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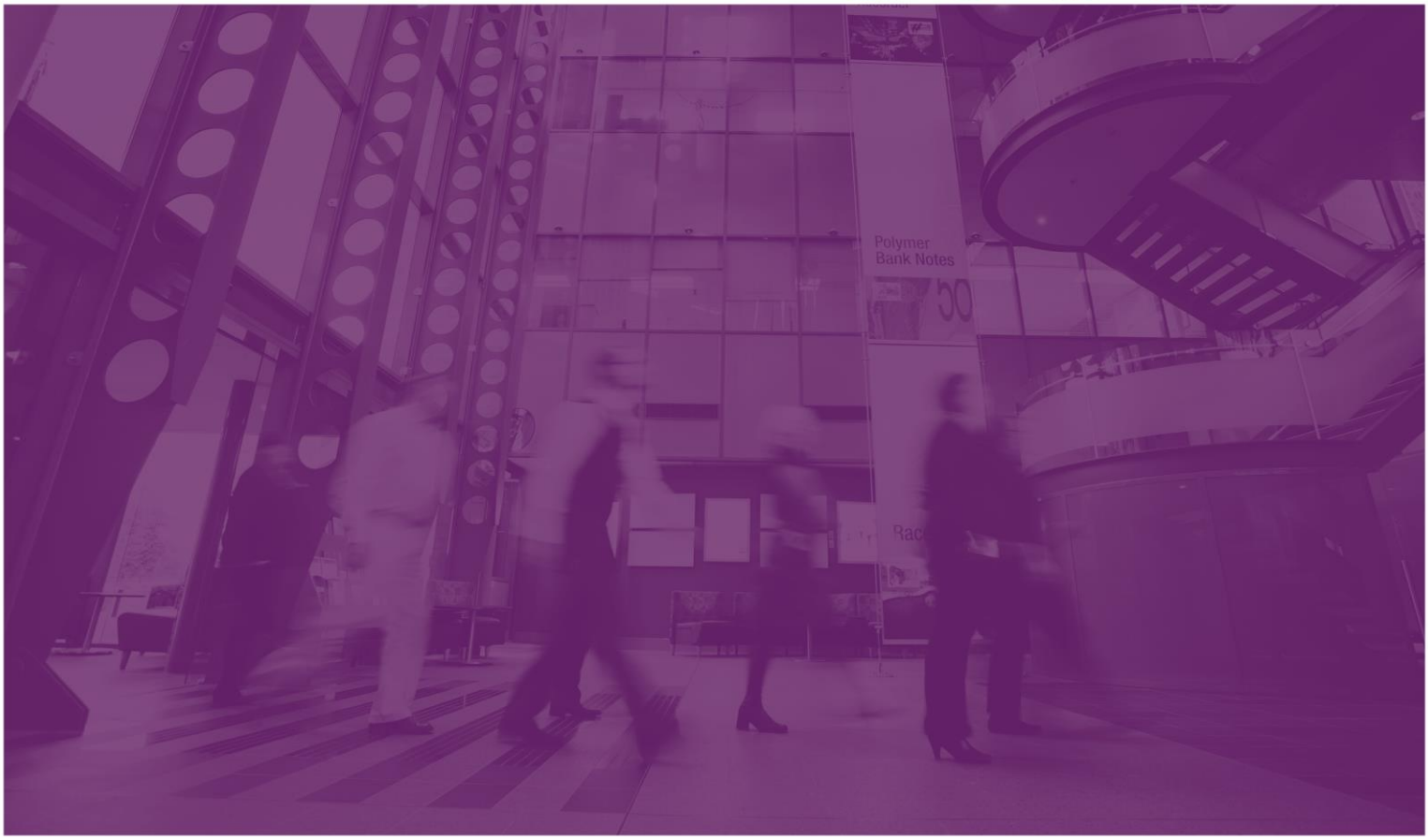
IP Australia

A Patent Analytics Study on the Australian Advanced Manufacturing Industry

April 2017



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Disclaimer
The information contained in this brief has been gathered from global intellectual property (IP) databases and represents a snapshot of IP rights in the advanced manufacturing industry at a particular point in time. It is provided for general information only and should not be relied upon for the purposes of any particular matter. It is not a report on patentability or freedom to operate and should not be relied upon for those purposes.

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Executive summary

Innovation is critical in developing new avenues for economic growth and prosperity for Australia. Innovation can take many different forms and is consequently used and produced by many different businesses.

In 2013-14, the manufacturing sector accounted for 6.4 per cent of Australian gross domestic product and 25.7 per cent of Australia's research and development (R&D) expenditure.[1] There is currently an array of diverse business models and government policies that aim to encourage and improve innovation for growth now and into the future.

In recent years, the emergence and growing importance of advanced manufacturing has been a critical part of Australia's innovation system and economy.[2] It is more challenging to define than conventional manufacturing, as it involves not only new ways to manufacture existing products and the manufacture of new products from emerging advanced technologies, but also it denotes the process by which knowledge-intensive value is added in both the pre- and post‑production phase including R&D and distribution. Advanced manufacturing embraces specialised technology from medical devices and pharmaceuticals to precision engineering and electronics. The growing impact of advanced manufacturing makes it important to have a better understanding of its activities.

This report analyses Australian advanced manufacturing through the lens of intellectual property. This report uses the scale and intensity of patent activity to provide an overview of an important part of the Australian innovation system.

The study identified 22 265 Patent Cooperation Treaty (PCT) applications related to advanced manufacturing that originated in Australia between 2000 and 2013. Australia ranked fourteenth in applications globally, which is comparable to Israel and Finland. This should be viewed positively given Australia's fifty-third ranking in population. The growth in Australian PCT applications was 15 per cent (203 PCT applications) over 14 years, which is much lower when compared with the steep growth of the rest of the world. There were 180 thousand PCT applications globally in 2013 which is a 102 per cent increase from 2000. Each of the individual Australian technology sectors also grew much less than its global counterpart.

When comparing the individual technology sectors, the electrical sector, which includes communication and measurement technologies and electrical components, had the largest number of applications originating in Australia and globally. This sector was a major focus and accounted for 43 per cent of global PCT applications and 32 per cent of Australian PCT applications. Following the electrical sector, the next largest numbers of applications were found in mechanical engineering, pharmaceuticals and medical devices. This was the same in Australia and globally. The major difference was that Australia had a strong chemical engineering presence due to mining technologies, ranking fifth of eight sectors. Globally this sector was eighth.

To identify if Australia has technological specialisations in the eight advanced manufacturing categories compared to other countries the Relative Specialisation Index (RSI) was used. The RSI normalises the patenting activity of each technology to identify areas of technological strength that may otherwise go unnoticed. The medical devices sector had the highest comparative ranking (tenth globally), followed by chemical engineering (thirteenth) and transport (fifteenth). This shows Australia's strength in these areas.

Research organisations such as CSIRO, universities and medical research institutes were the major applicants overall, accounting for 10 of the top 15 applicants. They were also prominent in six of the eight technology sectors, having less of a focus on mechanical engineering and

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[1] Australian Bureau of Statistics (2015), 8104.0 – Research and Experimental Development, Businesses, Australia, 2013-14; Australian Bureau of Statistics (2016), 5204.0 - Australian System of National Accounts 2015-16, Table 5 Gross Value Added (GVA) by Industry

[2] Committee for Economic Development of Australia (2014), Advanced Manufacturing: Beyond the production line

transport. Major corporate applicants included medical technology companies Cochlear and ResMed, along with BlueScope Steel and Rio Tinto. They accounted for 10 of the top 15 Australian advanced manufacturing applicants and were prominent in six technology sectors. Research institutions had the highest application numbers.

In this study we used multiple applicants as a proxy for collaboration. The proportion of applications involving collaborations varies with applicant type. Across the advanced manufacturing technologies overall, 20 per cent of applications from Australian research institutions are collaborative efforts, followed by large Australian firms at 15 per cent and international entities at 13 per cent. This proportion drops to less than five per cent when small-to-medium enterprises (SMEs) are involved. The results for individual technology sectors were similar; where research institutions collaborated most in seven of the eight technology sectors, while SMEs collaborated least across all sectors.

Glossary

ANZSIC	Australian and New Zealand Standard Industrial Classification
CAGR	Compound Annual Growth Rates
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CPC	Cooperative Patent Classification
EPO	European Patent Office
IP	Intellectual Property
IPC	International Patent Classification
IPGOD	Intellectual Property Government Open Data
ISIC	International Standard Industrial Classification of All Economic Activities
NACE	Statistical Classification of Economic Activities in the European Community
NPE	National Phase Entry
NICTA	National Information and Communications Technology Australia Limited
PATSTAT	EPO worldwide patent statistical database
PCT	Patent Cooperation Treaty
RSI	Relative Specialisation Index
SME	Small-to-Medium Enterprise
USPTO	United States Patent and Trademark Office
WEHI	Walter and Eliza Hall Institution of Medical Research
WIPO	World Intellectual Property Organization

1 Objectives and methodology

This report provides an analysis of Australian advanced manufacturing through the lens of patent applications. By using the scale and intensity of patent activity, identifying areas of technological specialisation, and assessing the level of collaboration, the report provides an overview of advanced manufacturing in Australia.

Objectives

The key objectives of this report were to:

1. Determine the scale of patenting activity in advanced manufacturing originating in Australia;
2. Identify the key applicants of Australian-originating advanced manufacturing patent applications;
3. Determine the technological distribution of advanced manufacturing patent applications; and
4. Assess the level of collaboration for Australian advanced manufacturing patent applications.

Patents

A patent is a right that is granted for any device, substance, method or process that is new, inventive and useful. Patents can be used as indicators of research output.[3] Australian patent rights are legally enforceable and give the owner exclusive rights to commercially exploit the invention for a period of up to 20 years in Australia. There are two major filing routes for patent applications: international and direct.

The international route involves filing a Patent Cooperation Treaty (PCT) application, which establishes an application date in all 148 contracting states.[4] Subsequent prosecution at national patent offices, referred to as national-phase entry (NPE), is made at the discretion of the applicant. A patent can only be enforced once it has been granted and a PCT application must enter the national phase to proceed towards grant. Applications generally relating to the same invention but filed in different countries are known as patent families. Patent families enable us to analyse inventive activity regardless of the number of countries in which protection is sought. Direct applications are only filed in the countries of interest.

This study focussed on patent applications of Australian origin filed through the PCT route. We classified patents as being of 'Australian origin' when at least one inventor or applicant had an Australian address. The inventor is the person responsible for the creation of the idea, while the applicant is the person or entity that applies for the patent. The inventor and the applicant can be the same entity, or the applicant can be an entity to whom the inventor has assigned their rights, such as the inventor's employer. There may be more than one inventor or more than one applicant on a single application, in which case it can be useful to assign 'shares'. For example, if one PCT application has two applicants, each is assigned an 'applicant share' of 0.5 for that application.

Definition of Australian advanced manufacturing

Advanced manufacturing refers to highly specialised products and processes in areas such as medical technology, biopharmaceuticals, mining, agribusiness, aerospace and defence, where Australian expertise is the source of competitive advantage. Just as importantly, it denotes the process by which knowledge-intensive value is added in both the pre- and post-production phase

[3] Katila, R. (2000), 'Using Patent Data to Measure Innovation Performance', International Journal of Business Performance Measurement, 2000, 2(1-3), 180-93

[4] WIPO, List of PCT Contracting States

in areas including research and development, concept design, planning, engineering and after-sales service.[5]

Given the diversity and emergence of these new types of manufacturing, advanced manufacturing is as not readily classified as more conventional industries. For the purposes of this report, the starting point was the Australian and New Zealand Standard Industry Classification (ANZSIC) classes,[6] providing industry sectors that could be translated into patent technology classes. The set of ANZSIC codes that accord best to advanced manufacturing can be found in Appendix A. It should be noted that not all potential sectors of advanced manufacturing were included in this report. Food manufacturing, which has been assessed in a previous report,[7] was not included, nor was technology related to energy generation. Also not included were digital technologies (software development) which are covered under copyright law. Advanced manufacturing technologies that were not captured under this methodology would be worthy of investigating in another study.

Time frame for analysis

Patents with a priority date between 1 January 2000 and 31 December 2013 were used in this analysis.[8] The priority date is the most relevant for ascertaining the date of invention. It is the earliest date recorded on patent applications and therefore allows the comparison of dates unaffected by administrative variations or delays. PCT applications typically have an 18-month delay from filing to publication as a result PCT applications published after September 2015 were not available at the time of extracting data for this report.

Applicant (entity) type

For Australian entities (private enterprises with a headquarters in Australia), company size was based on the number of employees. A company was considered to be a small to medium enterprise (SME) if it has less than 200 employees; otherwise it was considered a large firm. Australian research institutions include universities and their associated technology transfer offices and government research agencies. International entities include international research institutions and universities as well as private companies who are not headquartered in Australia, although they often have a domestic branch. They appear in the report because they have either collaborated with an Australian applicant or inventor, or applied for an application from their local branch.

Data extraction and analysis

In order to identify patents relating to advanced manufacturing, a list of ANZSIC were identified to define technology areas (listed in Appendix A). There is no simple matching approach between industry codes and patent classifications. We account for the differences in classification we used a series of conversions that encompassed ANZSIC 2006 to the International Standard Industry Codes (ISIC 4), which allowed us to use the NACE 2 to International Patent Classification Marks (IPC) conversion tables developed by Eurostat and the University of Leuven.[9] The IPC marks were then converted to Cooperative Patent Classification Marks (CPCs) (see Appendix B, Figure B.1). At the sub-class level these were identical, however we converted them to CPCs as it was beneficial for performing the technology breakdown. This method was employed as it was an

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[5] Advanced Manufacturing Growth Centre, Membership Prospectus

[6] Australian Bureau of Statistics (2013), Australian and New Zealand Standard Industrial Classification (ANZSIC), 2006 (Revision 2.0)

[7] IP Australia, The Australian food industry: a patent analytics report

[8] The Autumn 2015 edition of the PATSTAT database used to identify PCT applications in this study contains all publications to the beginning of September 2015, essentially comprising publications with a priority date up to March 2014. Some documents with later priority dates are published less than 18 months from the priority date and are in the database.

[9] Eurostat, Concordance IPC V8 – NACE REV.2

objective approach for identifying classification marks relating to advanced manufacturing. The final set of classification marks was reviewed and minor amendments made as needed. This predominantly involved removing a small number of marks that were clearly not advanced manufacturing. The methodology is described in Appendix B.

For the purposes of this report we developed a technology breakdown of PCT applications from Australia based on specified CPC marks. CPC marks are used internationally to classify the invention(s) disclosed in a patent document. The eight advanced manufacturing technology sectors are as follows:

- Materials
- Chemical engineering
- Chemistry
- Pharmaceutical
- Medical devices
- Electrical
- Mechanical engineering
- Transport

The technology sectors were chosen based on a combination of the specific focus of the industries and their distinctness in the classification system.

The bibliographic information for those applications includes application dates, the names and origins of applicants and inventors. That information was used to:

- Determine the number of inventions (PCT applications) originating in Australia;
- Visualise developments in patenting activity over time;
- Compare Australian and worldwide patenting activity; and
- Determine the share of PCT applications with multiple applicants, which is a proxy for collaboration.

For PCT applications that subsequently entered national phase in Australia, further information regarding the applicants was available through the Australian Intellectual Property Government Open Data (IPGOD) database.

Measuring collaboration in patent applications

The presence of multiple applicants on a patent document is a proxy for collaborative work, and was used in this report to analyse the level and nature of collaboration amongst applicants. The type of applicant was analysed in terms of patenting activity and levels of collaboration including:

- Business with business collaboration;
- Business with research institution collaboration; and
- Research institution with research institution collaboration.

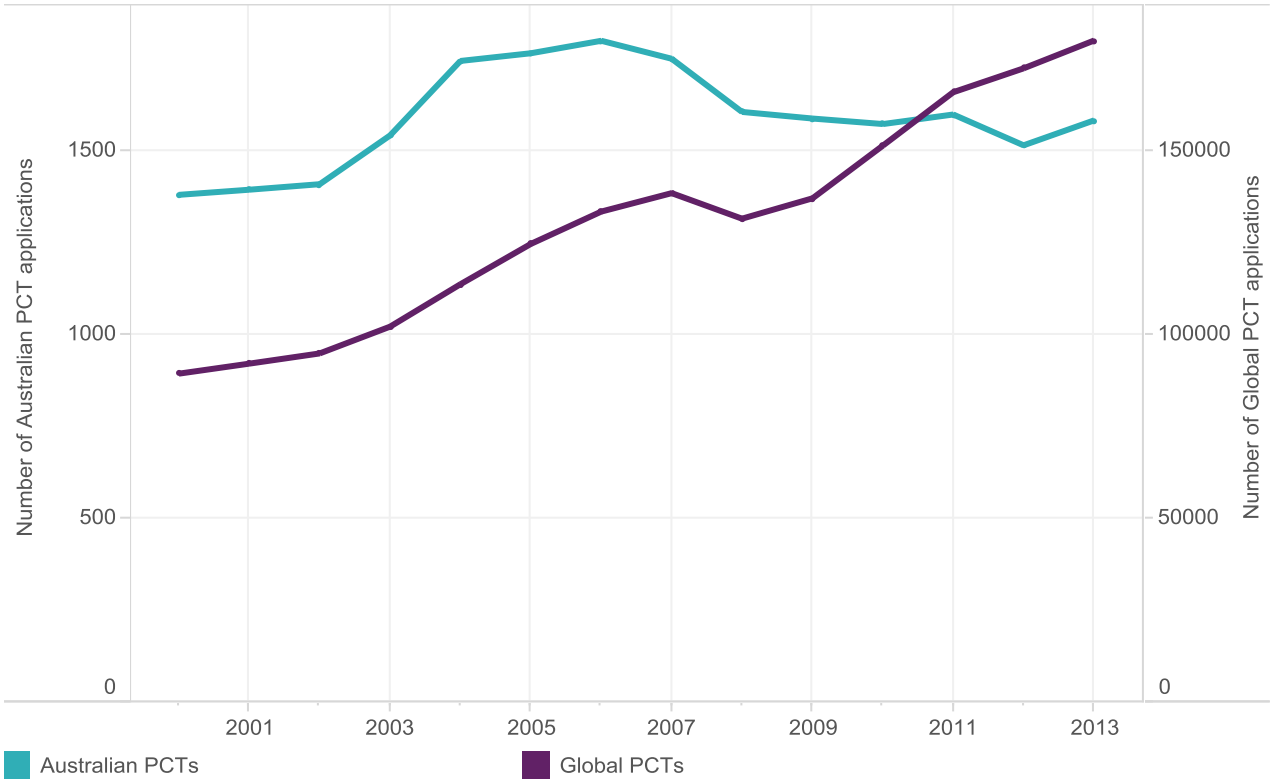
Technological specialisation

To identify if Australia has technological specialisations in the eight advanced manufacturing categories compared to other countries the Relative Specialisation Index (RSI) was used. The RSI normalises the patenting activity of each technology to identify areas of technological strength that may otherwise go unnoticed. The RSI accounts for some countries, like United States, which file more patent applications across all technologies generally than other countries, due to factors such as the size of their economy. Information about how the index is calculated is presented in Appendix D. A positive RSI indicates a specialisation for that technology, whereas a values less than zero indicates no specialisation. Countries applying for fewer than 100 patents are not measured since their contribution is not considered relevant for this metric.

2 Australia's patenting activity in advanced manufacturing

There were 22 265 Australian PCT applications in advanced manufacturing filed between 2000 and 2013, representing 0.9 per cent of 1.8 million global patent applications filed across this broad technology landscape. Global patent activity in advanced manufacturing grew strongly since 2000 and recorded around 180 000 applications in 2013 (Figure 2.1). In contrast, Australia's activity was stable over the same time with a relatively small amount of total growth from 2000-2013 (15 per cent or 203 applications).

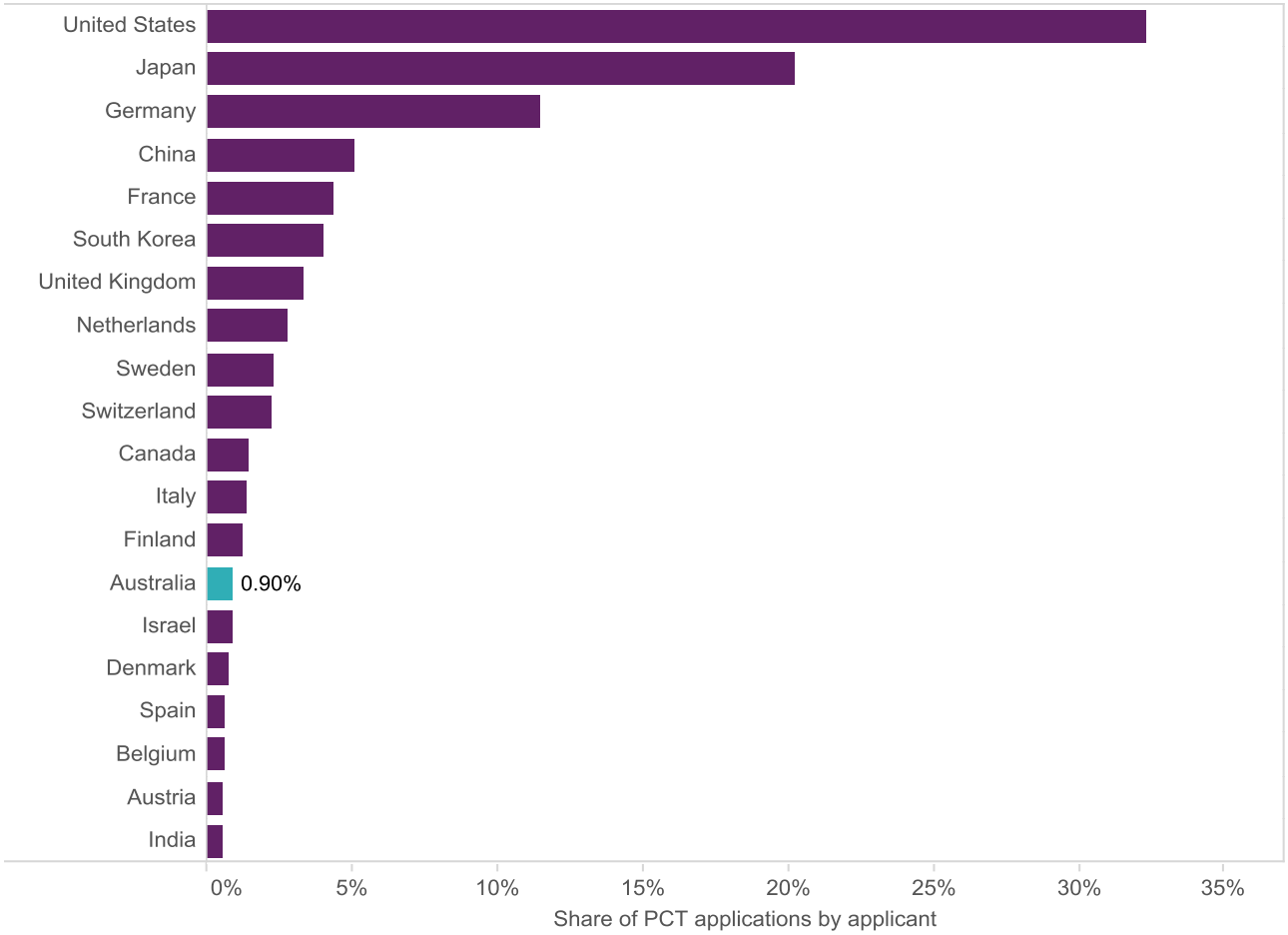
Figure 2.1: Australian and global PCT applications



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

The United States, Japan and Germany dominated the global PCT applications in advanced manufacturing (Figure 2.2). Australia, with 0.90 per cent of the global applicant share, ranked fourteenth.

Figure 2.2: Share of advanced manufacturing applications across the top twenty countries

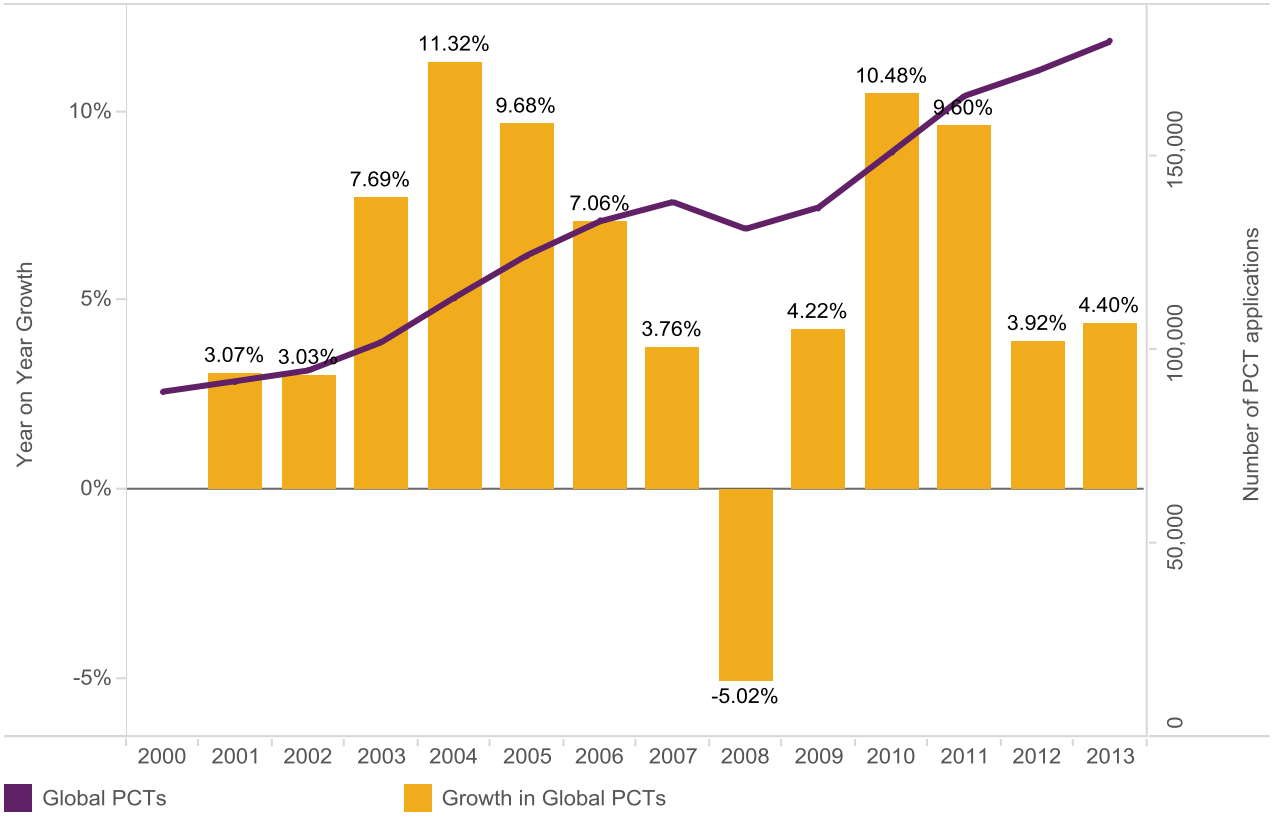


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Global filing rates for advanced manufacturing increased consistently since 2000 (Figure 2.3). Every year except 2008 showed positive growth and the numbers of applications by global applicants increased 102 per cent on the 2000 level. The decreased applications in 2008 can most likely be attributed to the global financial crisis when research and innovation activity slowed due to financial restrictions.

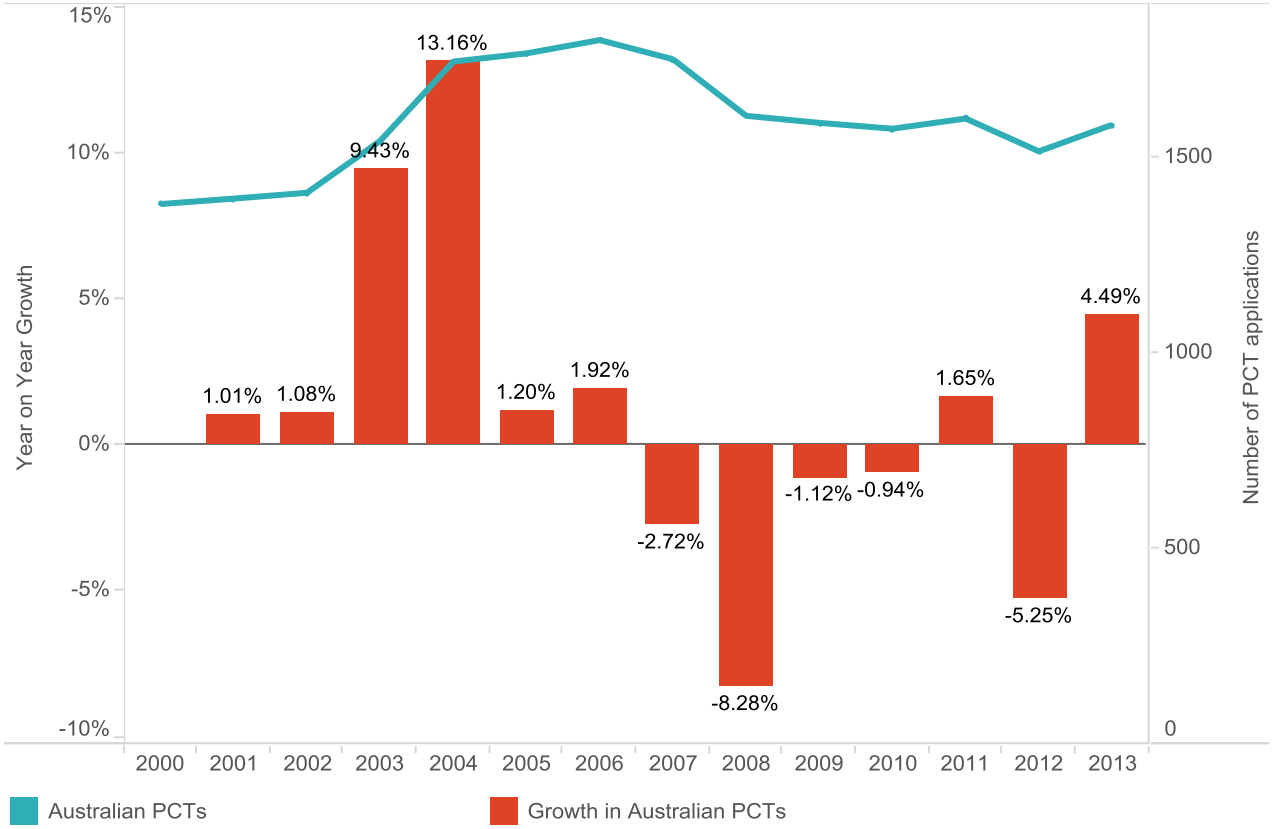
Unlike global filing rates, there was only a slight increase in Australian application activity between 2000 and 2013 (Figure 2.4). The only years to show significant growth were 2003 and 2004, while there was a general decrease in activity from 2007-2012. Overall the number of applications in 2013 was 15 per cent greater than the number filed in 2000 (203 applications).

Figure 2.3: Global PCT filing trends



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Figure 2.4: Australian PCT filing trends



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

The compound annual growth rates (CAGR[10]) for Australia were significantly less than the global rate with 0.98 per cent and 5.14 per cent, respectively (Table 2.1). The slow growth is consistent across all Australian advanced manufacturing sectors. Globally, the technology sectors with the most growth were electrical, mechanical engineering, medical devices and transport, while pharmaceuticals and chemistry had only a small amount of growth. Although the medical devices and chemical engineering technologies showed the most growth from Australian applicants, the small numbers of PCT applications originating in Australia each year for the technology sectors mean that the growth changes should be interpreted with caution.

Table 2.1: PCT application filing rates by advanced manufacturing sector

		Number of PCTs			
		2000	2013	% Change	CAGR
Chemical Engineering	AUSTRALIAN	103	137	33%	2.06%
	WORLD	4,748	9,165	93%	4.81%
Chemistry	AUSTRALIAN	56	63	13%	0.84%
	WORLD	6,950	8,605	24%	1.54%
Electrical	AUSTRALIAN	468	503	7%	0.52%
	WORLD	35,833	81,812	128%	6.07%
Materials	AUSTRALIAN	60	72	20%	1.31%
	WORLD	6,887	12,998	89%	4.64%
Mechanical Engineering	AUSTRALIAN	236	304	29%	1.82%
	WORLD	10,608	27,009	155%	6.90%
Medical Devices	AUSTRALIAN	128	187	46%	2.74%
	WORLD	6,105	14,159	132%	6.19%
Pharmaceuticals	AUSTRALIAN	225	204	-9%	-0.70%
	WORLD	13,436	14,552	8%	0.57%
Transport	AUSTRALIAN	105	114	9%	0.59%
	WORLD	4,469	11,244	152%	6.81%
TOTAL	AUSTRALIAN	1,381	1,584	15%	0.98%
	WORLD	89,036	179,544	102%	5.14%

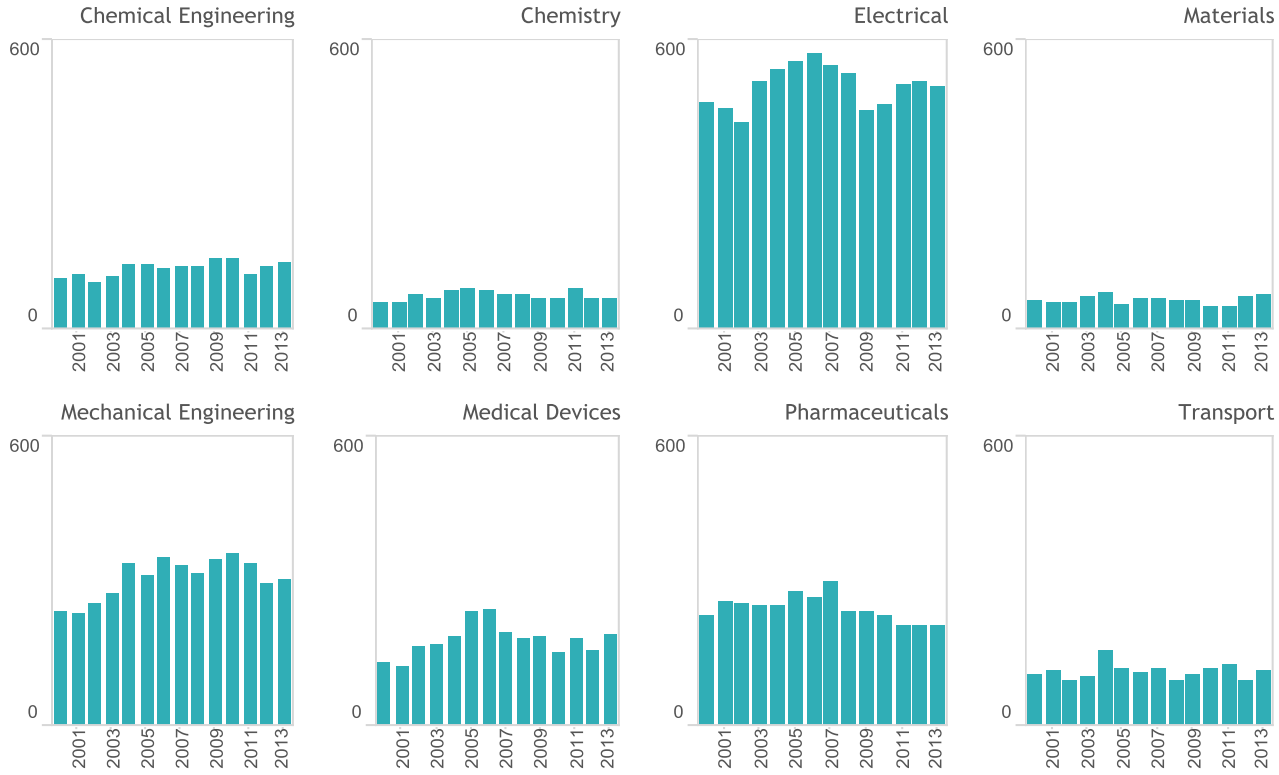
Source: PATSTAT database, Autumn 2015; and IP Australia calculations

[10] Compound annual growth rate (CAGR) is the mean annual growth rate for fillings over the time period. CAGR= [(Ending Value/ Starting Value)^(1/ Number of years)]-1.

Technological sectors in advanced manufacturing

The actual numbers of PCT applications originating in Australia for each technology sector are shown in Figure 2.5. There are no obvious growth trends for any category.

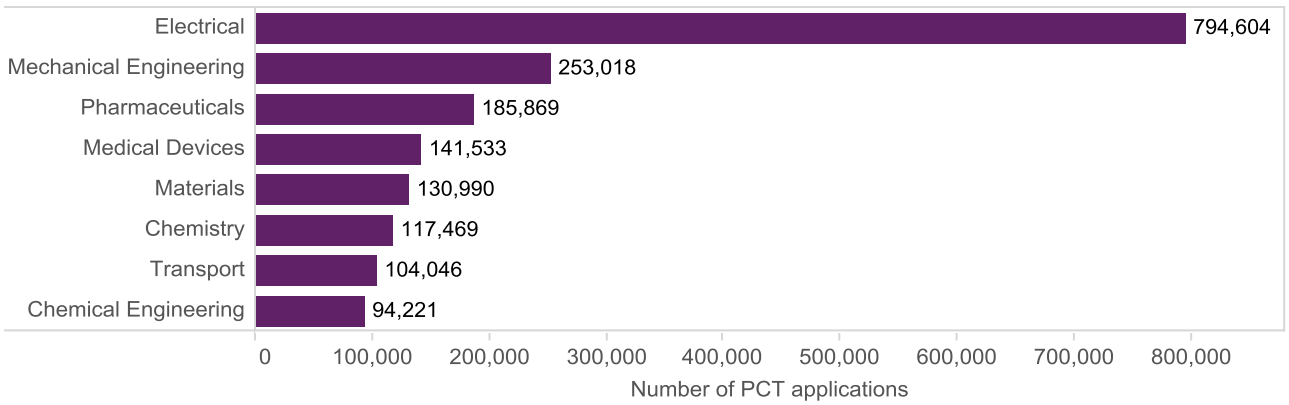
Figure 2.5: Australian PCT applications in each technology sector



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

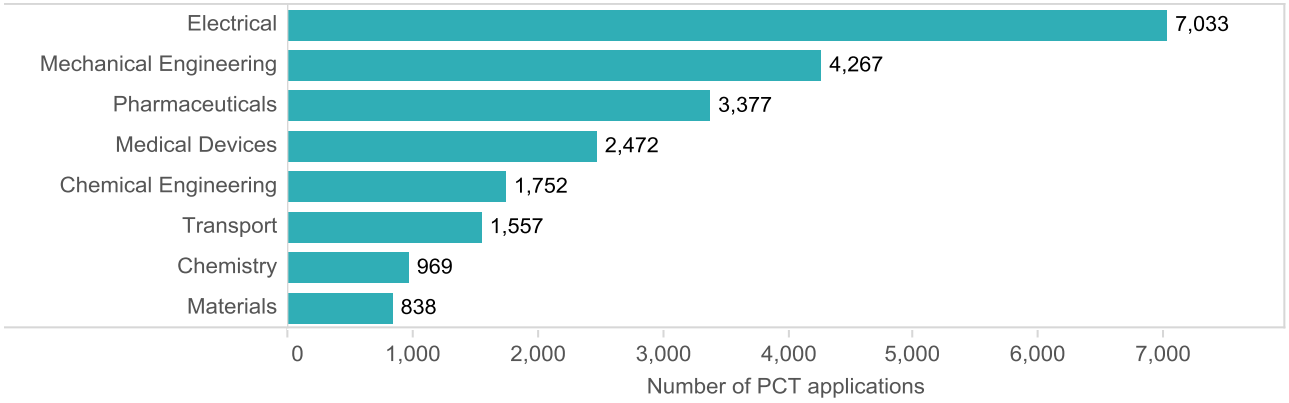
When comparing the individual technology sectors, the electrical sector, which includes communication and measurement technologies and electrical components, had the largest number of applications originating in Australia and globally (Figure 2.6 and Figure 2.7). This sector was a major focus and accounted for 43 per cent of global PCT applications and 32 per cent of Australian PCT applications. Following electrical, the next largest numbers of applications were found in mechanical engineering, pharmaceuticals and medical devices. This order of applications was also replicated with those originating from Australian. The major difference was that Australia had a strong chemical engineering presence due to mining technologies, ranking fifth of eight sectors. Chemical engineering had the fewest number of applications globally.

Figure 2.6: Global technology breakdown



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Figure 2.7: Australian technology breakdown



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

The RSI normalises the patenting activity of each technology to identify areas of technological strength that would otherwise go unnoticed. Australia showed specialisation in five of the advanced manufacturing technology sectors; however the chemistry, electrical and materials groups showed a negative RSI (Table 2.2). Australia's highest ranking was tenth in medical devices, followed by chemical engineering (thirteenth) and transport (fifteenth).

Table 2.2: Relative Specialisation Index for each technology sector

Industry Sector	World Rank	RSI
Medical Devices	10 of 36	0.099
Chemical Engineering	13 of 36	0.105
Transport	15 of 33	0.063
Mechanical Engineering	17 of 42	0.103
Pharmaceuticals	23 of 43	0.09
Materials	29 of 33	-0.355
Electrical	30 of 48	-0.219
Chemistry	32 of 35	-0.264

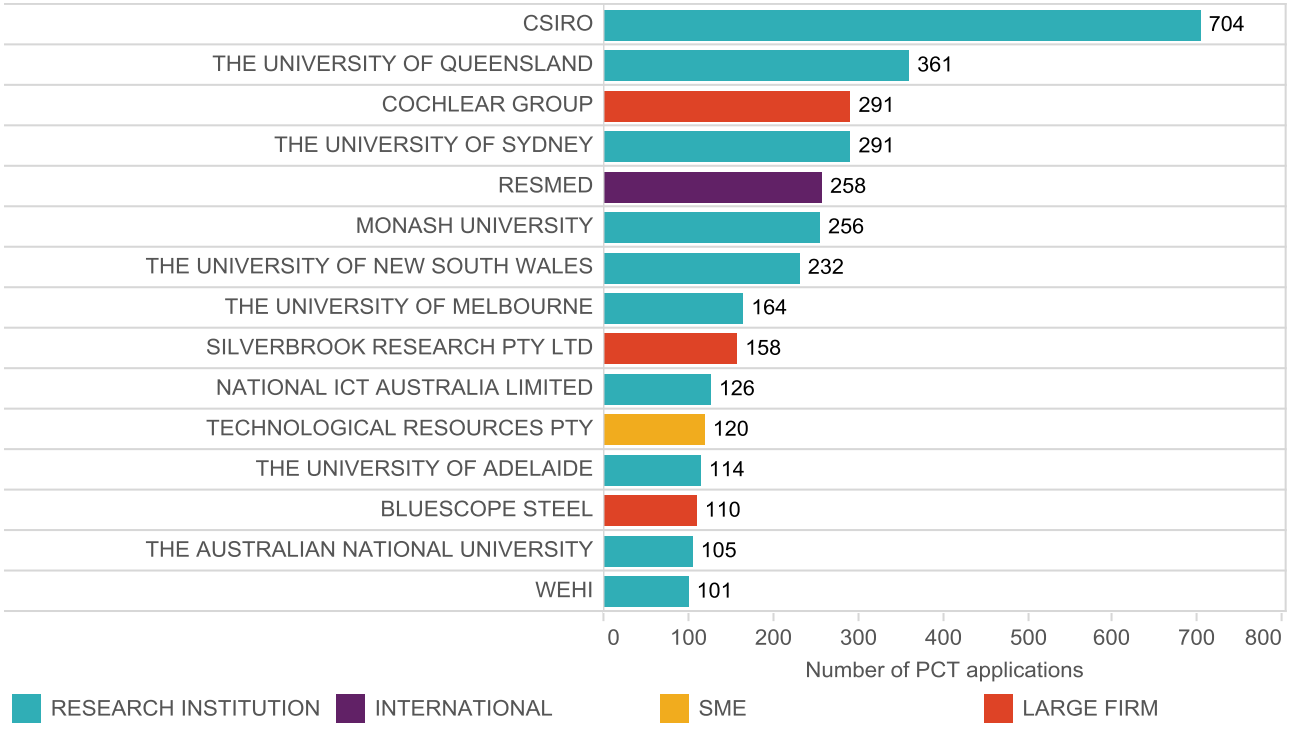
Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Top advanced manufacturing applicants in Australia

Australian research institutions overwhelmingly outnumbered private enterprise in the top 15 patent applicants (Figure 2.8). Based on average applications per applicant, research institutions were the most active applicant type, leading all technology sectors except transport, which was led by Australian large firms (see individual technology chapters for details).

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) had almost twice as many PCT applications as the next most active applicant. CSIRO was also the top applicant for six of the eight technologies: chemical engineering, chemistry, electrical, materials, mechanical engineering and pharmaceuticals. In contrast, CSIRO was not significantly involved in the transport industry (it does not rate in the top 15 applicants in transport), and was ranked ninth in the medical devices sector.

Figure 2.8: Top 15 advanced manufacturing applicants



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

The other Australian research entities in the list of top applicants include seven universities (The University of Queensland, The University of Sydney, Monash University, The University of New South Wales, The University of Melbourne, The University of Adelaide and The Australian National University).

In August 2015, National Information and Communications Technology Australia Limited (NICTA) merged with CSIRO to create a new information and communications technology (ICT) research entity called Data61. Prior to 2015 NICTA was Australia's ICT Research Centre of Excellence and the nation's largest organisation dedicated to ICT research.[11] While NICTA researched a wide range of ICT areas from computer vision to machine learning, it was most prevalent in the medical devices area due to innovations directed to neural and physiological sensing devices. It was also the top collaborating applicant in the medical sector with 13 collaborations.

The Walter and Eliza Hall Institute of Medical Research (WEHI) works in health care research directed to the treatment and prevention of an assortment of diseases including cancers, arthritis, coeliac disease and malaria.[12] WEHI research has resulted in the establishment of nine start-up companies including MuriGen Therapeutics Ltd., ImmusanT and Catalyst Therapeutics.[13] The institution is prominent in the pharmaceutical sector.

Of the top applicants who are not Australian research institutions, three (the Cochlear Group, Silverbrook Research and BlueScope Steel) are large Australian firms with varied origins and industrial positions. The Cochlear Group was third overall and represented in this report in the electrical and medical device sectors, in the areas of communication technology and diagnostic imaging and therapy respectively. It specialises in implantable hearing solutions to treat deafness and hearing loss such as cochlear and bone conduction implants.[14] The Cochlear Group

[11] NICTA, About

[12] Walter and Eliza Hall Institute of Medical Research, About

[13] Walter and Eliza Hall Institute of Medical Research, Start-up companies

[14] Cochlear, Home

collaborates with an assortment of domestic and international universities including The University of Melbourne, Swinburne University and the University of Zurich.

Silverbrook Research was a top applicant in three technology sectors in this report: chemistry, electrical and materials. The company's most well-known innovation is the Memjet high-speed colour printing technology[15] and innovations relating to printing inks and materials as well as details of printing devices are the focus of their patent applications. Silverbrook Research later became Worldwide Speciality Property Services Pty Ltd, however in April 2014 a liquidator was appointed to wind up the business.

BlueScope Steel is a large multinational steel producer,[16] with its corporate headquarters located in Melbourne, Victoria. Its major products include steel slab, automotive steel, galvanised steel, Zincalume® and Colourbond® brand pre-coated steels. The company demerged from BHP Billiton in July 2002 as BHP Steel and was renamed to BlueScope Steel in November 2003.[17] BlueScope was second on the list of top applicants in the materials sector and the third most prolific applicant in chemical engineering.

The only international enterprise to feature in the list of top applicants in this report is ResMed, a company with an Australian origin. It has a significant global presence and is now headquartered in the United States.[18] ResMed was founded in 1989 based on an Australian invention used to treat sleep apnoea. ResMed employs over 4000 people globally and operates in 100 countries. In the medical devices sector, and dominating respiratory care patent applications, ResMed focuses on products for the diagnosis, treatment and management of respiratory disorders such as sleep-disordered breathing.

Technological Resources Pty Ltd is a subsidiary of Rio Tinto Limited[19] and features strongly in the chemical and mechanical engineering technology areas, both with an emphasis on mining and mining equipment.

The high level of representation of research organisations in the top applicants likely reflects the broad research interests of major universities. They are large organisations with significant research activities across varied technology areas. In contrast, the major private applicants had a targeted technology focus, for example ResMed and Cochlear. Each of the individual technology chapters provides a more in-depth analysis of the private applicants.

Collaboration

One powerful component of the analysis of patent data is the ability to identify research partners collaborating on various applications. The presence of multiple applicants on a patent application may be used as a proxy indicator for collaboration.

Across the eight sectors, the top ten collaborators include seven Australian research institutions, comprising five universities, CSIRO, and the Grains Research and Development Corporation (GRDC) (Figure 2.9). CSIRO was the largest collaborator by a significant margin with 177 applications where it is not the sole applicant. The next most prevalent collaborator was The University of Melbourne with 80 applications involving collaborations. Both these institutions were involved in a wide range of research, and apply for patents in varied technology areas. Furthermore, research organisations were prominent collaborators in most of the individual advanced manufacturing technologies, and had the most collaboration in six of the eight technology sectors.

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[15] Pond N, Kia Silverbrook dumps name as business gets thrashed, Print21, 23 April 2014

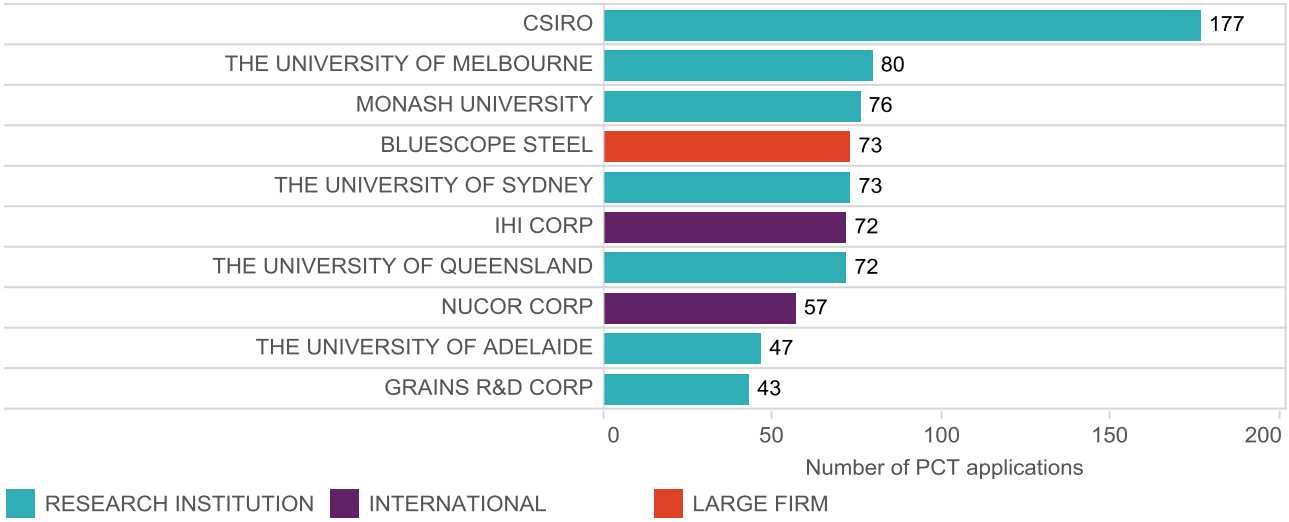
[16] BlueScope Steel, About Us

[17] BHP Billiton (2012), BHP Steel demerger effective following court approval, 1 July 2002

[18] ResMed, About Us

[19] Bloomberg, Company Overview of Technological Resources Pty Limited

Figure 2.9: Top 10 collaborators

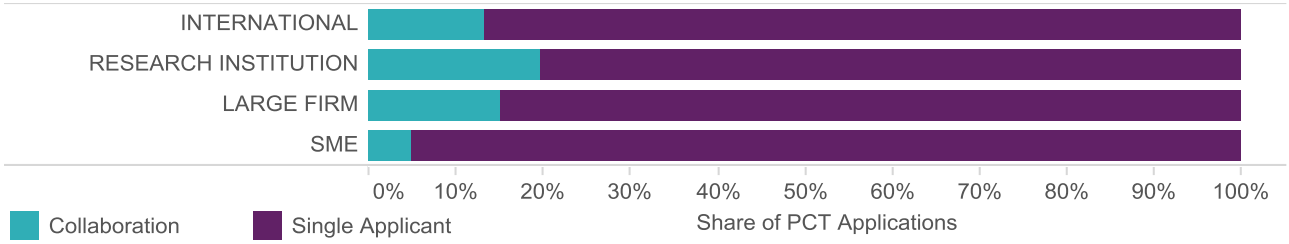


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

In contrast, the only private companies featured in the list of top ten collaborators were Bluescope Steel, IHI Corporation and Nucorp, who formed their own collaboration network. Innovations involving these entities account for 70 per cent of the collaboration in the entire chemical engineering sector. These companies specialise in the casting of carbon and stainless steels. Castrip[20] is a joint venture of the top three applicants and was formed to market and license intellectual property of its three owners.

The proportion of applications involving collaborations varied with applicant entity type. Across the advanced manufacturing technologies overall, 20 per cent of applications from Australian research institutions were collaborative efforts, followed by large Australian firms at 15 per cent and international entities at 13 per cent (Figure 2.10). This proportion dropped to less than five per cent when SMEs were involved. The results for individual technology sectors were similar whereby research institutions collaborated the most in seven of the eight technology sectors, while SMEs collaborated the least across all sectors.

Figure 2.10: Proportion of applications where collaboration is evident, by entity type



Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

[20] Castrip, Castrip Story

3 Chemical engineering

Patenting activity in the Australian chemical engineering sector covered a range of categories with a strong focus on process engineering including design, control and operation of plants, in particular techniques for separation and mixing of materials in different states and metallurgy.

There were 1752 PCT applications filed in the chemical engineering sector between 1 January 2000 and 31 December 2013. Australia's share of the global patenting activity was 1.44 per cent (a global rank of fourteenth) making it the advanced manufacturing sector with the highest global share.

Australia exhibited a positive specialisation in chemical engineering, meaning that chemical engineering was a technological focus in Australia, with a similar level of strength to Canada, Germany and France. Australia was ahead of countries such as the United States, Japan and China who had a negative specialisation.

The top applicant in the chemical engineering sector was CSIRO, with 85 applications, primarily in the category of process engineering, including technologies for gas capture processes and technologies for metal casting. Other major applicants include BlueScope Steel, IHI Corp, Siemens Group, Nucor Corp and Orica.

The most common type of applicant in the chemical engineering group was SMEs, making up nearly 60 per cent of applicants, and contributing 39 per cent of applications. Conversely large Australian firms made up five per cent of applicants and contributed only five per cent of applications. International firms had the most applications in the sector. Applicants from the United States were the preferred partners, followed by Finland and Japan.

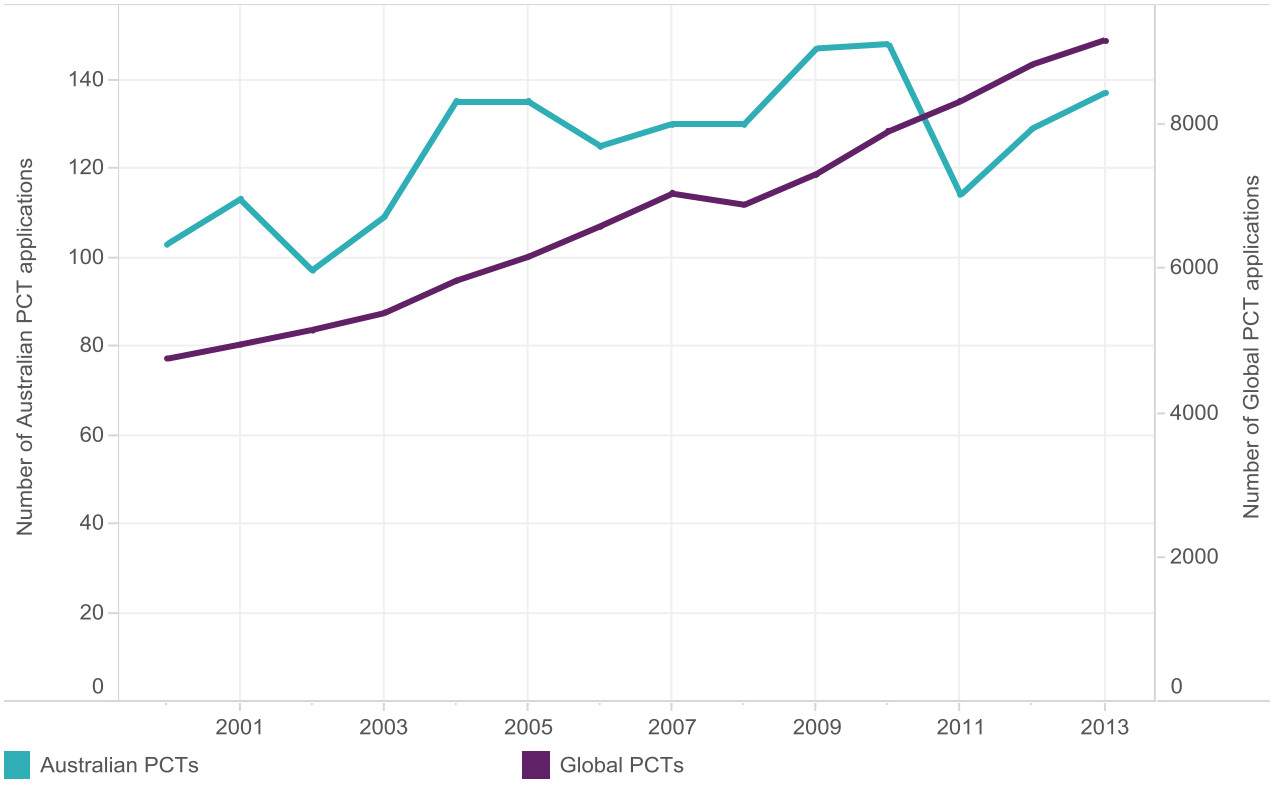
The major technology category was process engineering, which covers the design, control and operation of apparatus and methods for optimisation. This likely reflects our strength in mining technologies, particularly relating to ore separation. Other prominent categories included waste treatment and metal casting/powder metallurgy due to applicants such as BlueScope Steel.

Thirty seven per cent of applications by large firms were collaborative; along with 23 per cent of international applicants. These figures are inflated by the Bluescope Steel, IHI Corporation and Nucorp collaboration who collectively formed the joint venture Castrip (see previous chapter). Only three per cent of applications involving SMEs exhibited collaboration.

Patent activity over time

The number of PCT applications filed in the chemical engineering sector by Australian applicants was generally steady with minor fluctuations across the time period (Figure 3.1). Australia had total of 1752 applications identified as chemical engineering in this period. Global patent applications from this technology increased from 4748 applications in 2000 to 9165 applications in 2013.

Figure 3.1: Australian and global PCT applications

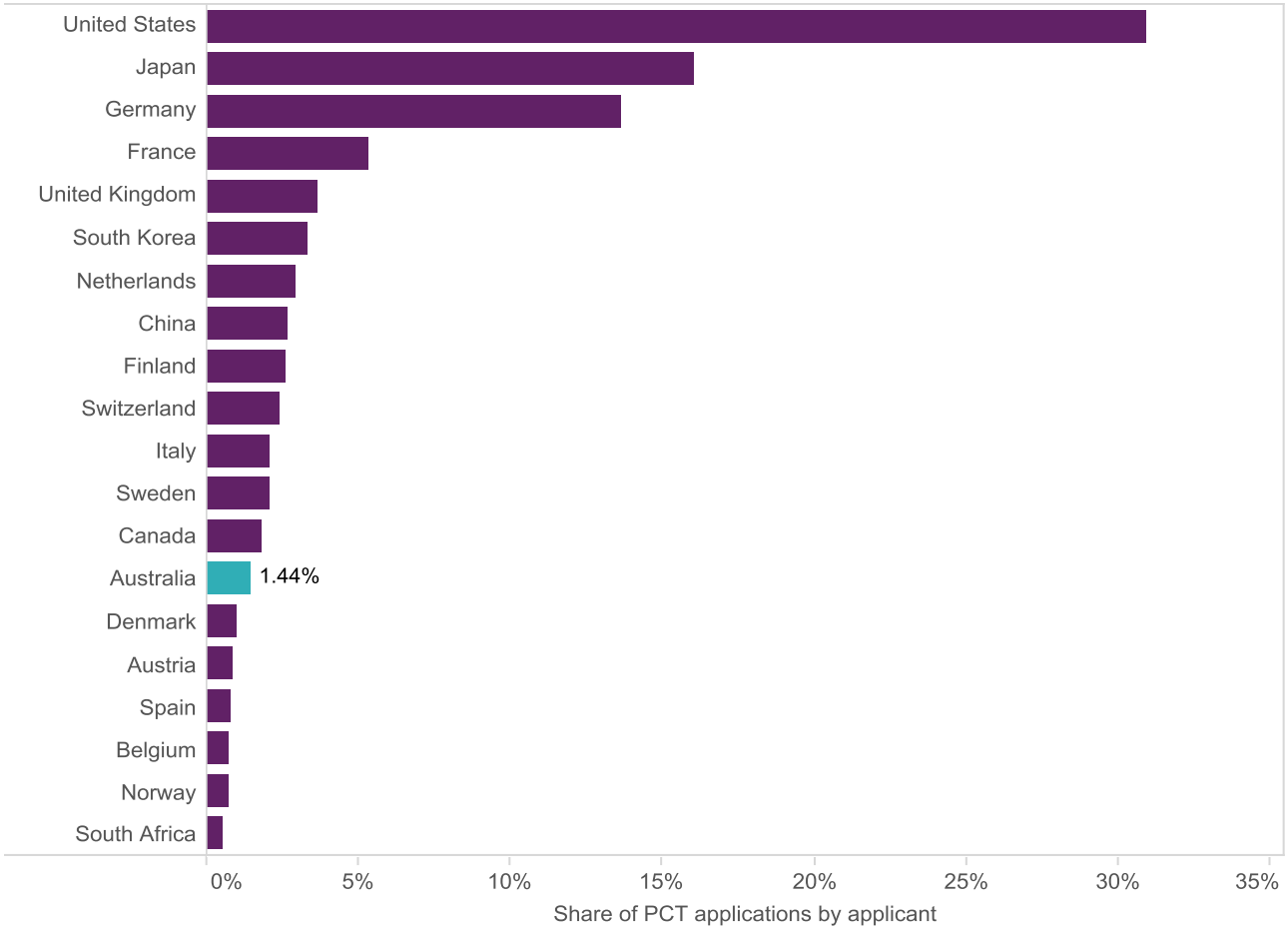


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

The number of Australian PCT applications increased by 33 per cent from 2000 to 2013. This represents a total increase of only 34 PCT applications over the period. This was much less than global patenting activity in this sector which increased 93 per cent over the same period.

Australia's share of global chemical engineering patents, based on applicant share ranked fourteenth, with 1.44 per cent of the global chemical engineering PCT applications (Figure 3.2). Applicants from the USA had the highest share of PCT applications with over 30 per cent in chemical engineering, followed by Japan and Germany.

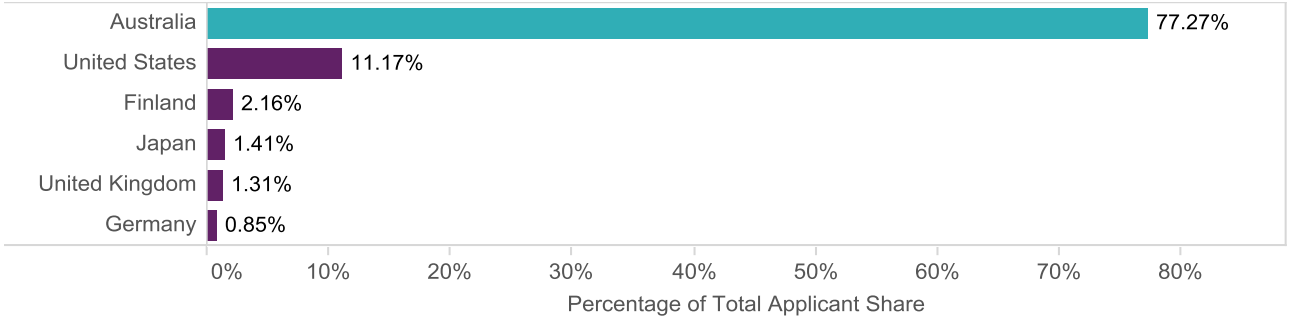
Figure 3.2: Share of PCT applications across the top 20 countries



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Countries that Australian applicants or inventors work with are shown in Figure 3.3. This is determined by identifying the country of origin of applicants on PCT applications. Applicants from the United States are the preferred overseas partners, followed by Finland and Japan and the United Kingdom.

Figure 3.3: Applicant origin

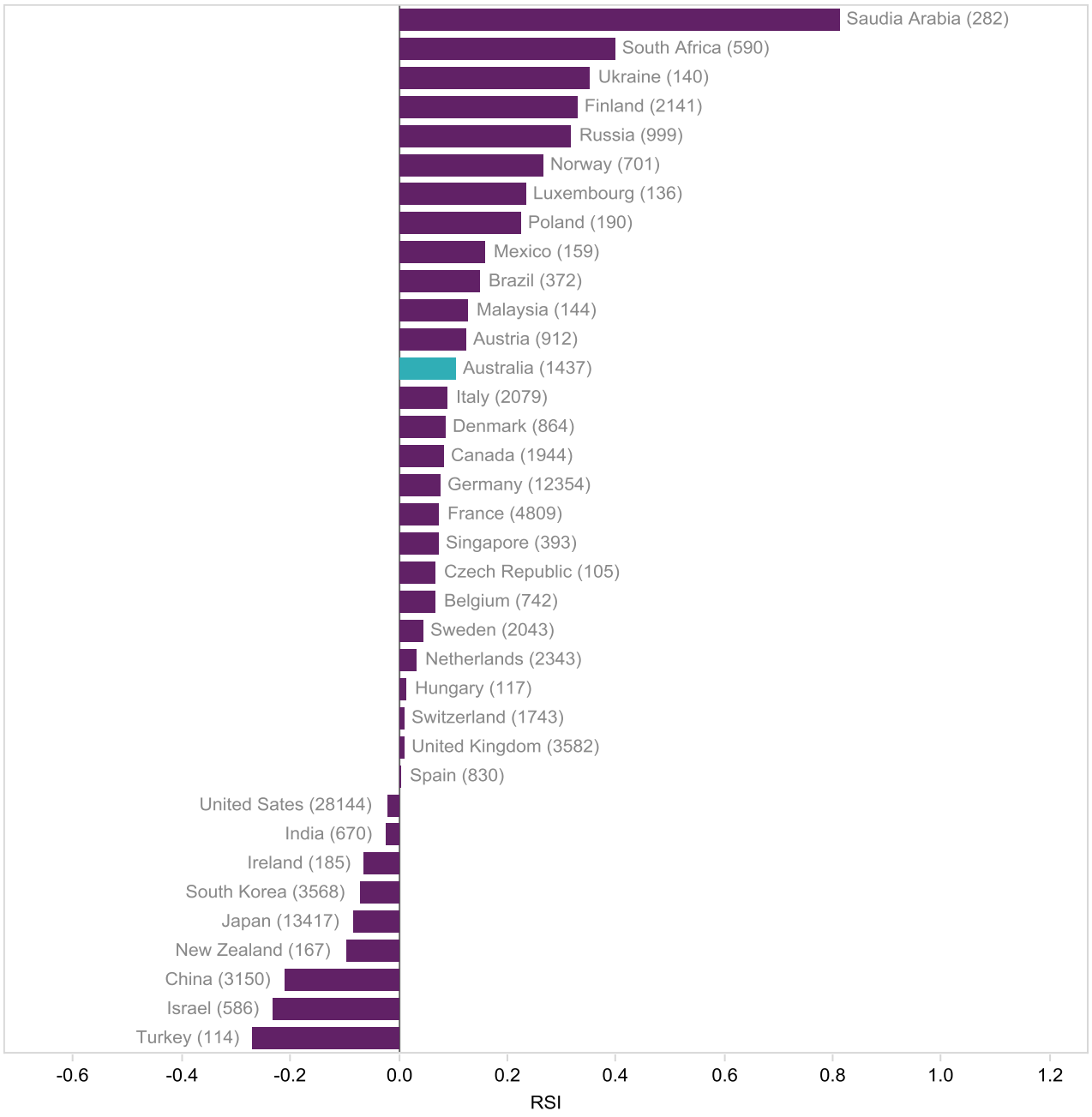


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Technological specialisation

Australia had a high level of specialisation in chemical engineering and ranked thirteenth, which is amongst the highest ranking of the Australian advanced manufacturing sectors (Figure 3.4). As a comparison, Switzerland, who has a similar number of applications to Australia, ranked twenty-fifth. Also, the most active countries in this technology rank lower than Australia; Germany ranks seventeenth, USA ranks twenty-eighth and Japan ranks thirty-second.

Figure 3.4: Relative Specialisation Index for chemical engineering



Source: PATSTAT database, Autumn 2015; and IP Australia Calculations

Chemical engineering technologies

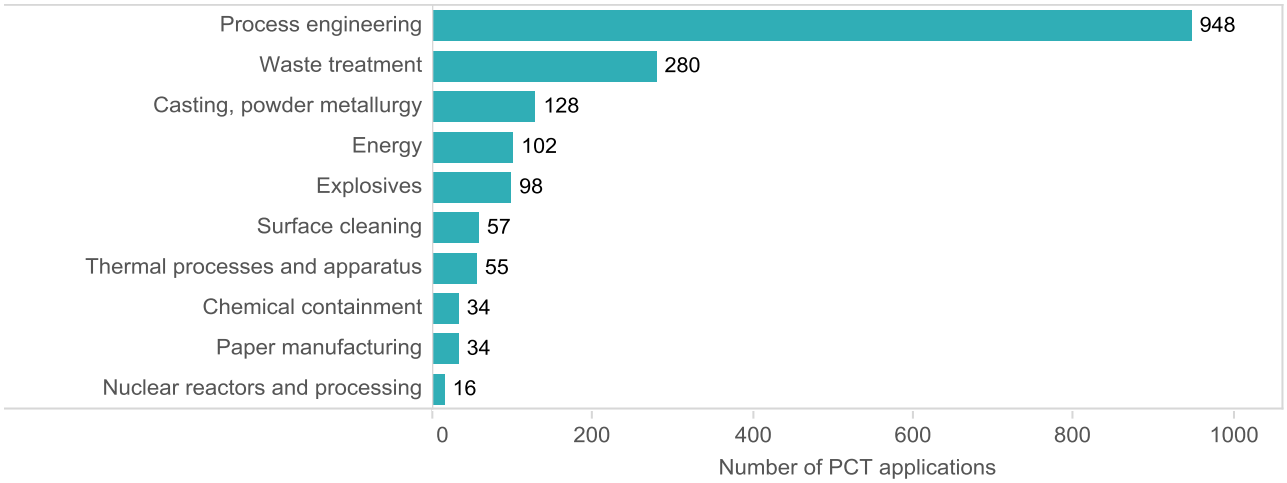
There were a diverse range of technologies that were identified from the Australian chemical engineering PCT applications. Applications were broken down into:

- *Process engineering* – design, control and operation of plants, in particular separation and mixing of items and materials; material state changing
- *Waste treatment* – disposal of solid waste, treatment of waste water and sewage
- *Casting; power metallurgy* – continuous casting, ingots, working of metallic powder
- *Energy* – gas, coke, cracking hydrocarbon oils
- *Explosives* – explosive charges and blasting
- *Surface cleaning* – cleaning using tools, brushes, liquid , steam, air or electrostatic means
- *Thermal processes and apparatus* – combustion, burners, furnaces, kilns and ovens
- *Paper manufacturing* – raw materials, cellulose, treatment of material, machines for making paper
- *Chemical containment* – vessels for holding compressed or liquefied gases, pipe lines
- *Nuclear reactors and processing* – fusion reactions, protection against radiation and plasma technique

A detailed breakdown of the CPC marks and the technology breakdown can be found in Appendix C.

Process engineering was the primary focus of Australian chemical engineering, making up 948 or 54 per cent of all applications (Figure 3.5). Waste treatment had 280 applications with the rest of the sector consisting of a large number of technology categories with a relatively small share.

Figure 3.5: Australian PCT applications by technology category



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Key applicants in chemical engineering

Applications by entity type

The most common type of applicant in chemical engineering was SMEs, making up nearly 60 per cent of applicants, and contributing 39 per cent of applications (Table 3.1). Conversely large Australian firms made up five per cent of applicants and contributed five percent of applications. Despite being the most prominent applicant type, SMEs had among the lowest average applications per applicant with 1.7. In contrast, research institutions had the highest rates of

applications per applicant with 9.2. Although similar numbers of applicants identified as Australian research institutions as large Australian firms (28 and 31 respectively), research institutions applied for more than three times the number of PCT applications in chemical engineering.

Table 3.1: PCT applications by entity type

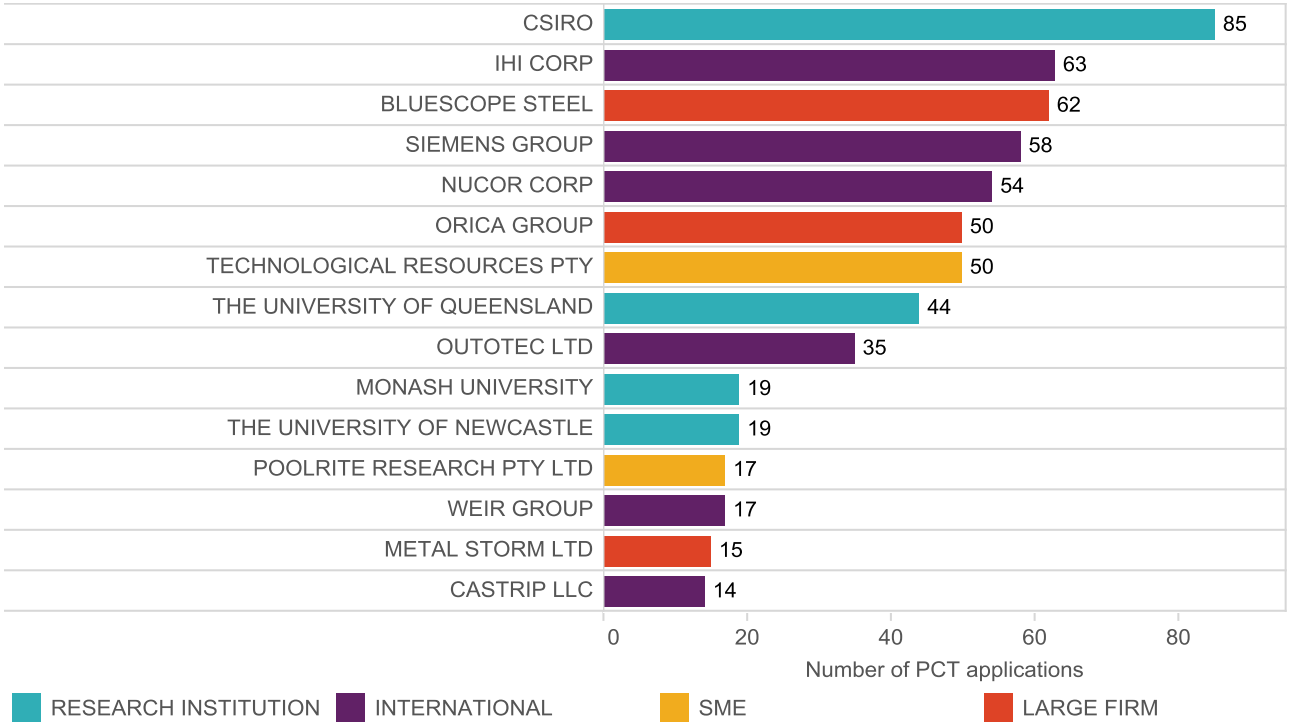
	Number of applicants	Number of applications	Average applications per applicant
INTERNATIONAL	175	543	3.1
RESEARCH INSTITUTION	28	258	9.2
LARGE FIRM	31	195	6.3
SME	368	640	1.7
INDIVIDUAL	23	24	1.0

Source: PATSTAT database, Autumn 2015; IPGOD, 2016 edition; and IP Australia calculations.

Top applicants

The top applicant in the chemical engineering sector was CSIRO, with 85 applications primarily in the category of process engineering, including technologies for gas capture processes and technologies for metal casting (Figure 3.6). Three of the top five applicants in chemical engineering were international entities, with IHI Corp, Siemens Group and Nucor Corp each having a comparable number of applications largely due to their collaboration network.

Figure 3.6: Top applicants



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Orica Group is an Australian-based multinational corporation with two-thirds of its 50 PCT applications related to explosives.

Poolrite Research Pty Ltd is an Australian-based company specialising in pumps for pools, chlorination systems, as well as valves and cleaning equipment. In 2013 Brisbane-based Evolve Composite Pty Ltd acquired a license to Poolrite's intellectual property.[21]

Metal Storm was a research and development company based in Brisbane that was focused on electronic ballistic technology for weapons. They were placed in voluntary administration in 2012. In 2015 their intellectual property rights were acquired by DefendTex, an Australian-based defense research and development company.[22]

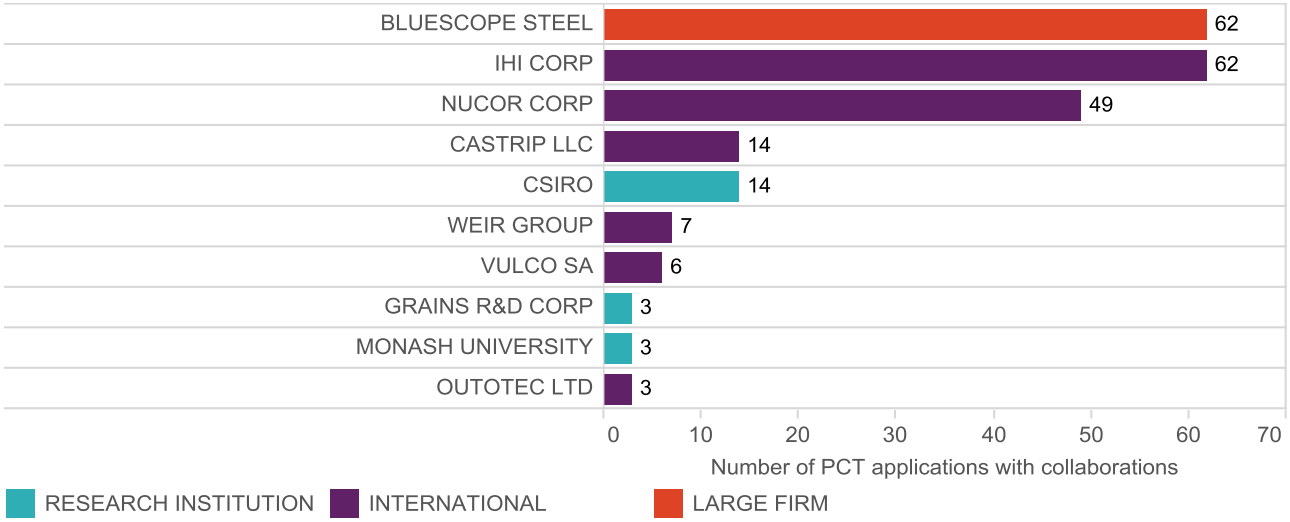
Collaboration in chemical engineering

Top collaborating applicants

Of the 1752 PCT applications in the Australian chemical engineering sector, seven per cent had multiple applicants. Bluescope Steel and IHI Corporation were the strongest collaborators in the chemical engineering sector, each with 62 applications involving co-applicants (Figure 3.7).

CSIRO is by far the top applicant in chemical engineering with 85 applications, although only 14 of those applications were collaborative.

Figure 3.7: Top 10 applicants who collaborate



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

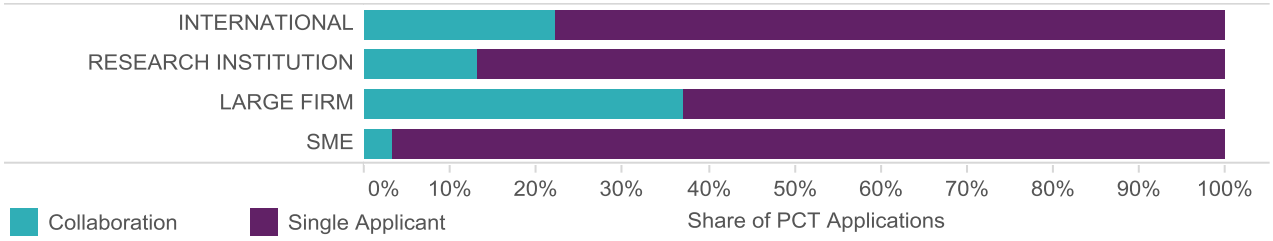
Collaboration between applicant entity-types

Thirty seven per cent of applications by large firms were collaborative; along with 23 per cent of international applicants. These figures are inflated by the Bluescope Steel, IHI Corporation and Nucorp collaboration network, and account for majority of collaboration in the entire chemical engineering sector. Only three per cent of applications that involved SMEs exhibited collaboration (Figure 3.8).

[21] Poolrite, About Poolrite

[22] DefendTex, DefendTex acquires Metal Storm assets, 12 August 2015

Figure 3.8: Proportion of applications assigned to entity types where collaboration is evident



Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

In the chemical engineering sector, collaboration was most prevalent amongst international entities and between international entities and large firms (Figure 3.9). This reflects the Bluescope Steel, IHI Corporation and Nucorp collaboration. Research organisations collaborated with international entities on 15 PCT applications and with other research organisations on eight PCT applications. There were very few applications found with SMEs as collaborating applicants, despite being the most prevalent applicant type, and having the greatest number of applications.

Figure 3.9: Number of PCT applications where collaboration existed between entity types

	INTERNATIONAL	RESEARCH INSTITUTION	LARGE FIRM	SME
INTERNATIONAL	75			
RESEARCH INSTITUTION	15	8		
LARGE FIRM	63	5	1	
SME	7	7	3	6

Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

4 Chemistry

Patenting activity in chemistry differs from chemical engineering as it focusses on chemicals and their use, rather than chemical production. The sector includes categories such as organic chemistry mostly directed to the pharmaceutical industry, and inorganic chemistry, directed to mining.

There were 969 PCT applications filed in the chemistry sector between 1 January 2000 and 31 December 2013. Australia's share of the global patenting activity was 0.6 per cent (ranked eighteenth), which is small when compared to the other advanced manufacturing sectors.

Australia had a negative specialisation in chemistry, meaning that Australian doesn't have a technological strength in chemistry. Australia was ranked thirty second out of thirty five countries on the index.

The top four applicants were Australian research institutions including universities and CSIRO. The list of top applicants also featured international entities with companies focused on chemistry in the pharmaceutical and mining industries such as Biota, Orica and Alcoa. Silverbrook Research was the top Australian company, in seventh position on the list of top applicants. In contrast to the other major applicants, the chemistry developed by Silverbrook Research was directed to ink, dyes and pigments industry. Spin-outs and start-ups from Australian and international research institutions, including Bionomics,[23] Cytopia,[24] Novogen[25] (a joint venture company with Yale University) and Avexa,[26] also featured in the list of top applicants in the chemistry sector, with a significant number of applications directed to organic chemistry with pharmaceutical applications.

The top technology category was organic chemistry, with a focus on pharmaceuticals. Agriculture, which in includes fertilisers, biocides and pest repellents, was also prominent.

The international entity type had the greatest number of applicants (167), followed closely by the SMEs (149). While research institutions had a much lower number of applicants (42) as compared to SMEs (149), research institutions filed almost the same number of PCT applications (257). Applicants from the United States are the preferred overseas partners, followed by the United Kingdom and Switzerland.

PCT applications with multiple applicants accounted for 11 per cent of chemistry applications. This level of collaboration in the PCT patenting landscape is higher than in most other sectors and comparable to the collaboration seen in the materials sector. Most collaborations occurred between Australian research institutions and international entities.

[23] Bionomics, About

[24] Delisted Australia, Cytopia Ltd (CYT)

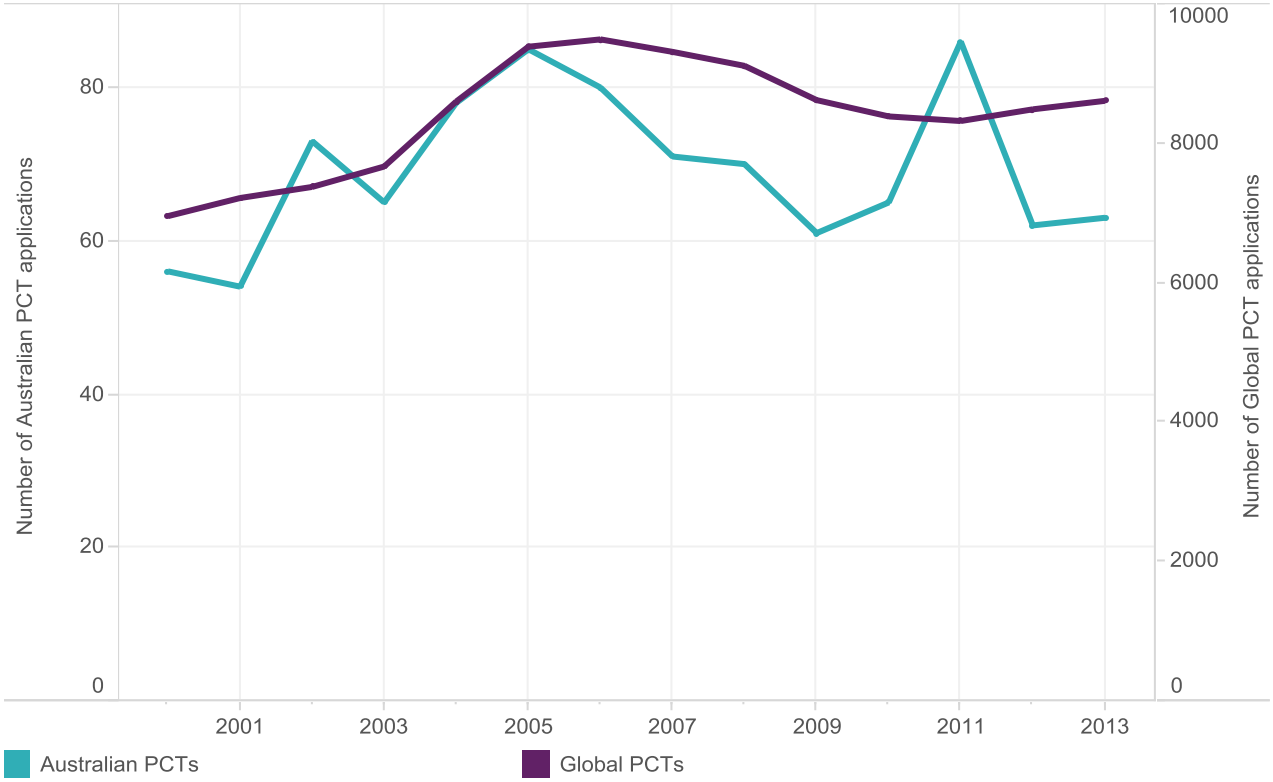
[25] Novogen, Our Story

[26] Avexa, About us; Encyclopedia of Australian Science, AMRAD Corporation Ltd. (1986 - 2005)

Patent activity over time

The number of applications involving Australian applicants was generally steady across the time period analysed (Figure 4.1), with 969 PCT applications filed in the chemistry sector. Global patent applications increased from 6950 in 2000 to 8605 in 2013, approximately a 24 per cent increase.

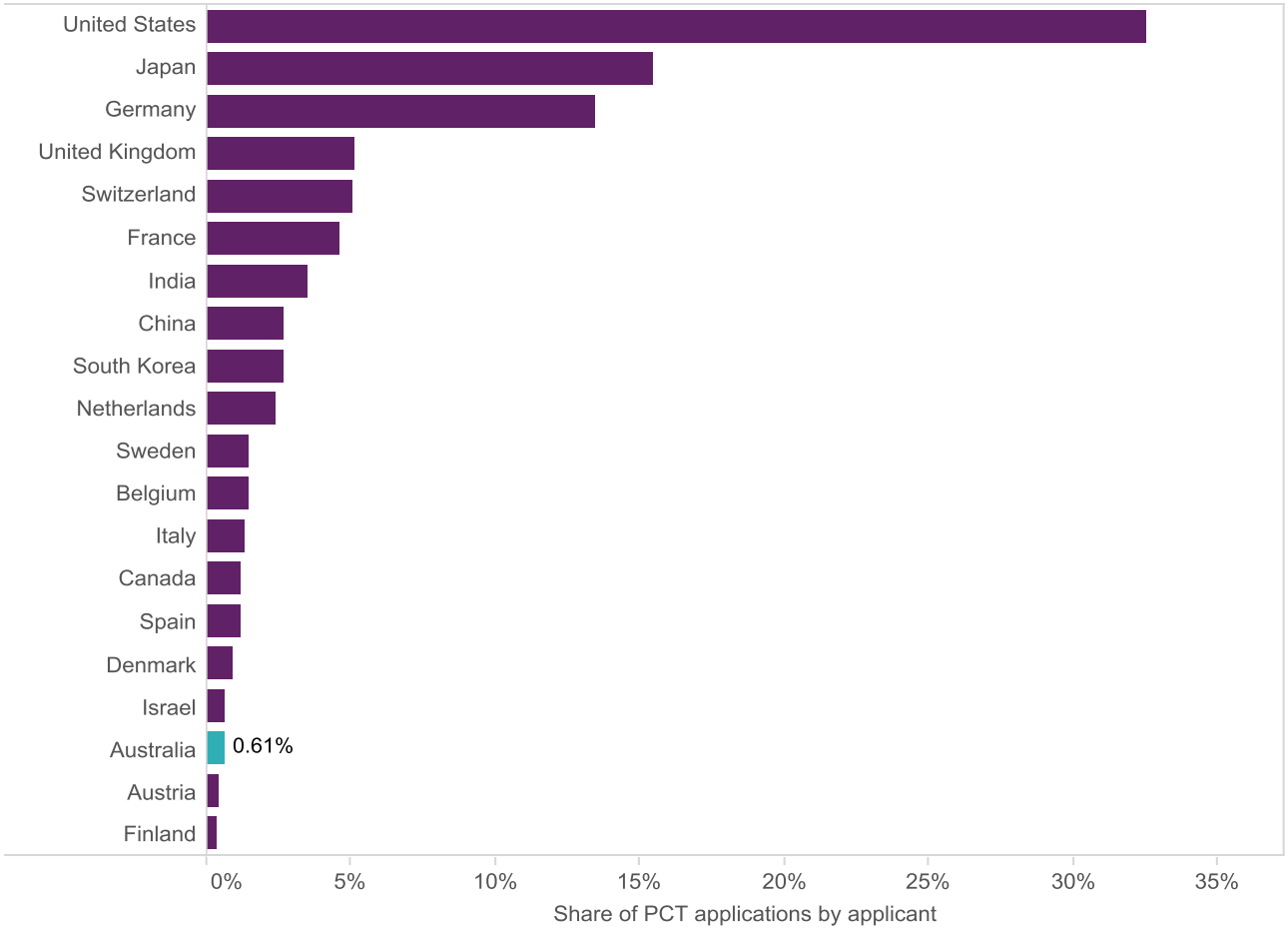
Figure 4.1: Australian and global PCT applications



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Australia had a relatively low share of global patenting activity in the chemistry sector with 0.6 per cent, ranked eighteenth (Figure 4.2). This is the lowest ranking of the Australian advanced manufacturing technologies. The USA is clearly the most active country on a global scale with Japan and Germany second and third.

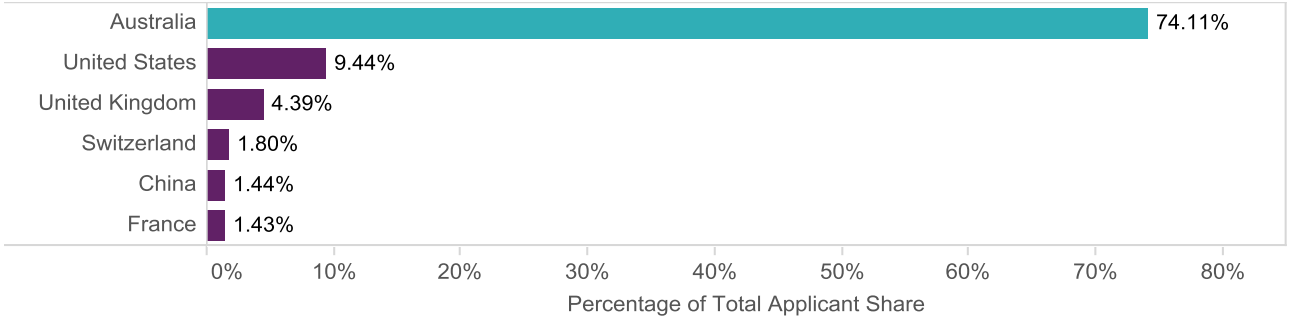
Figure 4.2: Share PCT applications across the top 20 countries



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Countries that Australian applicants or inventors work with are shown in Figure 4.3. This is determined by identifying the country of origin of applicants on PCT applications. Applicants from the United States are the preferred overseas partners, followed by the United Kingdom and Switzerland.

Figure 4.3: Applicant origin

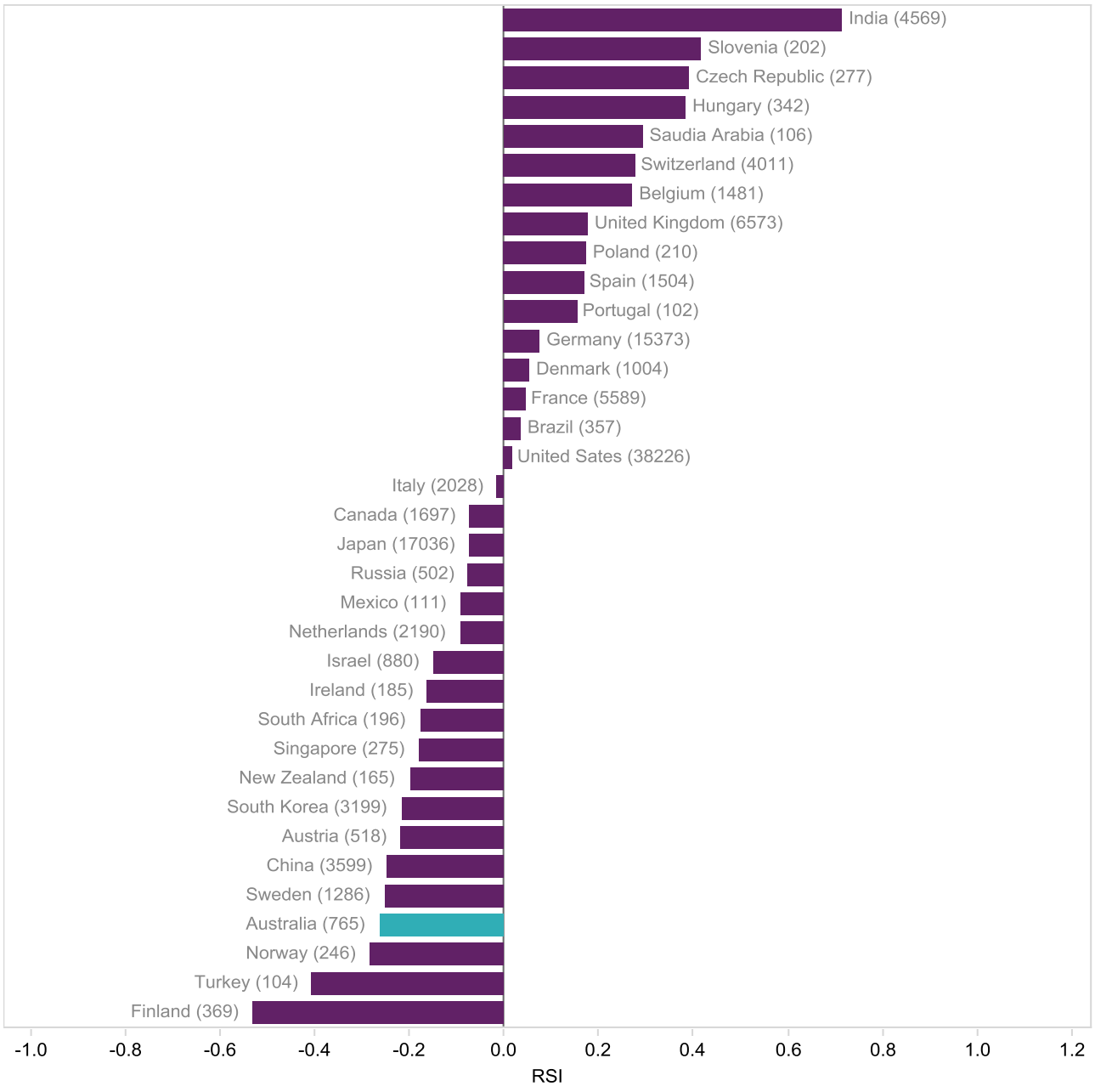


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Technological specialisation

Australia had a negative specialisation in chemistry and ranked 32nd (Figure 4.4). Other technology sectors that have a negative specialisation include electrical and materials. As a comparison, Israel who has similar applicant shares of patents to Australia, ranks twenty-third. Countries with strengths in the area include India (first), Switzerland (sixth) and the United Kingdom (eighth).

Figure 4.4: Relative Specialisation Index for PCT chemistry applications



Source: PATSTAT database, Autumn 2015; and IP Australia Calculations

Chemical technologies

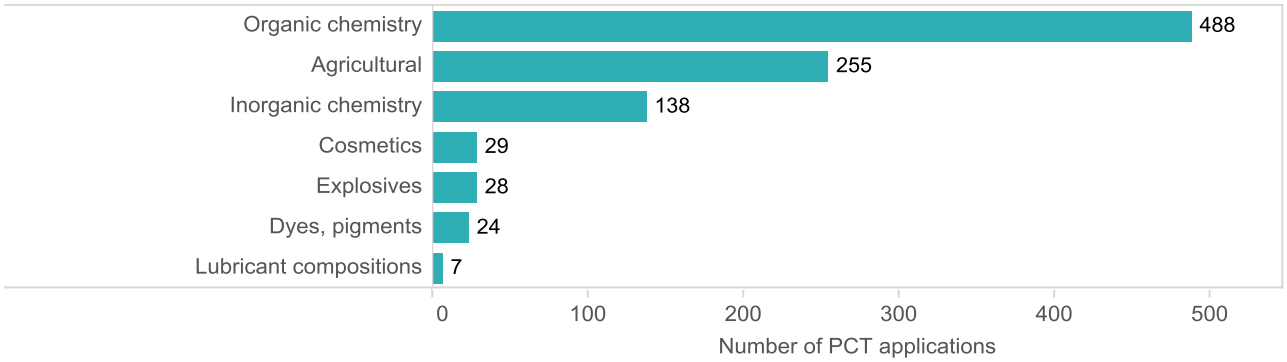
There were a range of technologies identified. Broadly, applications were broken down into:

- *organic chemistry* – methods of organic chemistry; acyclic, carbocyclic or heterocyclic compounds; compounds of unknown origin; fatty acids from fats, oils or waxes; candles; detergents, soaps, glycerol, and combinatorial chemical libraries
- *agricultural* – phosphatic, nitrogenous, organic and inorganic fertilisers, preservation of biological materials, biocides, pest repellents or attractants and plant growth regulators
- *inorganic chemistry* - metal compounds, non-metallic elements, ammonia and cyanogen
- *cosmetics* – specific uses of cosmetics or similar toilet preparations (e.g. make-up, hair care products, hair removal products, antiperspirants, toothpaste, sunscreen, perfumes)
- *explosives* – explosives or thermic compositions, detonators, primers and fuses, smoke, mist and gas attack or blasting compositions
- *dyes, pigments* – organics dyes, treatment of inorganic materials
- *lubricant compositions* – mixtures of lubricants

A detailed breakdown of the CPC marks and the technology breakdown can be found in Appendix C.

Organic chemistry was the primary focus of the Australian chemical sector, making up 488 or 50 per cent of all applications (Figure 4.5). A large number of PCT applications in this space were directed towards pharmaceuticals, wherein the main applications are directed to new chemical entities with pharmaceutical use. Agriculture, which in includes fertilisers, biocides and pest repellents was also prominent.

Figure 4.5: Australian PCT applications by technology category



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Key applicants in chemistry

Applications by entity type

International entities had the greatest number of applicants, followed closely by SMEs (Table 4.1). International entities were among the lowest average applications per applicant with 2.2, compared to research institutions which had 6.1 applications per applicant on average.

While research institutions had a much lower number of applicants (42) as compared to SMEs (150), research institutions filed almost the same number of PCT applications.

Table 4.1: PCT applications by entity type

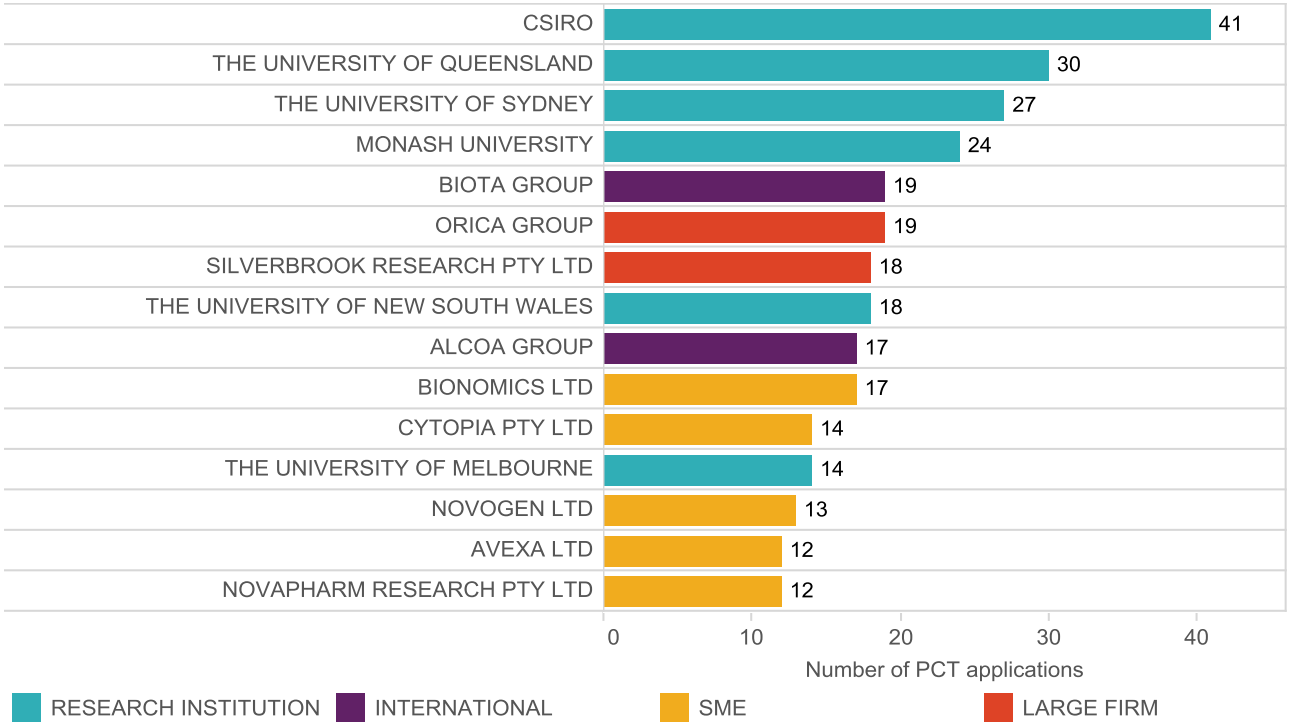
	Number of applicants	Number of applications	Average applications per applicant
INTERNATIONAL	165	362	2.2
RESEARCH INSTITUTION	42	258	6.1
LARGE FIRM	22	69	3.1
SME	150	307	2.0
INDIVIDUAL	11	11	1.0

Source: PATSTAT database, Autumn 2015; IPGOD, 2016 edition; and IP Australia calculations.

Top applicants

Research institutions and universities featured significantly in Australian PCT applications in chemistry (Figure 4.6). CSIRO, the University of Queensland, the University of Sydney, Monash University, the University of New South Wales and the University of Melbourne, all filed applications primarily in the category of organic chemistry.

Figure 4.6: Top applicants



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

The Australian chemistry patent landscape is led by CSIRO, with 41 applications, representing four per cent of the chemistry sector.

Biota Group primarily files applications for antiviral agents. In April 2016, Biota Pharmaceuticals announced its name change to Aviragen Therapeutics, Inc.[27] and has since transitioned from drug discovery and early-stage licensing to focusing on drug development and progression to key late-stage product candidates for viral diseases that currently have limited therapeutic options.

[27] Aviragen Therapeutics, Biota Pharmaceutical, Inc. Announces Name Change to Aviragen Therapeutics, Inc., 12 April 2016

Bionomics Limited is a biopharmaceutical company that develops treatments for cancer and central nervous system disorders, such as anxiety, depression and Alzheimer's Disease, and which concentrates on strategic partnering with large pharmaceutical companies for later stage drug development.[28]

Australian pharmaceutical SMEs made up many of the top applicants in the chemistry technology. Cytopia Pty Ltd[29] was a Melbourne-based Australian biotechnology therapeutic drug research and development company.[30] In 2010, Cytopia merged with YM BioSciences Inc., which was acquired by Gilead Sciences in 2013. Novogen[31] is a drug development company initially focussed on the development of benzopyran-base drugs, which was subsequently transferred to MEI Pharma Inc. Avexa Limited, [32] based in Melbourne, specialises in drug discovery and development for diseases such as HIV, hepatitis B and antibiotic resistant bacteria.[33]

Novapharm Research (Australia) Pty Ltd is a subsidiary of Regional Health Care Group, a 100 per cent Australian owned company in the healthcare research and development sector. Novapharm developed Ioscan, the world's first single unit-dose oral computed tomography contrast media.[34]

Collaboration in chemistry

Top collaborating applicants

Of the 969 PCT applications in the Australian chemistry sector, 106 applications (11 per cent) had multiple applicants. CSIRO was the top applicant in the chemistry sector with 41 applications, of which 10 were collaborative. Four of the top five collaborators in the chemistry sector are research organisations (Figure 4.7). The University of Melbourne had 11 collaborative applications out of a total of 14 applications (79 per cent). The University of Melbourne collaborated widely, with both Australian and international entities, and generally collaborated with more than one other applicant. In contrast to the University of Melbourne, all the collaborations for CSIRO were with other Australian research institutions or Australian SMEs. Avexa LTD, a SME, collaborated on five of 12 applications or 42 per cent of their total applications.

[28] Bionomics, About

[29] Gilead, Gilead Sciences Completes Acquisition of YM BioSciences, 8 February 2013

[30] Bionity.com, Cytopia Ltd Company Portrait

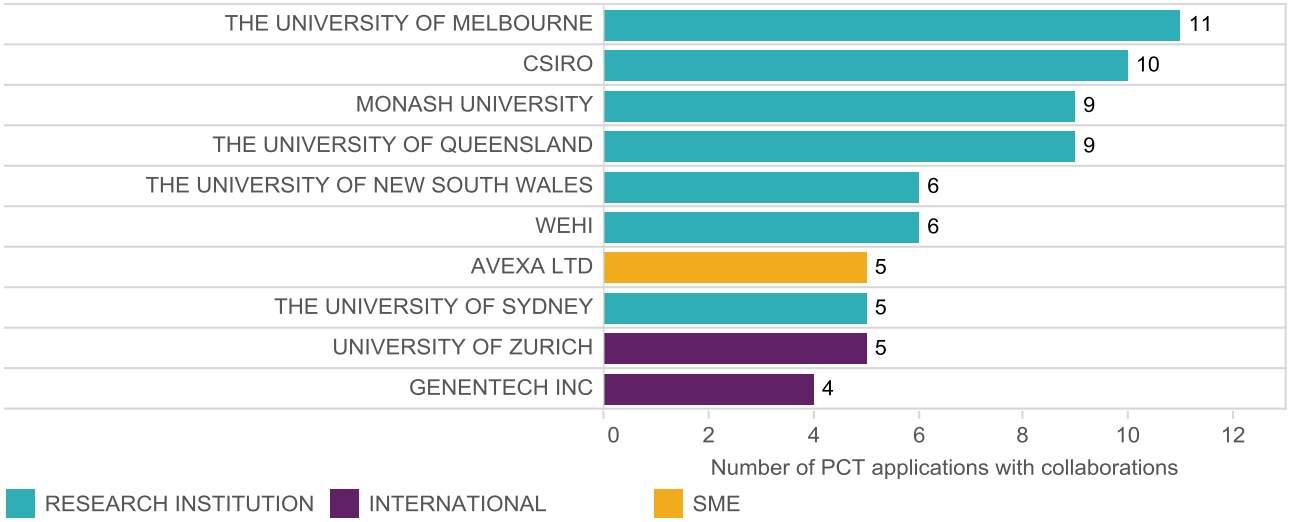
[31] Novogen, Our Story

[32] Avexa, About Us

[33] Bloomberg, Company Overview of Avexa Ltd.

[34] Regional Health Care Group, About Regional

Figure 4.7: Top 10 applicants who collaborate

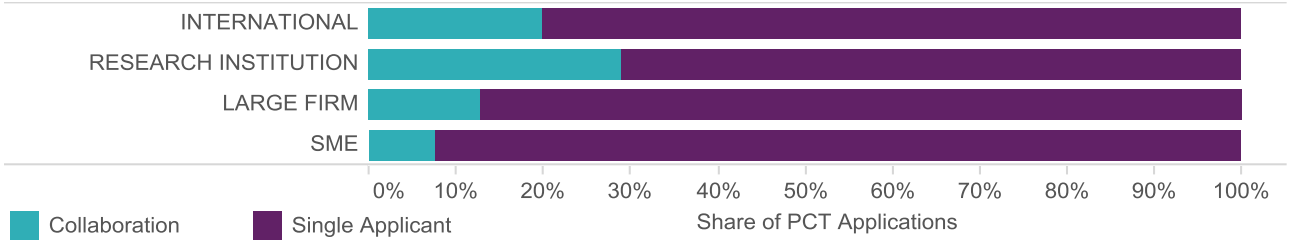


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Collaboration between applicant types

In line with their dominance in the list of top collaborators, Australian research institutions were the most prevalent entity type to appear as a collaborator on PCT applications in the chemistry sector. Almost 30 per cent of applications with an Australian research institution involved multiple applicants (Figure 4.8). This number falls to 20 per cent for international entities, 13 per cent for large Australian firms and eight per cent for Australian SMEs.

Figure 4.8: Proportion of PCT applications assigned to entity types where collaboration is evident



Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

In the chemistry sector, collaboration most commonly occurred between international entities and Australian research institutions, followed by international entities collaborating with other such entities (Figure 4.9). There was no collaboration between two or more large Australian firms.

Figure 4.9: Number of PCT applications with collaboration between entity types

	INTERNATIONAL	RESEARCH INSTITUTION	LARGE FIRM	SME
INTERNATIONAL	22			
RESEARCH INSTITUTION	31	18		
LARGE FIRM	3	4		
SME	8	16	1	3

Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

5 Electrical

Electrical technologies accounted for the largest Australian advanced manufacturing technology sector with 7033 (30 per cent) applications in categories including communications technologies, controlling and regulating devices, computer and data processing, general electronics, as well as heating and lighting, domestic appliances and power production. Australia's share of the global patenting activity was 0.62 per cent for a global ranking of fifteenth. The electrical sector was also the largest globally, accounting for almost forty four percent of applications.

Australia had a negative specialisation in electrical, meaning that Australian does not have a technological strength in in the sector. Australia was ranked thirty out of forty eight countries on the index.

Like many of the advanced manufacturing sectors, CSIRO was the top applicant and also the top collaborator. Large firms, such as Cochlear, and research institutions, such as the University of Sydney, made up the majority of the top applicants in the sector.

The most active Australian areas in the electronics sector were communication technologies, controlling, regulating and testing, and computing and data processing, the three categories combined accounted for 65 per cent of all applications. There was no single dominant player in any technology sub-category, with the exception of registration and checking devices, where Aristocrat Technologies[35] had almost 20 per cent of the applications. Aristocrat is an Australian business operating globally that develops gaming machines and casino management systems. They are a major applicant in the domestic patent system, although less prevalent internationally.

The most common applicant was SMEs with 51 per cent of the applicants and 29 per cent of the applications. International applicants have the most applications, with 31 per cent, and make up 33 per cent of the applicants. Large firms are at the opposite end of the spectrum with six per cent of the applicants and seven per cent of the applications. Applicants from the United States were the preferred international partners, followed by the United Kingdom and Japan.

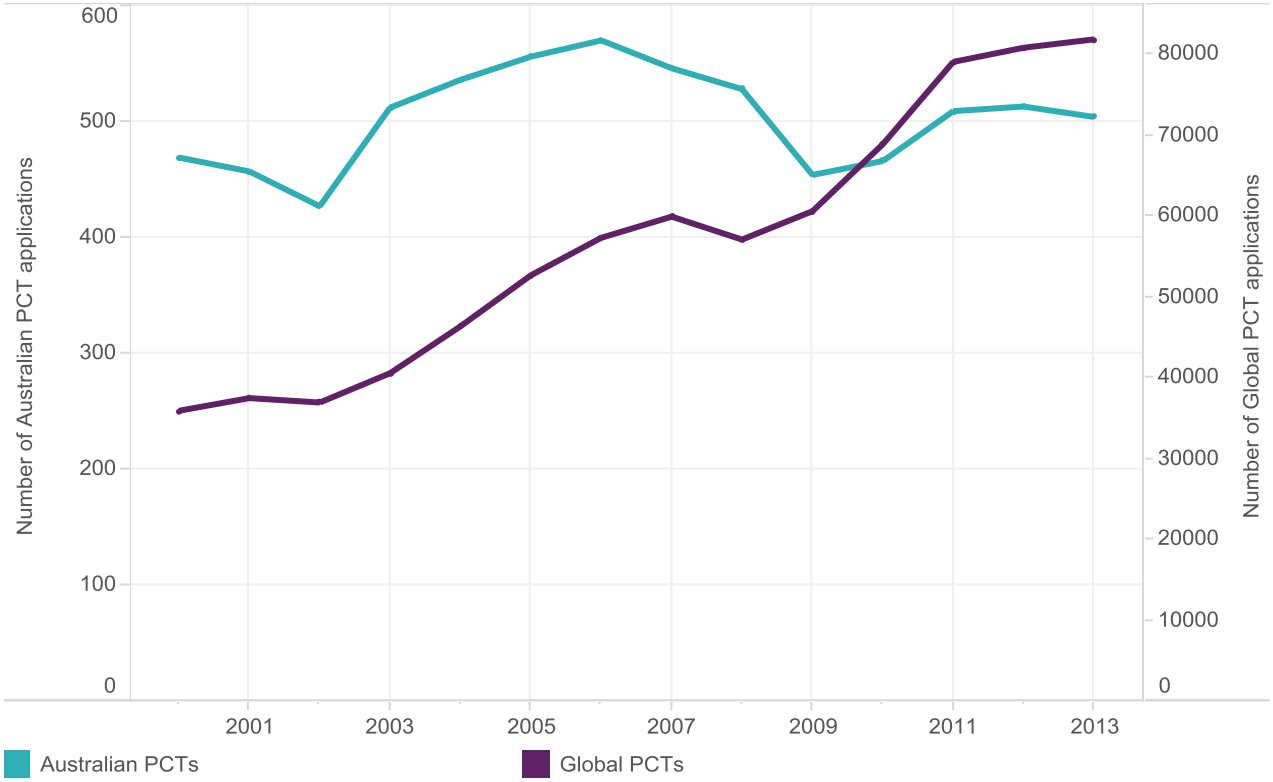
Most applications in the electrical sector did not involve collaborations. Of the 7033 electrical PCT applications, only four per cent (298 applications) involved multiple applicants. This was among the lowest collaboration in the advanced manufacturing sectors. All but one of the top ten collaborators in the electrical sector were Australian universities or other research institutions. The most prevalent collaborative relationships in terms of PCT applications in the electrical sector were between Australian research institutions and between Australian research institutions and international entities.

[35] Aristocrat, About

Patent activity over time

The number of Australian electrical PCT applications has been generally steady with a total of 7033 applications (Figure 5.1). In contrast global patent activity has seen a rapid increase, from 35 833 to 81 812 applications.

Figure 5.1: Australian and global PCT applications

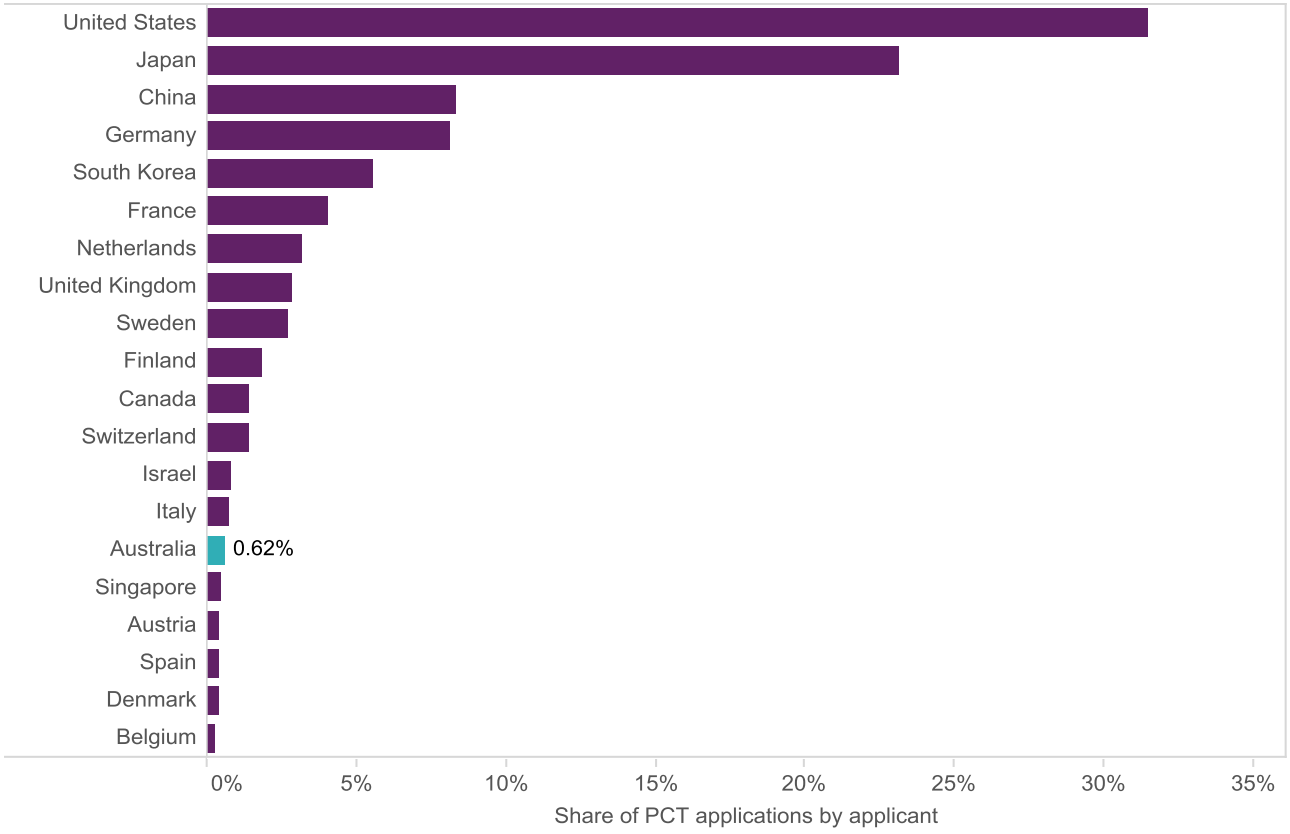


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Global applications grew by 128 per cent from 2000 to 2013. Whilst having a peak in 2006, Australian applications grew by seven per cent (fewer than 50 applications).

Australia had a relatively low share of global patenting activity in the electrical sector with 0.62 per cent, ranking fifteenth globally (Figure 5.2). This was one of the lower rankings in Australian advanced manufacturing. As is common with most advanced manufacturing sectors, the United States is the most active country globally. Japan is the second most active country with China and Germany following. The electrical sector is the only advanced manufacturing technology where China featured as one of the top three applicant nationalities.

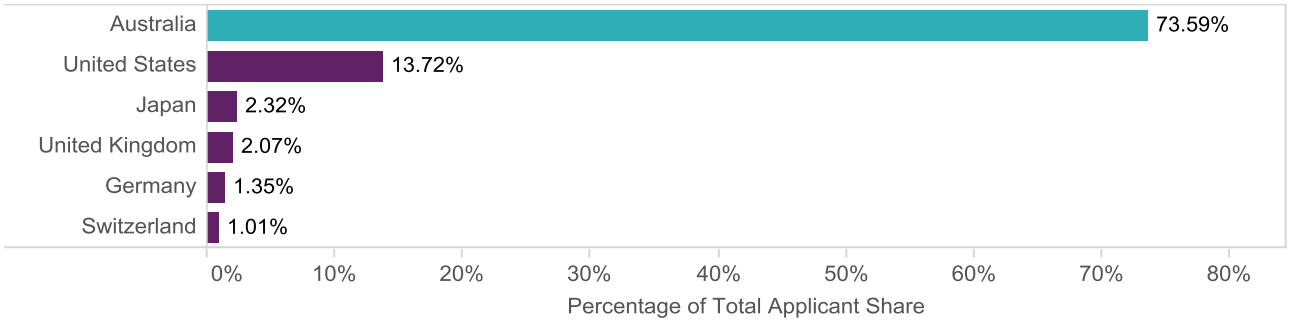
Figure 5.2: Applicant share of PCT applications across the top 20 countries



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Countries that Australian applicants or inventors work with are shown in Figure 5.3. This is determined by identifying the country of origin of applicants on PCT applications. Applicants from the United States are the preferred overseas partners, followed by Japan and the United Kingdom.

Figure 5.3: Applicant origin

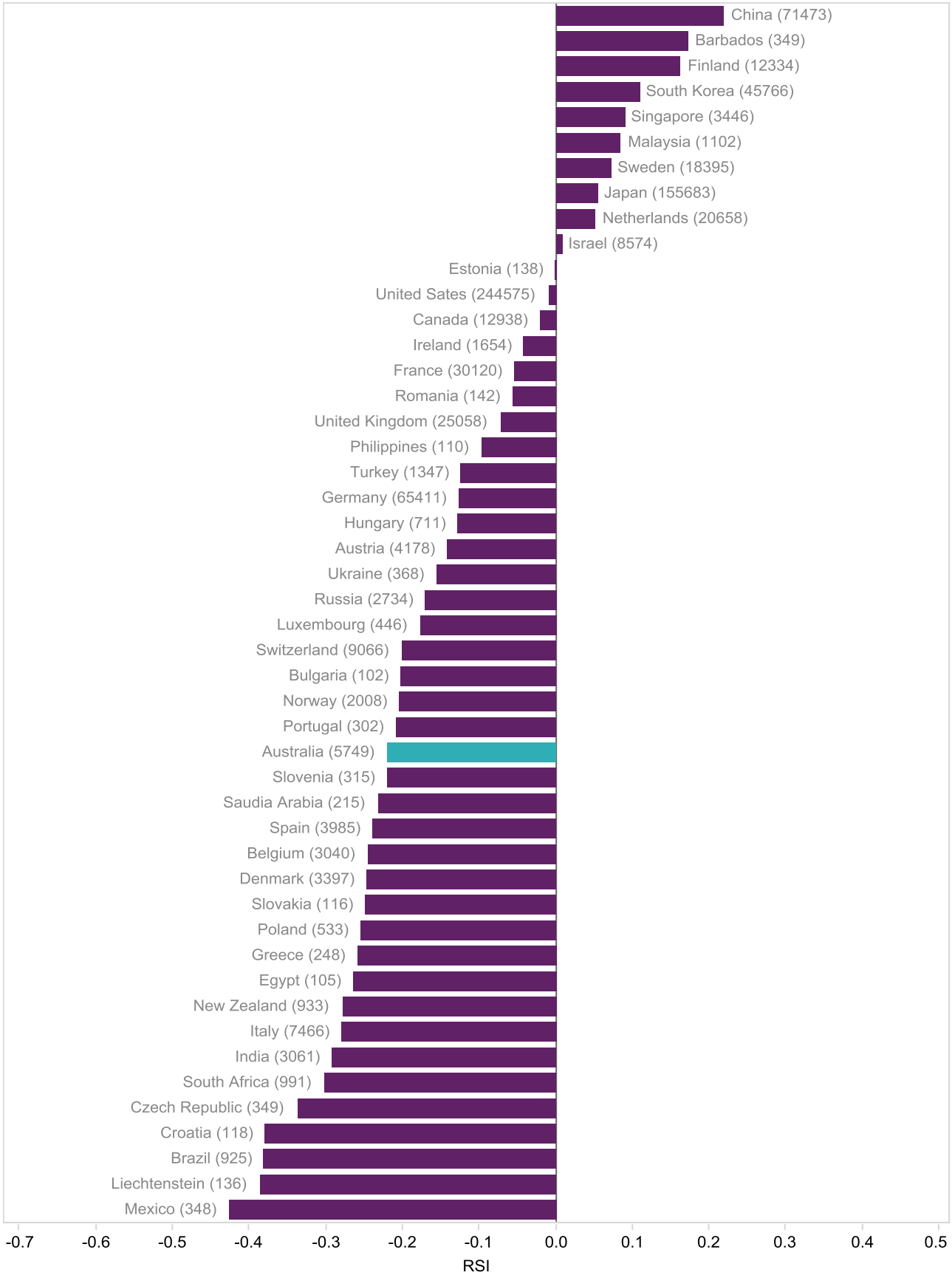


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Technological specialisation

Australia had a low level of specialisation in the electrical sector, ranking thirtieth (Figure 5.4). The extent of negative specialisation for this technology was similar to the chemistry and material groups. As a comparison, Spain had a similar number of PCT applications to Australia, and ranked thirty-third.

Figure 5.4: Relative Specialisation Index for PCT electrical applications



Source: PATSTAT database, Autumn 2015; and IP Australia Calculations

Electrical technologies

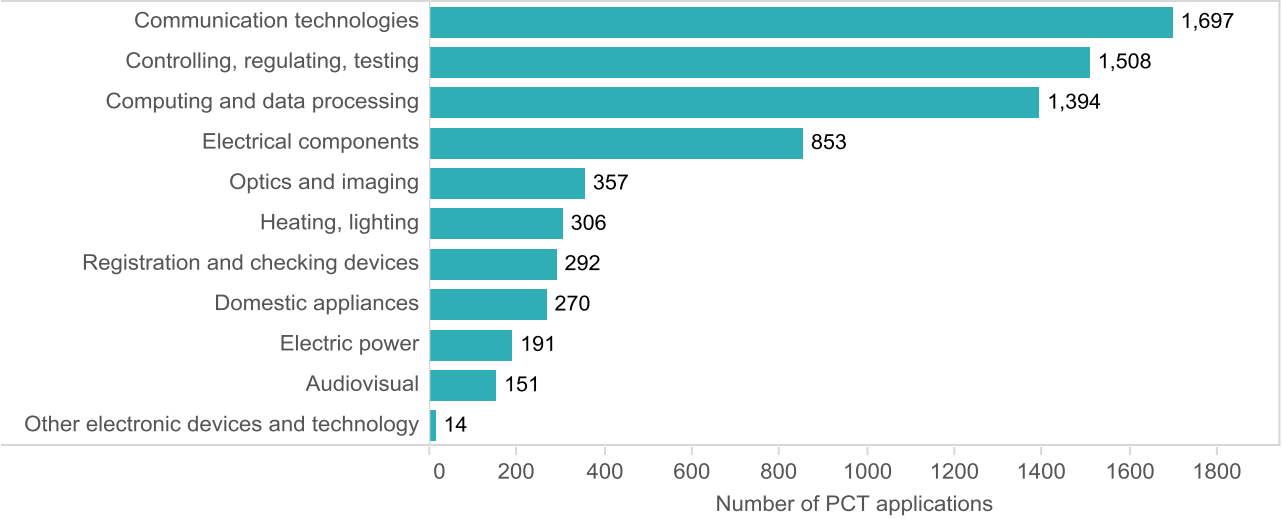
There were a diverse range of technologies that were identified from the Australian PCT applications. Applications were broken down into the following broad technology categories of:

- *communication technologies* includes wireless networks, telecommunications, television and data transmission as well as loudspeakers, microphones, public address systems as the like
- *controlling, regulating and testing* – instruments of a wide variety adapted to measure physical properties such as dimensions, mass, vibrations, chemical properties and parameters of movement
- *computing and data processing* – data and image processing and computational models and electronic computing devices
- *electrical components* – basic electronic circuitry and elements such as cables, magnets, conductors and insulators, switches, relays, waveguides and the like
- *optics and imaging* – optical elements such as lenses, light guides, refractors and reflectors, and devices relying on modification or control of optical properties including optical logic circuits, optical modulators and demodulators, and non-linear optics
- *heating and lighting* – electric heating and lighting and associated accessories
- *registration and checking devices* – coin-freed apparatus generally associated with dispensing goods or services as well as banking systems such as automatic teller machines and coin testing or sorting arrangements
- *electric power* – generation, conversion and distribution of electric power
- *audio-visual technology* – instruments for generating sound; speech analysis and synthesis; and apparatus for photography, electrography and holography
- *other electronic devices and technology* – technologies that are not considered to fit well into the other sections such as irradiation devices, gamma and x-ray microscopes; single-crystal growth techniques and micro-mechanical devices

A detailed breakdown of the CPC marks and the technology breakdown can be found in Appendix C.

The most active Australian areas in the electronics sector were communication technologies, controlling, regulating and testing, and computing and data processing (Figure 5.5), the three categories combined accounted for 65 per cent of all applications.

Figure 5.5: Australian electrical PCT applications by technology category



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Key applicants in the electrical sector

Applications by entity type

The SME entity type had the largest number of applicants (926), followed by international entities (596) in the electrical sector (Table 5.1). Research institutions were the most active entity type, with 1215 applications, and an average number of applications per applicant of 15.4, almost three times the application rate of the next most active entity type. This application rate is also one of the highest rates seen from any entity in any of the advanced manufacturing technologies.

Table 5.1: PCT applications by entity type

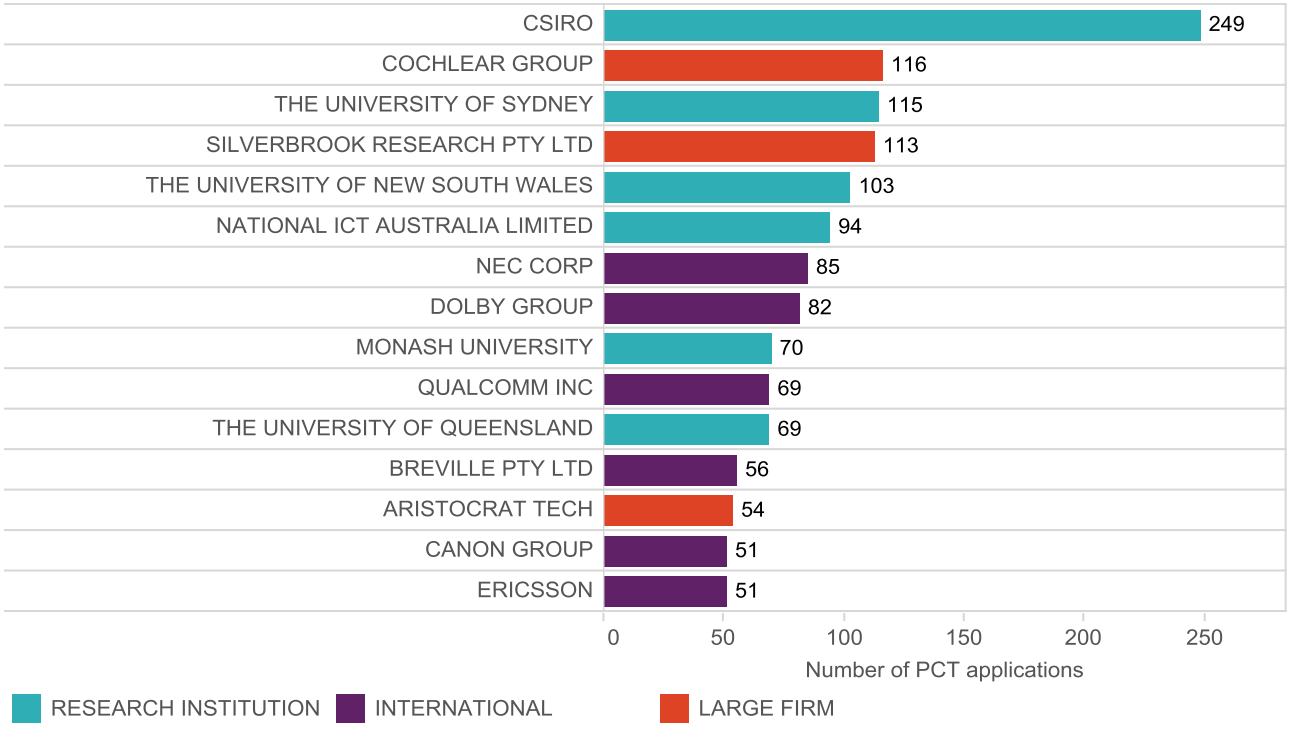
	Number of applicants	Number of applications	Average applications per applicant
INTERNATIONAL	596	2,106	3.5
RESEARCH INSTITUTION	79	1,215	15.4
LARGE FIRM	105	638	6.1
SME	925	1,931	2.1
INDIVIDUAL	100	120	1.2

Source: PATSTAT database, Autumn 2015; IPGOD, 2016 edition; and IP Australia calculations.

Top applicants

Of the top eleven applicants, four were Australian universities (The University of Sydney, The University of New South Wales, Monash University and The University of Queensland) and two (CSIRO and NICTA) were national research organisations (Figure 5.6).

Figure 5.6: Top applicants



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

The Cochlear group[36] is the second in the list of top applicants for the electrical sector with 116 PCT applications. The Cochlear group specialises in implantable hearing solutions to treat deafness and hearing loss including implantable electronics.

NEC Corporation[37] is a multinational provider of IT products and services, with applications generally relating to communications systems and data transmission while the Dolby group,[38] specialises in audio-visual technologies in particular noise reduction and audio encoding and compression.

Qualcomm[39] focusses on mobile technologies, impacting a wide range of industries. Their PCT applications include methods and apparatus for authenticating wireless communications and configuration protocols. Canon group filed applications relating to a range of technologies from liquid crystal devices to printing systems and image encoding.

Collaboration in the electrical sector

Top collaborating applicants

Most applications in the electrical sector did not involve collaborations. Of the 7033 electric PCT applications, only four per cent (298 applications) involved multiple applicants. This was among the lowest collaboration in the advanced manufacturing sectors.

The most prolific collaborator in the electrical sector was CSIRO (Figure 5.7) which shared PCT applications with Australian universities and research organisations (in particular Monash University, The University of Melbourne and The University of Adelaide) and with international

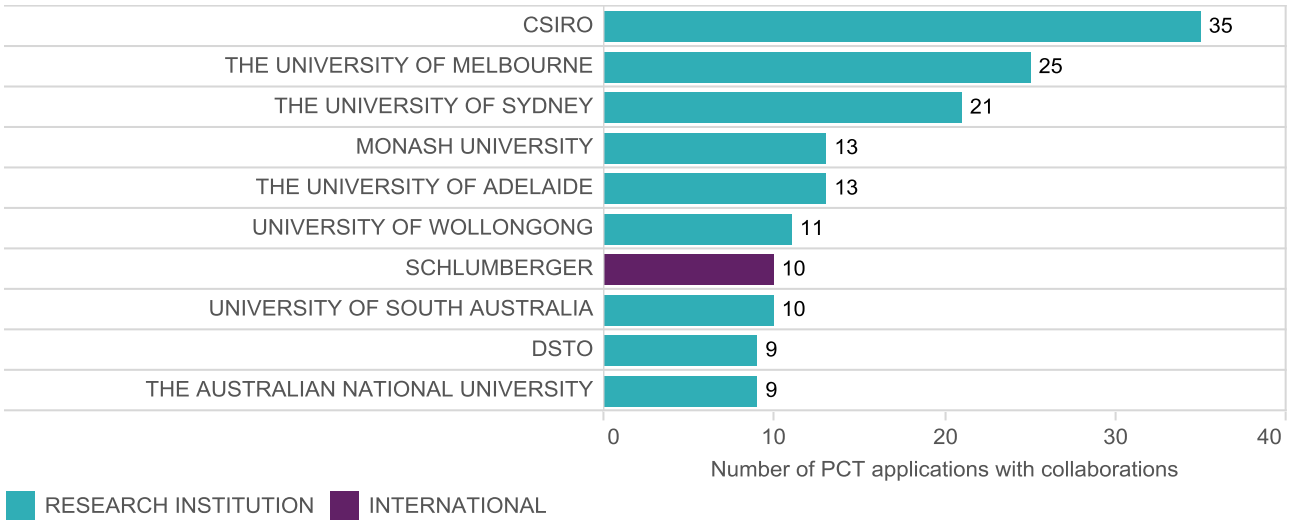
[36] Cochlear, Home
[37] NEC, Corporate Profile
[38] Dolby, LinkedIn profile
[39] Qualcomm, About

entities such as the Furukawa Battery Company[40] (7 shared applications) as well as small and large Australian firms.

Many of the Australian universities worked in collaborative groups: The University of Melbourne, The University of Adelaide, The University of Queensland, The University of South Australia and Flinders University were co-applicants on six PCT applications. Compaq Computer, CEA Tech, RLM Systems and Telstra were also applicants on these applications. The Defence Science and Technology Organisation (DSTO) and CSIRO also featured. In contrast, The University of Wollongong and the Australian National University were involved with a wider range of collaborative groups. Each filed PCT applications with domestic and international universities and with international firms.

Schlumberger[41] was the only collaborator in the list of top ten that was not an Australian research institution. This international firm collaborated with other international applicants and is focussed on seismic surveying technologies and data processing.

Figure 5.7: Top 10 applicants who collaborate



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

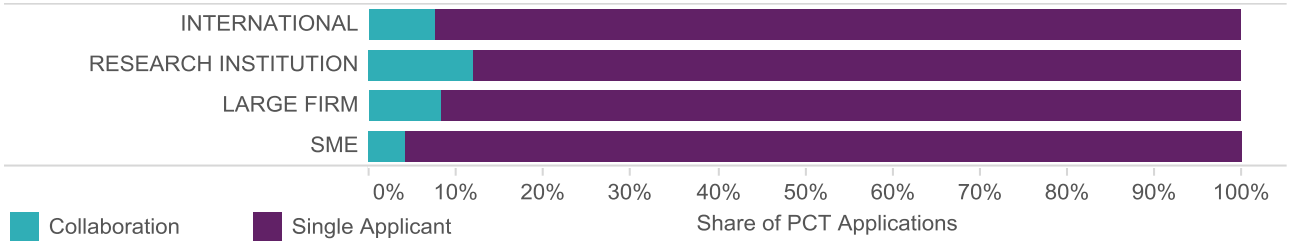
Collaboration between applicant types

Research institutions had the most applications with co-applicants (Figure 5.8). Less than 10 per cent of applications that involve large firms or international entities exhibited any collaboration. This proportion drops to less than five per cent for SME applicants.

[40] Furukawa Battery Company, Company profile

[41] Schlumberger, Corporate Profile

Figure 5.8: Proportion of applications assigned to entity types where collaboration is evident



Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

The most prevalent collaborative relationships in terms of PCT applications in the electrical sector were between Australian research institutions and between Australian research institutions and international entities (Figure 5.9).

Figure 5.9: Number of PCT applications where collaboration existed between entity types

	INTERNATIONAL	RESEARCH INSTITUTION	LARGE FIRM	SME
INTERNATIONAL	41			
RESEARCH INSTITUTION	50	51		
LARGE FIRM	12	29	5	
SME	18	28	11	19

Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

6 Materials

The materials sector covers processed components and resources such as polymers, coatings, cements, metals and alloys. The sector is the smallest advanced manufacturing sector in the study, with fewer than four per cent of the total PCT applications (838 applications).

There were 838 PCT applications filed in the materials sector between 1 January 2000 and 31 December 2013. Australia's share of global patenting activity is 0.49 per cent (ranked seventeenth), which was the smallest global share amongst the technology sectors.

Australia had a negative specialisation in materials, meaning that Australian doesn't have a technological strength in materials. Australia was ranked twenty ninth out of thirty three countries on the index. Countries with strength in the area include Japan (third), Germany (fifth) and Switzerland (sixth).

Like many of the sectors, CSIRO was the top applicant and the top collaborator. However, in the materials sector their influence was by far the greatest of all the technologies. CSIRO had almost three times the number of applications as the next applicant, BlueScope. Other major applicants include the University of Queensland, James Hardie and the University of New South Wales. The major technology focus was polymers and plastics, followed by coatings.

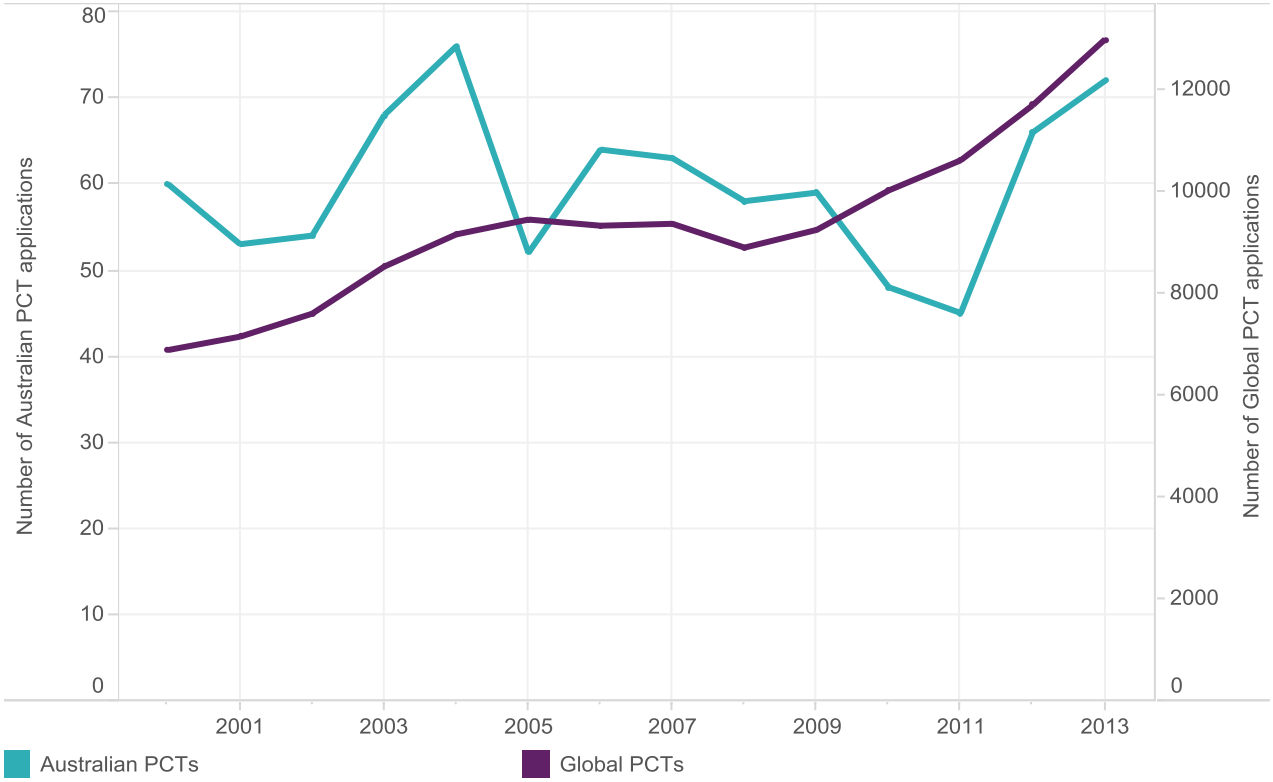
Australian SMEs (138 applicants) and international entities (121 applicants) were the most common applicant types, although they were not the most prolific applicants to file PCT applications. Instead, Australian research institutions, who were much less numerous contribute roughly 7.4 applications per applicant. This ratio was closer to two for SMEs, large firms and international entities. Applicants from the United States are the preferred international partners, followed by Germany and the Netherlands.

Of the 838 materials PCT applications identified, 84 applications (10 per cent) had multiple applicants. Collaboration between research institutions and international entities was the most common type. Where collaboration is present, CSIRO leads with 26 collaborations. CSIRO collaborated with the Grains Research and Development (GRDC) four times and with international company Boeing three times.

Patent activity over time

The number of applications involving Australian applicants was generally steady across the time period (Figure 6.1), with 838 PCT applications. Conversely, global patent applications increased from 6886 in 2000 to 12998 in 2013, equating to an 88 per cent increase.

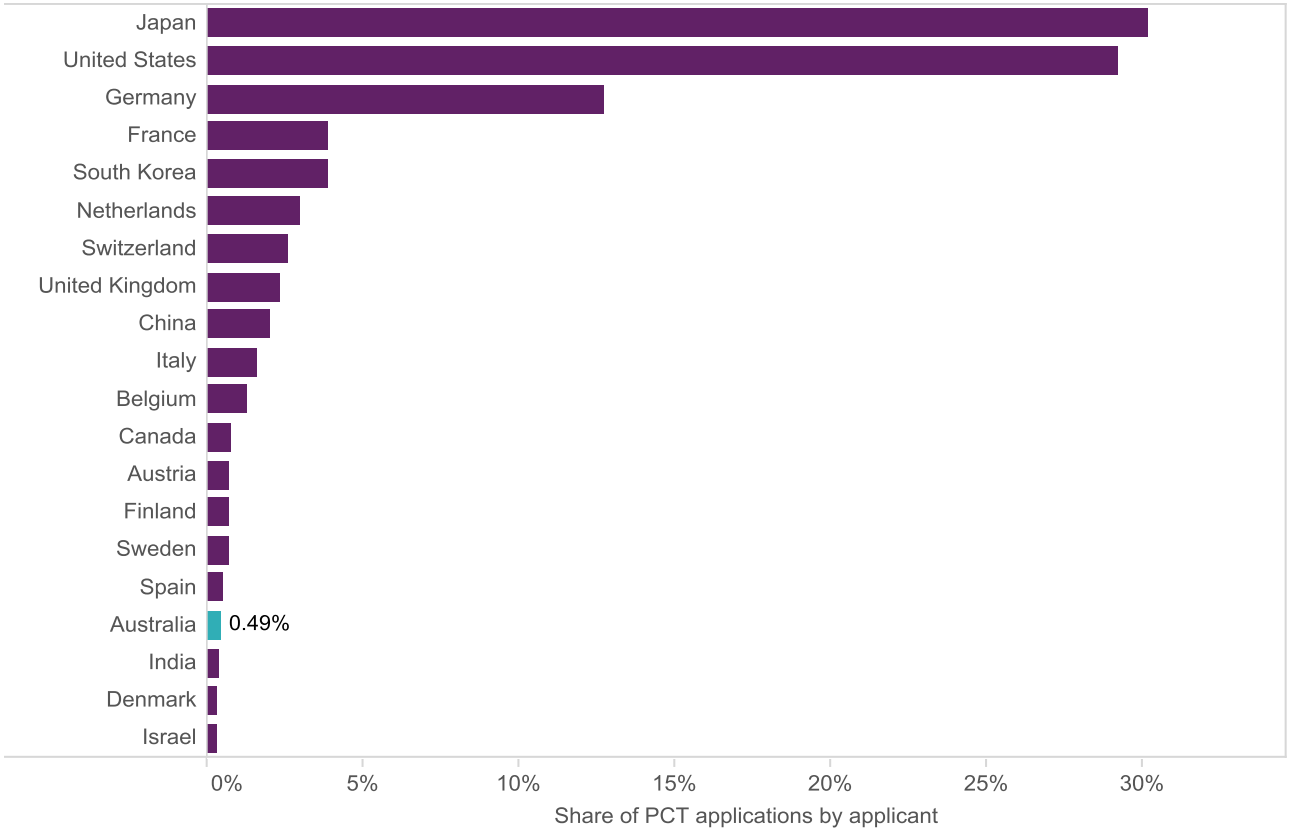
Figure 6.1: Australian and global PCT applications



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Australia had a very low share of global patenting activity in the materials sector with 0.49 per cent, and was ranked seventeenth (Figure 6.2). This was one of the lowest rankings, along with chemistry. Japan is the most active country on a global scale with the USA closely behind, followed by Germany.

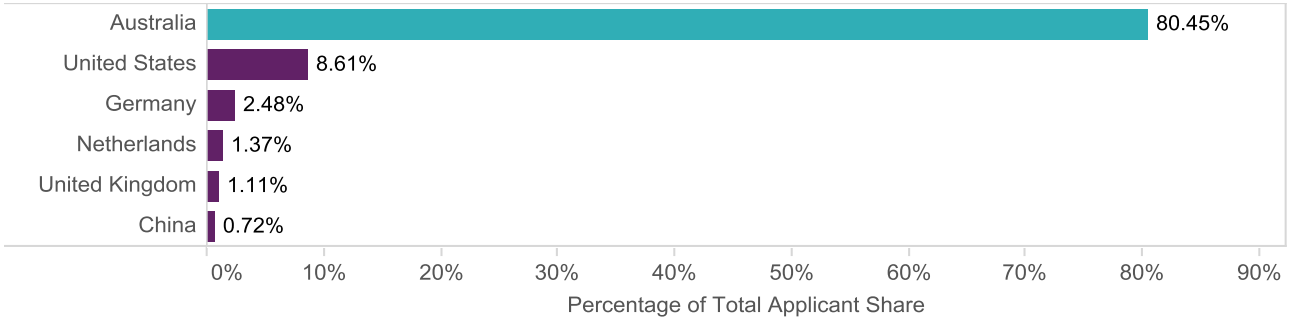
Figure 6.2: Share PCT applications across the top 20 countries



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Countries that Australian applicants or inventors work with are shown in Figure 6.3. This is determined by identifying the country of origin of applicants on PCT applications. Applicants from the United States are the preferred overseas partners, followed by Germany and the Netherlands.

Figure 6.3: Applicant origin

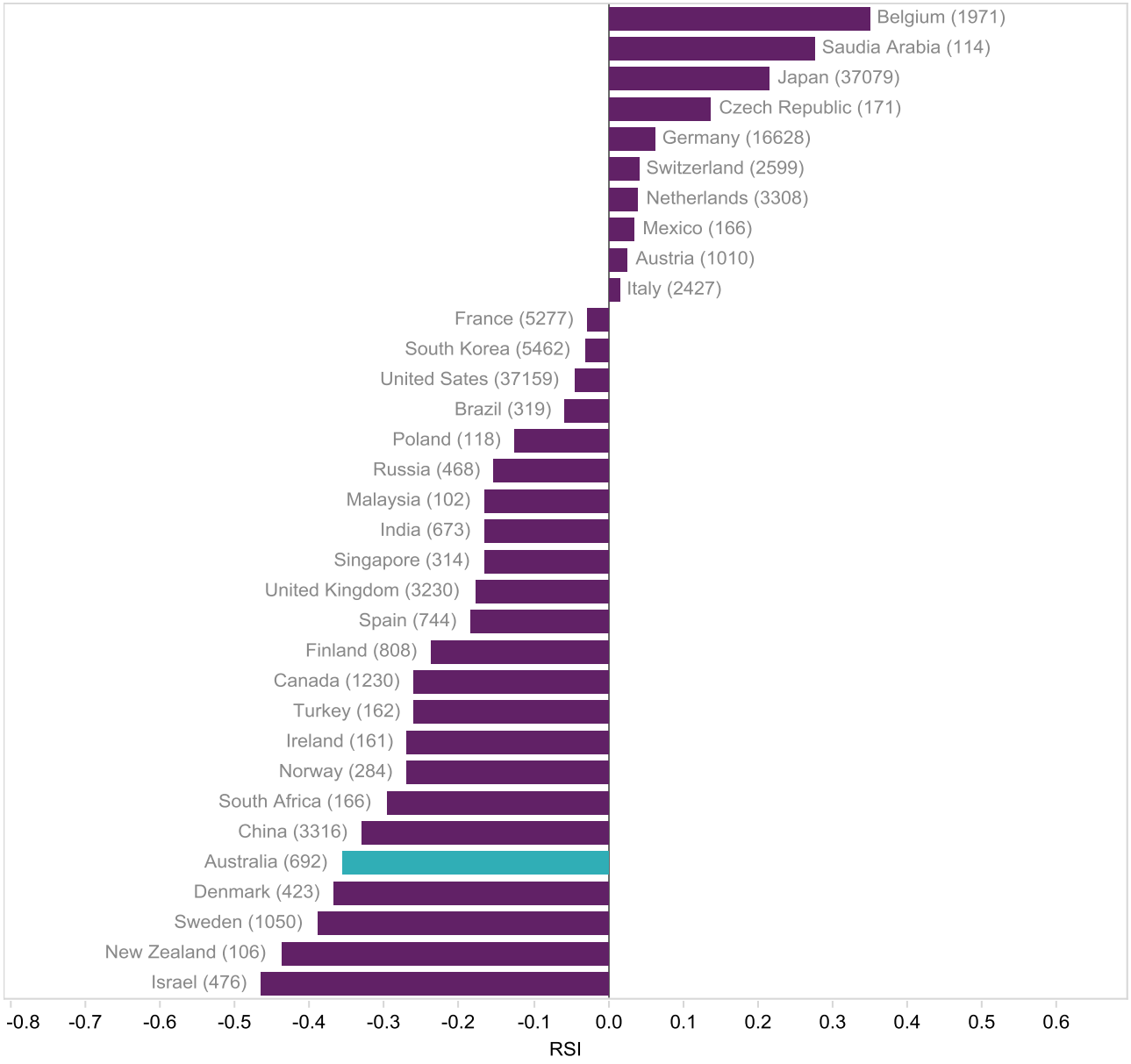


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Technological specialisation

Australia had a negative specialisation in materials, ranking twenty-ninth (Figure 6.4). The degree of negative specialisation is similar to Australia's chemistry and electrical sectors. As a comparison, India, who has a similar applicant share of patents to Australia, ranks eighteenth. Relatively few countries show a (positive) relative specialisation in the materials technology. Countries with strength in the area include Japan (third), Germany (fifth) and Switzerland (sixth).

Figure 6.4: Relative Specialisation Index for PCT materials applications.



Source: PATSTAT database, Autumn 2015; and IP Australia Calculations

Materials technologies

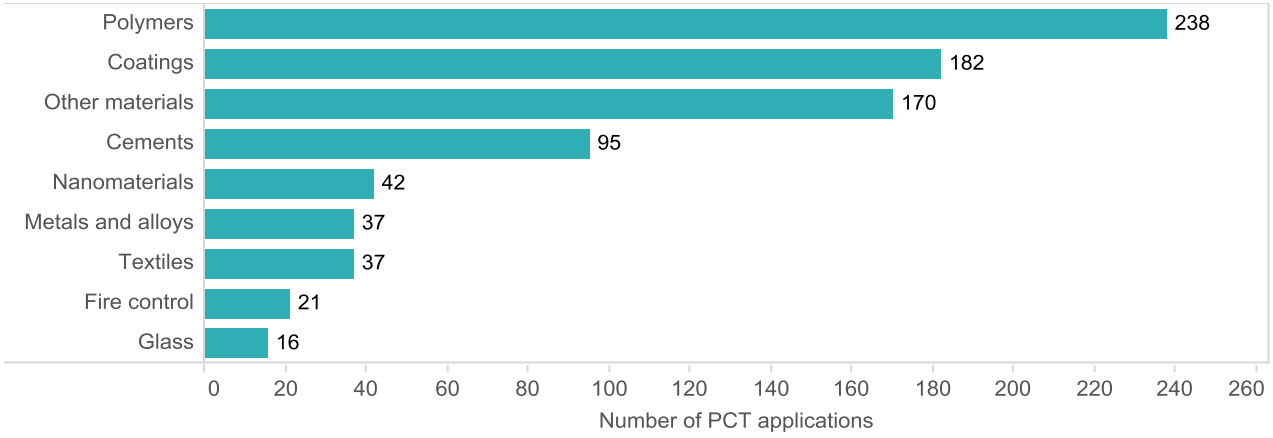
There were a range of technologies identified. Broadly, applications were broken down into:

- *polymers* – macromolecular compounds such as polysaccharides and carbon-to-carbon unsaturated macromolecules, along with compositions incorporating macromolecular compounds and methods of their treatment
- *coatings* – compositions such as paints, varnishes and lacquers, along with coatings of metallic materials
- *cements* – materials for incorporation into cements and compositions thereof
- *fire control* – fire extinguishing compositions, materials for fire protection and the fireproofing of materials using a chemical means
- *nanomaterials* – uses of materials for nano-technological applications and their preparation
- *metals and alloys* – compositions of alloys and the preparation of those alloys
- *textiles* – the production and treatment of natural and artificial threads along with their uses in applications such as weaving, braiding, sewing, embroidering, ropes and cables
- *glass* – the compositions of glasses, glazes and vitreous enamels along with their surface treatment
- *processed materials* – types of materials not covered in the above technologies including layered products and textured surfaces; adhesives; treated hides and leather

A detailed breakdown of the CPC marks and the technology breakdown can be found in Appendix C.

This technology sector was dominated by the top three categories, polymers, coatings and other materials (Figure 6.5). These technologies comprised 590 applications or 70 per cent of the Australian materials sector.

Figure 6.5: Australian materials PCT applications by technology category



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Key applicants in materials

Applications by entity type

SMEs were the most active applicant, followed closely by the international entities (Table 6.1). Australian research institutions and international entities had a similar number of applications in

total, although research institutions on average filed three times the number of applications per applicant than international entities.

Table 6.1: PCT applications by entity type

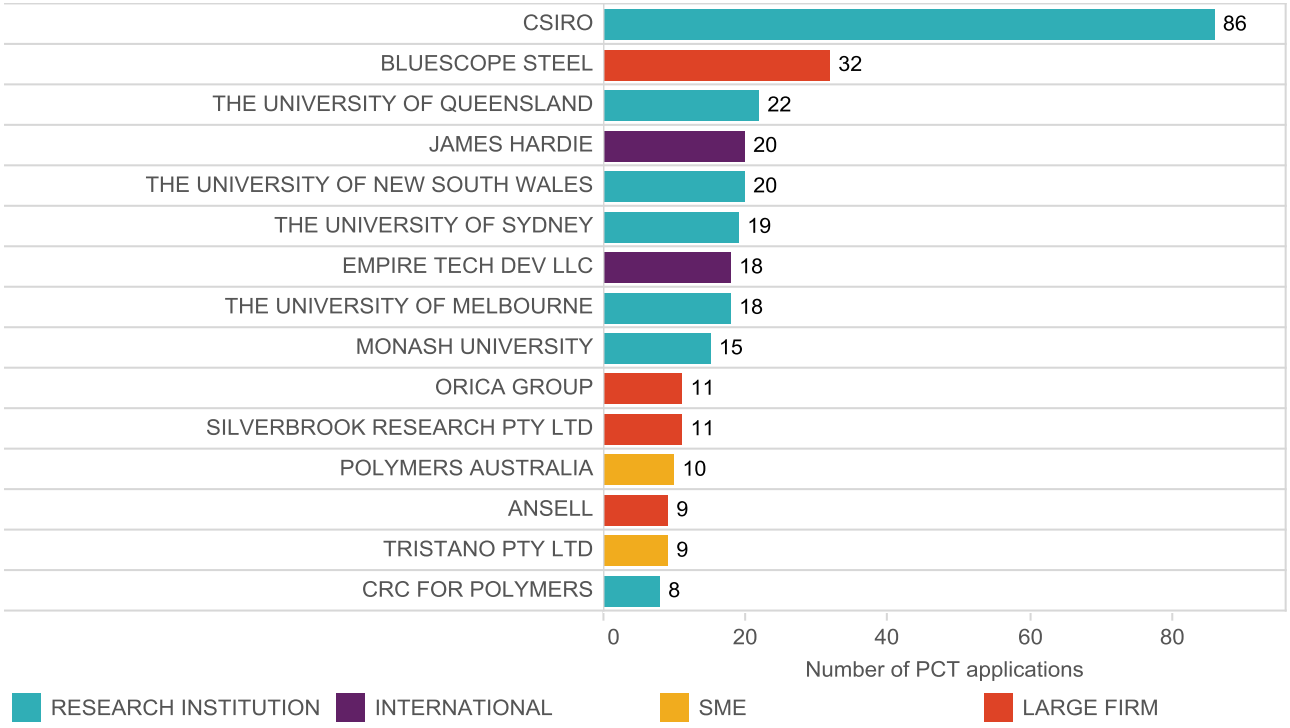
	Number of applicants	Number of applications	Average applications per applicant
INTERNATIONAL	117	213	1.8
RESEARCH INSTITUTION	34	252	7.4
LARGE FIRM	22	89	4.0
SME	138	211	1.5
INDIVIDUAL	14	14	1.0

Source: PATSTAT database, Autumn 2015; IPGOD, 2016 edition; and IP Australia calculations.

Top applicants

Research institutions dominate the top applicants in the materials sector with CSIRO, the University of Queensland, the University of New South Wales, the University of Sydney, the University of Melbourne and Monash University all appearing in the top 15 applicants (Figure 6.6).

Figure 6.6: Top Applicants



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Polymers Australia is a company established by the Cooperative Research Centre for Polymers and was founded to manage collaboration between researchers from industry, Australian universities and government laboratories.[42] There were 10 PCT applications by Polymers Australia. The company has innovations in the preparation of nano-composite materials and polymerisable compositions for forming photochromic articles.

[42] Polymers Australia, Our History

Tristano Pty Ltd is an Australian-based company, operating as a controlled entity of the international company Cardia Bioplastics.[43,44] The company has materials based research interests in the area of biodegradable polymers and materials.

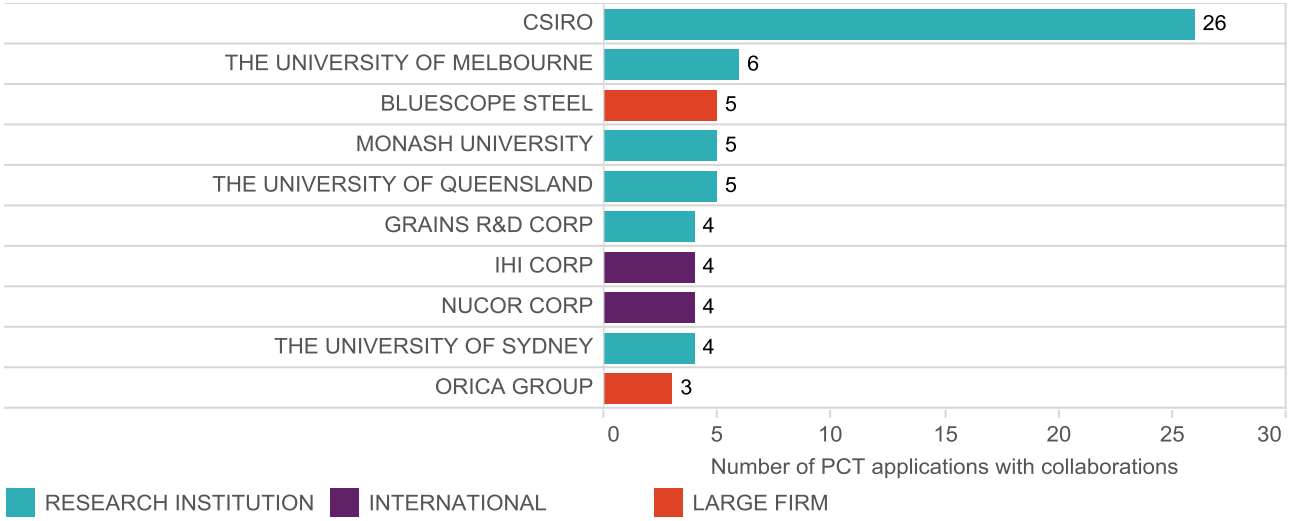
The Cooperative Research Centre for Polymers was established in 1992 and has eight materials PCT applications. It is an incorporated joint venture between universities and the public polymers sector. Unsurprisingly, the applications are focussed on polymer materials with uses such as membranes and coatings.[45]

Collaboration in materials

Top collaborating applicants

Of the 838 materials PCT applications identified, 84 applications (10 per cent) had multiple applicants. Collaboration between research institutions and international entities was the most common type. Where collaboration is present, CSIRO leads with 26 collaborations (Figure 6.7). CSIRO collaborated with the Grains Research and Development (GRDC) a total of four times and with international company Boeing three times. BlueScope Steel collaborated on five PCT applications, four of which were with international entities IHI Corp and Nucor Corp (see Introduction for further information).

Figure 6.7: Top 10 materials applicants who collaborate by number of applications



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

The University of Melbourne also collaborated with CSIRO, the University of Newcastle and private sector companies Tridan Pty Ltd and Albright & Wilson Ltd. This collaboration produced two PCT applications in the area of ceramic and metallic materials fabrication.

Collaboration between applicant types

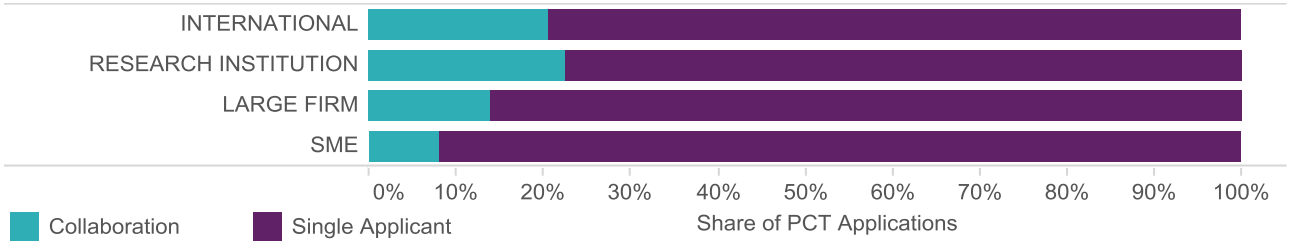
Australian research institutions were the most prevalent collaborators in the materials sector. Just over 20 per cent of applications that involve international firms or research institutions collaborated (Figure 6.8). This proportion dropped to 14 per cent for large Australian firms, and approximately eight per cent for SMEs.

[43] ASX, Cardia Bioplastics Annual Report

[44] Cardia Bioplastics, Company

[45] Cooperative Research Centre for Polymers, About Us

Figure 6.8: Proportion of applications assigned to entity types where collaboration is evident



Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

There were no collaborations between large firms or between large firms and international entities. Although there was collaboration between international entities and Australian research institutions a total of 27 times. Australian research institutions also collaborated amongst themselves 16 times (Figure 6.9). SMEs were quite active in this technology sector and collaborated the second most behind research institutions.

Figure 6.9: Number of PCT applications where collaboration existed between entity types

	INTERNATIONAL	RESEARCH INSTITUTION	LARGE FIRM	SME
INTERNATIONAL	12			
RESEARCH INSTITUTION	24	16		
LARGE FIRM	5	7		
SME	5	9	3	1

Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

7 Mechanical engineering

Mechanical engineering was the second largest advanced manufacturing sector with 4267 applications in categories such as building and construction, mining, engines, pumps and turbines and agricultural machinery.

Similar to chemical engineering, Australia's share of the global patenting activity in this sector was reasonably strong at 1.24 per cent, ranked fourteenth. It is one of the technology areas with the largest applicant share of PCT applications.

Australia also had a positive specialisation in mechanical engineering, which is this is a technological focus for Australia. In contrast, Japan and the United States have a negative specialisation in this area.

As with many of the advanced manufacturing sectors, CSIRO was the top applicant and one of the most prolific collaborators, although compared to other technology groups, in mechanical engineering there was a notable presence of applicants that were research organisations or international entities.

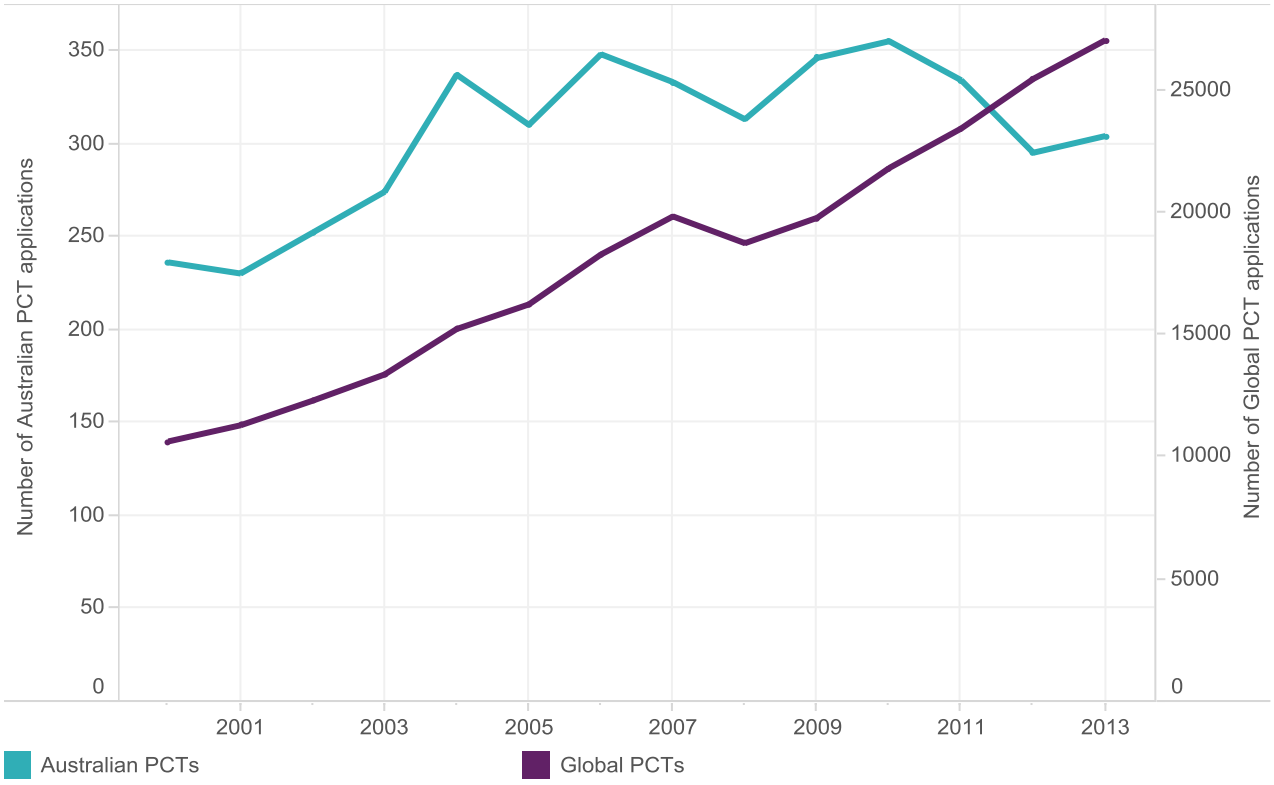
Australian SMEs, with more than 60 per cent, were the most common applicant type in mechanical engineering and also had the most applications. Research institutions had the fewest number of applicants, but filed on average over five applications per applicant, by far the most active per applicant in the sector.

Australian applicants and inventors worked with United States applicants on five per cent of applications, followed by the United Kingdom and China. The majority of collaboration in this sector was international firms with international firms, while SMEs collaborated with all of international firms, research institutions and large firms.

Patent activity over time

In mechanical engineering, a total of 4267 Australian applications were found, with almost a 30 per cent increase from 2000-2013 (Figure 7.1). By contrast, the numbers of global patent applications increased by 150 per cent with consistent growth each year except 2008; an aberration that can most likely be attributed to the global financial crisis.

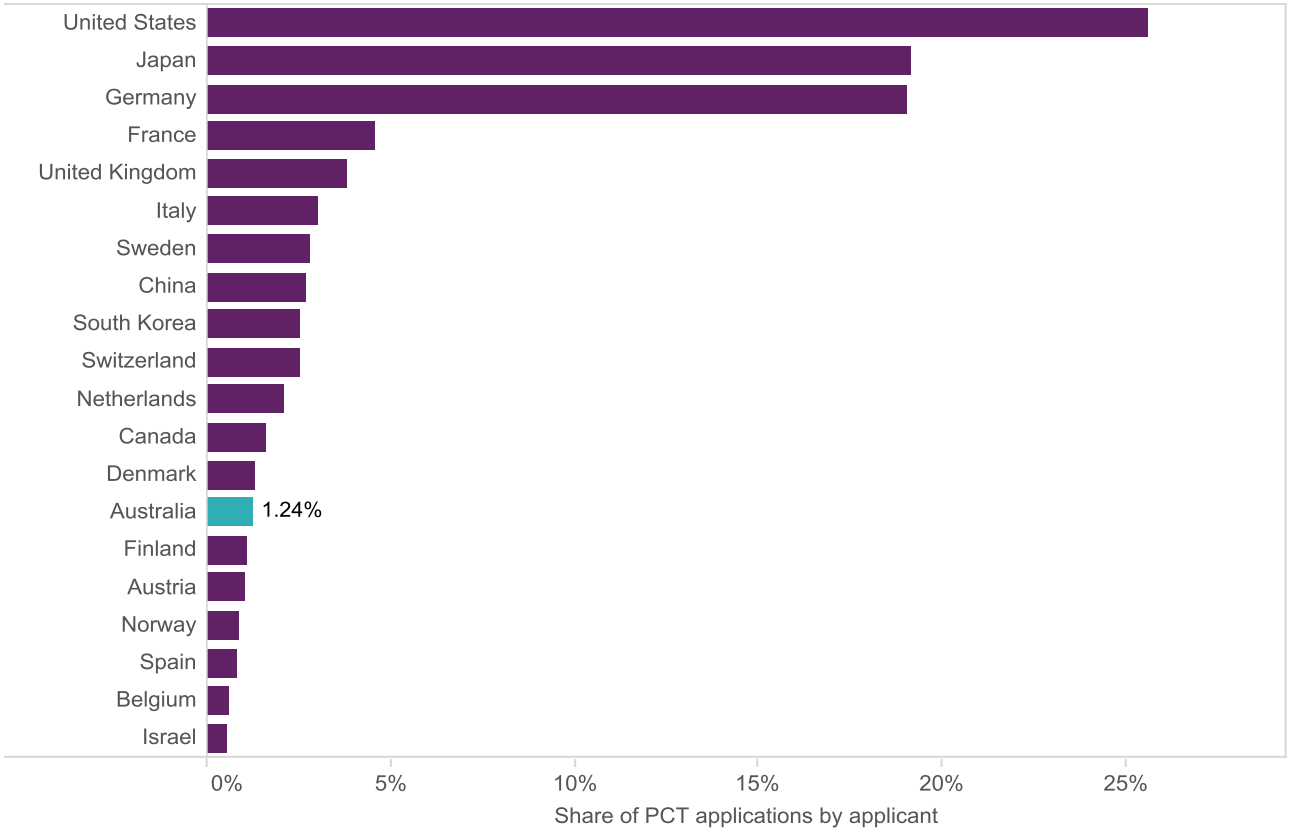
Figure 7.1: Australian and global PCT applications



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Australia's share of global patenting activity in the mechanical engineering sector was ranked fourteenth, with 1.24 per cent of the global share (Figure 7.2), one of the highest in all of the advanced manufacturing sectors. The United States was the most active country with over 25 per cent of the global share, followed by Japan and Germany.

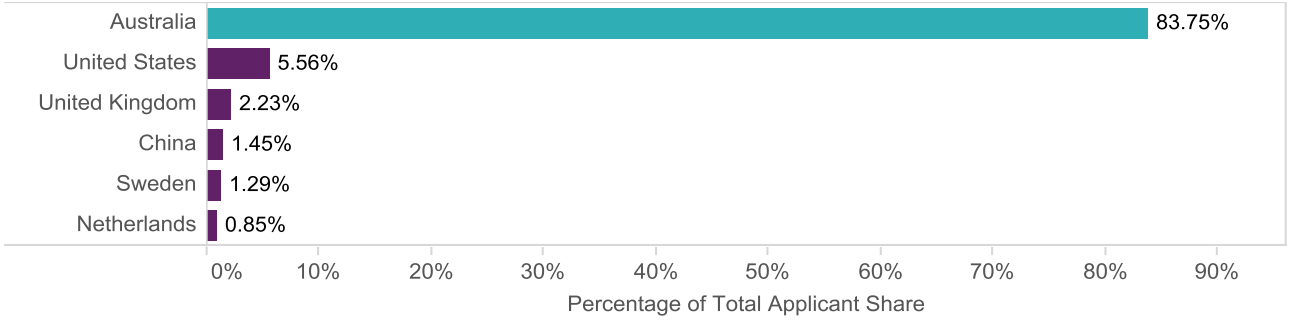
Figure 7.2: Share PCT applications across the top 20 countries



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Countries that Australian applicants or inventors work with are shown in Figure 7.3. This is determined by identifying the country of origin of applicants on PCT applications. Applicants from the United States are the preferred overseas partners, followed by the United Kingdom, China and Sweden.

Figure 7.3: Applicant origin

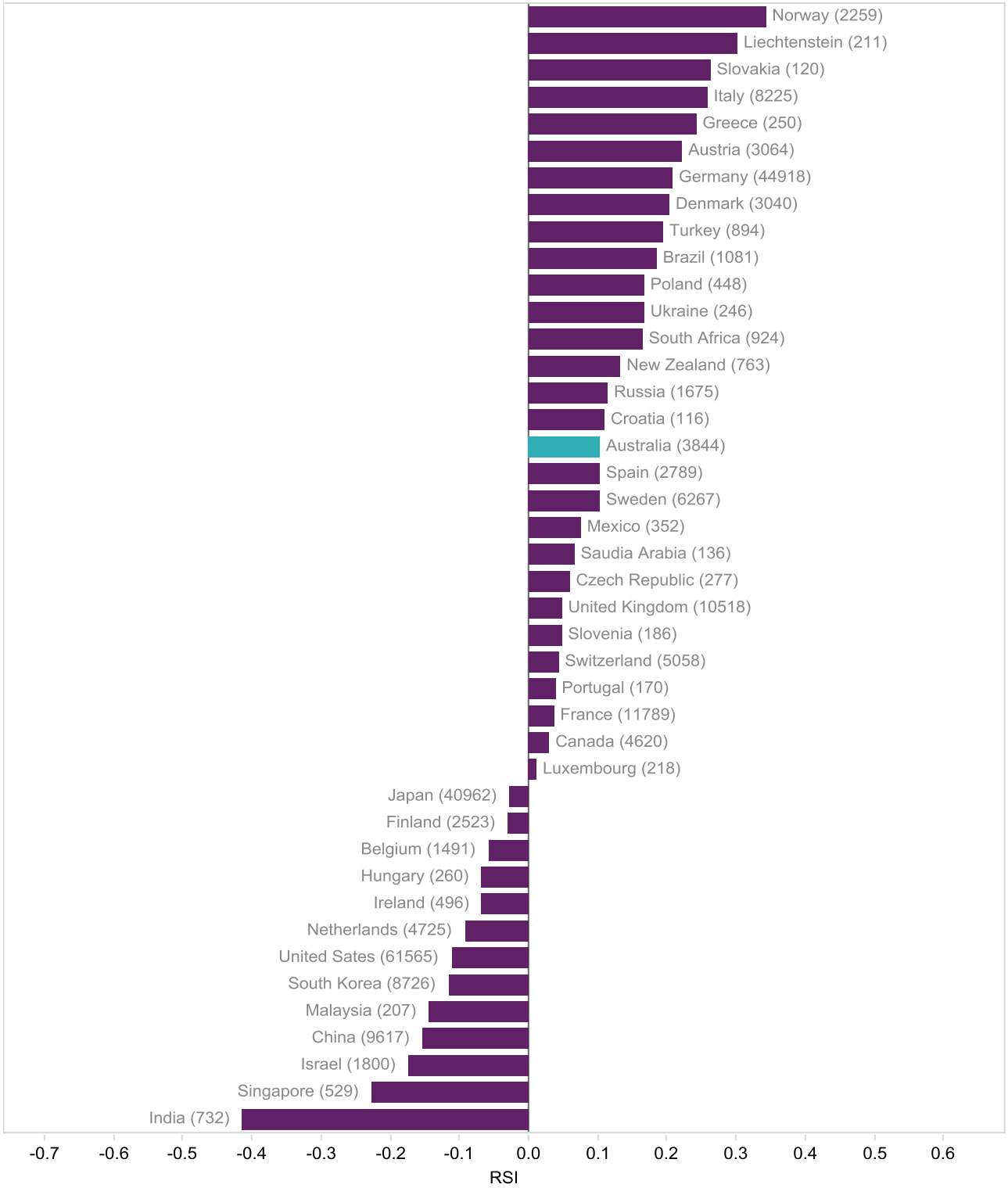


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Technological specialisation

Australia had a positive level of specialisation in mechanical engineering ranking seventeenth globally (Figure 7.4). As a comparison, Denmark, who has a similar applicant share of patents to Australia, ranks in eighth place.

Figure 7.4: Relative Specialisation Index for PCT mechanical engineering applications



Source: PATSTAT database, Autumn 2015; and IP Australia Calculations

Mechanical engineering technologies

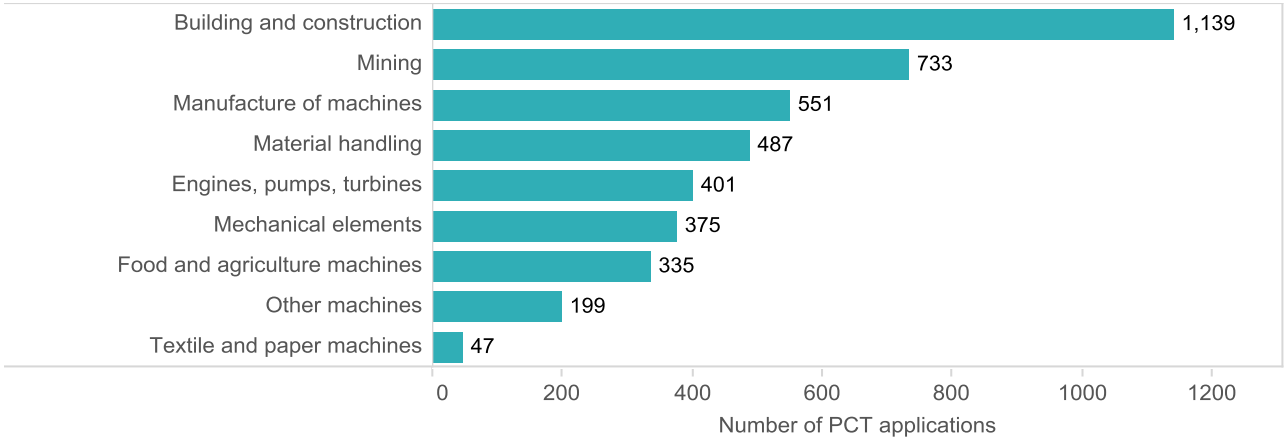
There were a diverse range of technologies that were identified from the Australian PCT applications from this study. Applications were broken down into the following broad technology categories (Figure 7.5):

- *building and construction* – locks, keys, windows, door fittings hinge and furniture
- *mining* – earth and rock drilling, shafts and safety devices for mines
- *manufacture of machine parts* – working of metal including milling, turning, grinding
- *materials handling* – hoisting, listing hauling, heat exchangers
- *engines, pumps and turbines* – combustion engines, positive displacement machines, steam generation and combustion
- *mechanical elements* – hydraulics, pneumatics, engineering components
- *machines for agriculture or processing food* – planting, sowing, harvesting, baking equipment, slaughtering equipment
- *textiles and paper machines* – appliances for making clothes, cardboard manufacture, printing
- *other special machines* – measuring equipment, mechanical control equipment

A detailed breakdown of the CPC marks and the technology breakdown can be found in Appendix C.

Building and construction was the primary focus of the mechanical engineering sector, with 1139 applications, or 27 per cent, of all applications (Figure 7.5).

Figure 7.5: Australian mechanical engineering PCT applications by technology category



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Key applicants in mechanical engineering

Applications by entity type

SMEs were by far the most active applicant type in mechanical engineering, with the largest number of applicants (878), over three times more than the second most (international with 279 applicants) (Table 7.1). Despite the high number of applicants and applications, SMEs had the second lowest average for applications per applicant at 1.8, in contrast research institutions had an average of 5.2 applications per applicant and large firms averaged 3.5 per applicant.

Table 7.1: PCT applications by entity type

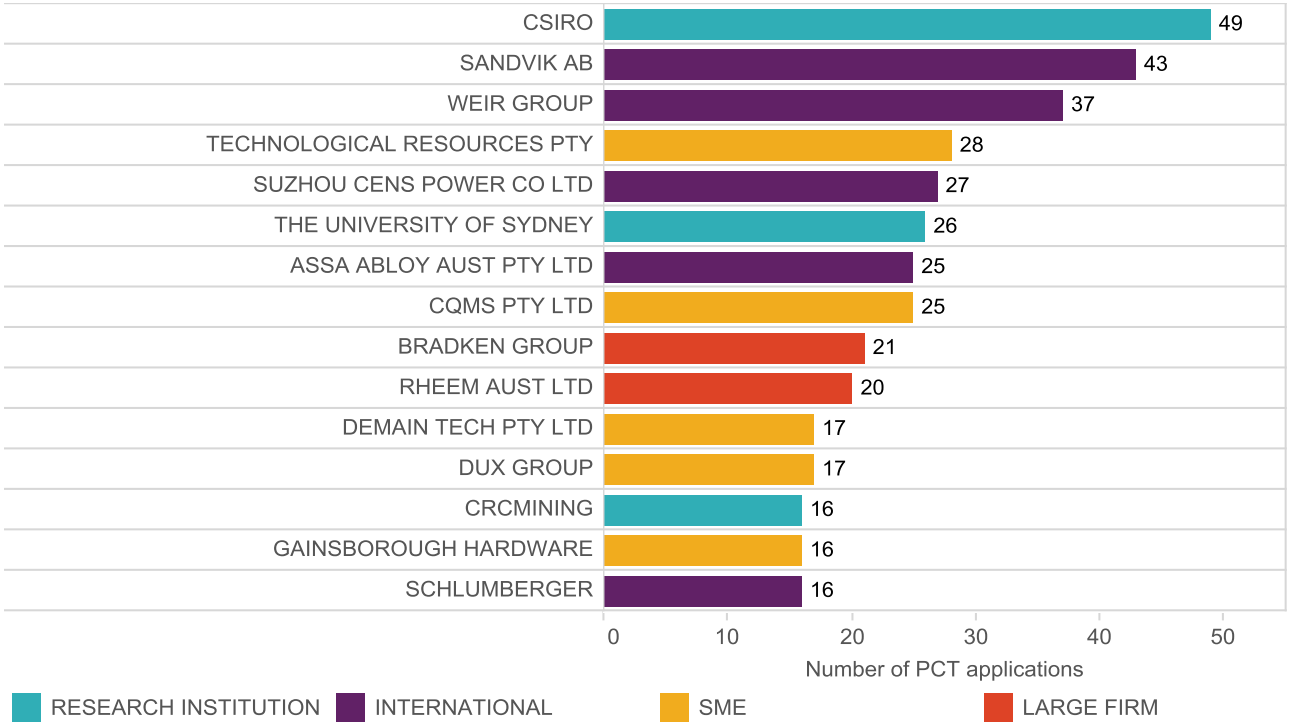
	Number of applicants	Number of applications	Average applications per applicant
INTERNATIONAL	279	830	3.0
RESEARCH INSTITUTION	34	177	5.2
LARGE FIRM	71	265	3.7
SME	878	1,559	1.8
INDIVIDUAL	106	132	1.2

Source: PATSTAT database, Autumn 2015; IPGOD, 2016 edition; and IP Australia calculations.

Top applicants

As with many of the advanced manufacturing sectors, the top applicant in mechanical engineering was CSIRO, with 49 applications (Figure 7.6).

Figure 7.6: Top applicants



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Assa Abloy Australia Pty Ltd, whose parent company is in Sweden, was formerly known as Lockwood Security Products, and Gainsborough focuses on locks. Gainsborough is an Australian owned and operated company with local development and production facilities in Melbourne.[46]

CQMS Pty Ltd is a global engineering, software and manufacturing company working in the mining industry.[47] Its patent families are particularly focussed on excavator components.[48]

[46] Austral Lock, About Us

[47] CQMS Razer, CQMS Razer Company Overview

[48] CQMS Razer, Excavator Bucket Cast Lip

Demain International Pty Ltd[49] designs power tools for licensing to power tool manufacturers and is based in Heatherton, Victoria. The company was founded in 2001 and has 17 PCT applications directed to power tools, storage systems and safety guards.

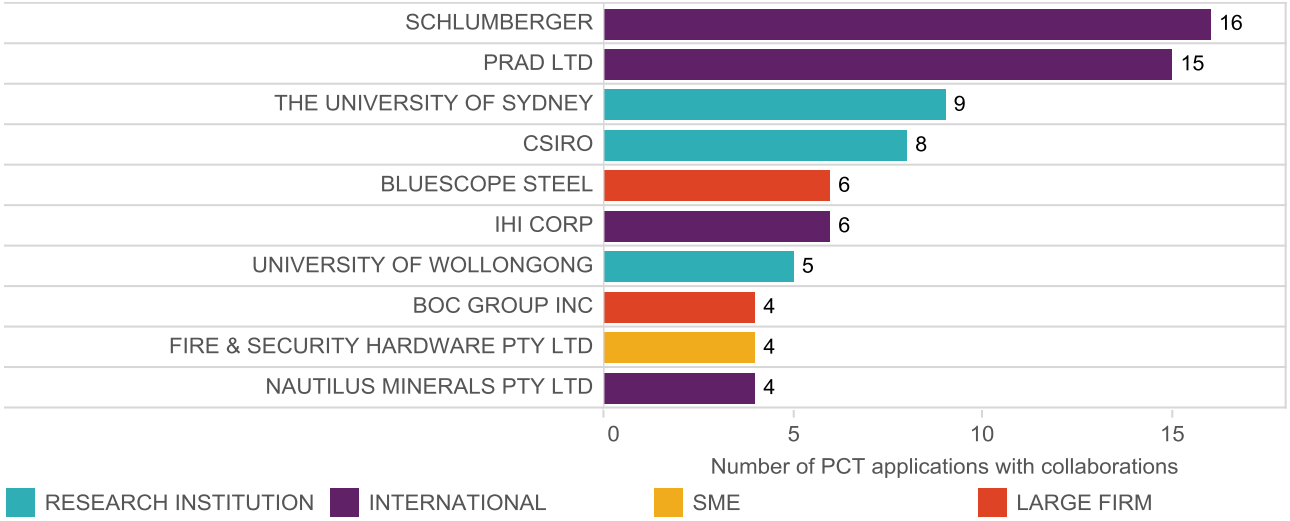
Dux, located in the Southern Highlands of New South Wales, manufactures water heaters (including solar water heaters) and pumps. The company was founded in 1915, but in 2014 was sold to Noritz Corporation of Kobe, Japan.[50]

Collaboration in mechanical engineering

Top collaborating applicants

Collaboration between international entities was the most common type. Of the 4267 Australian mechanical engineering applications, only 157 applications (less than four per cent) involved multiple applicants, which was amongst the lowest rate of all eight sectors. In mechanical engineering, the most active collaborator was Schlumberger, who collaborated on all 16 of its applications (Figure 7.7). CSIRO collaborated on only eight of its 49 applications.

Figure 7.7: Top 10 applicants who collaborate



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

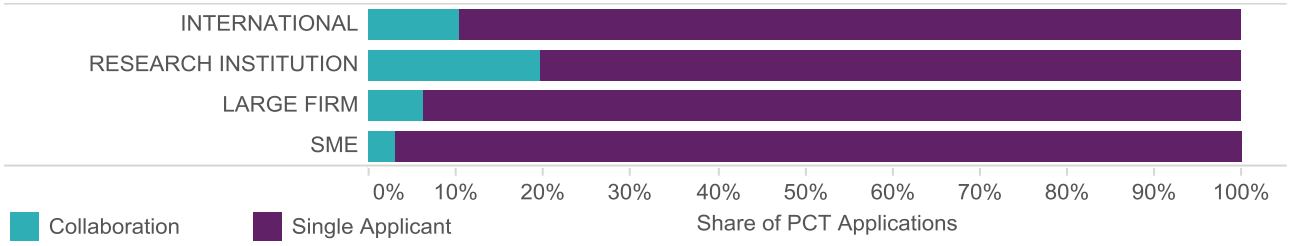
Collaboration between applicant types

In mechanical engineering, twenty per cent of applications that involved Australian research institutions were collaborative (Figure 7.8). This proportion dropped to 10 per cent for international entities, six per cent for large Australian firms and three per cent for Australian SMEs.

[49] Demain International, About Us

[50] GWA Group, GWA Group Limited announces agreement reached for sale of Dux Hot Water, 26 November 2014

Figure 7.8: Proportion of applications assigned to entity types where collaboration is evident



Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

The most common type of collaboration in the mechanical engineering sector was amongst international entities (Figure 7.9). SMEs were the most active collaboration entity, collaborating on 39 applications overall. They were also the most diverse having collaborated with each other entity type.

Figure 7.9: Number of PCT applications where collaboration existed between entity types

	INTERNATIONAL	RESEARCH INSTITUTION	LARGE FIRM	SME
INTERNATIONAL	38			
RESEARCH INSTITUTION	8	6		
LARGE FIRM	9	6	1	
SME	11	13	2	13

Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

8 Medical devices

The medical devices sector covers a range of technologies including surgical tools, implants, syringes and catheters, as well as diagnostic imaging. Patent applications for medical devices accounted for just over ten per cent of advanced manufacturing applications. Australia's share of global patenting activity is 1.42 per cent (ranked twelfth), making it one of Australia's strongest technology sectors.

Australia had a positive specialisation in medical devices, meaning that Australia has a technological strength in the area. Australia was ranked 10th, ahead of the United Kingdom, Germany and Japan. Other countries with strength in the area include Ireland (fourth), the United States (fifth) and Switzerland (seventh)

The top applicants—ResMed (named on ten per cent of the applications) and the Cochlear Group (seven per cent)—are both large international entities with Australian origins. Cook Medical and Unitract Syringe Inc. rank third and fourth, respectively. Australian research institutions also featured on the list of top applicants. The major technology focus was diagnostic instruments, followed by syringes/catheters and prostheses.

Half the applicants in the medical devices sector were Australian SMEs, followed by international entities (28 per cent). In terms of average numbers of applications filed per applicant, Australian research institutions were the most active, closely followed by international entities, respectively filing on average 6.9 and 5.9 applications per applicant of each type. Australian applicants or inventors preferred to collaborate with applicants from the United States, followed by the United Kingdom and Denmark.

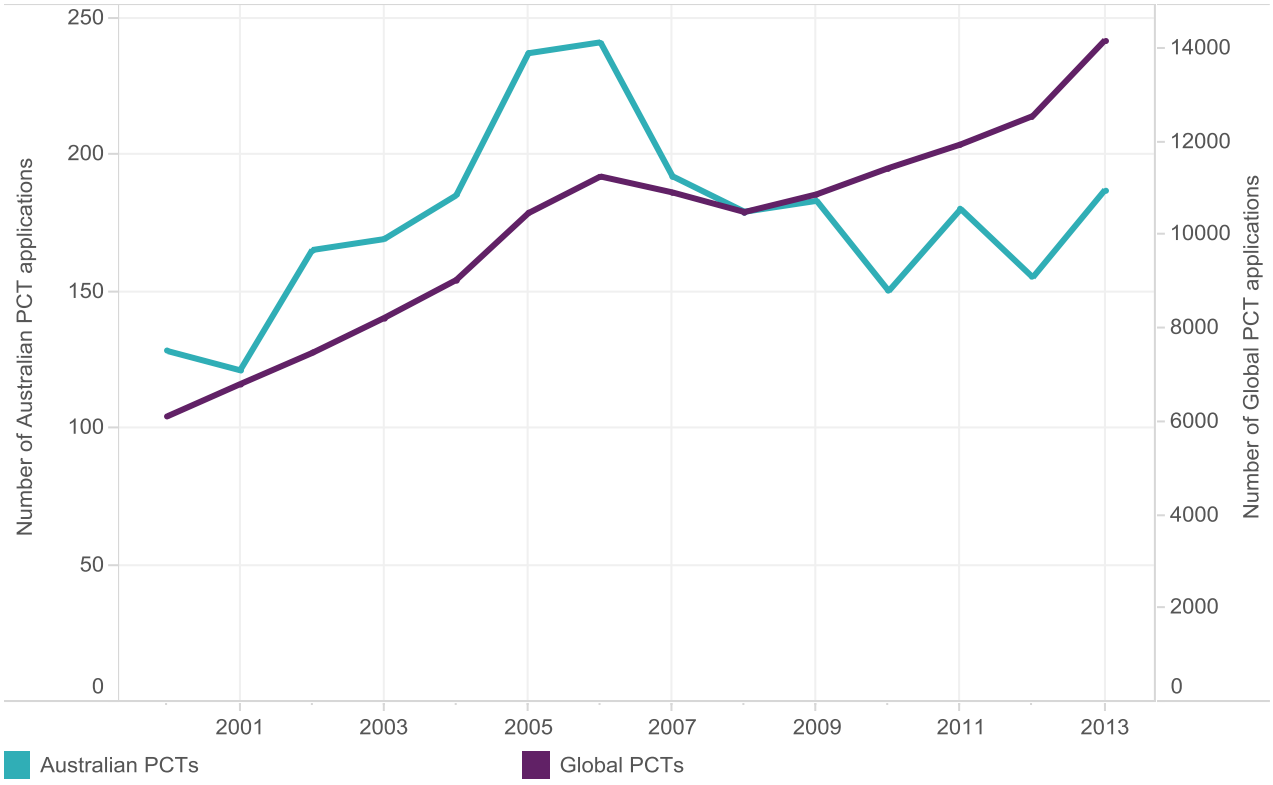
Most applications in the medical devices sector did not involve collaborations. Of the 2472 medical devices PCT applications, only about four per cent (93 applications) involved two or more applicants, which is amongst the lowest rate compared to the other technology sectors in this report. The top collaborating applicant in the medical devices patent landscape was National ICT Australia Ltd (NICTA) with 13 collaborations. The University of Melbourne was the most common partner with NICTA, sharing five PCT applications that represent collaborative efforts relating generally to implantable electrodes and techniques for ocular and neural tissues. The collaboration relates to developing a bionic eye.[51] Collaborations between Australian research institutions and international entities were the most prevalent type of collaboration.

[51] The University of Melbourne (2016), Centre for Neural Engineering, 7 January 2016

Patent activity over time

Australian applicants or inventors filed 2472 applications PCT applications across the period (Figure 8.1). Filing rates were generally steady, with spike in applications in 2005-2006. By contrast, the number of global applications, which also showed a surge in applications around 2005-2007, has steadily increased from 6105 in 2000 to 14 159 in 2013.

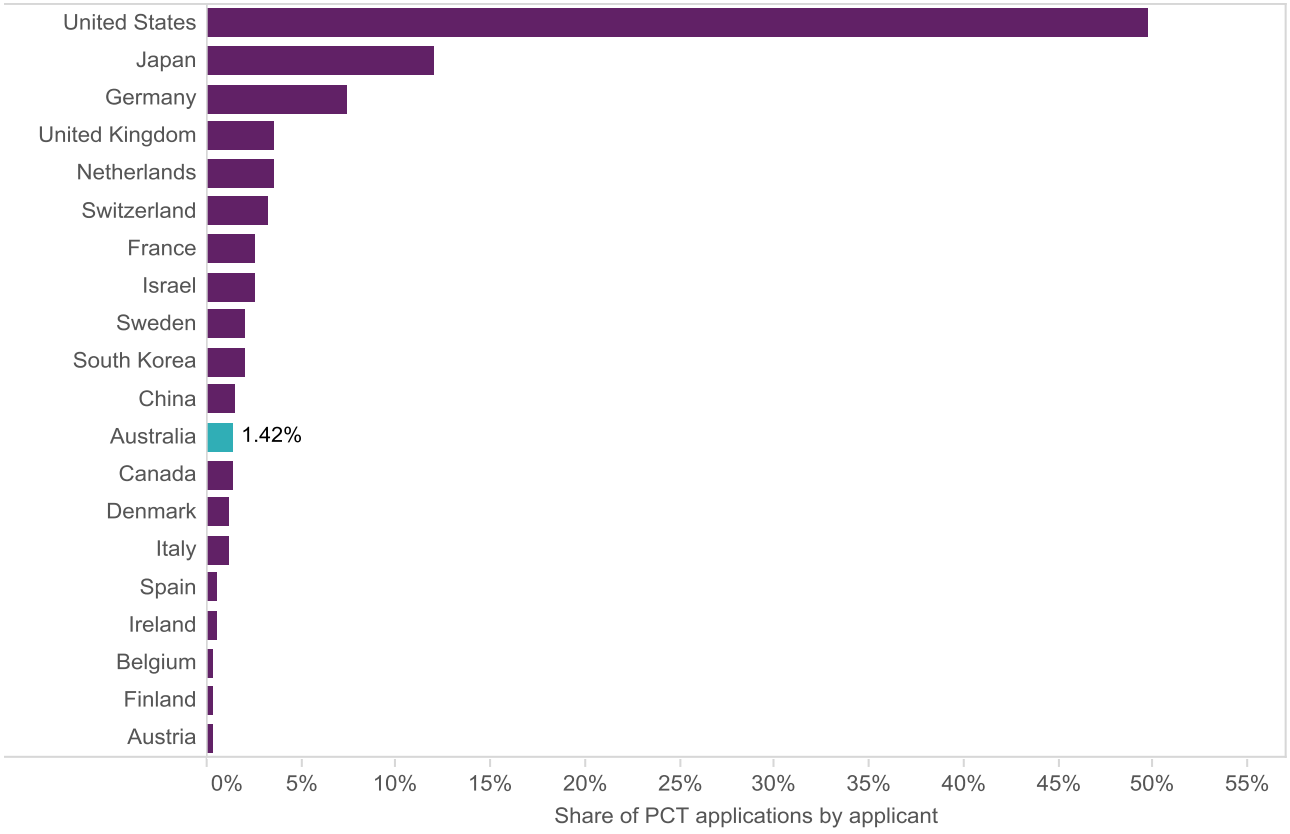
Figure 8.1: Australian and global PCT applications



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Australia had a 1.42 per cent share of all medical devices PCT applications (Figure 8.2), and ranked twelfth, which makes it one of Australia's strongest technology sectors. Over 50 per cent of applications were filed by the United States, followed by Japan and Germany.

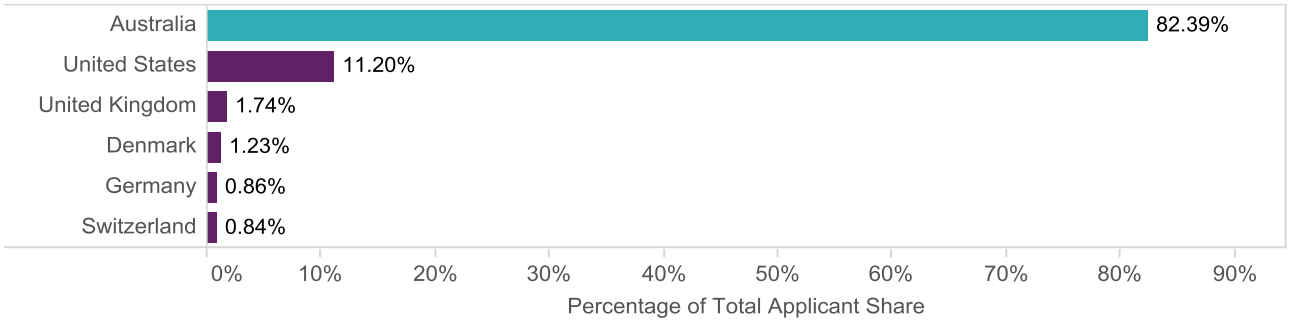
Figure 8.2: Share PCT applications across the top 20 countries



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Countries that Australian applicants work with are shown in Figure 8.3. This is determined by identifying the country of origin of applicants on PCT applications. Applicants from the United States are the preferred overseas partners, followed by the United Kingdom and Denmark.

Figure 8.3: Applicant origin

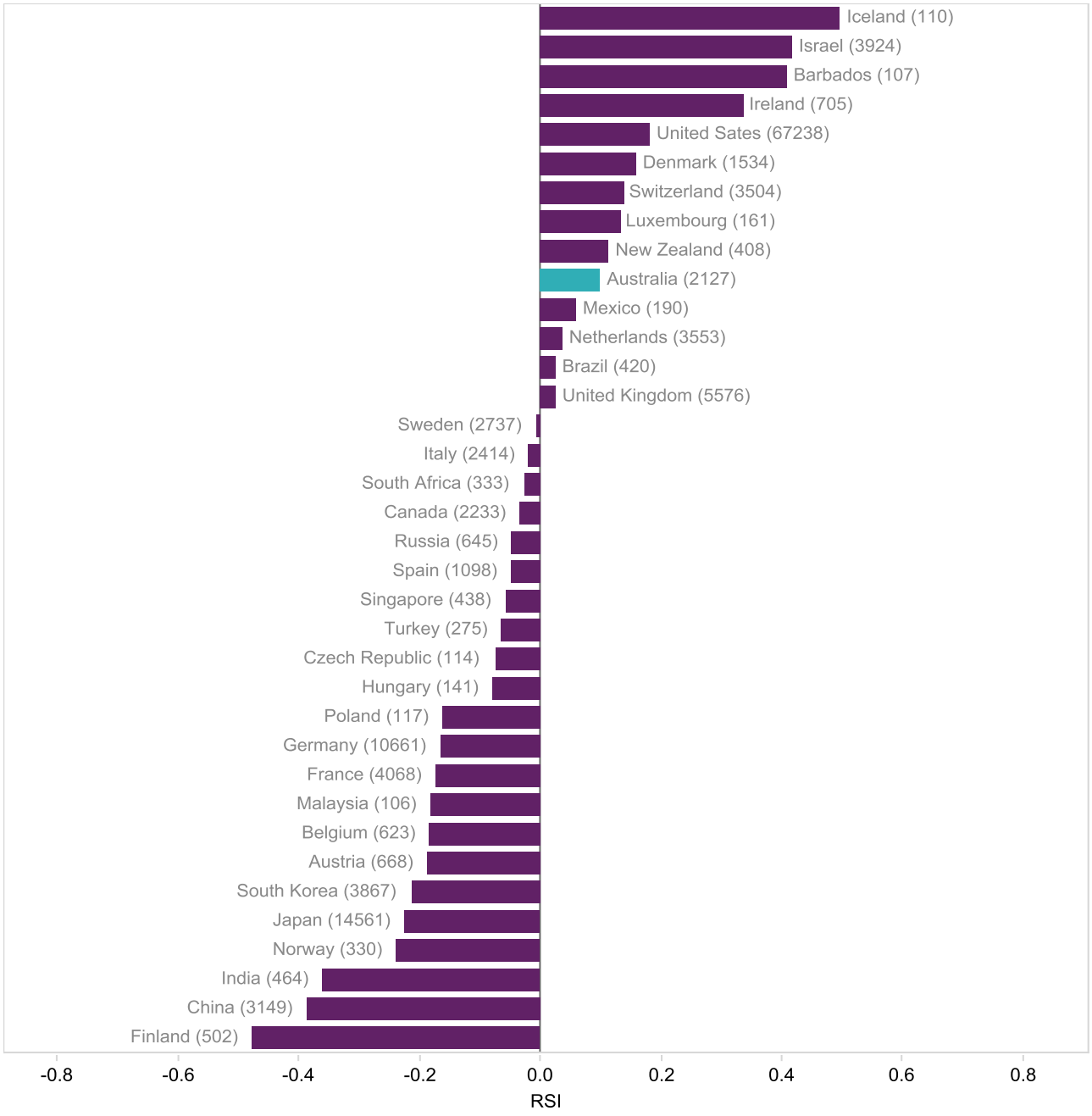


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Technological specialisation

Australia exhibited a positive relative specialisation in medical devices and ranked in 10th place, which was the highest ranking of any of the technology sectors (Figure 8.4). The Australian medical devices sector's specialisation ranked behind United States and Israel while it's ahead of the United Kingdom, Germany and Japan.

Figure 8.4: Relative Specialisation Index for PCT medical devices applications



Source: PATSTAT database, Autumn 2015; and IP Australia Calculations

Medical devices technologies

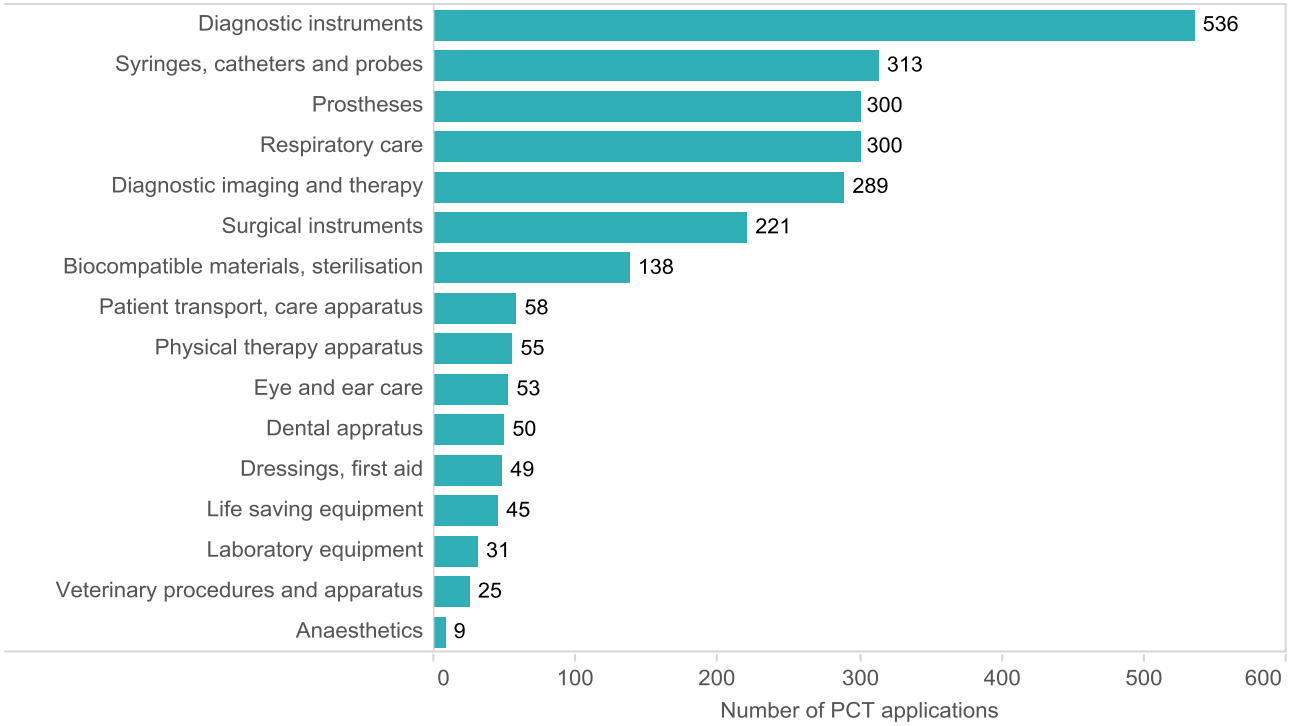
Australian medical device patents were broken down into the following broad technology categories:

- *diagnostic instruments* – devices for performing internal and external medical examinations
- *syringes, catheters and other probes* – drainage appliances for wounds and devices for introducing or retaining media in the body
- *prostheses* – treatment of bones and joints, artificial body parts including components implantable into the body, such as stent-grafts
- *respiratory care devices* – sprayers and inhalers
- *diagnostic imaging and therapy* – electrotherapy, magneto-therapy, radiation and ultrasound therapy
- *surgical instruments* – devices and accessories specially adapted for surgery
- *biocompatible materials and sterilisation* – materials for medical devices, biocompatible materials and processes and apparatus for disinfecting and sterilising objects other than foodstuffs
- *patient transport and care apparatus* – beds and accessories, ambulance services and treatment rooms, tables, chairs and the like
- *physical therapy apparatus* – devices for passive exercising, walking aides and massage devices
- *eye and ear care* – methods and devices for the treatment and protection of eyes and ears
- *dental apparatus* – dental machines, dental prosthetics, and tooth-cleaning or mouth-rinsing devices
- *dressings and first aid* – bandages and dressings and auxiliary appliances for wound care including first aid kits and dispensing containers
- *life-saving equipment* – devices and accessories for rescuing or providing escape from fire or buildings; safety belts and harnesses; gas masks and shields for protection against harmful chemicals or low oxygen
- *laboratory equipment* – containers specifically adapted for medical or pharmaceutical purposes, and applicators for administering food and medicines orally
- *veterinary procedures and apparatus* – instruments, implements, tool or methods specifically adapted for veterinary use
- *anaesthetics* – devices for producing or ending sleep or stupor

A detailed breakdown of the CPC marks and the technology breakdown can be found in Appendix C.

The predominate category in the Australian medical devices patent landscape was diagnostic instruments, consisting of 536 or 22 per cent of all applications (Figure 8.5). This was followed by syringes/catheters, prostheses and respiratory care.

Figure 8.5: Australian PCT applications by technology category



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Key applicants in medical devices

Applications by entity type

Australian SMEs were the most common applicant type, although they are not the most prolific in terms of numbers of applications per applicant at 2.3 (Table 8.1). Australian research institutions were the least numerous applicant entity type, but file on average three times as many applications per applicant (6.9 applications per applicant).

Table 8.1: PCT applications by entity type

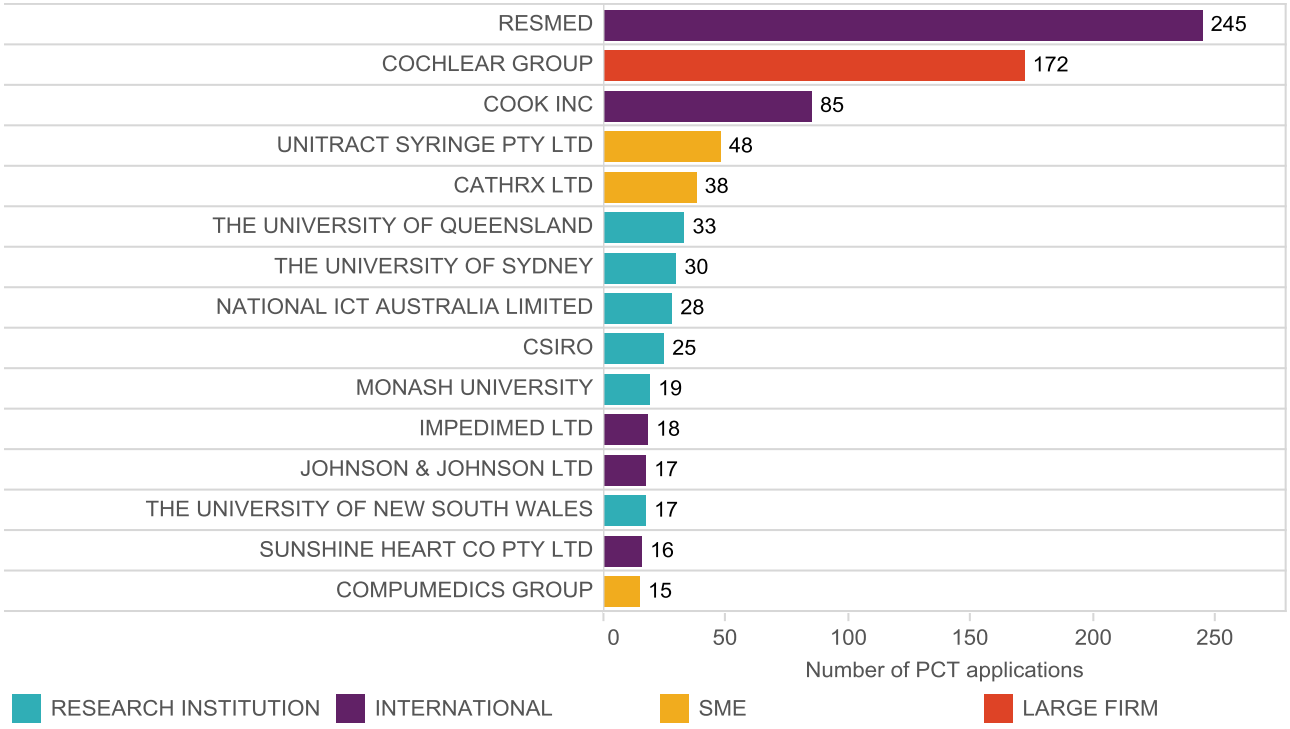
	Number of applicants	Number of applications	Average applications per applicant
INTERNATIONAL	159	771	4.8
RESEARCH INSTITUTION	41	282	6.9
LARGE FIRM	33	265	8.0
SME	294	684	2.3
INDIVIDUAL	48	59	1.2

Source: PATSTAT database, Autumn 2015; IPGOD, 2016 edition; and IP Australia calculations.

Top applicants

The top two applicants (ResMed and the Cochlear Group) are private companies founded on research carried out at Australian universities (Figure 8.6). Unlike the other sectors, the top applicants in medical devices were from the private sector.

Figure 8.6: Top Applicants



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Of the top 15 applicants, four were Australian universities (the University of Queensland, the University of Sydney, Monash University and the University of New South Wales) and two (CSIRO and NICTA) were national research organisations. The University of Sydney developed biocompatible materials and, with a presence on 11 of the 138 applications in the category, was the strongest applicant in biocompatible materials and sterilisation.

Among the top applicants are several Australian companies. Unitract Syringe Pty Ltd (Unitract) was named on 15 per cent of applications in the category of syringes, catheters and probes. Unitract is a private medical and hospital equipment SME founded in 2002 and based in Sydney. CathRx Ltd[52] is a medical device company based in Sydney specialising in cardiac catheter devices for use in the diagnosis and treatment of cardiac arrhythmias. Compumedics Group[53] was founded in Melbourne in 1987 and focusses on diagnostics technology for sleep, brain and ultrasonic blood-flow monitoring applications. Over the years, Compumedics has received numerous awards and accolades including Australia's exporter of the year and has been recognised as a Top 100 Innovator by both German and Australian Governments.

Collaboration in medical devices

Top collaborating applicants

Most applications in the medical devices sector did not involve collaborations. Of the 2472 medical devices PCT applications, only about four per cent (93 applications) involved two or more applicants, which is amongst the lowest rate of the technology sectors.

The top collaborating applicant in the medical devices patent landscape was National ICT Australia Ltd (NICTA) with 13 collaborations (Figure 8.7). The University of Melbourne was the most

[52] Khelix, About

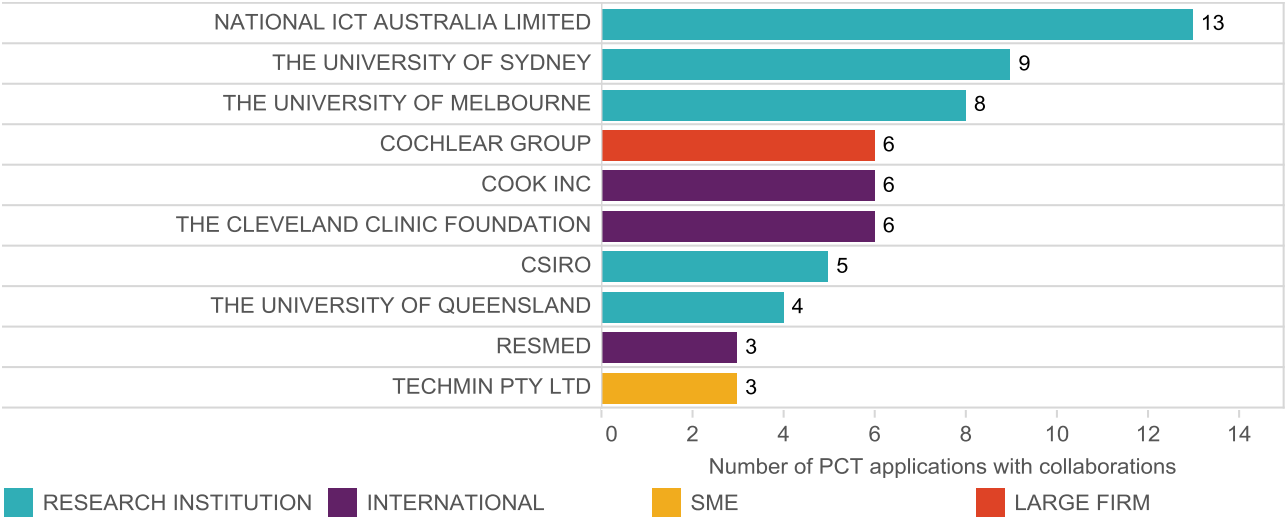
[53] Compumedics, About Us

common partner with NICTA, sharing five PCT applications that represent collaborative efforts relating generally to implantable electrodes and techniques for ocular and neural tissues. The collaboration relates to developing a bionic eye.[54]

In the above case, the shared applications indicated a single collaborative effort: each of the shared applications included at least one inventor in common. For example, both the University of Melbourne and NICTA have many independent research groups, yet the collaborations observed in the shared patenting activity from these entities indicated only one joint research venture. In contrast, the University of Sydney collaborated on an assortment of innovations with a range of different applicants including foreign universities (Stanford University, Harvard and the University of Cape Town), firms and research institutions (The Sydney Children's Hospital, and the Florey Institution of Neuroscience and Mental Health) and smaller enterprises. The University of Sydney and Ventracor Ltd were co-applicants on three PCT applications relating to blood pumps.

The Cochlear Group also collaborated with an assortment of domestic and international universities (the University of Melbourne, Swinburne University and the University of Zurich). Cook Inc. and The Cleveland Clinic Foundation had a strong collaborative relationship represented by six shared applications all relating to stent grafts.

Figure 8.7: Top 10 applicants who collaborate



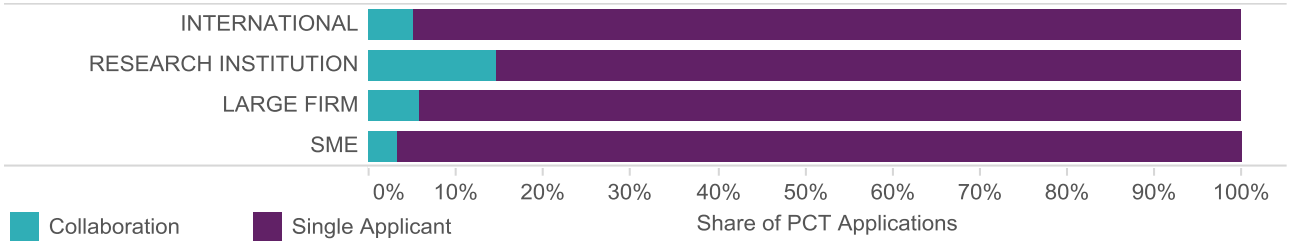
Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Collaboration between applicant types

In medical devices patenting, research institutions were the most prevalent collaborators, with roughly 15 per cent of applications from research institutions involving at least one other applicant (Figure 8.8). This proportion drops to roughly six, five and three per cent for applications involving large firms, international entities and SMEs, respectively.

[54] The University of Melbourne, Centre for Neural Engineering, 7 January 2016

Figure 8.8: Proportion of applications assigned to entity types where collaboration is evident



Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

There was a low level of collaboration within and across entity types in the Australian medical devices sector (Figure 8.9). Collaboration occurs most frequently between: (1) international firms and (2) research institutions.

Figure 8.9: Number of PCT applications where collaboration existed between entity types

	INTERNATIONAL	RESEARCH INSTITUTION	LARGE FIRM	SME
INTERNATIONAL	15			
RESEARCH INSTITUTION	7	13		
LARGE FIRM	2	5	1	
SME	4	6	3	4

Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

9 Pharmaceuticals

As the third largest advanced manufacturing sector (with 3377 applications), the pharmaceutical sector accounted for about 15 per cent of the applications. The major technology category in the pharmaceutical sector, accounting for one third of the applications, was methods of treatment, which covered the therapeutic activity derived from preparations of chemical compounds for medical, dental and cosmetic purposes. Peptides and micro-organisms and enzymes were also significant contributors to this sector, with 20 per cent and 18 per cent of patents filed in these categories respectively. This differs from the chemistry sector in that this focusses on the therapeutic activity of drugs or treatments, as opposed to the chemicals *per se* or their preparation.

Australia's share of the global patenting activity in pharmaceuticals was reasonably strong in comparison to other sectors with 1.56 per cent share of the global pharmaceutical patent applications, which placed Australia fourteenth in the world.

Australia had a positive RSI in the pharmaceutical technology. However, despite this apparent strength, there was a nine per cent reduction in filing rates of Australian pharmaceutical PCT applications since 2000. Pharmaceuticals was the only sector to record a reduction in patenting activity. It should be noted that global filing rates in this technology have been stagnant over the analysed time period.

The most common types of applicant in the pharmaceutical sector were international entities followed by Australian SMEs, although the most active applicants were Australian research institutions, who filed on average 17.6 PCT applications per institution. This was the strongest patenting activity from any applicant entity-type in any of the sectors. Applicants from the United States are preferred international partners, followed by the United Kingdom and Denmark.

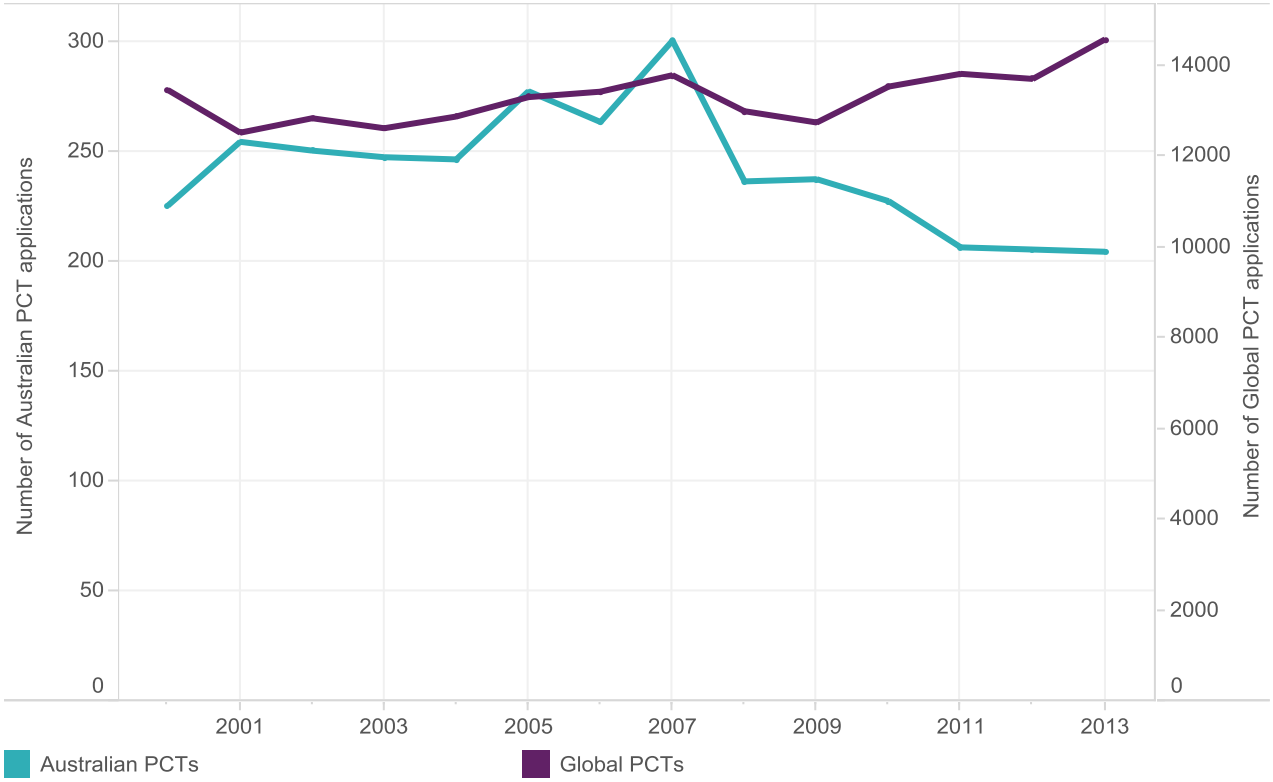
The list of top applicants was dominated by Australian research institutions and there are many spin-outs or commercialisation ventures of research institutions or government bodies. The international entity CSL Limited (in sixth position) was the first company to appear on the top applicants list, followed by Agriculture Victoria Services Pty Ltd (seventh), Glycom AS (eighth) and Medvet Science (ninth).

Pharmaceuticals had the highest rate of collaboration in any of the advanced manufacturing sectors, accounting for 15 per cent of applications. The most prevalent collaborations were amongst Australian research institutions and between Australian research institutions and international entities.

Patent activity over time

Australian's filed 3377 PCT applications over the period with a gradual decline in the number of applications per year (Figure 9.1). Over the same time, the number of global applications has remained steady, unlike other technology sectors that showed significant increases.

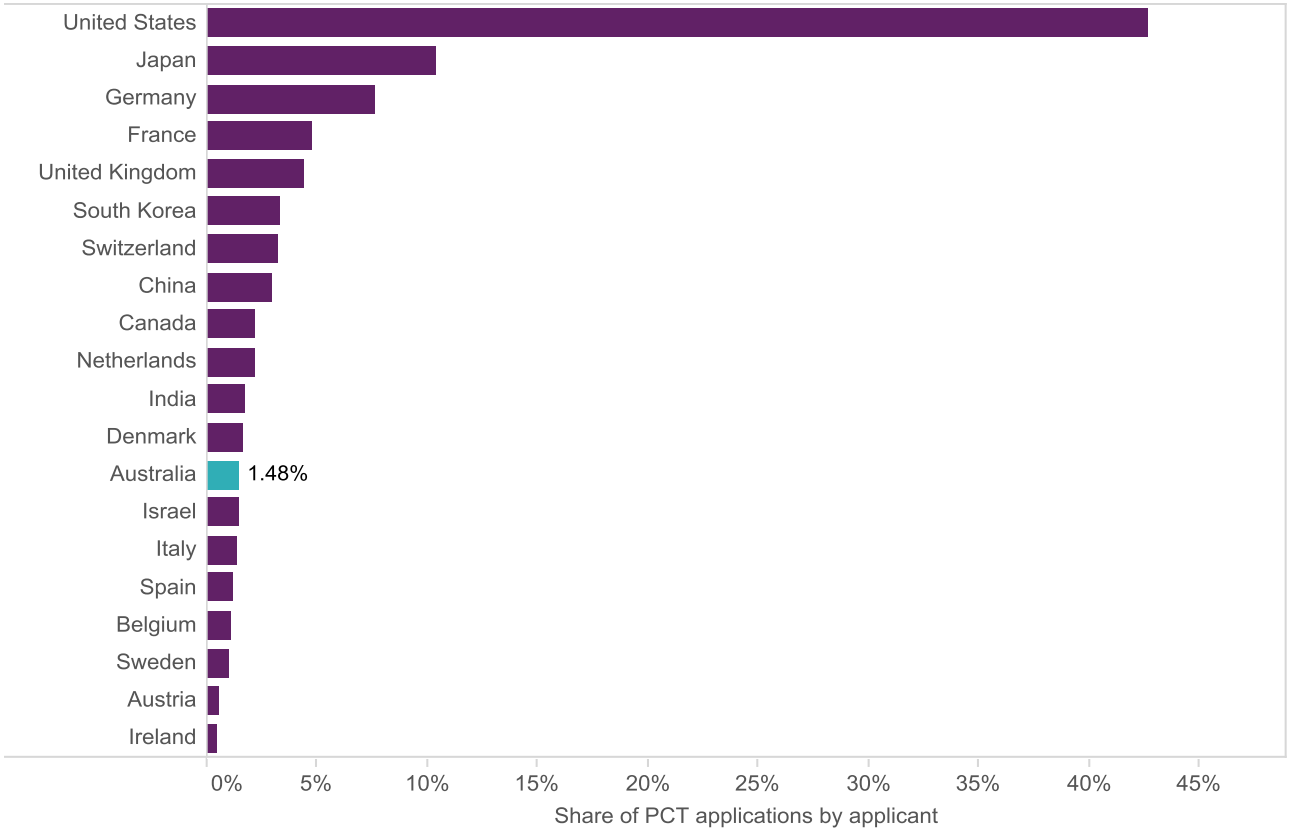
Figure 9.1: Australian and global PCT applications



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Australia's share of global pharmaceutical PCT applications was 1.48 per cent (Figure 9.2) with a ranking of thirteenth. This was the second highest ranking sector behind medical devices. The United States was the top filer with over 40 per cent of applications, followed by Japan and Germany.

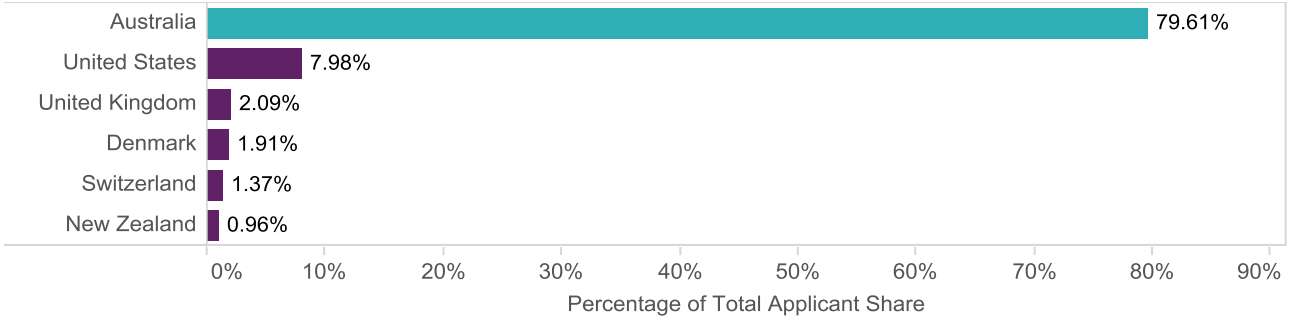
Figure 9.2: Share PCT applications across the top 20 countries



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Countries that Australian applicants or inventors work with are shown in Figure 9.3. This is determined by identifying the country of origin of applicants on PCT applications. Applicants from the United States are the preferred overseas partners, followed by the United Kingdom and Denmark.

Figure 9.3: Applicant origin

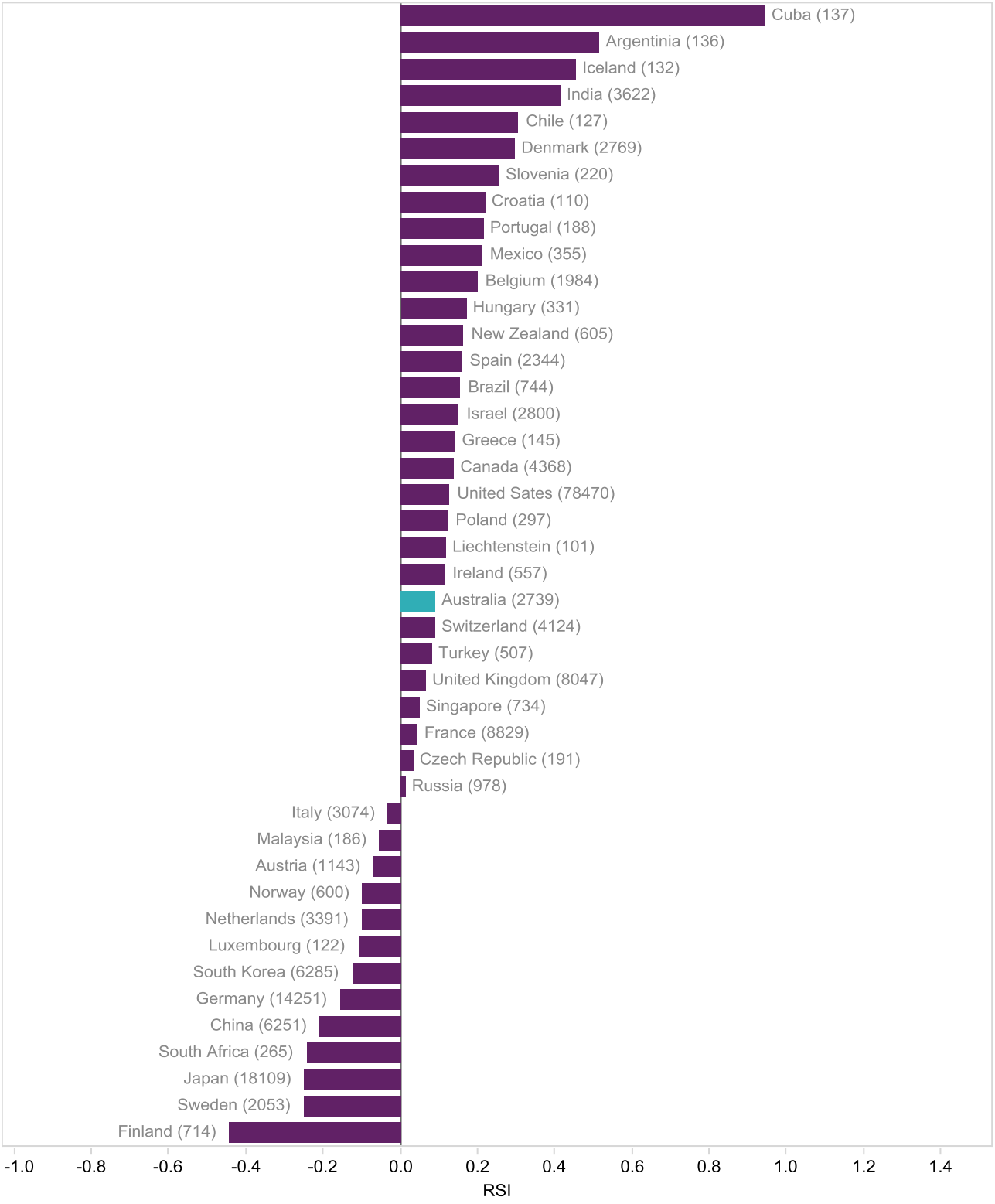


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Technological specialisation

Australia exhibited a positive specialisation in pharmaceuticals and ranked in twenty-third place (Figure 9.4), similar to Switzerland and Ireland. Australia ranked behind Israel, Canada and the United States, but ahead of the United Kingdom.

Figure 9.4: Relative Specialisation Index for PCT pharmaceutical applications



Source: PATSTAT database, Autumn 2015; and IP Australia Calculations

Pharmaceutical technologies originating from Australia

The Australian pharmaceutical sector was broken down into the broad technology categories of:

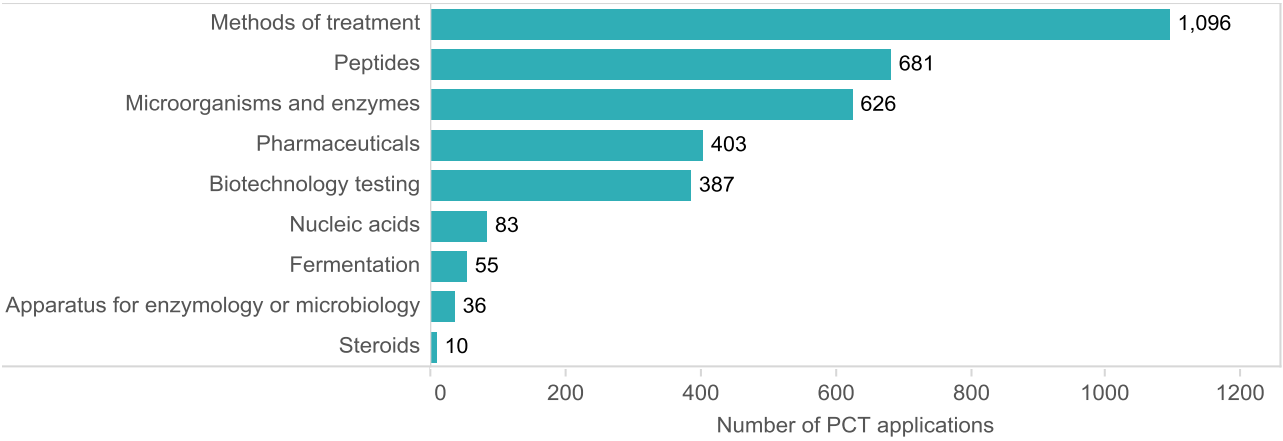
- *pharmaceuticals* – pharmaceutical formulations *per se*, for medical, dental or cosmetic use
- *methods of treatment* – pharmaceutical compositions together with a specified use in treatment
- *microorganisms and enzymes* – microorganisms, viruses and eukaryotic cell culture, as well as mutation or genetic engineering
- *biotechnology testing* – measuring or testing processes involving enzymes or microorganisms and nucleic acids
- *peptides* – peptides, antibodies and antigens with a diverse range of uses
- *nucleic acids* – sugars and sugar derivatives; nucleosides; nucleotides and nucleic acids
- *fermentation* – fermentation or enzyme-using processes to produce chemical compounds
- *apparatus for enzymology or microbiology* – apparatus associated with enzymology or microbiology such as culturing devices
- *steroids – compounds with a steroidal skeleton*

For applications with an A61K first CPC mark, the existence of a concurrent A61P mark in the International Patent Classification system (IPC) was determined as an indicator of innovation specifically directed to the method of treatment, or use of a pharmaceutical composition, rather than to the formulation itself.

A detailed breakdown of the CPC and IPC classifications and the technology breakdown can be found in Appendix C.

Methods of treatment was the largest category (32 per cent of all applications), followed by peptides (20 per cent) and microorganisms and enzymes (19 per cent) (Figure 9.5). There were four areas that had less than 100 applications between 2000 and 2013.

Figure 9.5: Australian PCT applications by technology category



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Key applicants in pharmaceuticals

Applications by entity type

Although there were roughly the same numbers of applicants identified as Australian research institutions as large firms, the research institutions were significantly more active in the pharmaceutical sector. With an average filing rate of 17.6 applications per applicant, they were the most active applicants of any entity across all advanced manufacturing sectors (Table 9.1). This suggests Australian research institutions have a particular strength in innovation in this sector.

Table 9.1: PCT applications by entity type

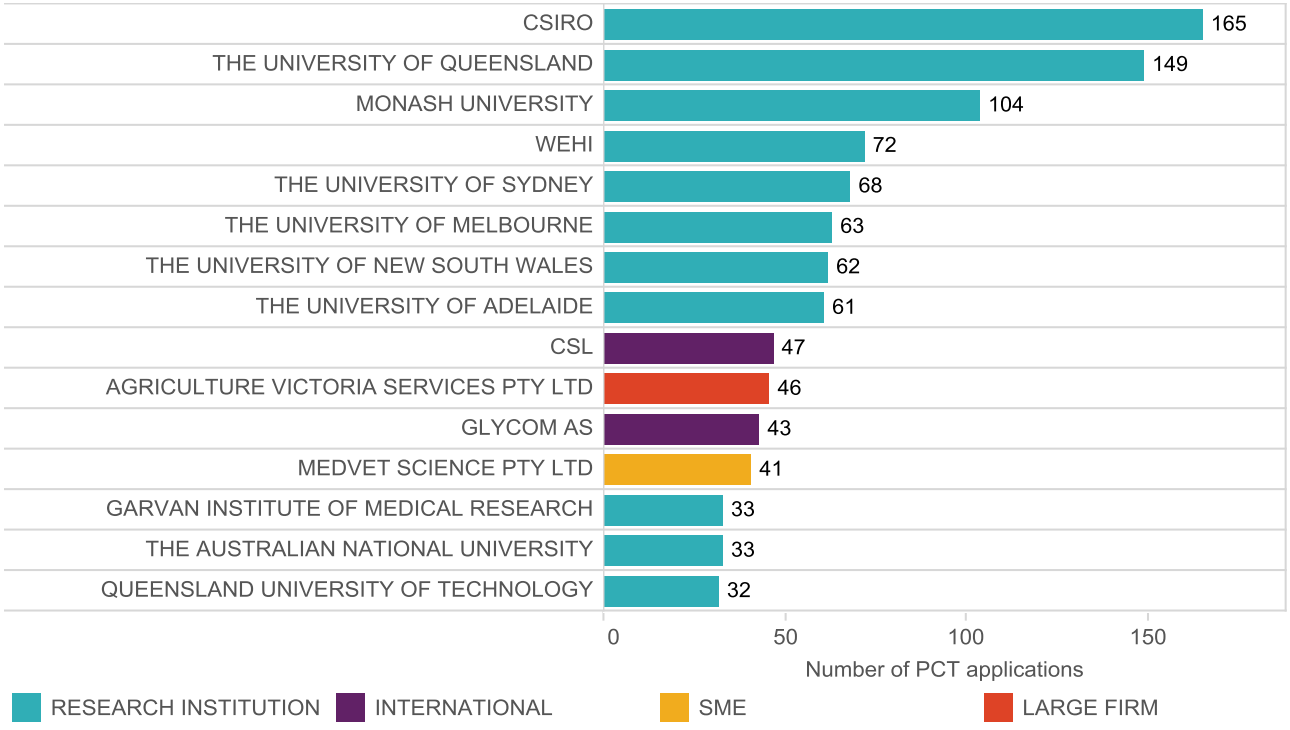
	Number of applicants	Number of applications	Average applications per applicant
INTERNATIONAL	415	1,032	2.5
RESEARCH INSTITUTION	77	1,353	17.6
LARGE FIRM	72	366	5.1
SME	311	961	3.1
INDIVIDUAL	56	64	1.1

Source: PATSTAT database, Autumn 2015; IPGOD, 2016 edition; and IP Australia calculations.

Top applicants

Research institutions dominated pharmaceutical research with 13 of the top 15 pharmaceutical applicants in Australia (Figure 9.6). CSIRO, with 165 applications, represented nearly five per cent of all pharmaceutical PCT applications while the best performing private sector applicant, CSL, had only 47 applications (1.4 per cent).

Figure 9.6: Top Applicants



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

CSL is a public company based in Melbourne, founded in 1916 as a government body, the Commonwealth Serum Laboratories, working on vaccines and anti-venoms. Agriculture Victoria Services Ltd (founded in 1986) is the commercialisation arm of the research and development divisions of the Victorian Government's Department of Economic Development, Jobs, Transport and Resources, covering technologies including pasture improvement and livestock tracing data

systems. Medvet Science was formerly the commercial arm of the Institution for Medical and Veterinary Science (IMVS) in South Australia. In 2008, IMVS merged with the pathology departments of two other Adelaide hospitals and was renamed SA Pathology.[55] The sole shareholder of this private company is a division of the South Australian Government.

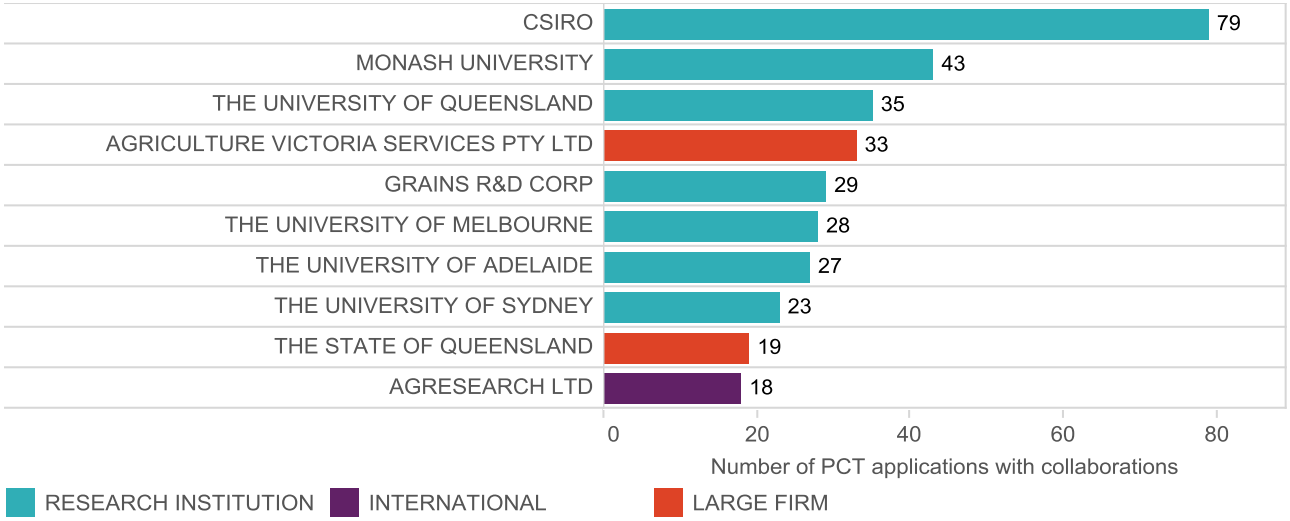
Collaboration in pharmaceuticals

The pharmaceutical sector had the highest rate of collaboration across the technology sectors with 523 of 3377 applications (15 per cent) having multiple applicants.

Top collaborating applicants

Of the 10 top collaborators in the pharmaceutical sector, nine were research institutions or government entities, and one was an international entity (Figure 9.7). The top collaborator was CSIRO, with 79 collaborative applications from a total of 165 applications (48 per cent). Monash University was in second place, with 43 collaborative applications from a total of 104 applications (41 per cent). The agricultural commercialisation companies showed a strong tendency to collaborate. In particular, Agriculture Victoria Services Pty Ltd has collaborated for 33 of a total of 46 patent applications (72 per cent) and the Grains Research and Development Corporation collaborated on all of its 29 patent applications in this sector.

Figure 9.7: Top 10 applicants who collaborate



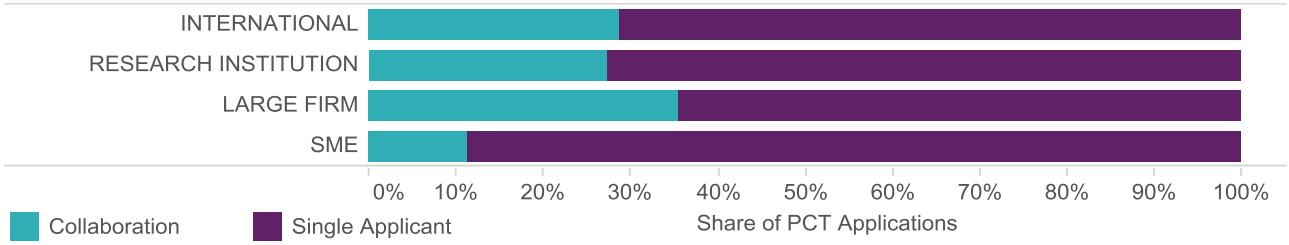
Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Collaboration between applicant types

Large Australian firms, international entities and Australian research institutions collaborated extensively in the pharmaceutical area, with collaboration of applications of 35, 29 and 27 per cent respectively (Figure 9.8). This proportion fell to 11 per cent for applications from SMEs.

[55] SA Pathology, Our History

Figure 9.8: Proportion of applications assigned to entity types where collaboration is evident



Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

The most prevalent collaborative relationships in terms of PCT applications in the pharmaceutical sector were amongst Australian research institutions (121 such collaborations) and between Australian research institutions and international entities (115 collaborations). International entities collaborated with other international entities 96 times. The least common collaboration type observed was between large Australian firms collaborating with Australian SMEs (Figure 9.9).

Figure 9.9: Number of PCT applications where collaboration existed between entity types

	INTERNATIONAL	RESEARCH INSTITUTION	LARGE FIRM	SME
INTERNATIONAL	96			
RESEARCH INSTITUTION	115	121		
LARGE FIRM	41	65	32	
SME	14	60	9	19

Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

10 Transport

There were 1557 PCT applications filed in the transport sector including a range of transportation modes, associated components and transport infrastructure. This was a relatively small sector in the study. Australia's share of the global patenting activity is 1.01 per cent (ranked thirteenth), which is average when compared to the other advanced manufacturing sectors.

Australian applications had nine percent growth over the period, although this was only nine applications. In contrast, global applications increased dramatically, by 152 per cent. Despite the low growth Australia had a positive specialisation in transport.

Like many of the other advanced manufacturing sectors, SMEs had the most number of applicants, followed by international entities. However, in contrast to other sectors, research institutions were the least active applicants.

The top applicant was Orbital Australia Pty Ltd, with thirty seven applications, with a strong background in prime vehicle components through their innovation of engines,[56] and the company continues to focus on engine control means such as fuel injection methods. More recently Orbital Australia has ventured into the development of prime vehicle components for unmanned aerial vehicles.[57]

Only two percent of applications were determined to have collaboration. This is mostly attributed to the occurrence of around 95 per cent of SMEs having never collaborated. Although they appeared on only four per cent of applications, six of the top eleven applicants who collaborated were universities.

When working with international applicants, Australians favour working with the United States (four per cent of applications). Australia did not have a high collaboration rate with the leading countries in this technology sector, compared to the other technology sectors. For example, Australia collaborated with Germany on just under two per cent of applications.

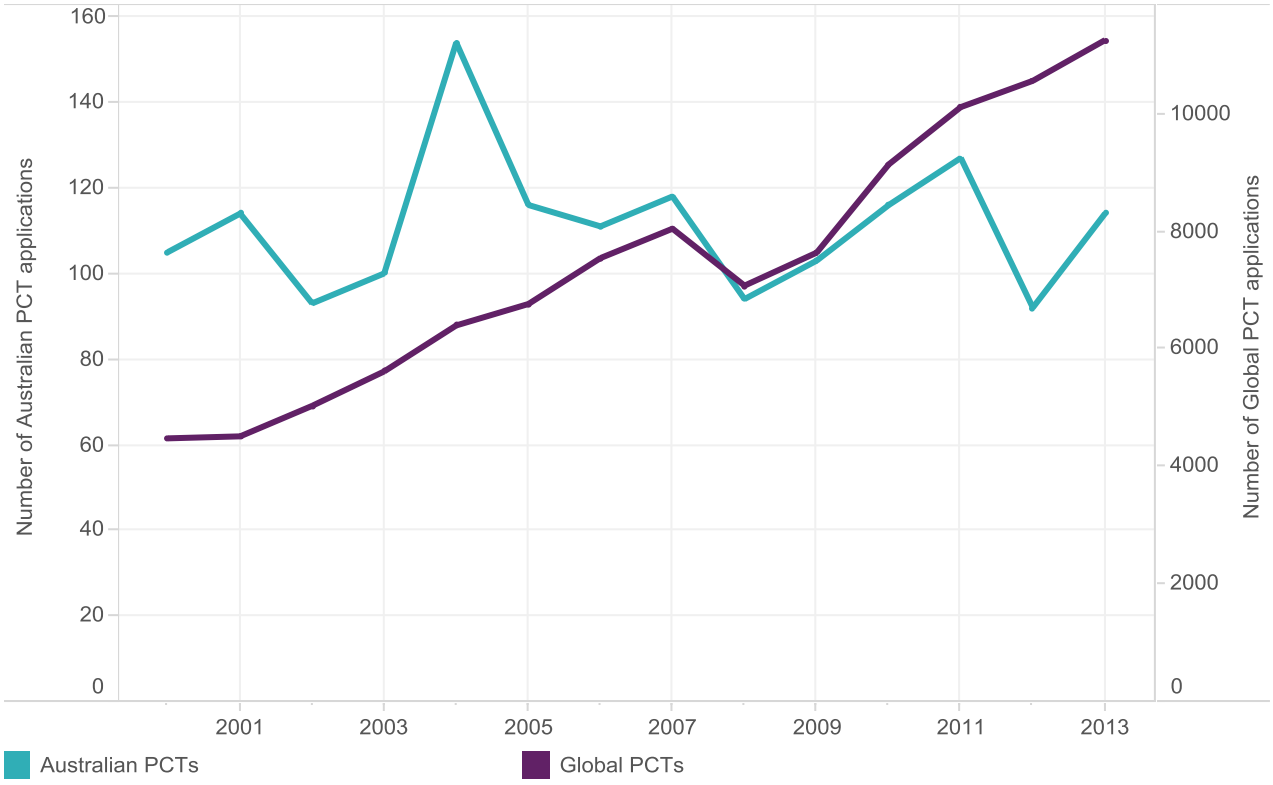
[56] Powerhouse Museum, Orbital engine technology

[57] Orbital, Aerospace

Patent activity over time

The number of PCT applications in the transport sector by Australian applicants had been generally steady with minor fluctuations across the time period (Figure 10.1), whereas the number of global patent applications increased by 152 per cent, from 4468 applications in 2000 to 11 244 applications in 2013.

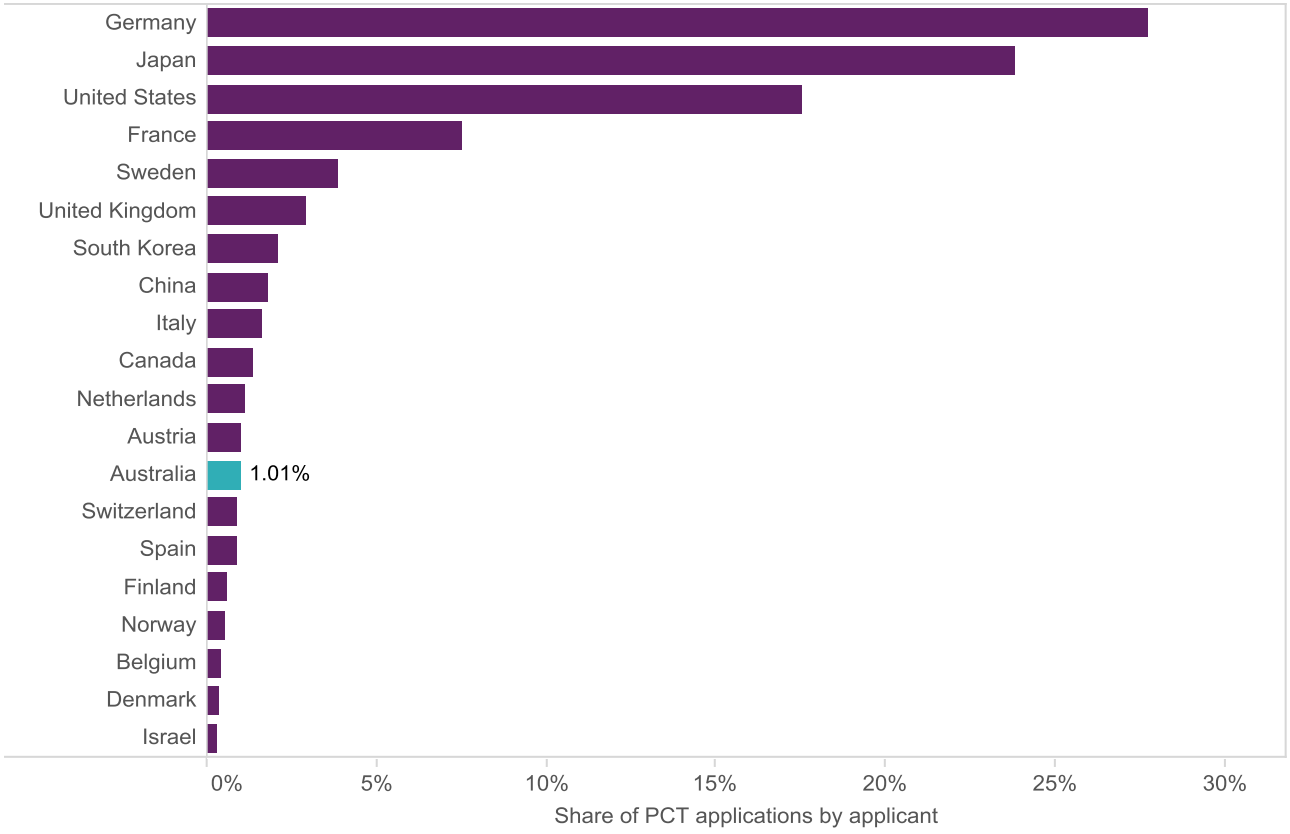
Figure 10.1: Australian and global PCT applications



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Australia had a 1.01 per cent share of global transport PCT applications (Figure 10.2). This gave Australia a ranking of thirteenth globally, which was among the highest in the eight sectors. Differing from most advanced manufacturing technology sectors, Germany was the most active country globally, followed by Japan and the United States.

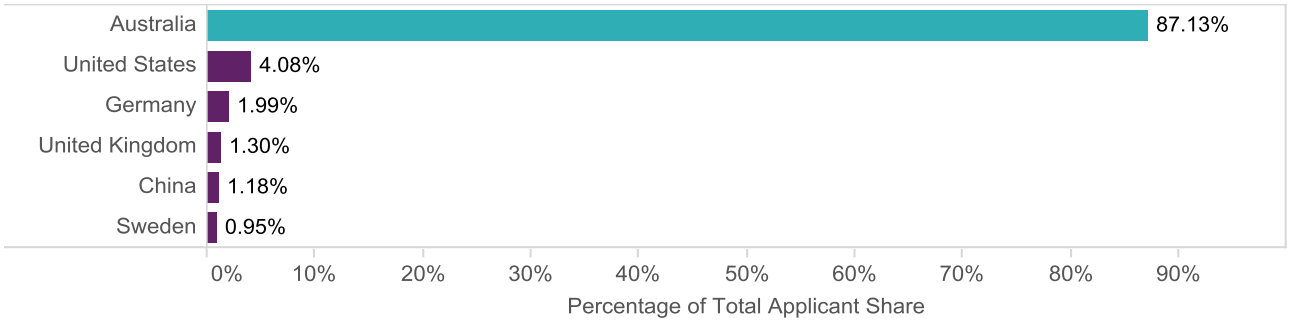
Figure 10.2: Share of transport PCT applications across the top 20 countries



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

When collaborating with other countries, Australian applicants and inventors work most often with the United States (four per cent of applications) followed by Germany, the United Kingdom and Japan (Figure 10.3).

Figure 10.3: Applicant origin

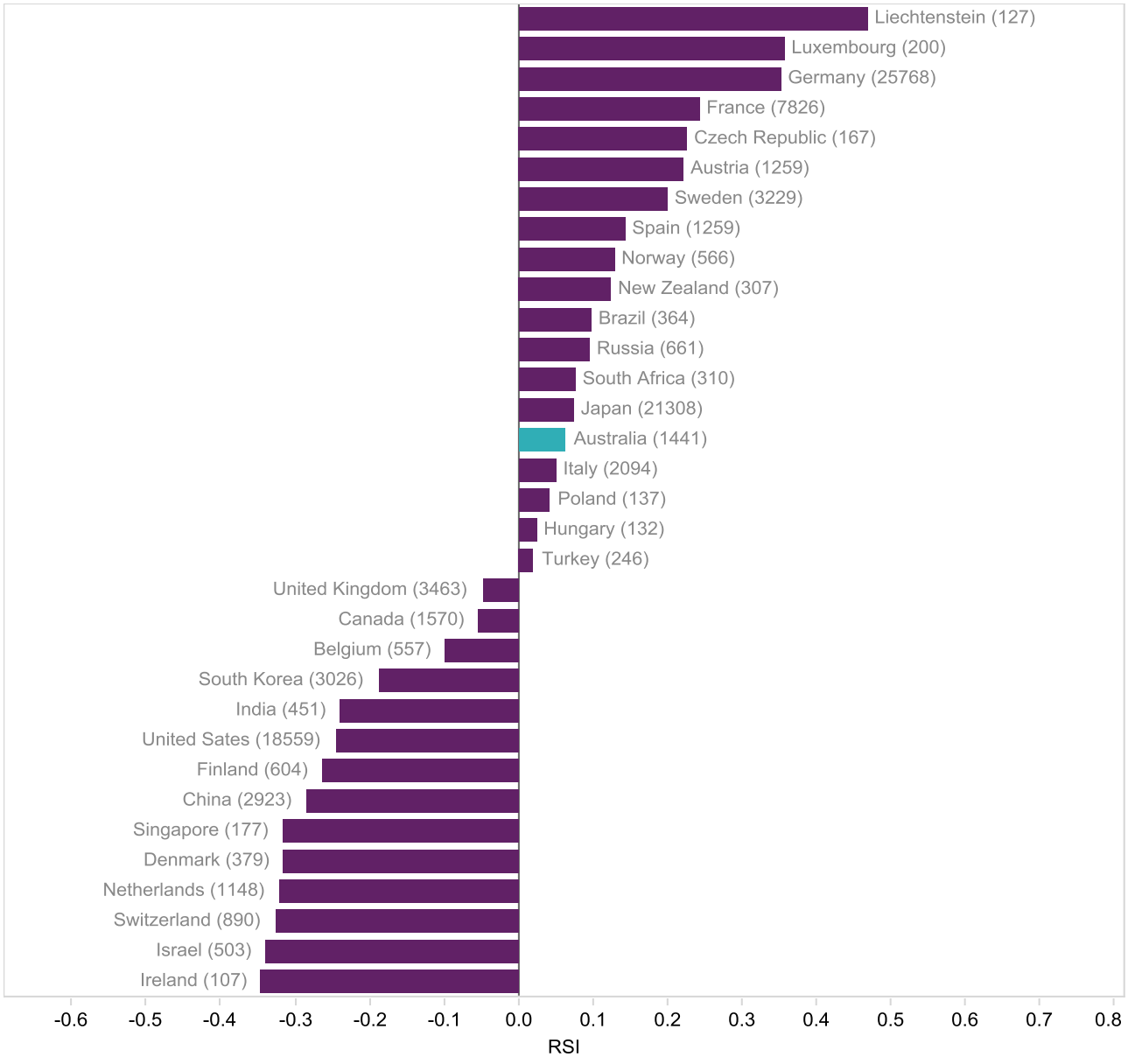


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Technological specialisation

Australia had a positive specialisation in transport ranking fifteenth globally (Figure 10.4). As a comparison, Canada, having a similar share of applications to Australia, ranked twenty-first. European countries show a strong specialisation in transport, occupying the top nine places on the RSI.

Figure 10.4: Relative Specialisation Index for PCT transport applications



Source: PATSTAT database, Autumn 2015; and IP Australia Calculations

Transport technologies originating from Australia

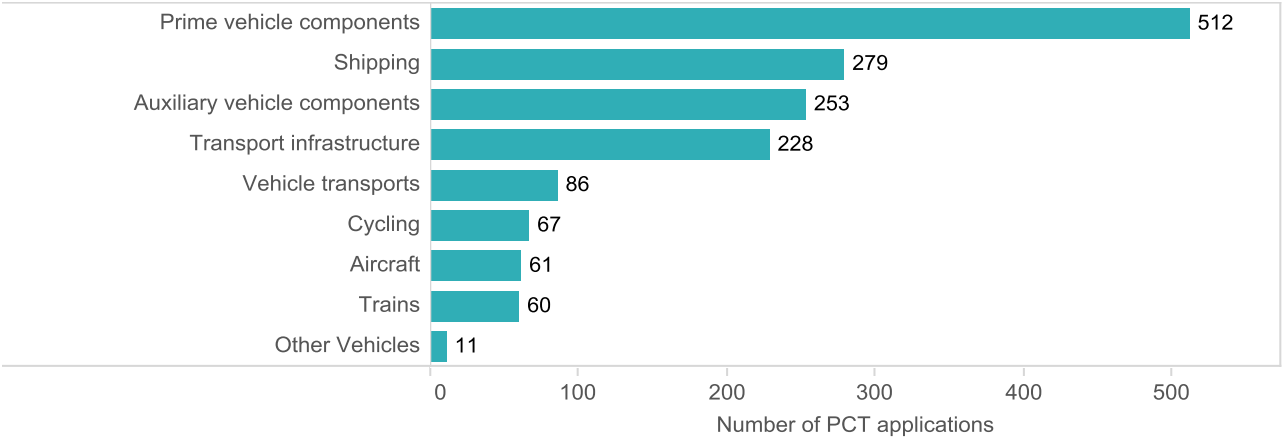
There were a diverse range of technologies that were identified from the Australian PCT applications from this study. Applications were broken down into the following broad technology categories:

- *prime vehicle components* – components related to vehicles that are core to the function of the vehicle
- *auxiliary vehicle components* – components that are not core to the function of the vehicle such as windows and mirrors
- *vehicle transports* – vehicles that have been adapted to transport, to carry, or that incorporate loads or objects
- *shipping* – sea-going vessels and shipping components
- *cycling* – innovations relating to cycling components
- *aircraft* – aircraft along and components for use in and for aircraft
- *trains* – components for rail such as couplings and braking systems as well as other auxiliary components such as body details
- *transport infrastructure* – fixed transport constructions such as roads, rail and bridges
- *other vehicles* – vehicles not covered above including examples such as amphibious and cosmonautic vehicles

A detailed breakdown of the CPC marks and the technology breakdown can be found in Appendix C.

Prime vehicle components was the largest category in the transport sector, accounting for 512, or 33 per cent, of all applications (Figure 10.5).

Figure 10.5: Australian transport PCT applications by technology category



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Key applicants in transport

Applications by entity type

Innovation in the transport technology is driven by Australian SMEs and to a lesser extent, international entities. In contrast to every other sector, where research institutions were significant innovators, large Australian firms are the most active in the transport industry filing on average 3.7 applications across the analysed time period (Table 10.1).

Table 10.1: PCT applications by entity type

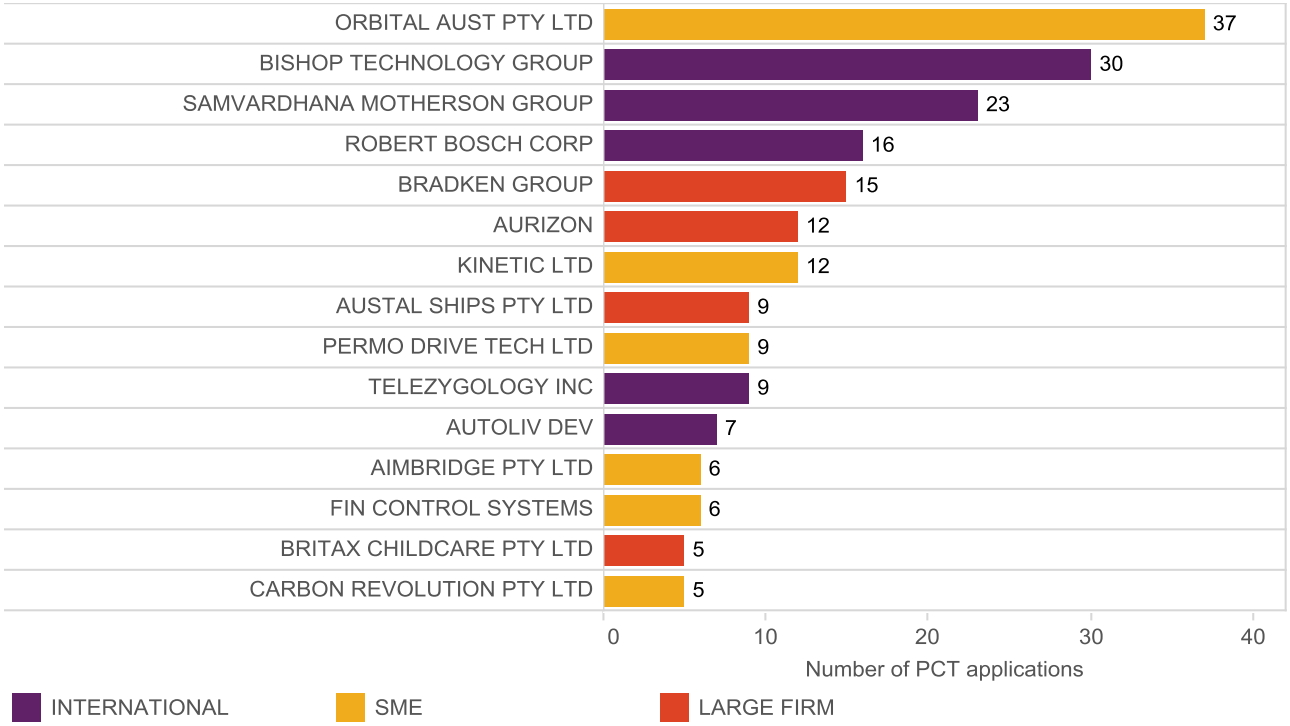
	Number of applicants	Number of applications	Average applications per applicant
INTERNATIONAL	107	230	2.1
RESEARCH INSTITUTION	18	47	2.6
LARGE FIRM	23	84	3.7
SME	333	505	1.5
INDIVIDUAL	42	48	1.1

Source: PATSTAT database, Autumn 2015; IPGOD, 2016 edition; and IP Australia calculations.

Top applicants

Top applicants in the transport sector include many SMEs (Figure 10.6). There were no research institutions in the top 15 applicants.

Figure 10.6: Top applicants



Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Seven of the top 10 applicants filed PCT applications in areas of either prime or auxiliary vehicle components. Bishop Technology Group has expertise in the production of automotive steering. The Bishop Technology group last filed a PCT application in 2011 that corresponded with a restructuring of the country that saw the steering component of the company merge with Gmbh Metallbeitung Ostlab (MVO).[58]

Aurizon is a large firm that was originally owned by the Queensland government as Queensland Rail. The government controlled company was split to separate its passenger and freight services. In 2010 the freight services were publically listed as QR National before subsequently changing

[58] Bishop Steering Technology Pty Ltd, Company History

their name to Aurizon.[59] Aurizon has 13 PCT applications in total with interests in the development of rail technology including track infrastructure management and train components.

Kinetic Ltd was a SME that had been acquired by the international entity Tenneco. The company had made a name for itself though its ride control technology to improve vehicle stability.[60] This innovation is reflected in the current search that uncovered 13 transport PCT applications. In 2008, it was reported that the Australian operations were shut down in response to effects of the global financial crisis.

Austal is a large Australian based global ship building company for both defence and commercial vessels.[61] Austal has nine PCT applications with the earliest filed in 2006 and has a focus on ships and associated shipping components.

Permo-Drive was a SME based on the north coast of New South Wales before the company went into liquidation in 2012. Permo-Drive had nine PCT applications primarily in the development of hydraulic regenerative drive systems for vehicles.[62]

Fin Control Systems is a small company that develops innovations for surfboards.[63] The company has six PCT applications in detachable fins for surfboards.

There were no research organisations in the top 15 applicants. The Central Queensland University was the top research institution in the technology sector and the 17th applicant. The University of Queensland and CSIRO are the 23rd and 24th applicants, respectively.

The list of top applicants is noteworthy for the number of applicants that have innovations in the prime vehicle component area that no longer operate or have moved into other areas of operation. Kinetic, Permodrive and Aimbridge have all ceased operations. The Samvardhana Motherson group had to let go of workers at their Adelaide operations and has since diversified their operations into manufacturing medical devices with its partner Visiocorp. Orbital has seen an opportunity to utilise its strong engine capabilities into the development of unmanned aerial vehicles. Of the remaining top SMEs still operating, Carbon Revolution, with advanced manufacturing capabilities in the vehicle component category, has emerged as a company on the rise: Carbon Revolution filed all five of their applications in the last three years of the time period analysed.

Collaboration in transport

Collaboration between applicants

Collaboration was low in the transport sector with no entity type having more than four occurrences of collaboration with another. Of the 1557 Australian PCT applications identified in the transport sector, only 32 applications (two per cent) had multiple applicants. This was the lowest collaboration rate of all eight sectors. Despite their absence in the list of top applicants, Australian research institutions were some of the top collaborators in the transport technology group together with large firms (Figure 10.7).

While SMEs and international entities account for the majority of top applicants, not a single applicant from either grouping was found in the top collaborators list. Aurizon, an Australian large firm, was the top collaborator, collaborating on four of their 12 applications, or 33 per cent.

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[59] Aurizon, Company Overview

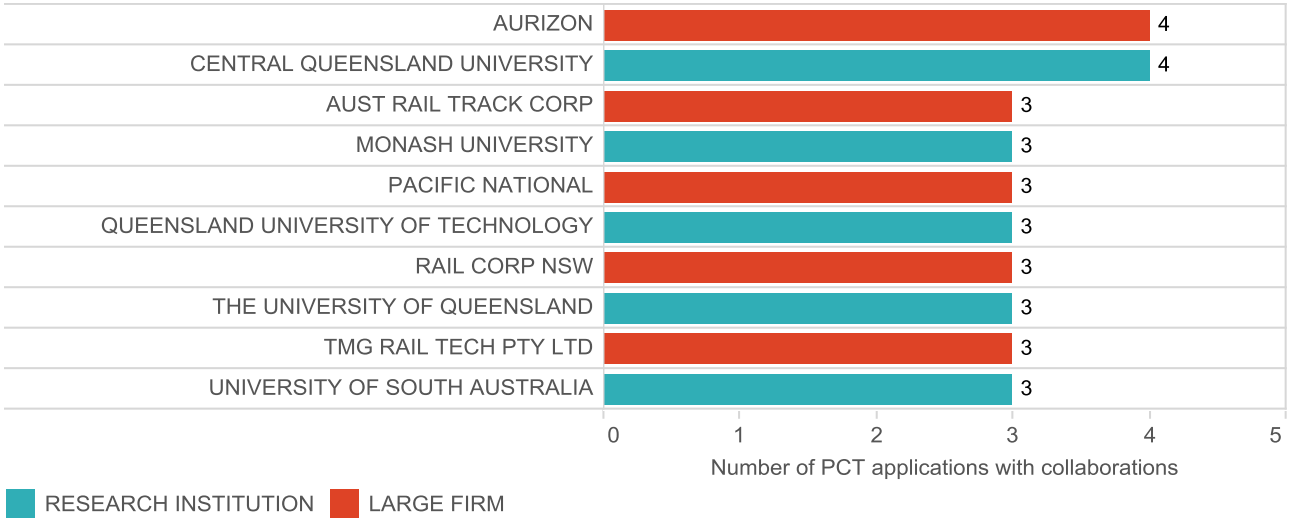
[60] Tenneco, Our Brands, Kinetic

[61] Austal, Ships

[62] Permo-Drive, The Technology

[63] FCS, FCS Origin

Figure 10.7: Top 10 applicants who collaborate

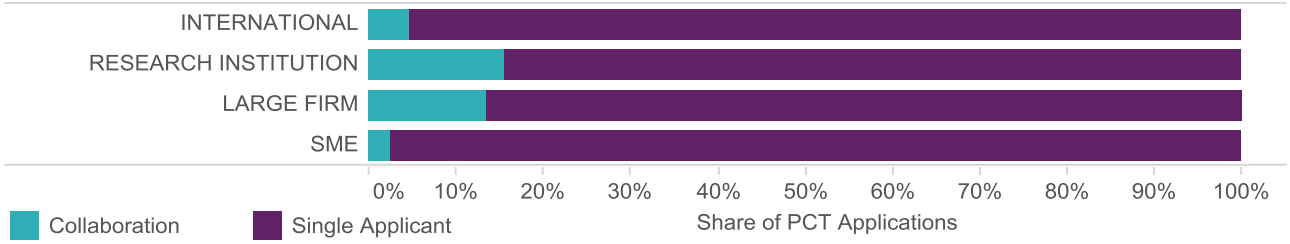


Source: PATSTAT database, Autumn 2015; and IP Australia calculations

Collaboration between applicant types

Less than 20 per cent of applications that involve large firms or research institutions exhibited collaboration (Figure 10.8). This proportion drops to less than five per cent for both SMEs and international applicants.

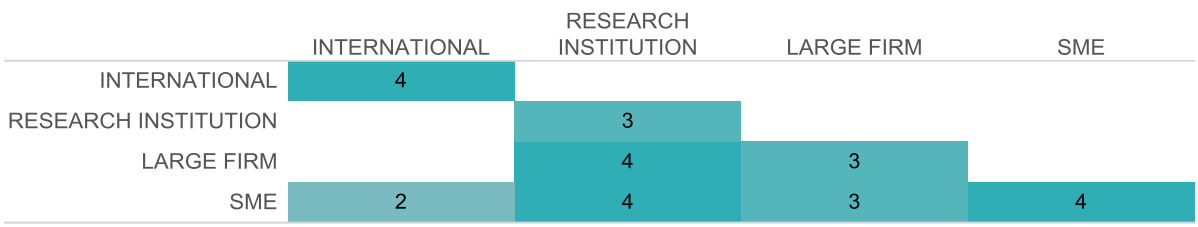
Figure 10.8: Proportion of applications assigned to entity types where collaboration is evident



Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

There is no clear leader in collaboration between entity types, most tied with equally low rates (Figure 10.9). There was no collaboration between international organisations and either Australian large firms or research institutions whereas some collaboration has occurred between and amongst large Australian firms, research institutions and SMEs.

Figure 10.9: Number of PCT applications where collaboration existed between entity types



Source: PATSTAT database, Autumn 2015; IPGOD 2016 edition; and IP Australia calculations

Appendix A: Advanced manufacturing ANZSIC codes

For the purposes of this survey, the Advanced manufacturing Growth Sector is defined as employing Australian businesses classified within the following ANZSIC 2006 classes:

1811 Industrial gas manufacturing

1812 Basic organic chemical manufacturing

1813 Basic inorganic chemical manufacturing

1821 Synthetic resin and synthetic rubber manufacturing

1829 Other basic polymer manufacturing

1831 Fertiliser manufacturing

1832 Pesticide manufacturing

1841 Human pharmaceutical and medicinal product manufacturing

1842 Veterinary pharmaceutical and medicinal product manufacturing

1851 Cleaning compound manufacturing

1852 Cosmetic and toiletry preparation manufacturing

1891 Photographic chemical product manufacturing

1892 Explosive manufacturing

1899 Other basic chemical product manufacturing n.e.c.

2311 Motor vehicle manufacturing

2312 Motor vehicle body and trailer manufacturing

2313 Automotive electrical component manufacturing

2319 Other motor vehicle parts manufacturing

2391 Shipbuilding and repair services

2392 Boatbuilding and repair services

2393 Railway rolling stock manufacturing and repair services

2394 Aircraft manufacturing and repair services

2399 Other transport equipment manufacturing n.e.c.

2411 Photographic, optical and ophthalmic equipment manufacturing

2412 Medical and surgical equipment manufacturing

2419 Other professional and scientific equipment manufacturing

2421 Computer and electronic office equipment manufacturing

2422 Communication equipment manufacturing

2429 Other electronic equipment manufacturing

2431 Electric cable and wire manufacturing

2432 Electric lighting equipment manufacturing

2439 Other electrical equipment manufacturing

2441 Whiteware appliance manufacturing

2449 Other domestic appliance manufacturing

2451 Pump and compressor manufacturing

2452 Fixed space heating, cooling and ventilation equipment manufacturing

2461 Agricultural machinery and equipment manufacturing

2462 Mining and construction machinery manufacturing

2463 Machine tool parts and parts manufacturing

2469 Other specialised machinery and equipment manufacturing

2491 Lifting and material handling equipment manufacturing

2499 Other machinery and equipment manufacturing

Appendix B: Search methodology

This study drew on patent data from:

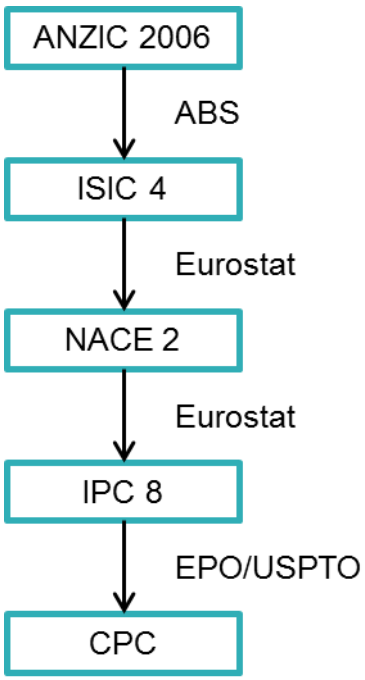
- IPGOD: Australian Intellectual Property Government Open Data; and
- Worldwide patent statistical database (PATSTAT), Autumn 2015 edition, developed by the European Patent Organisation, covering data from over 100 countries.

The identification of patents relating to advanced manufacturing was completed in two phases using Structured Query Language (SQL).

Phase 1: Identification of Advanced Manufacturing CPCs

In order to identify CPCs relating to advanced manufacturing, this study used a list of ANZSIC codes that are identified as advanced manufacturing. The appropriate CPCs codes were then identified with a sequence of classification concordances (Figure B.1).

Figure B.1: Concordances of technology and business classification codes[64]



Phase 2: PATSTAT search

The Autumn 2015 edition of the PATSTAT database used to identify Patent Cooperation Treaty (PCT) applications in this study contains all publications to the beginning of September 2015, essentially comprising publications with a priority date up to March 2014. Some documents with later priority dates are published less than 18 months from the priority date and are in the database.

The Cooperative Patent Classification (CPC) system is a system jointly developed by the European Patent Office (EPO) and the United States Patent and Trademark Office (USPTO) in an effort to develop a common, internationally compatible classification system.[65] It is a hierarchical

[64] ABS 1292.0.15.005 - Concordance Between the International Standard Industrial Classification and the Australian and New Zealand Standard Industrial Classifications, 1993; Eurostat NACE REV. 2 - ISIC REV. 4 Correspondence Tables; Eurostat Patent Statistics: Concordance IPC V8 – NACE REV.2; EPO & USPTO CPC Concordances

[65] Cooperative Patent Classification, About

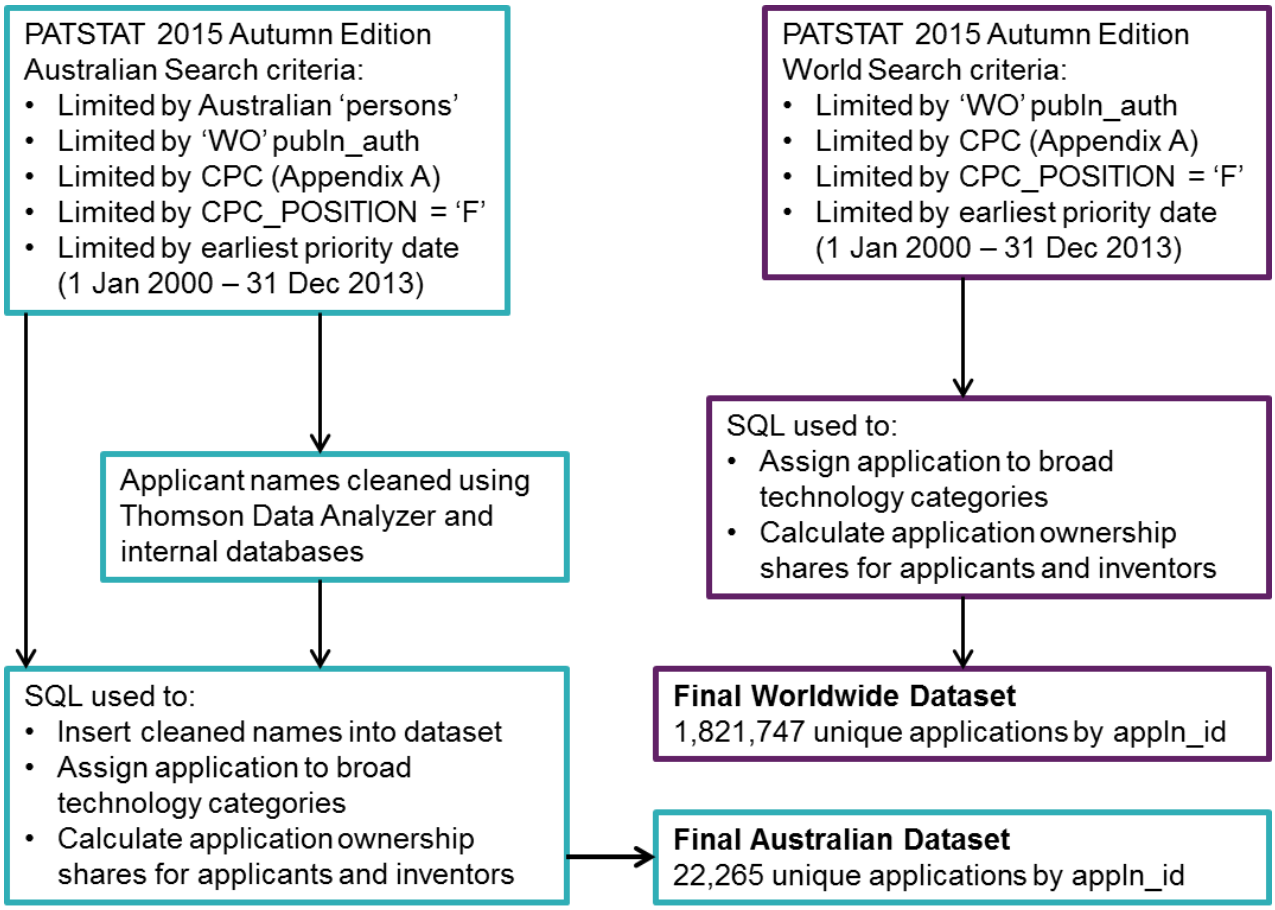
system with multiple layers labelled as sections, subsections, classes, subclasses and groups. All-in-all, the CPC includes about 260 000 fine-grained subdivisions. CPC marks are used to classify the invention(s) disclosed in a patent document. In this report we used CPC marks (generally at the subclass level) to sort patent applications into one of eight broad advanced manufacturing technology sectors.

The present analysis used the CPC mark found in the “F” (first) position in the PATSTAT database for each application. This classification indicates the position of the symbol in the sequence of classes that form the classification for the application.[66] It is a mark that will always have a classification value attributed to the invention of the application. It is acknowledged that patent applications do not have a primary CPC mark in the sense of a primary, most important, inventive concept. However, applications are typically assigned more than one CPC mark which may cause an application to belong to different technology sectors. In this report the first classification has been used to sort applications into one, and only one, of the advanced manufacturing sectors to prevent the same application being analysed across various technologies. For a detailed description of CPC marks used to classify application to the various Advanced Manufacturing Sectors see Appendix C.

The first phase of the search was to identify the patent applications relevant to the advanced manufacturing industries filed via the PCT route with a priority date between 2000 and 2013 (Figure B.2). Phase one of the search identified 22 265 unique applications from the PATSTAT database. The patent search encompasses PCT applications where at least one Australian applicant or inventor is listed on the application. The names retrieved from the Australian search were subsequently cleaned using Thomson Data Analyzer and other internal databases before being fed back into the final Australian dataset. In a second aspect of phase one of the search, a global dataset was assembled without any limitation for the origin of persons involved in the application that retrieved 1 821 747 PCT applications.

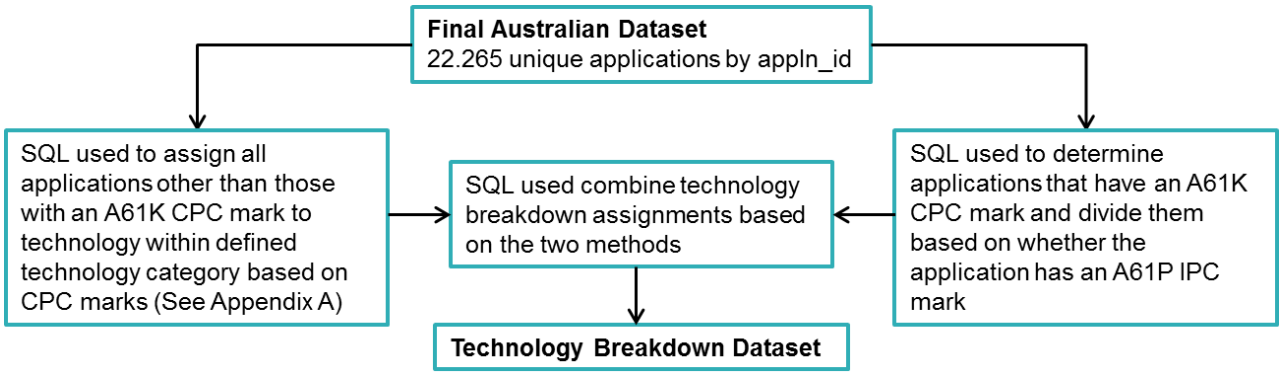
[66] PATSTAT Data Catalog, 2015 Autumn Edition, Version 5.06, 8 February 2016, section 6.29, page 120

Figure B.2: Search strategy



Phase 3: Technology Breakdown

Figure B.3: Assignment methodology

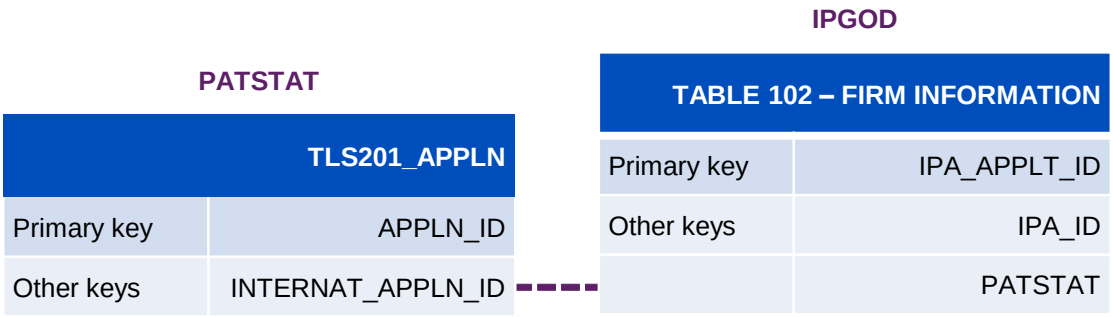


As outlined in chapter 1, applications were assigned to particular technologies within each advanced manufacturing sector (see Appendix C). This assignment used two separated techniques. For applications with a first CPC mark other than A61K, each application was assigned by matching them to a technology using the subclass and in some instances the main group of the CPC mark. For applications with an A61K first CPC mark, the existence of an A61P mark for the application was identified using the PATSTAT database and used to breakdown the technologies in the pharmaceutical sector (Figure B.3). The results of the two methods were unified using SQL to obtain the technology breakdown dataset.

Phase 4: IPGOD—Patents

Australian national-phase entry (NPE) and firm data were extracted from the Intellectual Property Government Open Data (IPGOD) published by IP Australia.[67] [68] IPGOD includes over 100 years of IP rights administered by IP Australia comprising patents, trademarks, designs and plant breeder's rights. The data are highly detailed, including information on each aspect of the application process, from application through to granting of IP rights. An important feature of the IPGOD is the ability to match IP administrative data with firm-level business characteristics for Australian companies. PATSTAT and the IPGOD databases are linked via respective application identifiers (Figure B.4).

Figure B.4: Relationship between the PATSTAT and the IPGOD databases



The NPEs for PCT applications can be identified in PATSTAT by cross-referencing the appln_id against internat_appln_id in the PATSTAT database (Figure B.5).

For the purposes of this analysis, an applicant is regarded as being a company or an individual that is not also an inventor for the PCT application (i.e. invt_seq_nr = 0 in the PATSTAT database).

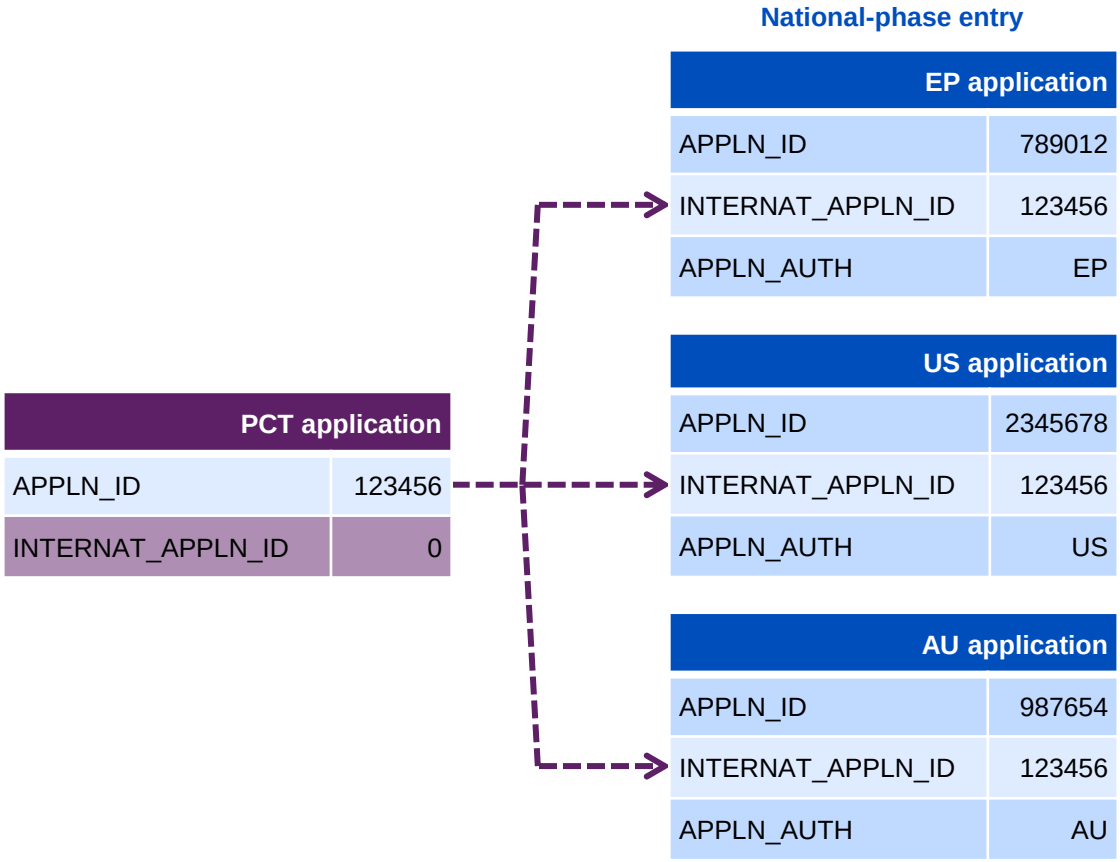
We link applicants with the size of their business using IPGOD. Table 102 in IPGOD contains firm-level information on applications by Australian applicants, where those applications have entered national phase in Australia. Therefore PCT applicants with no national phase entries in Australia were matched to IPGOD using applicant name to determine firm-level information where possible. Australian NPE applications are identified by selecting applications with the value AU in the appln_auth field in the PATSTAT database. Based on the 22 265 unique applications identified in the first phase of the search, a total of 13 073 Australian NPE applications were found.

The bibliographic and firm-level information of persons on Australian NPE applications were assigned from data in the IPGOD database (table 102) associated with corresponding applicant names. Some PATSTAT person_ids were not able to be assigned firm-level information in this way because the cleaned name associated with the person_id in PATSTAT was not the same as the name recorded in IPGOD. In these cases, firm-level information was determined by matching the cleaned names corresponding to person_ids which had been assigned.

[67] Man B, 'Overview of the Intellectual Property Government Open Data', IP Australia Economic Research Paper 02;

[68] Julius TD, 'Harmonising and Matching IPR Holders at IP Australia', Melbourne Institute Working Paper Series Working Paper No. 15/14

Figure B.5: Relationship between a PCT application and corresponding national-phase entries in PATSTAT



Detailed firm-level information is only available for Australian applicants, and so all international applicants, regardless of entity type are all labelled as “International”. For Australian entities, company size was based on the number of employees, with a company considered to be an SME if it has less than 200 employees.

In a second stage of data cleaning, where a PCT application had not entered national phase in Australia, firm-level information was assigned where possible for cleaned names that had featured on other applications which did have a corresponding NPE application.

Based on the above cleaning process, firm-level information was able to be determined for 38 458 of the 40 206 persons identified in the first phase of the search.

Multiple applicants and inventors on a single application are accounted for using shares. For example, if one PCT application has two applicants, each is assigned an ‘applicant share’ of 0.5 for that application. The shares from all applications can be summed to determine the total national share of the patenting landscape.

In other cases, when considering how many applications involve given applicant types, each applicant was counted as having one application each. For example, a patent having a SME and a large firm as co-applicants was counted as one application for SMEs and one application for large firms.

Appendix C: Description of CPC marks

Chemical engineering

Subclass	Broad technology class	Description
B01D F J L	Process engineering	Chemical or physical laboratory processes or apparatus
B02C	Process engineering	Crushing, milling grain
B03	Process engineering	Separating, mixing
B04	Process engineering	Mixing centrifugal or vortex
B07C	Process engineering	Sorting individual items
B08B	Surface cleaning	Cleaning
B09B	Waste treatment	Disposal of solid waste
B22	Casting; Powder Metallurgy	Casting; Powder Metallurgy
C02F	Waste treatment	Treatment of water, waste water, sewage, sludge
C10B C F G H J K L	Energy	Petroleum, gas, coke industries, carbon fuels
C11B	Waste treatment	Producing, refining, preserving fats, oils
C23G	Surface cleaning	Cleaning metallic material using chemicals
C25B	Process engineering	Electrolytic or electrophoretic processes and apparatus for producing chemicals
D06B	Process engineering	Treating textiles by liquids, gases or vapours
D21	Paper Manufacturing	Paper making, production of cellulose
F17C D	Chemical containment	Vessels for compressed gas; pipe-lines
F23C D G J K L M N	Thermal processes and apparatus	Combustion and apparatus for combustion
F25J	Process engineering	Liquefication, solidifcation and processing of compressed gases
F27B	Thermal processes and apparatus	Furnaces, kilns, ovens
F42B D	Explosives	Explosive charges, blasting
G21B C D F	Nuclear reactors and processing	Nuclear reactors and power plants; protection against radiation
H05H	Nuclear reactors and processing	Plasma techniques, accelerated particles

Chemistry

Subclass	Broad technology class	Description
A01N	Agricultural	Preservation of bodies of humans or animals or plants; biocides; pest repellants or attractants; plant growth regulators
A61Q	Cosmetics	Specific use of cosmetics or similar toilet preparations
C01B	Inorganic chemistry	Non-metallic elements
C01C	Inorganic chemistry	Ammonia; cyanogen
C01D	Inorganic chemistry	Compounds of alkali metals

Subclass	Broad technology class	Description
C01F	Inorganic chemistry	Compounds of the metals beryllium, magnesium, aluminium, calcium, strontium, barium, radium, thorium, or of the rare-earth metals
C01G	Inorganic chemistry	Compounds containing metals not covered by subclasses C01D or C01F
C05B	Agricultural	Phosphatic fertilisers
C05C	Agricultural	Nitrogenous fertilisers
C05D	Agricultural	Inorganic fertilisers not covered by subclasses C05B,C05C; fertilisers producing carbon dioxide
C05F	Agricultural	Organic fertilisers not covered by subclasses C05B, C05C, e.g. fertilisers from waste or refuse
C05G	Agricultural	Mixtures of fertilisers of class C05; mixtures of fertilisers with materials not having a specific fertilising activity, e.g. pesticides, soil conditioners, wetting agents fertilisers characterised by their form
C06B	Explosives	Explosives or thermic compositions
C06C	Explosives	Detonating or priming devices; fuses chemical lighters; pyrophoric compositions
C06D	Explosives	Means for generating smoke or mist; gas-attack compositions; generation of gas for blasting or propulsion (chemical part)
C07B	Organic chemistry	General methods of organic chemistry; apparatus therefor
C07C	Organic chemistry	Acyclic or carbocyclic compounds
C07D	Organic chemistry	Heterocyclic compounds
C07F	Organic chemistry	Acyclic, carbocyclic or heterocyclic compounds containing elements other than carbon, hydrogen, halogen, oxygen, nitrogen, sulfur, selenium or tellurium
C07G	Organic chemistry	Compounds of unknown constitution
C09B	Dyes / pigments	Organic dyes or closely-related compounds for producing dyes; mordants; lakes
C09C	Dyes / pigments	Treatment of inorganic materials, other than fibrous fillers, to enhance their pigmenting or filling properties; preparation of carbon black
C10M	Lubricants	Lubricating compositions
C11C	Organic chemistry	Fatty acids from fats, oils or waxes; candles
C11D	Organic chemistry	Detergent compositions; soap or soap-making; resin soaps; recovery of glycerol
C40B	Organic chemistry	Combinatorial chemistry; libraries, e.g. chemical libraries, in silico libraries

Electrical

Subclass	Broad technology class	Description
G10K L	Audiovisual	Sound-producing devices; speech analysis or synthesis
G03B G H	Audiovisual	Apparatus for taking or viewing photographs; electrography, electrophotography, magnetography; holograph

Subclass	Broad technology class	Description
G09G	Audiovisual	Arrangements or circuits for control of indicating devices using static means to present variable information
G08B C	Communication technologies	Signalling or calling systems; order telegraphs; alarm systems; transmission systems for measured values, control or similar signals
H04 (all)	Communication technologies	Electric communication technique
F15C	Computing and data processing	Fluid circuit elements for control or computing
G06C D E F G J K M N T	Computing and data processing	Computing, calculating, counting
G09C	Computing and data processing	Coding or ciphering apparatus for cryptography
G01C F H J K L M N Q R S W V	Controlling /Regulating/Testing	Measuring, testing, surveying, navigation, speed, heat, force, stress, pressure, analysing, electrical variables, direction finding, use of radio waves, gravity, geophysics, meteorology
G04G	Controlling /Regulating/Testing	Electronic time-pieces
G05B F	Controlling /Regulating/Testing	Control or regulating systems; regulating electric or magnetic variables
A21B	Domestic appliances	Machines or equipment for baking; baker's ovens
A45D	Domestic appliances	Hairdressing, shaving, manicure equipment
A47J	Domestic appliances	Kitchen equipment
F24B C	Domestic appliances	Domestic stoves or ranges
F25C D	Domestic appliances	Production, working, storage, distribution of ice
H02B G H J M N P	Electric power	Generation, conversion or distribution of electric power
H01 (all)	Electrical components	Basic electric elements
H03C D F G H J K L M	Electrical components	Basic electronic circuitry
H05C F K	Electrical components	Electric apparatus for killing, stunning or guiding; static or natural electricity; electric circuits and assembly
F21H K S V	Heating/Lighting	Lighting, non-electric
F24J	Heating/Lighting	Heating
H05B	Heating/Lighting	Electric heating / lighting
G21K Y	Nuclear physics and engineering	Handling radioactive particles or devices
G02 (all)	Optics and imaging	Optics
G04C	Other instruments	Electromechanical clocks or watches
G07F G	Other instruments	Coin-freed or like apparatus
G12 (all)	Other instruments	Constructional details or instruments or apparatus
B01B	Physical or chemical processes	Boiling, evaporation; apparatus

Subclass	Broad technology class	Description
B81B	Physical or chemical processes	Micro-strucutral devices or systems
C30 (all)	Physical or chemical processes	Metallurgy, crystal growth

Materials

Subclass	Broad technology class	Description
A62D	Fire Control	Chemical means for extinguishing fires or protecting against harmful chemical agents
B32B	Other materials	Layered products, cellular, honeycomb
B82B Y	Nanomaterials	Nanotechnology, nanostructures
C03C	Glass	Chemical compositions of glasses, glazes or enamels, surface treatments or glass or glass fibres
C04B	Cements	Cements, concrete, artificial stone, ceramics, refractories, lime, magnesia, slag; treatment of natural stone
C08 (all)	Polymers	Organic macromolecular compounds, their preparation or compositions thereof
C09D F G	Coatings	Coating compositions, paints, varnishes, lacquers; filling pasts; paint or ink removers; inks; correcting fluids; wood stains
C09H J	Other materials	Glues and adhesives
C09K (not C09K 21)	Other materials	Materials for miscellaneous applications
C09K 21	Fire Control	Fireproofing materials
C14B C	Other materials	Chemical treatment of skins, hides, leather e.g. tanning
C22C	Metals and alloys	Alloys
C23C F	Coatings	Coating metallic material; non-mechanical surface removal of metallic material
D01 (all)	Textiles	Natural or artificial threads or fibres; spinning
D02 (all)	Textiles	Yarns; mechanical finishing or yarns or ropes; warping or beaming
D03 (all)	Textiles	Weaving
D04B C	Textiles	Knitting; braiding, lace manufacture
D05B C	Textiles	Sewing, embroidering, tufting
D06G H L	Textiles	Cleaning or textiles; marking, seaming, serving textiles; pleating, kilting, goffering textiles; bleaching, dry-cleaning, washing textiles
F16N	Other materials	Lubricating
G03C F	Other materials	Photosensitive materials for photographic processes; auxiliary processes; photomechanical production of textured or patterned surfaces

Mechanical engineering

Subclass	Broad technology class	Description

Subclass	Broad technology class	Description
A01B C D F G	Machines for agriculture or processing food	Machines for soil working; planting, sowing, fertilising, harvesting, mowing, processing harvested product, storing produce, horticulture, watering
A21C	Machines for agriculture or processing food	Machines for making, processing or handling dough products
A22B C	Machines for agriculture or processing food	Machines for slaughtering or processing meats
A23N	Machines for agriculture or processing food	Machines for treating or preparing harvested agricultural products, preparing fruit or vegetables, preparing animal feed
A24C	Machines for agriculture or processing food	Machines for making cigars or cigarettes
A41H	Textile and paper machines	Manufacturing clothes
A42C	Textile and paper machines	Manufacturing hats
A43D	Textile and paper machines	Manufacturing footwear
A47B C D F G K L	Building and construction	Furniture and domestic equipment
A62C	Building and construction	Chemical fire extinguishers or protection against harmful chemicals or in breathing apparatus
B02B	Machines for agriculture or processing food	Milling or refining grain or fruit
B05B	Machine parts/tools	Spraying or atomising apparatus; nozzles
B06B	Machine parts/tools	Means for generating infrasonic, sonic, ultrasonic vibration
B21B D F H J K L	Machine parts/tools	Mechanical metal working
B23 (all)	Machine parts/tools	Machine tools for metal working
B24 (all)	Machine parts/tools	Machines for grinding or polishing
B25 (all)	Machine parts/tools	Hand tools; portable power tools
B26 (all)	Machine parts/tools	Hand cutting tools
B27B C F G J L	Machine parts/tools	Tools for working wood or similar materials
B28D	Material handling	Working stone
B30B	Machine parts/tools	Presses
B31(all)	Textile and paper machines	Working paper or cardboard
B41B C D F G L N	Textile and paper machines	Printing machines
B42B C	Textile and paper machines	Bookbinding
B44B C	Building and construction	Printing for decorative arts
B65B C G H	Material handling	Handling thin or filamentary material
B66 (all)	Material handling	Hoisting, lifting, hauling
B67B C	Material handling	Opening, closing, filling, emptying containers
B68F	Textile and paper machines	Manufacture using leather or canvas
C12L	Machines for agriculture or processing food	Pitching or depitching machines
E02D	Building and construction	Foundations, excavations, embankments, underground or underwater structures

Subclass	Broad technology class	Description
E02F	Mining	Dredging, soil shifting
E05B D F G	Building and construction	Locks, keys, window or door fittings, safes
E06B	Building and construction	Doors, windows, shutters, blinds, fences, gates
E21 (all)	Mining	Earth drilling, mining
F01C D K M N P	Engines, pump, turbines	Machines or engines; steam engines
F02C G K	Engines, pump, turbines	Combustion engines
F03B C D G H	Engines, pump, turbines	Machines or engines for liquids; wind motors; means to produce mechanical power
F04 (all)	Engines, pump, turbines	Positive displacement machines or pumps for liquids
F15BD	Mechanical elements	Fluid pressure actuators, hydraulics, pneumatics
F16C D F G H J K M P	Mechanical elements	Engineering elements; safety devices
F22D	Engines, pump, turbines	Pre-heating steam
F23H R	Mechanical elements	Combustion grates, means for cleaning grates; combustion with high pressure or high velocity products
F24D F H	Building and construction	Heating, air conditioning, fluid heaters
F28B C D F	Material handling	Heat exchange systems
G01B D G P T	Other special machines	Measuring dimensions, angles, areas, speed, weight, radiation
G03D	Other special machines	Apparatus for processing exposed photographic materials
G04D F	Other special machines	Apparatus for making clocks or watches; time interval measuring
G05D G	Other special machines	Systems for controlling non-electric variables
G07B	Other special machines	Apparatus for ticket issuing, fare registering, franking
G07D	Material handling	Handling of currency

Medical devices

Subclass	Broad technology class	Description
A61B	Medical or veterinary science; hygiene	Medical procedures and apparatus
A61C	Medical or veterinary science; hygiene	Dental apparatus
A61D	Medical or veterinary science; hygiene	Veterinary procedures and apparatus
A61G	Medical or veterinary science; hygiene	Patient transport/care apparatus
A61F	Medical or veterinary science; hygiene	Medical procedures and apparatus
A61H	Medical or veterinary science; hygiene	Physical therapy apparatus
A61J	Medical or veterinary science; hygiene	Laboratory equipment

A61L	Medical or veterinary science; hygiene	Sterilisation methods
A61M	Medical or veterinary science; hygiene	Medical procedures and apparatus
A61N	Medical or veterinary science; hygiene	Diagnostic imaging and therapy
A62B	Lifesaving	Lifesaving equipment
H05G	Diagnostic imaging and therapy	X-ray apparatus

Pharmaceuticals

Subclass	Broad technology class	Description
A61K (not A61P)	Pharmaceutical formulations	Preparations for medical, dental, or toilet purposes
A61K (with A61P)	Pharmaceutical methods of treatment	Pharmaceutical methods of treatment
C07H	Nucleic acids	Sugars, nucleic acids
C07J	Steroids	Steroids
C07K	Peptides	Peptides
C12M	Apparatus for enzymology or microbiology	Apparatus for enzymology or microbiology
C12P	Fermentation	Fermentation or enzyme-using processes to provide a desired chemical compound
C12N	Microorganisms and enzymes	Microorganisms or enzymes**;** mutation **or** genetic engineering; culture media
C12Q	Biotechnology testing	Measuring or testing processes involving enzymes **or** micro-organisms
C12Y	Microorganisms and enzymes	Enzymes

Transport

Subclass	Broad technology class	Description
B64B C D F	Aircraft	Aeroplanes, helicopters, aircraft equipment; aircraft-carrier deck installations
B60D H J N Q R S	Auxiliary vehicle components	Vehicle connections; vehicle heating / cooling devices; windows and doors; passenger accommodation; lighting or signalling; servicing and repairing
B60F V	Other Vehicles	Vehicles for rail and road; amphibious vehicles; air-cushion vehicles
B62C	Other Vehicles	Vehicles drawn by animals
B62H J K L M	Cycling	Cycles and equipment; stands; locks; seats; frames; controls; brakes; transmissions; sledges
B64G	Other Vehicles	Cosmonautics
B65F	Other Vehicles	Vehicles for gathering or removing domestic refuse
B60B G K L T W	Prime vehicle components	Vehicle wheels, castors, axles; suspension; mounting engines and transmission; electric equipment; brake systems; combined control systems

Subclass	Broad technology class	Description
B62D	Prime vehicle components	Motor vehicles; trailers
F01B L	Prime vehicle components	Machines or engines, positive displacement type; cyclically operating valves
F02B D F M N P	Prime vehicle components	Internal combustion engines; controls; cylinders, pistons; fuel supply; starting; ignition
B63B C H J	Shipping	Ships, waterborne vessels; equipment; launching; dry-docking; life-saving in water; equipment of dwelling or working under water; salvage and search; auxiliaries; marine propulsion or steering
E02C	Shipping	Ship-lifting devices or mechanisms
B61C D F G H J K L	Trains	Locomotives, rail cars; suspensions; vehicles for use on tracks of different widths; wheel guards; brakes; shifting or shunting; guiding and safety of rail traffic; body details of railway vehicles; couplings, draught and buffering; auxiliary equipment
B61B	Transport infrastructure	Railway systems
E01 (all)	Transport infrastructure	Construction of roads, railways or bridges
G08G	Transport infrastructure	Traffic control systems
B60P	Vehicle transports	Vehicles for load transportation

Appendix D: Relative specialisation index

The Relative Specialisation Index (RSI) is a measure to account for how specialised a country is in a particular technology area. The RSI compares a country's fraction of the total number of patent applications filed across all countries, with its fraction of the number of applications across all technologies. The formula is given below:

$$RSI = \log_{10}\left(\frac{n_i/n_{total}}{N_i/N_{total}}\right)$$

where:

n_i = number of *category* patents from country *i*

n_{total} = number of total *category* patent applications worldwide

N_i = total number of patent applications *across all technologies* from country *i*

N_{total} = total number of patent applications worldwide *across all technologies*

The RSI accounts for that fact that some countries, like United States and Japan, file more patent applications across all technologies than other countries. The measure therefore highlights countries that have a greater level of patenting in the searched technology than might be expected given their overall level of patenting. The index is equal to zero when the country's share in a given technology field is equal to all patents filed in all fields (no specialisation), and positive when a specialisation is observed. If a country is less active in a particular field than its overall level of innovation it has a negative RSI.

The calculation was performed for patent applications with at least one applicant recorded (i.e. applt_seq_nr > 0 in the PATSTAT database).

Countries with less than 100 patents applications in the technology area of interest were excluded.