516	369	55	2,196	2,151	1,371	716	4,929	3,438
Master	3,114	1,253	753	48	862	710	521	58	5,250	2,069
Bachelor	8,189	2,427	1,034	61	1,150	690	828	44	11,201	3,222
Postgrad students*	-	-	-	-	1,410	4,514	-	-	1,410	4,514
Master Level	-	-	-	-	122	197	-	-	122	197
PhD Level	-	-	-	-	1,288	4,317	-	-	1,288	4,317
Non-Degree	1,935	230	80	1	77	21	54	1	2,146	253
Technicians	1,164	387	404	44	582	18	404	19	2,554	468
Other Supporting Staff	1,449	339	884	73	532	10	259	1	3,124	423
Total	16,844	5,152	3,524	282	6,809	8,114	3,437	839	30,614	14,387

Table 1.3 R&D Manpower by Age Group

Type of R&D Manpower	Private Sector						Government Sector						Higher Education Sector						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	666	8,578	6,555	2,429	387	42	86	1,093	796	332	84	10	1,720	8,149	2,063	1,202	553	94	112	1,802	1,154	431	85	9	2,584	19,622	10,568	4,394	1,109	155
RSEs#	549	7,909	5,798	1,961	250	25	71	1,071	786	311	73	8	388	3,678	1,875	1,183	542	93	102	1,776	1,139	427	85	9	1,110	14,434	9,598	3,882	950	135
PhD	1	497	640	311	52	8	0	95	192	105	25	7	0	1,656	1,350	854	411	76	1	884	832	297	67	6	2	3,132	3,014	1,567	555	97
Master	90	1,847	1,709	645	71	5	11	306	336	115	32	1	50	837	350	228	94	13	4	269	201	95	9	1	155	3,259	2,596	1,083	206	20
Bachelor	458	5,565	3,449	1,005	127	12	60	670	258	91	16	0	338	1,185	175	101	37	4	97	623	106	35	9	2	953	8,043	3,988	1,232	189	18
Postgrad students*	-	-	-	-	-	-	-	-	-	-	-	-	1,292	4,443	172	14	3	0	-	-	-	-	-	-	1,292	4,443	172	14	3	0
Non-Degree	117	669	757	468	137	17	15	22	10	21	11	2	40	28	16	5	8	1	10	26	15	4	0	0	182	745	798	498	156	20
Technicians	196	621	439	218	75	2	46	157	147	60	36	2	47	119	131	217	82	4	80	129	90	92	30	2	369	1,026	807	587	223	10
Other Supporting Staff	105	588	620	355	102	18	75	419	246	123	78	16	60	159	159	107	49	8	9	65	90	71	23	2	249	1,231	1,115	656	252	44
Total	967	9,787	7,614	3,002	564	62	207	1,669	1,189	515	198	28	1,827	8,427	2,353	1,526	684	106	201	1,996	1,334	594	138	13	3,202	21,879	12,490	5,637	1,584	209

* Local postgraduate students at the Public Research Institutes are reported under the Higher Education Sector.
# 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 12 of explanatory notes.

Table 1.4 R&D Manpower by Gender

Type of R&D Manpower	Private Sector		Government Sector		Higher Education Sector		Public Research Institutes		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Researchers	13,904	4,753	1,525	876	9,305	4,476	2,332	1,261	27,066	11,366
RSEs#	12,312	4,180	1,488	832	5,549	2,210	2,298	1,240	21,647	8,462
PhD	1,165	344	283	141	3,445	902	1,484	603	6,377	1,990
Master	3,387	980	535	266	1,007	565	373	206	5,302	2,017
Bachelor	7,760	2,856	670	425	1,097	743	441	431	9,968	4,455
Postgrad students*	-	-	-	-	3,710	2,214	-	-	3,710	2,214
Non-Degree	1,592	573	37	44	46	52	34	21	1,709	690
Technicians	979	572	209	239	353	247	266	157	1,807	1,215
Other Supporting Staff	686	1,102	249	708	102	440	67	193	1,104	2,443
Total	15,569	6,427	1,983	1,823	9,760	5,163	2,665	1,611	29,977	15,024

Table 1.5 R&D Expenditure by Type of Costs

$ million

Type of Costs	Private Sector	Government Sector	Higher Education Sector	Public Research Institutes	Total
Capital Costs	807.94	43.22	145.12	144.98	1,141.26
Land, Buildings & Other Structures	156.59	24.32	18.22	10.07	209.21
Vehicles, Plant, Machinery & Equipment	651.34	18.90	126.90	134.91	932.06
Manpower Costs	1,859.68	332.03	691.37	424.97	3,308.05
Researchers	1,640.88	232.11	625.24	371.53	2,869.75
RSEs#	1,509.48	225.55	476.21	368.35	2,579.59
Postgrad students*	0.00	0.00	146.26	0.00	146.26
Non-Degree	131.39	6.56	2.77	3.18	143.90
Technicians	71.64	38.25	16.43	34.13	160.44
Other Supporting Staff	147.17	61.67	49.71	19.32	277.86
Other Operating Costs	1,747.59	349.71	356.22	341.91	2,795.43
Total	4,415.21	724.96	1,192.71	911.86	7,244.74

* Local postgraduate students at the Public Research Institutes are reported under the Higher Education Sector.
# 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 12 of explanatory notes.

Table 1.6 R&D Expenditure by Source of Funding

$ million

Source of Funding	Private Sector	Government Sector	Higher Education Sector	Public Research Institutes	Total
Own Funds	3,622.40	123.63	147.04	3.28	3,896.35
Private Sector	126.42	27.52	69.95	20.46	244.35
Government Sector	275.66	559.00	957.34	876.17	2,668.17
Higher Education Sector	0.48	2.13	4.52	0.68	7.82
Foreign-Based Companies	326.02	11.86	6.18	9.80	353.86
Foreign Governments & International Organisations	64.23	0.82	7.67	1.47	74.19
Total	4,415.21	724.96	1,192.71	911.86	7,244.74

Table 1.7 Patenting Indicators

Patenting Indicators	Private Sector	Government Sector	Higher Education Sector	Public Research Institutes	Total
Patents Applied	1,024	71	345	282	1,722
Patents Awarded	665	7	51	97	820
Patents Owned (Cumulatively as at 31 Dec 2011)	3,878	52	486	713	5,129

Table 1.8 Revenue Indicators

$ million

Revenue Indicators	Private Sector	Government Sector	Higher Education Sector	Public Research Institutes	Total
Licensing Revenue from Patents and New Technologies Developed in Singapore	1,329.58	26.74	1.09	0.65	1,358.06
Sales Revenue from Commercialised Products/ Processes Attributed to R&D Performed in Singapore	21,252.78	26.50	0.00	18.05	21,297.32

Table 2.1A Researchers by Field of Science & Technology

Field of Science & Technology	Private Sector				Government Sector				Higher Education Sector					Public Research Institutes				Total			
	PhD	Master	Bachelor	Non-Degree	PhD	Master	Bachelor	Non-Degree	PhD	Master	Bachelor	Postgrad Students	Non-Degree	PhD	Master	Bachelor	Non-Degree	PhD	Master	Bachelor	Non-Degree
Agricultural & Food Sciences	115	102	299	95	23	26	34	8	27	11	31	13	3	0	0	0	0	165	139	364	106
Biomedical & Related Sciences	280	247	618	93	183	202	284	36	1,012	318	490	1,246	7	785	149	427	13	2,260	916	1,819	149
Basic Medicine	58	27	65	21	17	7	29	1	60	15	47	114	0	28	4	27	1	163	53	168	23
Biological Sciences	126	85	139	12	10	4	12	0	535	122	223	760	2	491	94	255	7	1,162	305	629	21
Clinical Medicine	6	15	25	0	102	78	170	30	176	105	129	150	4	5	6	7	0	289	204	331	34
Health Sciences	9	3	25	3	19	91	51	0	164	55	65	89	1	1	0	0	0	193	149	141	4
Pharmaceutical Sciences & Manufacturing	68	91	199	37	2	2	2	0	68	18	24	133	0	56	15	34	0	194	126	259	37
Other Related Biomedical Sciences	13	26	165	20	33	20	20	5	9	3	2	0	0	204	30	104	5	259	79	291	30
Engineering & Technology	811	3,453	8,382	1,752	97	331	460	21	1,785	769	700	2,988	62	1,047	379	380	40	3,740	4,932	9,922	1,875
Aeronautical Engineering	5	51	173	33	11	18	14	1	29	10	5	48	0	2	2	0	0	47	81	192	34
Biomedical Engineering	23	53	75	5	3	3	5	0	315	94	100	345	7	43	2	3	2	384	152	183	14
Civil & Architecture Engineering	8	23	45	5	7	30	42	0	120	52	31	284	3	2	0	2	0	137	105	120	8
Computer Engineering	52	522	1,374	110	0	0	0	0	168	47	82	352	1	23	12	9	0	243	581	1,465	111
Electrical & Electronics Engineering	303	1,596	3,622	691	61	195	293	16	290	213	155	555	21	231	77	122	33	885	2,081	4,192	761
Infocommunication & Media Technology	43	288	856	145	0	0	3	0	263	182	151	579	14	243	130	77	2	549	600	1,087	161
Marine Engineering	34	89	266	136	0	14	2	0	26	10	5	0	0	1	0	0	0	61	113	273	136
Material Sciences & Chemical Engineering	255	371	572	105	11	11	6	0	318	70	100	412	7	287	66	83	2	871	518	761	114
Mechanical Engineering	79	432	1,336	488	4	60	95	4	247	90	69	401	9	213	90	84	1	543	672	1,584	502
Metallurgy & Metal Engineering	9	28	63	34	0	0	0	0	9	1	2	12	0	2	0	0	0	20	29	65	34
Natural Sciences (excluding Biological Sciences)	279	481	1,148	183	91	215	278	16	1,144	297	396	1,361	15	247	51	63	2	1,761	1,044	1,885	216
Chemical Sciences	175	170	267	68	8	13	41	0	175	35	50	366	2	89	8	31	1	447	226	389	71
Computer & Related Sciences	69	266	805	102	34	133	165	6	136	71	115	368	9	86	34	21	1	325	504	1,106	118
Earth & Related Environmental Sciences	28	31	42	10	40	48	62	10	372	127	135	204	2	4	0	0	0	444	206	239	22
Physical Sciences & Mathematics	7	14	34	3	9	21	10	0	461	64	96	423	2	68	9	11	0	545	108	151	5
Energy	19	33	75	11	0	1	0	0	327	80	101	267	1	0	0	0	0	346	114	176	12
Other Areas	5	51	94	31	30	26	39	0	52	97	122	49	10	8	0	2	0	95	174	257	41
Total	1,509	4,367	10,616	2,165	424	801	1,095	81	4,347	1,572	1,840	5,924	98	2,087	579	872	55	8,367	7,319	14,423	2,399

Table 2.1B Researchers (FTE) by Field of Science & Technology

Field of Science & Technology	Private Sector				Government Sector				Higher Education Sector					Public Research Institutes				Total			
	PhD	Master	Bachelor	Non-Degree	PhD	Master	Bachelor	Non-Degree	PhD	Master	Bachelor	Postgrad Students	Non-Degree	PhD	Master	Bachelor	Non-Degree	PhD	Master	Bachelor	Non-Degree
Agricultural & Food Sciences	105.2	94.3	274.6	87.1	17.3	17.3	17.0	2.7	16.0	4.2	19.5	13.0	2.3	0.0	0.0	0.0	0.0	138.5	115.7	311.1	92.1
Biomedical & Related Sciences	272.0	235.5	583.4	88.1	160.3	114.4	260.2	31.5	659.3	257.8	452.1	1,246.0	7.0	765.3	144.5	413.0	13.0	1,856.9	752.2	1,708.6	139.6
Basic Medicine	61.0	28.0	65.0	21.0	15.4	6.1	24.0	1.0	31.5	13.7	41.9	114.0	0.0	27.5	4.0	27.0	1.0	135.3	51.7	157.9	23.0
Biological Sciences	118.2	82.5	135.5	11.4	8.3	4.0	12.0	0.0	365.4	116.2	214.0	760.0	2.0	473.9	89.5	241.0	7.0	965.8	292.2	602.5	20.4
Clinical Medicine	6.0	15.0	23.0	0.0	96.3	63.0	164.7	30.0	111.9	63.6	109.4	150.0	4.0	5.0	6.0	7.0	0.0	219.2	147.6	304.1	34.0
Health Sciences	9.0	3.0	25.0	3.0	16.6	30.5	50.2	0.0	107.4	47.8	64.7	89.0	1.0	1.0	0.0	0.0	0.0	134.0	81.3	139.9	4.0
Pharmaceutical Sciences & Manufacturing	64.8	81.0	173.9	33.2	2.0	2.0	2.0	0.0	38.2	14.0	19.7	133.0	0.0	54.8	15.0	34.0	0.0	159.8	112.0	229.6	33.2
Other Related Biomedical Sciences	13.0	26.0	161.0	19.5	21.8	8.9	7.3	0.5	5.0	2.5	2.5	0.0	0.0	203.0	30.0	104.0	5.0	242.8	67.4	274.7	25.0
Engineering & Technology	790.3	3,297.6	7,710.4	1,519.9	75.5	253.2	359.1	17.2	1,198.6	498.6	556.2	2,988.0	28.0	959.0	343.8	348.8	40.0	3,023.5	4,393.1	8,974.5	1,605.1
Aeronautical Engineering	5.0	47.0	134.5	4.6	8.8	14.4	11.2	0.8	20.1	9.5	5.1	48.0	0.0	2.0	2.0	0.0	0.0	35.9	72.9	150.8	5.4
Biomedical Engineering	22.5	53.5	74.0	4.1	2.4	2.4	4.0	0.0	220.5	62.8	77.1	345.0	2.6	42.2	2.0	3.0	2.0	287.6	120.7	158.1	8.7
Civil & Architecture Engineering	5.6	18.2	25.7	2.6	3.5	11.8	23.8	0.0	75.4	40.3	26.0	284.0	2.2	2.0	0.0	2.0	0.0	86.5	70.3	77.5	4.8
Computer Engineering	51.9	514.4	1,324.8	105.7	0.0	0.0	0.0	0.0	101.4	46.2	79.5	352.0	1.0	23.0	12.0	9.0	0.0	176.3	572.7	1,413.3	106.7
Electrical & Electronics Engineering	295.9	1,527.3	3,376.7	606.1	48.8	156.2	235.8	13.2	180.0	97.9	103.0	555.0	6.4	230.2	77.0	122.0	33.0	754.8	1,858.4	3,837.5	658.7
Infocommunication & Media Technology	37.5	260.8	716.0	121.7	0.0	0.0	0.7	0.0	166.5	104.9	113.8	579.0	6.9	243.0	130.0	77.0	2.0	447.0	495.6	907.6	130.6
Marine Engineering	36.0	92.0	296.2	149.2	0.0	11.2	1.6	0.0	19.9	9.9	4.6	0.0	0.0	1.0	0.0	0.0	0.0	56.9	113.1	302.4	149.2
Material Sciences & Chemical Engineering	250.3	357.3	534.3	101.9	8.8	8.8	4.8	0.0	239.4	59.8	91.1	412.0	4.9	245.5	56.0	73.4	2.0	744.0	482.0	703.6	108.8
Mechanical Engineering	77.4	400.4	1,170.7	392.9	3.2	48.4	77.2	3.2	169.1	66.2	54.1	401.0	4.0	168.2	64.8	62.4	1.0	417.9	579.8	1,364.4	401.1
Metallurgy & Metal Engineering	8.2	26.7	57.6	31.2	0.0	0.0	0.0	0.0	6.5	1.0	1.9	12.0	0.0	2.0	0.0	0.0	0.0	16.7	27.7	59.5	31.2
Natural Sciences (excluding Biological Sciences)	269.1	456.4	1,026.8	168.0	55.3	127.1	163.9	6.7	805.3	256.7	354.0	1,361.0	7.1	229.3	46.2	60.6	2.0	1,358.9	886.4	1,605.3	183.8
Chemical Sciences	173.4	182.4	272.5	62.9	6.4	10.6	32.8	0.0	123.4	30.9	47.6	366.0	2.0	86.5	8.0	31.0	1.0	389.7	231.9	383.9	65.9
Computer & Related Sciences	61.5	227.6	681.3	92.1	26.9	86.8	89.9	4.8	77.1	49.0	78.5	368.0	2.9	86.0	34.0	21.0	1.0	251.5	397.4	870.7	100.8
Earth & Related Environmental Sciences	27.2	30.9	39.5	10.0	14.8	12.9	33.2	1.9	276.1	113.9	131.9	204.0	0.2	4.0	0.0	0.0	0.0	322.1	157.8	204.6	12.1
Physical Sciences & Mathematics	7.0	15.5	33.5	3.0	7.2	16.8	8.0	0.0	328.7	62.9	96.1	423.0	2.0	52.8	4.2	8.6	0.0	395.7	99.4	146.2	5.0
Energy	18.5	32.1	72.0	9.7	0.0	1.0	0.0	0.0	233.7	73.1	100.6	267.0	0.1	0.0	0.0	0.0	0.0	252.2	106.2	172.6	9.8
Other Areas	5.0	49.7	93.0	30.5	24.0	20.8	31.2	0.0	49.1	91.5	116.4	49.0	10.0	8.0	0.0	2.0	0.0	86.1	162.0	242.5	40.5
Total	1,460.0	4,165.5	9,760.2	1,903.3	332.4	533.8	831.4	58.1	2,962.0	1,181.8	1,598.6	5,924.0	54.4	1,961.6	534.5	824.4	55.0	6,716.0	6,415.6	13,014.6	2,070.8

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

Field of Science & Technology	Local SMEs				Local LEs				Foreign Companies			
	PhD	Master	Bachelor	Non-Degree	PhD	Master	Bachelor	Non-Degree	PhD	Master	Bachelor	Non-Degree
Agricultural & Food Sciences	67	36	114	24	0	5	19	10	48	61	166	61
Biomedical & Related Sciences	79	73	145	38	0	1	1	0	201	173	472	55
Basic Medicine	7	5	33	19	0	0	0	0	51	22	32	2
Biological Sciences	60	39	50	3	0	1	0	0	66	45	89	9
Clinical Medicine	3	3	2	0	0	0	0	0	3	12	23	0
Health Sciences	0	2	4	0	0	0	0	0	9	1	21	3
Pharmaceutical Sciences & Manufacturing	9	19	39	11	0	0	0	0	59	72	160	26
Other Related Biomedical Sciences	0	5	17	5	0	0	1	0	13	21	147	15
Engineering & Technology	161	537	1,217	421	49	555	2,089	558	601	2,361	5,076	773
Aeronautical Engineering	3	7	21	1	1	8	69	32	1	36	83	0
Biomedical Engineering	7	31	26	3	0	2	10	1	16	20	39	1
Civil & Architecture Engineering	6	15	28	2	0	1	6	3	2	7	11	0
Computer Engineering	6	44	113	11	2	80	284	27	44	398	977	72
Electrical & Electronics Engineering	41	136	375	146	26	272	819	177	236	1,188	2,428	368
Infocommunication & Media Technology	30	137	341	81	1	31	153	35	12	120	362	29
Marine Engineering	21	56	45	15	2	27	220	121	11	6	1	0
Material Sciences & Chemical Engineering	38	46	57	14	12	40	77	15	205	285	438	76
Mechanical Engineering	8	56	181	126	5	92	442	145	66	284	713	217
Metallurgy & Metal Engineering	1	9	30	22	0	2	9	2	8	17	24	10
Natural Sciences (excluding Biological Sciences)	48	110	376	70	15	87	316	34	216	284	456	79
Chemical Sciences	30	28	101	30	0	5	11	1	145	137	155	37
Computer & Related Sciences	16	73	259	38	3	68	281	25	50	125	265	39
Earth & Related Environmental Sciences	0	8	9	2	12	13	23	8	16	10	10	0
Physical Sciences & Mathematics	2	1	7	0	0	1	1	0	5	12	26	3
Energy	3	2	7	3	5	22	60	7	11	9	8	1
Other Areas	2	2	8	5	0	3	5	5	3	46	81	21
Total	360	760	1,867	561	69	673	2,490	614	1,080	2,934	6,259	990

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				Higher Education Sector				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	18.73	65.98	95.39	0.20	0.00	11.70	0.00	1.73	0.32	5.78	0.12	0.00	0.00	0.00	0.00	20.98	83.47	95.51
Biomedical & Related Sciences	58.19	211.48	232.89	0.68	12.87	116.29	52.27	99.95	87.14	95.10	28.54	92.01	89.79	140.43	86.44	440.62	563.30	400.15
Basic Medicine	0.00	69.31	9.36	0.00	0.00	11.30	7.78	10.37	3.80	8.20	1.96	1.70	3.34	6.41	2.33	19.21	95.22	21.43
Biological Sciences	22.93	49.32	54.36	0.00	0.00	0.72	4.84	64.02	53.63	28.02	5.77	89.98	74.06	68.34	0.00	304.61	146.41	64.97
Clinical Medicine	2.01	27.38	6.78	0.68	10.28	58.61	12.35	8.95	19.08	31.19	10.06	0.00	1.37	0.81	0.13	42.36	117.99	29.32
Health Sciences	0.01	26.14	7.26	0.00	2.59	26.62	11.11	14.30	8.93	22.42	6.15	0.00	0.20	0.00	0.00	26.03	75.18	24.52
Pharmaceutical Sciences & Manufacturing	25.47	23.44	144.51	0.00	0.00	0.24	4.10	2.15	1.07	4.28	4.44	0.00	5.74	6.74	57.09	34.43	34.70	210.15
Other Related Biomedical Sciences	7.78	15.88	10.63	0.00	0.00	18.81	12.09	0.16	0.63	0.99	0.16	0.34	5.09	58.13	26.89	13.99	93.81	49.77
Engineering & Technology	201.00	1,015.18	2,102.89	0.00	0.00	44.97	296.73	74.82	137.07	150.96	55.93	0.78	100.70	217.95	102.83	514.37	1,429.05	2,558.38
Aeronautical Engineering	2.11	26.56	15.75	0.00	0.00	0.00	30.01	0.08	1.87	4.07	0.48	0.00	0.39	0.20	0.00	4.45	30.82	46.24
Biomedical Engineering	2.11	11.34	36.56	0.00	0.00	0.00	10.01	11.90	19.61	24.24	9.33	0.00	9.34	1.17	0.00	42.96	36.75	55.89
Civil & Architecture Engineering	1.74	3.82	4.96	0.00	0.00	11.18	16.83	4.29	17.24	19.10	4.13	0.00	0.39	0.39	0.00	23.66	34.50	25.92
Computer Engineering	9.03	150.30	101.78	0.00	0.00	0.00	0.00	8.78	20.97	7.13	2.14	0.00	0.98	0.98	0.00	39.75	158.40	103.92
Electrical & Electronics Engineering	98.72	407.89	1,212.66	0.00	0.00	28.53	130.89	11.11	19.82	27.83	8.16	0.20	22.31	107.16	4.07	152.16	571.41	1,355.78
Infocommunication & Media Technology	13.10	103.00	81.78	0.00	0.00	0.00	0.10	7.85	20.81	27.95	8.93	0.00	11.30	42.91	22.39	53.06	173.87	113.19
Marine Engineering	0.91	87.67	22.01	0.00	0.00	0.00	6.25	1.27	1.16	4.19	0.00	0.00	0.00	0.20	0.00	3.35	92.06	28.27
Material Sciences & Chemical Engineering	49.73	59.36	331.00	0.00	0.00	2.67	0.00	17.46	20.97	17.10	16.84	0.39	46.46	44.89	26.42	135.01	124.01	374.25
Mechanical Engineering	21.69	144.52	275.25	0.00	0.00	2.59	102.63	10.85	13.56	18.61	5.66	0.20	9.34	19.86	49.95	55.63	185.59	433.49
Metallurgy & Metal Engineering	1.86	20.71	21.14	0.00	0.00	0.00	0.00	1.25	1.06	0.75	0.26	0.00	0.20	0.20	0.00	4.36	21.65	21.41
Natural Sciences (excluding Biological Sciences)	147.98	74.25	149.46	2.19	0.00	24.14	70.80	37.35	118.33	100.35	30.75	2.54	25.18	33.91	17.35	333.58	232.66	268.36
Chemical Sciences	99.61	50.47	74.28	0.00	0.00	10.01	0.33	9.03	9.12	12.05	3.41	0.39	13.72	17.76	0.00	131.87	90.29	78.02
Computer & Related Sciences	44.00	17.03	57.91	0.00	0.00	0.00	47.49	4.04	14.27	15.19	2.42	0.78	6.75	13.61	4.63	69.83	45.83	112.45
Earth & Related Environmental Sciences	3.38	3.70	10.24	2.19	0.00	7.47	22.98	7.43	42.89	47.86	17.81	0.20	0.20	0.20	0.00	56.28	59.23	51.02
Physical Sciences & Mathematics	0.99	3.05	7.03	0.00	0.00	6.66	0.00	16.86	52.05	25.25	7.12	1.17	4.52	2.34	12.72	75.60	37.30	26.86
Energy	0.67	6.48	7.26	0.00	0.00	0.32	0.33	15.82	25.82	27.08	18.07	0.00	0.00	0.00	0.00	42.31	33.88	25.66
Other Areas	2.94	1.47	22.96	0.00	0.00	0.00	91.45	9.56	51.97	10.60	9.56	0.59	0.78	0.59	0.00	65.84	12.65	123.97
Total	429.52	1,374.84	2,610.86	3.07	12.87	197.43	511.59	239.24	420.64	389.86	142.97	95.92	216.46	392.87	206.62	1,417.71	2,355.01	3,472.03

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 SMEs			Local LEs			Foreign Companies			Total		
	Basic Research	Applied Research	Experimental Development	Basic Research	Applied Research	Experimental Development	Basic Research	Applied Research	Experimental Development	Basic Research	Applied Research	Experimental Development
Agricultural & Food Sciences	17.22	17.94	3.66	0.00	2.06	3.42	1.51	45.97	88.31	18.73	65.98	95.39
Biomedical & Related Sciences	22.34	50.71	22.53	0.26	1.40	1.03	35.59	159.37	209.34	58.19	211.48	232.89
Basic Medicine	0.00	19.93	0.00	0.00	0.00	0.00	0.00	49.38	9.36	0.00	69.31	9.36
Biological Sciences	15.08	19.57	9.89	0.00	0.11	0.00	7.85	29.65	44.47	22.93	49.32	54.36
Clinical Medicine	0.44	5.46	0.00	0.00	0.00	0.00	1.57	21.92	6.78	2.01	27.38	6.78
Health Sciences	0.01	2.86	0.17	0.00	0.00	0.00	0.00	23.28	7.09	0.01	26.14	7.26
Pharmaceutical Sciences & Manufacturing	6.81	1.93	7.57	0.00	0.00	0.00	18.66	21.51	136.94	25.47	23.44	144.51
Other Related Biomedical Sciences	0.00	0.96	4.89	0.26	1.29	1.03	7.52	13.63	4.71	7.78	15.88	10.63
Engineering & Technology	26.18	125.31	182.53	15.54	243.73	453.41	159.28	646.14	1,466.95	201.00	1,015.18	2,102.89
Aeronautical Engineering	0.88	0.01	13.55	1.23	7.86	0.02	0.00	18.69	2.18	2.11	26.56	15.75
Biomedical Engineering	0.06	0.68	12.53	0.00	0.00	2.99	2.05	10.66	21.03	2.11	11.34	36.56
Civil & Architecture Engineering	0.33	0.87	2.64	0.00	0.29	0.00	1.41	2.66	2.32	1.74	3.82	4.96
Computer Engineering	0.64	6.77	6.64	0.99	6.36	44.05	7.39	137.17	51.09	9.03	150.30	101.78
Electrical & Electronics Engineering	15.10	51.74	57.64	4.52	59.31	249.91	79.10	296.84	905.11	98.72	407.89	1,212.66
Infocommunication & Media Technology	3.14	28.55	17.45	0.00	14.85	19.72	9.96	59.61	44.61	13.10	103.00	81.78
Marine Engineering	0.73	3.09	21.88	0.00	79.33	0.13	0.18	5.25	0.00	0.91	87.67	22.01
Material Sciences & Chemical Engineering	2.28	10.62	19.05	6.33	9.46	84.85	41.12	39.27	227.10	49.73	59.36	331.00
Mechanical Engineering	2.51	8.16	20.74	2.47	64.65	49.96	16.71	71.71	204.55	21.69	144.52	275.25
Metallurgy & Metal Engineering	0.50	14.81	10.42	0.00	1.62	1.77	1.36	4.28	8.95	1.86	20.71	21.14
Natural Sciences (excluding Biological Sciences)	35.98	11.08	23.88	0.18	7.77	23.44	111.83	55.41	102.14	147.98	74.25	149.46
Chemical Sciences	9.94	5.55	9.76	0.00	5.61	4.36	89.67	39.31	60.15	99.61	50.47	74.28
Computer & Related Sciences	26.02	4.94	12.30	0.18	1.98	10.95	17.79	10.11	34.66	44.00	17.03	57.91
Earth & Related Environmental Sciences	0.00	0.00	1.05	0.00	0.00	8.10	3.38	3.70	1.08	3.38	3.70	10.24
Physical Sciences & Mathematics	0.01	0.58	0.77	0.00	0.18	0.02	0.98	2.29	6.24	0.99	3.05	7.03
Energy	0.07	2.55	0.22	0.00	0.00	0.44	0.60	3.93	6.60	0.67	6.48	7.26
Other Areas	0.29	1.12	2.82	0.00	0.00	0.00	2.65	0.35	20.14	2.94	1.47	22.96
Total	102.08	208.71	235.65	15.98	254.96	481.74	311.46	911.17	1,893.47	429.52	1,374.84	2,610.86

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

$ million

Industrial Classification	Local SMEs			Local LEs			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	Total Sales Revenue	R&D Expenditure as % of Total Sales Revenue
Primary Industries & Construction	10.20	102.75	9.93%	0.00	0.00	-	0.67	42.36	1.58%	10.87	145.11	7.49%
Agriculture & Fishing	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
Mining, Quarrying, Energy & Water	8.92	82.89	10.76%	0.00	0.00	-	0.67	42.36	1.58%	9.59	125.25	7.66%
Construction	1.28	19.86	6.44%	0.00	0.00	-	0.00	0.00	-	1.28	19.86	6.44%
Manufacturing	143.30	4,342.38	3.30%	625.23	14,527.97	4.30%	1,890.14	149,586.84	1.26%	2,658.67	168,457.20	1.58%
Biomedical Manufacturing	9.42	34.87	27.02%	0.00	0.00	-	217.70	18,276.86	1.19%	227.12	18,311.72	1.24%
Medical Technology	9.05	22.37	40.46%	0.00	0.00	-	83.27	1,411.19	5.90%	92.32	1,433.57	6.44%
Pharmaceuticals	0.37	12.49	2.94%	0.00	0.00	-	134.43	16,865.66	0.80%	134.80	16,878.16	0.80%
Chemicals	20.48	806.88	2.54%	4.70	2,021.51	0.23%	77.72	27,268.52	0.29%	102.89	30,096.92	0.34%
Petrochemicals	0.67	91.52	0.73%	4.65	1,687.64	0.28%	3.63	1,765.06	0.21%	8.95	3,544.22	0.25%
Petroleum	0.18	191.53	0.09%	0.05	333.87	0.01%	1.01	22,570.82	0.00%	1.24	23,096.22	0.01%
Specialties	18.37	481.38	3.82%	0.00	0.00	-	47.25	2,335.15	2.02%	65.62	2,816.53	2.33%
Other Chemicals	1.26	42.45	2.97%	0.00	0.00	-	25.83	597.49	4.32%	27.09	639.95	4.23%
Electronics	13.50	408.84	3.30%	420.25	5,173.61	8.12%	1,248.80	80,224.77	1.56%	1,682.55	85,807.22	1.96%
Computer Peripherals	1.20	102.96	1.17%	39.78	291.87	13.63%	83.25	18,957.28	0.44%	124.23	19,352.11	0.64%
Data Storage	0.00	0.00	-	0.00	0.00	-	111.01	19,660.49	0.56%	111.01	19,660.49	0.56%
Electronic Modules & Components	2.81	251.29	1.12%	0.00	0.00	-	153.41	1,013.64	15.13%	156.22	1,264.94	12.35%
Infocomms & Consumer Electronics	5.08	51.10	9.94%	97.34	3,378.51	2.88%	27.86	1,076.83	2.59%	130.28	4,506.44	2.89%
Semiconductors	4.41	3.49	126.36%	283.13	1,503.22	18.83%	873.27	39,516.53	2.21%	1,160.81	41,023.25	2.83%
Precision Engineering	70.66	1,463.01	4.83%	52.78	1,594.29	3.31%	187.80	9,087.09	2.07%	311.24	12,144.40	2.56%
Machinery & Systems	25.94	858.36	3.02%	52.27	1,478.94	3.53%	161.31	7,433.15	2.17%	239.52	9,770.46	2.45%
Precision Modules & Components	44.71	604.65	7.39%	0.52	115.35	0.45%	26.49	1,653.94	1.60%	71.72	2,373.95	3.02%
Transport Engineering	18.28	447.32	4.09%	144.66	4,292.47	3.37%	78.39	8,950.59	0.88%	241.32	13,690.38	1.76%
Aerospace	15.33	190.23	8.06%	22.32	2,127.70	1.05%	20.61	149.68	13.77%	58.26	2,467.61	2.36%
Land	0.00	0.00	-	61.97	859.83	7.21%	54.40	1,197.81	4.54%	116.38	2,057.64	5.66%
Marine & Offshore Engineering	2.95	257.09	1.15%	60.37	1,304.94	4.63%	3.37	7,603.11	0.04%	66.69	9,165.13	0.73%
General Manufacturing	10.97	1,181.47	0.93%	2.84	1,446.09	0.20%	79.73	5,779.00	1.38%	93.54	8,406.56	1.11%
Food, Beverage & Tobacco	2.82	744.09	0.38%	2.71	694.55	0.39%	16.46	1,190.61	1.38%	21.99	2,629.25	0.84%
Printing & Recorded Media	0.42	72.70	0.58%	0.00	0.00	-	0.00	0.00	-	0.42	72.70	0.58%
Miscellaneous Industries	7.73	364.67	2.12%	0.13	751.55	0.02%	63.27	4,588.38	1.38%	71.13	5,704.60	1.25%
Services	392.94	2,303.53	17.06%	127.44	7,848.15	1.62%	1,225.29	114,621.08	1.07%	1,745.67	124,772.76	1.40%
R&D	236.54	188.18	125.70%	0.00	0.00	-	455.80	749.38	60.82%	692.35	937.56	73.85%
Biotechnology, Life, Medical Science	116.58	62.49	186.54%	0.00	0.00	-	135.90	153.78	88.37%	252.48	216.28	116.74%
Chemicals	11.59	11.60	99.87%	0.00	0.00	-	44.07	41.15	107.10%	55.66	52.75	105.51%
Electronics	80.88	72.74	111.19%	0.00	0.00	-	114.18	69.72	163.77%	195.06	142.46	136.92%
Engineering	25.79	34.78	74.13%	0.00	0.00	-	29.90	36.55	81.82%	55.69	71.33	78.07%
Environment & Clean Technologies	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
IT	1.72	6.53	26.31%	0.00	0.00	-	11.62	20.55	56.56%	13.34	27.07	49.27%
Medical Technologies	0.00	0.00	-	0.00	0.00	-	3.90	2.10	185.71%	3.90	2.10	185.71%
Other Natural Sciences	0.00	0.04	0.00%	0.00	0.00	-	116.23	425.53	27.31%	116.23	425.58	27.31%
Financial Intermediation & Other Business Activities	45.79	186.48	24.56%	73.58	3,677.92	2.00%	205.54	5,074.92	4.05%	324.92	8,939.32	3.63%
Engineering, Scientific & Technical Activities	38.21	100.37	38.07%	12.11	121.13	10.00%	37.46	417.47	8.97%	87.78	638.96	13.74%
Finance & Insurance	4.55	71.19	6.39%	61.47	3,556.80	1.73%	24.17	577.71	4.18%	90.20	4,205.70	2.14%
Other Business Activities	3.03	14.92	20.29%	0.00	0.00	-	143.91	4,079.74	3.53%	146.94	4,094.66	3.59%
Education, Health & Social Services	4.28	25.39	16.85%	0.00	0.00	-	3.90	2.95	132.24%	8.18	28.34	28.85%
Information & Communications	65.69	376.01	17.47%	7.63	299.00	2.55%	75.95	1,576.68	4.82%	149.27	2,251.68	6.63%
Logistics	0.00	0.00	-	2.78	2,360.00	0.12%	24.52	244.47	10.03%	27.30	2,604.47	1.05%
Wholesale & Retail Trade	40.03	1,522.02	2.63%	43.45	1,511.22	2.88%	455.63	105,036.66	0.43%	539.11	108,069.90	0.50%
Other Services	0.59	5.45	10.92%	0.00	0.00	-	3.95	1,936.04	0.20%	4.54	1,941.48	0.23%
Total	546.44	6,748.67	8.10%	752.67	22,376.12	3.36%	3,116.10	264,250.28	1.18%	4,415.21	293,375.07	1.50%

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

Industrial Classification	Local SMEs			Local LEs			Foreign Companies			Total		
	Patents Applied	Patents Awarded	Patents Owned	Patents Applied	Patents Awarded	Patents Owned	Patents Applied	Patents Awarded	Patents Owned	Patents Applied	Patents Awarded	Patents Owned
Primary Industries & Construction	3	0	5	0	0	0	0	0	2	3	0	7
Agriculture & Fishing	0	0	0	0	0	0	0	0	0	0	0	0
Mining, Quarrying, Energy & Water	0	0	0	0	0	0	0	0	2	0	0	2
Construction	3	0	5	0	0	0	0	0	0	3	0	5
Manufacturing	40	37	193	159	160	389	331	220	1,940	530	417	2,522
Biomedical Manufacturing	0	2	9	0	0	0	12	30	173	12	32	182
Medical Technology	0	2	9	0	0	0	11	29	173	11	31	182
Pharmaceuticals	0	0	0	0	0	0	1	1	0	1	1	0
Chemicals	1	0	2	0	0	0	2	2	21	3	2	23
Petrochemicals	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum	0	0	0	0	0	0	0	0	0	0	0	0
Specialties	1	0	2	0	0	0	2	2	21	3	2	23
Other Chemicals	0	0	0	0	0	0	0	0	0	0	0	0
Electronics	1	0	6	126	152	316	208	101	1,267	335	253	1,589
Computer Peripherals	0	0	0	0	0	0	14	5	7	14	5	7
Data Storage	0	0	0	0	0	0	9	3	274	9	3	274
Electronics Modules & Components	1	0	2	0	0	0	1	4	0	2	4	2
Infocomms & Consumer Electronics	0	0	3	6	2	18	8	4	7	14	6	28
Semiconductor	0	0	1	120	150	298	176	85	979	296	235	1,278
Precision Engineering	28	27	150	25	1	16	56	28	330	109	56	496
Machinery & Systems	20	21	79	25	1	16	39	17	242	84	39	337
Precision Modules & Components	8	6	71	0	0	0	17	11	88	25	17	159
Transport Engineering	2	2	18	8	7	57	6	2	81	16	11	156
Aerospace	0	0	0	1	0	1	0	0	4	1	0	5
Land	0	0	0	5	5	47	6	2	77	11	7	124
Marine & Offshore Engineering	2	2	18	2	2	9	0	0	0	4	4	27
General Manufacturing	8	6	8	0	0	0	47	57	68	55	63	76
Food, Beverage & Tobacco	1	0	0	0	0	0	0	0	0	1	0	0
Printing & Recorded Media	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous Industries	7	6	8	0	0	0	47	57	68	54	63	76
Services	239	77	598	23	56	270	229	115	481	491	248	1,349
R&D	189	56	352	0	0	0	106	20	99	295	76	451
Biotechnology, Life, Medical Science	47	16	64	0	0	0	32	4	0	79	20	64
Chemicals	1	1	86	0	0	0	12	0	4	13	1	90
Electronics	42	22	160	0	0	0	33	12	17	75	34	177
Engineering	99	17	41	0	0	0	8	0	0	107	17	41
Environment & Clean Technologies	0	0	0	0	0	0	0	0	0	0	0	0
IT	0	0	0	0	0	0	0	0	0	0	0	0
Medical Technologies	0	0	0	0	0	0	2	0	0	2	0	0
Other Natural Sciences	0	0	1	0	0	0	19	4	78	19	4	79
Financial Intermediation & Other Business Activities	27	11	79	18	33	120	75	68	73	120	112	272
Engineering, Scientific & Technical Activities	23	10	72	0	0	0	11	7	35	34	17	107
Finance & Insurance	3	0	1	18	33	120	4	0	9	25	33	130
Other Business Activities	1	1	6	0	0	0	60	61	29	61	62	35
Education, Health & Social Services	1	2	2	0	0	0	0	0	0	1	2	2
Information & Communications	11	3	71	0	0	1	1	0	0	12	3	72
Logistics	0	0	0	0	0	0	0	0	0	0	0	0
Wholesale & Retail Trade	11	5	94	5	23	149	47	27	309	63	55	552
Other Services	0	0	0	0	0	0	0	0	0	0	0	0
Total	282	114	796	182	216	659	560	335	2,423	1,024	665	3,878

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 SMEs		Local LEs		Foreign Companies		Total	
	Licensing Revenue	Sales Revenue	Licensing Revenue	Sales Revenue	Licensing Revenue	Sales Revenue	Licensing Revenue	Sales Revenue
Primary Industries & Construction	0.0.20	1.35	0.00	0.00	0.00	5.27	0.20	6.62
Agriculture & Fishing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining, Quarrying, Energy & Water	0.00	0.00	0.00	0.00	0.00	5.27	0.00	5.27
Construction	0.20	1.35	0.00	0.00	0.00	0.00	0.20	1.35
Manufacturing	0.27	461.43	2.40	1,795.62	1,259.54	17,773.45	1,262.21	20,030.50
Biomedical Manufacturing	0.00	4.89	0.00	0.00	0.00	216.62	0.00	221.52
Medical Technology	0.00	4.89	0.00	0.00	0.00	216.62	0.00	221.52
Pharmaceuticals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemicals	0.00	16.95	0.00	0.00	0.00	368.73	0.00	385.68
Petrochemicals	0.00	0.00	0.00	0.00	0.00	24.94	0.00	24.94
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Specialties	0.00	16.95	0.00	0.00	0.00	237.47	0.00	254.42
Other Chemicals	0.00	0.00	0.00	0.00	0.00	106.32	0.00	106.32
Electronics	0.00	53.31	0.00	752.86	1,259.54	15,060.73	1,259.54	15,866.89
Computer Peripherals	0.00	0.00	0.00	141.24	0.00	6.85	0.00	148.09
Data Storage	0.00	0.00	0.00	0.00	0.00	3,360.49	0.00	3,360.49
Electronic Modules & Components	0.00	24.00	0.00	0.00	0.00	69.20	0.00	93.20
Infocomms & Consumer Electronics	0.00	27.56	0.00	456.37	0.00	201.71	0.00	685.63
Semiconductor	0.00	1.75	0.00	155.26	1,259.54	11,422.48	1,259.54	11,579.49
Precision Engineering	0.00	164.22	0.00	470.77	0.00	1,742.86	0.00	2,377.85
Machinery & Systems	0.00	120.51	0.00	470.77	0.00	1,437.47	0.00	2,028.75
Precision Modules & Components	0.00	43.71	0.00	0.00	0.00	305.38	0.00	349.10
Transport Engineering	0.00	61.42	2.40	486.57	0.00	329.23	2.40	877.22
Aerospace	0.00	0.00	0.00	32.30	0.00	64.17	0.00	96.47
Land	0.00	0.00	2.40	454.27	0.00	265.06	2.40	719.33
Marine & Offshore Engineering	0.00	61.42	0.00	0.00	0.00	0.00	0.00	61.42
General Manufacturing	0.27	160.63	0.00	85.42	0.00	55.29	0.27	301.34
Food, Beverage & Tobacco	0.00	68.73	0.00	85.42	0.00	55.29	0.00	209.43
Printing & Recorded Media	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous Industries	0.27	91.90	0.00	0.00	0.00	0.00	0.27	91.90
Services	35.88	264.73	0.00	467.69	31.29	483.23	67.17	1,215.65
R&D	15.03	38.02	0.00	0.00	9.90	30.90	24.92	68.91
Biotechnology, Life, Medical Science	1.16	11.69	0.00	0.00	9.49	9.62	10.65	21.31
Chemicals	0.00	0.00	0.00	0.00	0.40	0.43	0.40	0.43
Electronics	0.00	9.58	0.00	0.00	0.00	19.42	0.00	29.00
Engineering	13.87	14.17	0.00	0.00	0.00	0.22	13.87	14.39
Environment & Clean Technologies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IT	0.00	2.54	0.00	0.00	0.00	0.00	0.00	2.54
Medical Technologies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Natural Sciences	0.00	0.04	0.00	0.00	0.00	1.20	0.00	1.25
Financial Intermediation & Other Business Activities	7.67	25.01	0.00	237.69	0.00	61.38	7.67	324.08
Engineering, Scientific & Technical Activities	7.67	24.37	0.00	0.00	0.00	10.00	7.67	34.37
Finance & Insurance	0.00	0.11	0.00	237.69	0.00	44.27	0.00	282.08
Other Business Activities	0.00	0.53	0.00	0.00	0.00	7.11	0.00	7.64
Education, Health & Social Services	0.03	21.41	0.00	0.00	0.00	0.00	0.03	21.41
Information & Communications	12.51	114.62	0.00	170.00	0.75	60.09	13.26	344.71
Logistics	0.00	0.00	0.00	0.00	0.00	23.96	0.00	23.96
Wholesale & Retail Trade	0.29	62.59	0.00	60.00	0.00	306.90	0.29	429.49
Other Services	0.35	3.08	0.00	0.00	20.64	0.00	20.99	3.08
Total	36.35	727.51	2.40	2,263.31	1,290.83	18,261.95	1,329.58	21,252.78

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

Industrial Classification	Local SMEs	Local LEs	Foreign Companies												Total
			USA	Canada	UK	France	Germany	Netherlands	Italy	Japan	China (incl. HK)	Taiwan	Asean (excl. S'pore)	Others	
Primary Industries & Construction	6	0	0	0	0	1	0	0	0	0	0	0	0	0	7
Agriculture & Fishing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining, Quarrying, Energy & Water	1	0	0	0	0	1	0	0	0	0	0	0	0	0	2
Construction	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Manufacturing	142	33	39	0	6	1	10	18	1	36	2	6	3	30	327
Biomedical Manufacturing	7	0	4	0	1	0	1	3	0	1	0	0	0	5	22
Medical Technology	6	0	2	0	0	0	1	2	0	1	0	0	0	3	15
Pharmaceuticals	1	0	2	0	1	0	0	1	0	0	0	0	0	2	7
Chemicals	19	2	11	0	1	0	2	7	1	8	1	0	1	6	59
Petrochemicals	2	1	3	0	0	0	0	0	1	2	0	0	0	0	9
Petroleum	2	1	0	0	0	0	0	1	0	0	0	0	0	0	4
Specialties	9	0	7	0	1	0	2	6	0	6	1	0	1	5	38
Other Chemicals	6	0	1	0	0	0	0	0	0	0	0	0	0	1	8
Electronics	11	10	10	0	3	1	3	6	0	7	0	4	2	11	68
Computer Peripherals	3	1	1	0	1	0	0	2	0	1	0	0	0	1	10
Data Storage	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2
Electronic Modules & Components	1	0	2	0	1	0	1	0	0	3	0	1	0	0	9
Infocomms & Consumer Electronics	4	6	1	0	0	1	1	0	0	2	0	0	1	2	18
Semiconductor	3	3	6	0	1	0	1	4	0	0	0	3	1	7	29
Precision Engineering	62	5	8	0	1	0	3	0	0	11	1	2	0	3	96
Machinery & Systems	35	4	4	0	0	0	1	0	0	8	1	2	0	2	57
Precision Modules & Components	27	1	4	0	1	0	2	0	0	3	0	0	0	1	39
Transport Engineering	9	11	3	0	0	0	0	0	0	2	0	0	0	3	28
Aerospace	3	6	2	0	0	0	0	0	0	0	0	0	0	0	11
Land	0	2	1	0	0	0	0	0	0	2	0	0	0	0	5
Marine & Offshore Engineering	6	3	0	0	0	0	0	0	0	0	0	0	0	3	12
General Manufacturing	34	5	3	0	0	0	1	2	0	7	0	0	0	2	54
Food, Beverage & Tobacco	17	3	0	0	0	0	0	1	0	7	0	0	0	1	29
Printing & Recorded Media	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Miscellaneous Industries	14	2	3	0	0	0	1	1	0	0	0	0	0	1	22
Services	197	11	39	1	7	7	13	12	0	29	7	1	4	37	365
R&D	48	0	18	0	1	2	3	0	0	8	2	0	1	12	95
Biotechnology, Life, Medical Science	16	0	6	0	1	0	0	0	0	3	1	0	1	1	29
Chemicals	3	0	2	0	0	0	0	0	0	1	0	0	0	3	9
Electronics	9	0	1	0	0	1	2	0	0	2	0	0	0	2	17
Engineering	13	0	0	0	0	1	0	0	0	0	1	0	0	2	17
Environment & Clean Technologies	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IT	6	0	3	0	0	0	0	0	0	1	0	0	0	0	10
Medical Technologies	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Other Natural Sciences	1	0	5	0	0	0	1	0	0	1	0	0	0	4	12
Financial Intermediation & Other Business Activities	31	5	6	0	1	1	2	1	0	8	0	0	0	8	63
Engineering, Scientific & Technical Activities	19	1	0	0	0	0	0	0	0	1	0	0	0	3	24
Finance & Insurance	4	4	0	0	0	0	2	0	0	1	0	0	0	2	13
Other Business Activities	8	0	6	0	1	1	0	1	0	6	0	0	0	3	26
Education, Health & Social Services	7	0	1	0	1	0	0	0	0	0	0	0	0	0	9
Information & Communications	64	1	3	0	2	1	0	1	0	0	4	0	1	7	84
Logistics	0	1	1	0	0	0	0	0	0	0	0	0	0	2	4
Wholesale & Retail Trade	44	4	10	1	2	3	8	10		13	1	1	2	7	106
Other Services	3	0	0	0	0	0	0	0	0	0	0	0	0	1	4
Total	345	44	78	1	13	9	23	30	1	65	9	7	7	67	699

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	3	1	2	0	0	1	0	0	0	0	7
Agriculture & Fishing	0	0	0	0	0	0	0	0	0	0	0
Mining, Quarrying, Energy & Water	0	0	1	0	0	1	0	0	0	0	2
Construction	3	1	1	0	0	0	0	0	0	0	5
Manufacturing	59	64	44	41	46	23	8	9	9	24	327
Biomedical Manufacturing	0	2	4	3	4	2	1	1	2	3	22
Medical Technology	0	1	4	3	3	1	1	0	1	1	15
Pharmaceuticals	0	1	0	0	1	1	0	1	1	2	7
Chemicals	12	13	10	6	15	2	0	0	1	0	59
Petrochemicals	2	2	3	1	1	0	0	0	0	0	9
Petroleum	3	0	0	1	0	0	0	0	0	0	4
Specialties	5	7	7	4	13	2	0	0	0	0	38
Other Chemicals	2	4	0	0	1	0	0	0	1	0	8
Electronics	3	6	4	9	12	7	2	5	5	15	68
Computer Peripherals	3	1	1	2	0	1	0	0	0	2	10
Data Storage	0	0	0	0	0	0	0	0	0	2	2
Electronic Modules & Components	0	1	0	3	3	0	0	0	0	2	9
Infocomms & Consumer Electronics	0	2	1	3	6	1	2	2	0	1	18
Semiconductors	0	2	2	1	3	5	0	3	5	8	29
Precision Engineering	21	22	16	14	9	8	2	1	1	2	96
Machinery & Systems	13	10	9	8	8	4	2	1	0	2	57
Precision Modules & Components	8	12	7	6	1	4	0	0	1	0	39
Transport Engineering	3	4	4	5	2	3	2	2	0	3	28
Aerospace	1	1	1	4	0	1	2	1	0	0	11
Land	0	0	0	0	1	2	0	0	0	2	5
Marine & Offshore Engineering	2	3	3	1	1	0	0	1	0	1	12
General Manufacturing	20	17	6	4	4	1	1	0	0	1	54
Food, Beverages & Tobacco	13	9	2	2	2	1	0	0	0	0	29
Printing & Recorded Media	2	1	0	0	0	0	0	0	0	0	3
Miscellaneous Industries	5	7	4	2	2	0	1	0	0	1	22
Services	74	68	59	36	54	32	11	9	7	15	365
R&D	11	13	21	6	15	11	3	4	4	7	95
Biotechnology, Life, Medical Science	2	3	7	1	3	6	2	1	1	3	29
Chemicals	0	0	3	2	1	1	0	1	1	0	9
Electronics	2	1	6	0	3	1	0	0	2	2	17
Engineering	3	5	1	0	6	0	0	2	0	0	17
Environment & Clean Technologies	0	0	0	0	0	0	0	0	0	0	0
IT	3	2	2	2	0	1	0	0	0	0	10
Medical Technologies	0	0	0	0	1	0	0	0	0	0	1
Other Natural Sciences	1	2	2	1	1	2	1	0	0	2	12
Financial Intermediation & Other Business Activities	10	12	9	9	9	7	4	0	0	3	63
Engineering, Scientific & Technical Activities	4	3	4	3	4	2	4	0	0	0	24
Finance & Insurance	1	0	2	3	4	2	0	0	0	1	13
Other Business Activities	5	9	3	3	1	3	0	0	0	2	26
Education, Health & Social Services	1	2	3	2	1	0	0	0	0	0	9
Information & Communications	23	27	10	10	9	3	0	1	0	1	84
Logistics	0	0	0	2	1	0	0	0	1	0	4
Wholesale & Retail Trade	28	12	16	7	18	11	4	4	2	4	106
Other Services	1	2	0	0	1	0	0	0	0	0	4
Total	136	133	105	77	100	56	19	18	16	39	699

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	112	77	29	7	5	4	1	0	0	0	235
6 - 10	19	43	44	21	15	3	0	0	1	0	146
11 - 20	4	10	28	29	35	7	0	0	0	1	114
21 - 40	0	2	4	18	31	13	4	4	2	3	81
41 - 60	1	0	0	0	10	13	7	3	3	5	42
61 - 80	0	1	0	1	1	6	2	2	1	1	15
81 - 100	0	0	0	1	1	6	2	3	3	1	17
101 and Above	0	0	0	0	2	4	3	6	6	28	49
Total	136	133	105	77	100	56	19	18	16	39	699

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%	0.97%	0.57%
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%	1.05%	0.66%
1995	8,340	4,163	1,887	-	47.7	-	1,366.56	881.37	64.50%	1.11%	0.71%
1996	10,153	5,085	2,237	-	50.1	-	1,792.14	1,133.42	63.24%	1.34%	0.84%
1997	11,302	5,792	2,485	-	53.4	-	2,104.56	1,314.52	62.46%	1.43%	0.89%
1998	12,655	6,573	2,733	-	57.8	-	2,492.26	1,536.10	61.63%	1.75%	1.08%
1999	13,817	7,502	3,054	-	62.6	-	2,656.30	1,670.86	62.90%	1.85%	1.16%
2000	14,483	7,997	3,111	2,570	66.1	77.8	3,009.52	1,866.05	62.00%	1.85%	1.15%
2001	15,366	8,389	3,347	3,211	65.9	79.7	3,232.68	2,045.02	63.26%	2.06%	1.30%
2002	15,654	8,598	3,639	3,723	67.5	83.5	3,404.66	2,091.33	61.43%	2.10%	1.29%
2003	17,074	9,827	3,791	4,065	73.8	91.4	3,424.47	2,081.19	60.77%	2.05%	1.24%
2004	18,935	11,596	4,063	3,705	80.9	96.7	4,061.90	2,589.99	63.76%	2.13%	1.36%
2005	21,338	13,217	4,575	3,718	90.1	105.8	4,582.21	3,031.34	66.15%	2.19%	1.45%
2006	22,675	13,893	5,005	3,761	87.4	101.9	5,009.70	3,292.99	65.73%	2.16%	1.42%
2007	24,506	14,921	5,637	4,094	90.4	105.5	6,339.09	4,234.99	66.81%	2.36%	1.58%
2008	25,745	15,349	6,147	4,605	87.6	103.2	7,128.11	5,120.02	71.83%	2.64%	1.90%
2009	26,608	15,068	6,751	5,295	87.8	105.3	6,042.83	3,724.49	61.63%	2.20%	1.36%
2010	28,296	15,640	7,477	5,760	90.2	108.6	6,489.02	3,947.61	60.84%	2.05%	1.25%
2011	29,482	16,535	7,754	5,990	91.1	109.6	7,448.48	4,628.19	62.14%	2.23%	1.39%
2012	30,109	16,492	8,367	5,924	89.6	107.2	7,244.74	4,415.21	60.94%	2.10%	1.28%

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	1562.8	70,390.6
1991	-	-	-	-	-	311	1673.7	78,059.0
1992	-	20	96	38.45	-	331	1733.6	84,724.7
1993	142	52	200	41.22	-	410	1,762.7	97,711.9
1994	263	58	204	52.80	-	427	1,842.2	111,862.2
1995	242	51	256	111.41	-	440	1,749.3	123,399.8
1996	316	91	614	27.34	6,381.02	496	2,024.9	134,207.6
1997	490	132	831	26.61	9,647.26	508	2,116.0	147,435.5
1998	579	136	847	50.97	13,369.92	571	2,187.9	142,278.1
1999	673	161	1,077	671.89	10,663.94	593	2,208.7	143,867.9
2000	774	239	1,268	74.63	15,577.77	539	2,192.3	162,584.1
2001	913	410	1,456	55.17	16,659.52	513	2,330.5	157,136.1
2002	936	451	1,739	87.50	11,445.60	519	2,320.6	162,299.5
2003	1,001	460	2,314	132.37	10,360.46	617	2,312.3	167,174.0
2004	1,257	599	2,570	82.70	12,068.56	765	2,341.9	190,484.2
2005	1,594	877	3,475	93.66	13,508.99	900	2,367.3	208,763.7
2006	2,036	933	4,717	139.15	25,678.32	897	2,594.1	231,407.2
2007	1,727	953	5,785	127.88	16,385.51	992	2,710.3	268,062.2
2008	1,581	730	5,455	42.43	21,548.81	888	2,939.9	269,658.1
2009	1,569	747	6,067	31.80	12,299.85	854	3,030.0	274,655.3
2010	1,762	653	5,450	32.16	10,900.29	799	3,135.9	315,921.2
2011	1,913	855	4,763	95.63	13,478.21	804	3,237.1	334,092.7
2012	1,722	820	5,129	1,358.06	21,297.32	699	3,361.8	345,560.5

[1] **Source - Yearbook of Statistics 2013**

[2] **Source - Singapore Department of Statistics: http://www.singstat.gov.sg/statistics/browse_by_theme/economy/time_series/gdp2.xls (Last updated 22 Feb 2013)**

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