Australian Government
Department of Industry
IP Australia

Research Performance of University Patenting in Australia:

A Pilot Assessment

October 2013

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Robust intellectual property rights delivered efficiently

Contents

Executive summary

Universities contribute to economic growth not only through teaching and research, but through engagement and collaborations with industry and other off campus entities. One way of measuring the economic effects of these activities is to examine patent data.

Recent years have seen an increased use of patent metrics to evaluate innovation and research performance.[1] Patent documents are accessible in electronic formats and provide details of inventions resulting from university research and collaboration. Specialised software enables us to examine these documents and 'track' technological knowledge and its diffusion in the economy.

This pilot study examined patents originating from 12 Australian universities and considered metrics such as the number of patents published, technology specialisations and the frequency of citations of patents in other literature. From this data we were able to extend our understanding of the relationship between patents and the impact of university originated research.

Findings

The results revealed that all 12 universities (presented anonymously in the study) showed patenting activity. The study identified 4,056 university patent documents relating to 1,293 inventions. University patenting activity over the study period averaged 16.58 new inventions per university per year.

Leading technology areas of university patenting include:

- pharmaceuticals (1,255 patent documents)
- medical technology (438 patent documents)
- chemical engineering (292 patent documents)
- biotechnology (278 patent documents)
- measurement (262 patent documents)
- materials, metallurgy (182 patent documents)
- food chemistry (173 patent documents).

Citations are indicative of follow on innovation.

A patent citation indicates that an invention was useful for later innovators. The key technology areas in which university patents received more citations than the Australian average included:

- Textile and paper machines
- Civil engineering
- Other consumer goods
- Electrical machines, apparatus, energy
- Engines, pumps, turbines
- Transport
- Basic communication processes

The results suggested that smaller and regional universities tend to concentrate their patent filings in a few (4 – 5) technology fields, while the patents filed by larger universities are generally spread across several more technology fields (over 15).

Small and regional universities tend to specialise

Patent citation rates varied across universities. Two smaller universities received considerably more citations than the Australian average in areas of medical technology, electrical machinery, civil engineering and pharmaceuticals.

Conclusion

We apply patent metrics to assess the scope and impact of inventions originating from university research. This study demonstrates that such an assessment can be undertaken efficiently by relying on the identification, analysis, interpretation and visual representation of patent datasets.

In addition, the methodology employed in this study promises to be useful in further developing approaches to patent analytics.

1 See OECD Science, Technology and Industry Scoreboard 2011 and *Performance-based funding for Public Research in Tertiary Education Institutions: Workshop Proceedings*, OECD Dec 2010. See also 'Patentometrics as Performance Indicators for Allocating Research Funding to Universities,' by P. Mortensen, University of Aarhus, January 2011.

Introduction

Objectives

The primary purpose of this study was to develop patent metrics to assess university research, including methodologies and results against the metrics.

A secondary purpose was to explore the linkages across existing data sets from the Innovation and Research Portfolio. The analysis involved collaboration and consultation across IP Australia, the Department of Industry (the Department), the Australian Research Council and the university sector.

Methodology

This study utilised the mining, analysis, interpretation and visual presentation of information included in patent documents that originated from research conducted by 12 Australian universities.

University patents are defined as patents where at least one applicant is a university, a technology transfer organisation of a university, a spin-off company or any other entity that a university controls, as reflected in its annual reports.

Patent documents filed by any of these university entities and published over the study period **1 January 2006 to 30 June 2012** are included in this study.

These patent documents were then grouped into **patent families** – documents generally relating to the same invention but filed in different countries. This enabled us to distinguish between the level of university patent filings and inventive activity.

Finally, patent metrics were calculated from the resulting university patent data set.

The metrics

This study adopts quantitative and qualitative metrics for determining the scope and impact of patents originating from the 12 Australian universities. These metrics are:

- Metric 1 **– Patent publications per year:** the total number of patent documents for each university published over the study period.
- Metric 2 **– Patent families per university:** a proxy for the number of inventions disclosed in university patent documents during the study period.
- Metric 3 **– Technology specialisation:** the distribution of a university's patent documents across 35 different technology fields as defined by the World Intellectual Property Office (WIPO).
- Metric 4 **– Technology specialisation by visualisation of keywords:** identifies areas where university patenting is concentrated.
- Metric 5 **– Relative specialisation index:** the ratio of a university's share of patents in a particular technology field to the university's share of patents in all technology fields.
- Metric 6 **– Patent citation frequency by technology field:** the average citation count of forward citations received by university patents per technology field.
- Metric 7 **– Relative citation impact by technology field:** the number of citations the university patents received compared to average forward citation rates for all patents originating from Australia in the same publication year range and in the same technology field.
- Metric 8 **– Patent citation frequency per patent family:** forward citations received by a group of university patent documents relating to the same invention.
- Metric 9 **– Average citation frequency per year of publication:** the average forward citations for university patents per year of publication.
- Metric 10 **– Geographical filing breadth:** the total number of published documents per patent family.
- Metric 11 **– Collaboration measured through co-applicants:** illustrated on the Aduna Cluster Map.

A detailed description of the metrics and the results are presented in the chapters below.

Structure

This study includes five sections and one appendix.

Section 1 describes the approach and methodology adopted in this study.

Section 2 presents metrics relating to the scope, size and technology profile of university patent portfolios.

Section 3 focuses on patent citation analyses and provides insights into the quality of university patents and their impact and follow on innovation.

Section 4 evaluates the commercialisation potential of university patents and assesses collaboration between university entities and other partners.

Section 5 summarises the key findings and considers policy implications.

Curtin University

UNSW
THE UNIVERSITY OF NEW SOUTH WALES

UTAS

University of
South Australia

QUT
Queensland University
of Technology

THE UNIVERSITY OF
MELBOURNE

THE UNIVERSITY OF
NEWCASTLE
AUSTRALIA

THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

UNIVERSITY OF
TECHNOLOGY SYDNEY

CHARLES
DARWIN
UNIVERSITY

RMIT
UNIVERSITY

THE UNIVERSITY OF
WESTERN AUSTRALIA

1. Background and methodology

1.1 Objectives

In 2012 the Department engaged the National Patent Analytics Hub at IP Australia to undertake a pilot study assessing the impact of university research. This study is based on the mining, analysis, interpretation and visualisation of patent documents originating from 12 Australian universities.

This pilot study has arisen as one component of a broader suite of work undertaken by the Department, the Australian Technology Network of Universities, the Group of Eight universities and selected others, as part of the Excellence in Innovation for Australia (EIA) Trial.[2] The universities involved in the EIA Trial have also been included in this study.

The 12 Australian universities included in the study represent a cross-section of Australian universities, including:

- Curtin University
- University of South Australia
- RMIT University
- University of Technology Sydney
- Queensland University of Technology
- The University of Queensland
- The University of Melbourne
- The University of Western Australia
- The University of New South Wales
- The University of Newcastle
- Charles Darwin University
- The University of Tasmania

This pilot study also explored connections between patent data and other available data sets. IP Australia gratefully acknowledges the Australian Research Council for approaching the EIA universities and sharing patent data reported as part of the Excellence in Research for Australia 2012 survey for those eight universities which consented to this data being shared (see also section 5 Lessons Learned).

1.2 Patents as indicators of research impact

Patents are often used as indicators of R&D output.[3] It is a requirement of patent law that patent documents are published and that they fully disclose inventions. Patent documents also include other useful information, such as international patent classifications and information about inventors and applicants.

As a result of the disclosure requirement, the patent literature reflects developments in science and technology. Through the mining and analysis of data associated with patent documents, it is possible to measure aspects of inventive activity across various technology sectors and at many different levels including individuals (inventors), institutions, regions, countries and globally.

Recent years have seen an increased use of patent metrics to evaluate innovation and research performance. The Organisation for Economic Cooperation and Development notes several uses of patent information by policy makers for innovation and R&D assessment purposes:

- measuring inventive output of countries, regions, institutions or individual inventors
- mapping certain aspects of the dynamics of the innovation process, such as cooperation in research and diffusion of technology across industries or countries
- tracking globalisation patterns and internationalisation of research.[4]

Patent data is also used to identify the economic benefits of publicly-funded research. Much of this research is conducted in universities, public research organisations and hospitals.

By some measures, interactions between the public and private research sectors are increasing.[5] It is now generally acknowledged that universities not only contribute to economic growth through teaching and research, but also through their entrepreneurship,

2 See < http://www.go8.edu.au/university-staff/programs-_and_-fellowships-1/atngo8-excellence-in-innovation-for-australia-trial-excellence-in-innovation-for-australia-eia>

3 For example, see Griliches, Z. (1998), Patent Statistics as Economic Indicators: *A Survey, R&D and Productivity: The Econometric Evidence*, University Chicago Press.

4 OECD (2009). OECD Patent Statistics Manual, OECD Publishing, 26.

5 OECD data indicate that the percentage of government intramural expenditure on R&D financed by industry has increased from 1.71% in 1981 (for OECD average and Australia) to 9.92% for Australia in 2008 and 3.57% for OECD average. Source: OECD Main Science and Technology Indicators.

engagement and collaborations formed with industry and other off-campus organisations.[6]

In this context, various attempts to analyse the connections between citations in patents and academic literature have emerged.

1.3 The linkages between academic research and corporate patenting

Several patent-based methodologies are relevant to assessing the impact of academic research. In 1997, Dr Francis Narin and his team developed a novel approach to evaluating the benefits of publicly-funded research. Their study concluded that up to 73% of the papers cited in 400,000 US patents were owned by private companies and authored by academic, governmental, and other public institutions. The study also found a strong correlation between the nationality of inventors and literature citations, with inventors preferentially citing papers authored in their own country.[7]

The National Science Foundation adopted the methodology proposed by Narin *et al*. and continues to measure citations to science and engineering literature on the cover pages of issued US patents. This measure is an indicator of the contribution of research to the development of practical innovations.[8]

The methodology proposed by Narin *et al*. also received considerable attention in Australia. In 1999 the Australian Research Council and Commonwealth Scientific and Industrial Research Organisation (CSIRO) commissioned a study of Australian patents filed in the US. The authors found that 90% of the scientific research papers cited in Australian-originated US patents were authored by publicly-funded research organisations, predominantly Australian organisations.[9] Those results suggest the potential importance of public-private linkages in Australia.

In 2009, IP Australia studied patent holdings originating from 15 Australian universities. The analysis provided insights into the size, type and impact of academic patent portfolios. It developed a methodology for aggregating academic patents on the basis of the names of applicants listed on patent documents originating from universities, including their commercialisation arms (technology transfer offices), spin-off companies, and cooperative research centres.

A more recent example of patent-based approaches to measuring academic patenting activity is a 2012 study by the Fraunhofer Institute in Germany.[10] The authors proposed a methodology for identifying patents originating from university research based on matching the names of authors in scientific publications with the names of inventors listed on patent applications.

Attempts to match academic inventors with academic publications are emerging in the United States, as part of the Open Researcher and Contributor ID (ORCID) project.[11] ORCID is a unique digital identifier that distinguishes one researcher from another, through integration of key research outputs such as manuscripts and grant applications. At this stage it is unclear whether patents are intended to be included in the ORCID research outputs and if so, what methods could be used to accurately match the names of inventors in patents with the names of authors in scientific publications.

While these novel approaches are being tested, governments and universities continue to collect statistics on university patenting and licensing activities. Such statistics are generally limited to the numbers of patent applications filed by, or granted to, universities and to the income derived from university intellectual property.

These statistics are useful to monitor university technology transfer activities over time. Yet they capture little or no corporate patenting activity derived from university research. Moreover, such survey results should be interpreted with caution. University patent filings are not wholly representative of a university's research impact or research commercialisation potential, but rather indicative of a university's propensity to file patents.

1.4 Approach to this study

The methodology presented here is distinctive for establishing the scope and impact of university patenting originating from academic research, and assessing the quality of those patents and their impact on follow-on innovation.

Utilising patent data in this capacity rests on two premises:

- That patents are an indicator of prior R&D and signal the translation of research into the development of technologies
- That securing patent protection incurs substantial costs for the applicant. Existence of a patent application or granted patent thus signals intent to utilise the invention, typically for commercial purposes.

6 The concept of entrepreneurial university is often referred to as the university third mission. See also Martin, B. R. and Etzkowitz, H., 2000. The Origin and Evolution of the University Species, Vest 13, 9-34.

7 Narin, F., Hamilton, K., Olivastro, D., (1997). The increasing linkage between U.S. technology and public science, Research Policy 26, 317–330.

8 National Science Foundation, Science and Engineering Indicators 2012, <http://www.nsf.gov/statistics/seind12/c5/c5s4.htm#s6>. Patent-based data should be interpreted with caution. Patent office practices and pendency periods can change over time and patterns in the data can reflect such changes. Similarly, changes in applicant behaviour can also influence patterns in patent-based data.

9 <http://www.arc.gov.au/pdf/00_02.pdf>

10 Dornbusch F., Schmoch, U., Schulze N., Bethke N. (2012). Identification of university-based patents: a new large-scale approach. Fraunhofer ISI Discussion Papers *Innovation Systems and Policy Analysis* 32.

11 <http://orcid.org/>

1.5 The patenting domain

Not all inventions are patentable. Patents cover inventions which are new, susceptible to industrial application and not obvious to someone with knowledge and experience in the technology area.

The academic research fields that fall under patentable subject matter include engineering, physical and life sciences, environmental sciences, medical research, communications and computing.

Patents can also cover industrial applications of other academic research fields, such as mathematics and psychology.

Social sciences and humanities generally fall outside the scope of patent-eligible subject matter.

1.6 Methodology

Defining university patents

In order to establish the definition of a university patent, it is useful to consider patent filing strategies by universities.

Universities can file patents under their own name, through their commercialisation offices or spin-off companies. They also frequently collaborate with industry partners, Cooperative Research Centres and philanthropic organisations. These entities typically co-fund research projects conducted by universities.

Accordingly, to establish the scope of university patenting activity, it was necessary to:

1. Determine which university entities should be included in the scope of a 'university'
2. Identify the names of those entities over the relevant period
3. Identify patents filed by all those entities over the relevant period
4. Attribute the patents to universities according to a set of defined rules.

Step 1 – Defining university entities

A patent document was considered to belong to one of the 12 universities if it was filed under the name of at least one of the following categories:

- A university or a spelling variant thereof (e.g. The University of Western Australia, UWA, University Western Australia, Western Australia University)
- A technology transfer organisation affiliated with one of the 12 universities (e.g. UniQuest, QUTBluebox)
- A spin-off company reported by any of the 12 universities in the National Survey of Research Commercialisation
- A company that is reported within a university's annual report as its controlled entity.

All universities operating in Australia and registered with Tertiary Education Quality Standards Agency are classified as trading or financial corporations and are required to prepare financial reports in accordance with Part 2M.3 of the *Corporations Act 2001*. As such, if a university has control or significant influence over one or more entities, it is required to disclose that information in its annual reports.

The Department and IP Australia worked together to establish these key parameters of university entities for this pilot study.

Step 2 – Identifying the names of university entities

The following information sources were used to ascertain the names of university entities:

- University annual reports
- University websites and other internet resources
- The National Survey of Research Commercialisation, all available editions except 2010 – 2012.

Step 3 – Identifying patents filed by university entities

In order to identify patents filed by university entities, IP Australia primarily used and queried the **Derwent World Patent Index** (DWPI) developed by Thomson Reuters. This database covers patent documents[12] originating from 47 jurisdictions (countries or regional patent offices), including Australia.

IP Australia also used **AusPAT** – the online database of Australian patents – to check selected records retrieved from DWPI.

Patent documents reported by eight universities as part of ERA 2012 were considered as a supplementary data source. The dataset included patent numbers reported in ERA 2012 by eight universities which gave consent to the data being shared with IP Australia (See also Section 5 Lessons learned).[13]

Timeframes for the analyses

Patent documents published between **1 January 2006 and 30 June 2012** were identified and analysed in this pilot study with citation counts being measured at the time of the initial data extraction (end of December 2012).

On the date of publication the information included in patent documents enters the public domain. This date is 18 months from the earliest date of filing. For example, a patent application published on 1 January 2006 was first filed on 1 July 2004.

12 A patent document refers to any complete application for a standard patent filed in any jurisdiction or internationally. This includes applications filed under the Patent Cooperation Treaty as well as those filed directly with national patent offices.

13 It is noted that the 4056 documents located during this search is not the absolute number of patents attributable to the 12 universities. While care has been taken to ensure integrity and robustness of the results, variations in search strings, such as the choice of proximity parameters and truncations in applicant names, will produce slight variations. Such differences, however, are not expected to be great enough to affect the general picture.

Step 4 – Attributing patents to universities

Patent documents have been attributed to universities according to two factors:

- The name(s) of patent applicants listed on the document
- Grouping of patent documents into patent families.[14]

The application of this methodology is illustrated in the following two examples.

Example 1: University A developed an invention jointly with University B. Patent applications for the invention were filed in Australia, the UK and the US. The applicants listed on these applications were as follows:

- The patent application filed in Australia listed University A along with University B.
- The application filed in the UK listed University A along with a private entity Z.
- The application filed in the US listed University A only.

In the first stage, we assigned a value of either 1 or 0 to each of the entities listed on patent applications as follows:

	Patent document		
	AU	UK	US
University A	1	1	1
University B	1	0	0
Private entity Z	0	1	0

In the second stage, Universities and other entities not part of this study were omitted and the total university share was calculated as follows:

	Patent document			Total university share
	AU	UK	US	
University A	1	1	1	3/4 = 0.75
University B	1	0	0	1/4 = 0.25

Example 2: University A developed an invention jointly with a non-university entity X, and University F. Applications for the invention were filed in Australia, Germany, China and the European Patent Office. The applicants listed on these applications were:

- The application filed in Australia listed University A and non-university entity X.
- The application filed in Germany listed non-university entity X and University F.
- The application filed in China listed University A only.
- The application filed in the European Patent Office listed University entity A along with non-university entity X.

This study only considers patenting activity of the selected 12 universities. Accordingly, for the purpose of this study, when assigning the values of either 1 or 0, the applications filed by non-university entities or other Australian universities were not counted as being university patents.

In example 2, the values 1 and 0 were thus assigned as follows:

	Patent document			
	AU	DE	CN	EP
University A	1	0	1	1
University F	0	1	0	0
Non-university entity X	N/A	N/A		N/A

Note: AU = Australia; DE = Germany; CN = China; EP = European Patent Office.

The total university share was then calculated as follows:

	Patent document				Total university share
	AU	DE	CN	EP	
University A	1	0	1	1	3/4 = 0.75
University F	0	1	0	0	1/4 = 0.25

14 Patent applicants typically file an application for the same invention in several countries (or patent authorities) where they would like to seek protection. A group of patent applications relating to the same invention is known as a patent family.

Classification of inventions

The International Patent Classification (IPC) and the WIPO Technology Classification were used in this study.

The IPC is a comprehensive patent classification system developed and maintained by WIPO. It provides a hierarchical system of symbols for the classification of patents according to the different areas of technology. IPCs are assigned to each patent application prior to its publication.

The IPC classifies technology areas into 70,000 different IPC codes. In order to group the IPC codes into a tractable number of technology sectors we use the WIPO technology classification,[15] which clusters the IPC codes into 35 distinct technology fields. The WIPO technology classification is a widely accepted technology grouping system for use in patent analytics (see Appendix A).[16]

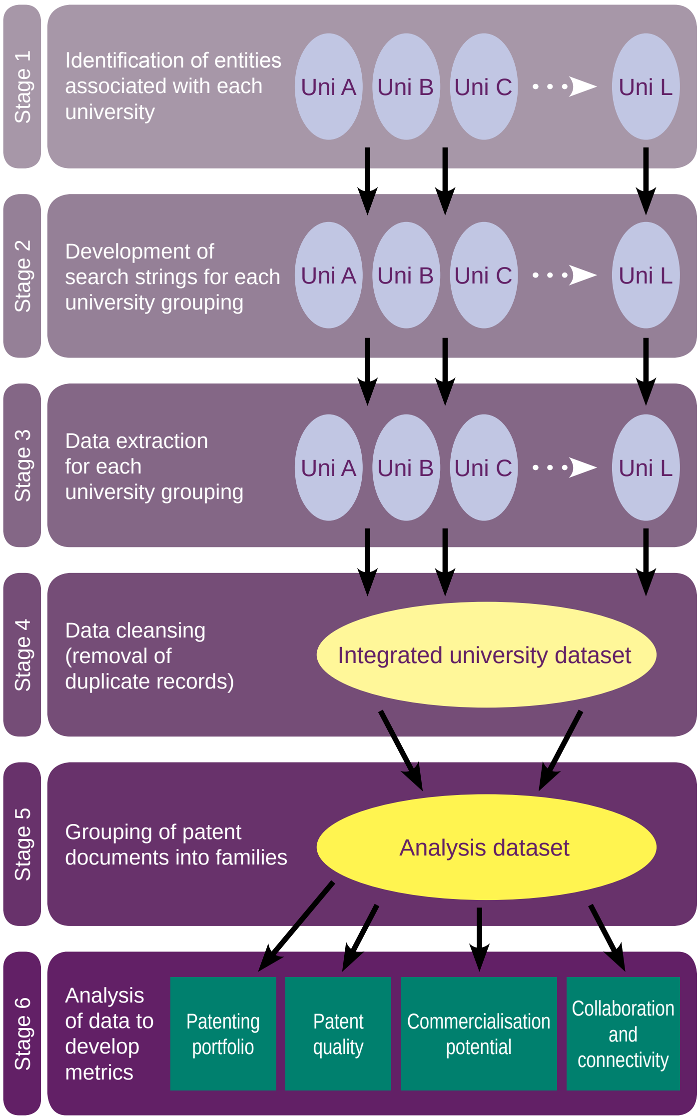

Figure 1: The process of extracting and analysing university patent data

Data extraction and analysis

The extraction and analysis of the data from multiple datasets involved six key stages as depicted in Figure 1.

- In stage 1, the entities associated with each of the 12 universities were identified
- In stage 2, the search strings for each of the universities were developed
- In stage 3, the patent documents for each university were extracted from the DWPI database
- In stage 4, the individual datasets for each university were grouped together and duplicate entries were removed
- In stage 5, patent documents belonging to the same family were grouped together and the proportional counts were attributed to each of the 12 universities. This resulted in the final dataset used for the pilot study
- In stage 6, the metrics for assessing the scope and impact of academic patenting were extracted from the dataset.

1.7 The metrics

The metrics are grouped into four broad categories:

- **Category 1: Patenting portfolio**
  These metrics relate to the scope, size and technology profile of patent portfolios for the 12 universities.
- **Category 2: Patent impact**
  These metrics are indicative of a patent's impact on follow-on innovation.
- **Category 3: Commercialisation potential**
  These metrics assess the potential for published patent applications originating from universities to be commercialised globally.
- **Category 4: Collaboration and connectivity**
  These metrics identify the level of collaboration between university entities and other partners (e.g. industry).

Detailed description of the metrics and results are presented in the chapters that follow.

For the purposes of this report, the 12 universities are presented with letter codes. Presenting the universities anonymously was done to encourage open discussion and feedback.

15 See Schmoch U. 'Concept of Technology Classification for Country Comparisons', *Final Report to the World Intellectual Property Organisation (WIPO)*, June 2008. http://www.wipo.int/edocs/mdocs/classifications/en/ipc_ce_41/ipc_ce_41_5-annex1.pdf

16 This pilot study also considered linking the Fields of Research (FoR) used for ERA purposes with the International Patent Classifications (IPC) included in patent documents. This did not prove to be feasible (see Section 5 Lessons Learned for further details).


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2. University patent portfolios

This section introduces the metrics relating to the scope, size and technology profile of patent portfolios for the 12 Australian universities. These metrics include:

- Metric 1 – Patent publications per year
- Metric 2 – Patent families per university
- Metric 3 – Technology concentration by WIPO Technology Fields
- Metric 4 – Technology concentration by visualisation of keywords included in patent documents
- Metric 5 – Relative specialisation index

Metric 1 – Patent publications per year

This metric refers to the total number of patent documents for each university published over the study period (1 January 2006 to 30 June 2012).

The metric is an indicator of a university's propensity to seek patent protection for inventions originating from its research, whether the research was conducted by the university itself or any of its controlled entities.

The results

In total 4,056 patent documents were found for the 12 universities, as shown in Figure 2 and Table 1.

All 12 universities exhibited steady patenting activity over the study period. University patent publications peaked in 2008 at 690, followed by a slight decrease in 2009 and 2010 (most likely a lag effect of the Global Financial Crisis since patent documents are published 18 months after their priority date, or date of first filing) and began to increase again in 2011. Over the past three years, university patent publications have averaged roughly 630 per year (based on 2012 data annualised).

The patent documents shown in Table 1 have been attributed to universities according to the methodology section (section 1.6, step 4).

The most prolific filer is University J (with a share of 1,304 patent publications) followed by University I (845 patent publications) and University H (687 patent publications).

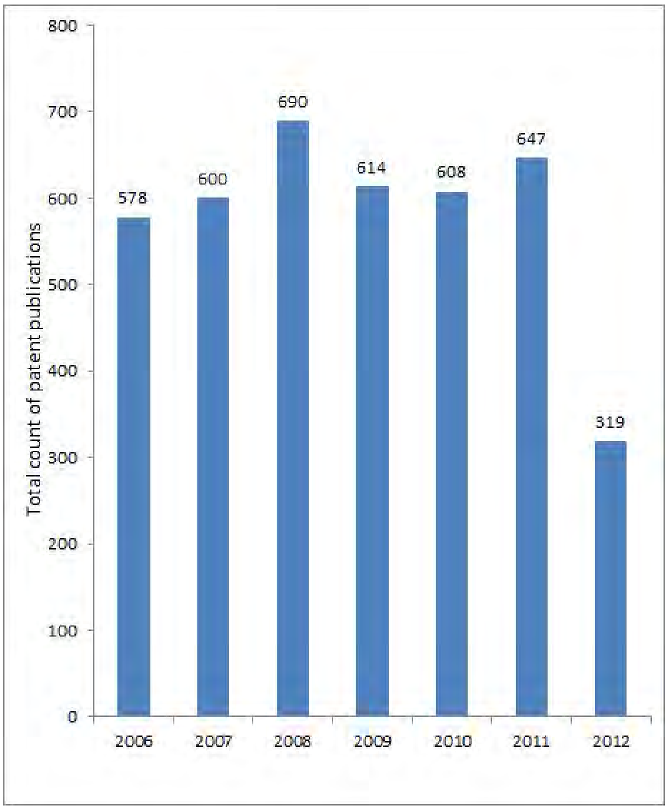


Figure 2: Historical patent publications January 2006 – June 2012

University	Publication Date							University total
	2006	2007	2008	2009	2010	2011	2012	
A	6.50	9.00	5.00	2.00	14.00	9.00	1.00	46.50
B	20.64	30.28	24.80	20.38	23.00	28.01	19.90	167.00
C	29.18	38.16	63.38	46.53	36.49	32.17	26.10	272.00
D	12.08	17.18	13.40	16.20	21.91	23.24	4.20	108.20
E	10.75	7.38	18.38	1.00	7.00	3.00	9.00	56.50
F	2.50	7.50	5.00	4.50	3.00	2.00	4.00	28.50
G	28.09	26.03	35.05	28.36	54.98	49.79	29.64	251.95
H	98.66	101.55	134.96	103.43	82.22	117.72	48.25	686.80
I	129.91	132.11	143.22	130.66	120.50	127.26	60.89	844.54
J	203.18	189.19	207.16	223.02	200.48	199.82	80.96	1303.81
K	9.40	7.00	13.00	7.00	19.80	7.00	8.00	71.20
L	27.10	34.62	26.66	30.93	24.62	48.00	27.06	218.99
Annual total	**578**	**600**	**690**	**614**	**608**	**647**	**319**	**4056**

Table 1: Patent documents by university, 2006-2012 (up to July 2012)

Metric 2 – Patent families per university

This metric represents a proxy for the total number of inventions disclosed in patent documents. These patent documents have been attributed to each of the 12 universities according to the names of applicants listed on patent applications in the same patent family (see also Section 1.6 Methodology).

The results

Over the study period, there were 1,293 patent families (or inventions) originating from the 12 universities.

The distribution of inventions corresponds with the distribution of patent filings among the 12 universities. University J is the most prolific filer and also has the largest number of inventions originating from its research (417.4 families) followed by University I (258.3 families) and University H (201.2 families).

Universities C, G and L each sought to protect 75 to 100 inventions while the remaining universities each sought to protect less than 50 inventions over the study period.

Figure 3 depicts the distribution of inventions among the 12 universities.

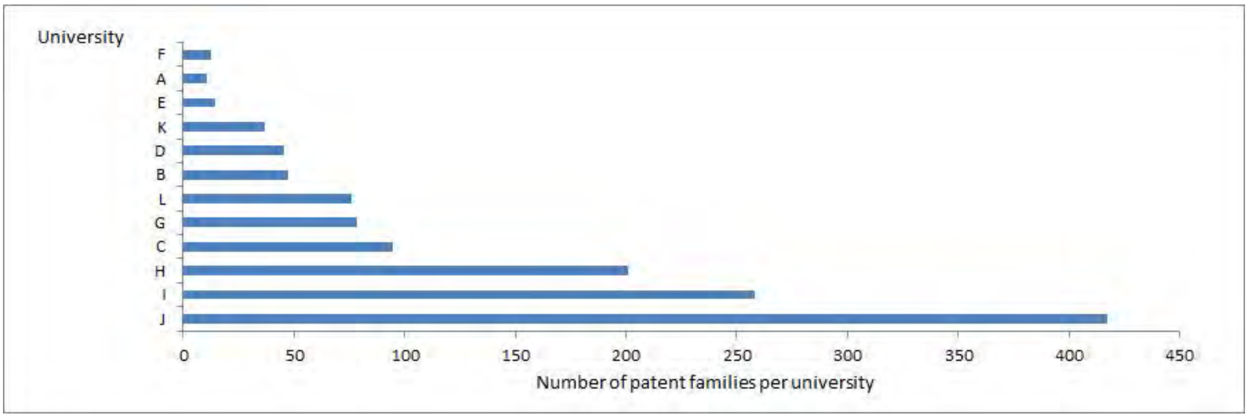


Figure 3: Patent families (inventions) originating from the 12 Australian universities

Measuring the distribution of university inventions across technology fields

University patents cover many technology areas. This section provides insights into these areas and assesses the strength of university patents across different technology sectors.

This study uses two metrics to measure the distribution of patented inventions among the 12 universities:

- The first metric is based on the assignment of each university invention into one of the 35 WIPO Technology Fields.
- The second metric is based on topographical patent maps based on the analysis of keywords frequently appearing in patent documents.

These two metrics and results are discussed below.

Metric 3 – Technology specialisation by WIPO Technology Fields

This metric measures the distribution of university patent documents across 35 different technology fields (WIPO Technology Classification). The concordance table between various IPC codes and the 35 technology fields is at Appendix A.

The first IPC code listed on each patent document has been used for the purposes of clustering university patent documents into the 35 technology fields.

The results

Aggregate findings

In order to assess prolific technology areas of university patenting, we identify the first IPC listed in the patent application. The first IPCs for the patent documents identified in this study are spread across 33 technology fields (Figure 4).

The technology areas with the greatest occurrence as the first listing were:

- pharmaceuticals (1,255 patent documents)
- medical technology (438 patent documents)
- chemical engineering (292 patent documents)
- biotechnology (278 patent documents)
- measurement (262 patent documents)
- materials, metallurgy (182 patent documents) and
- food chemistry (173 patent documents).

An assessment of technology fields by university (Table 2) suggests that smaller and regional universities tend to concentrate their patent filings in a few technology fields (4 – 5), while the documents attributed to larger universities are generally spread across several technology fields (over 15).

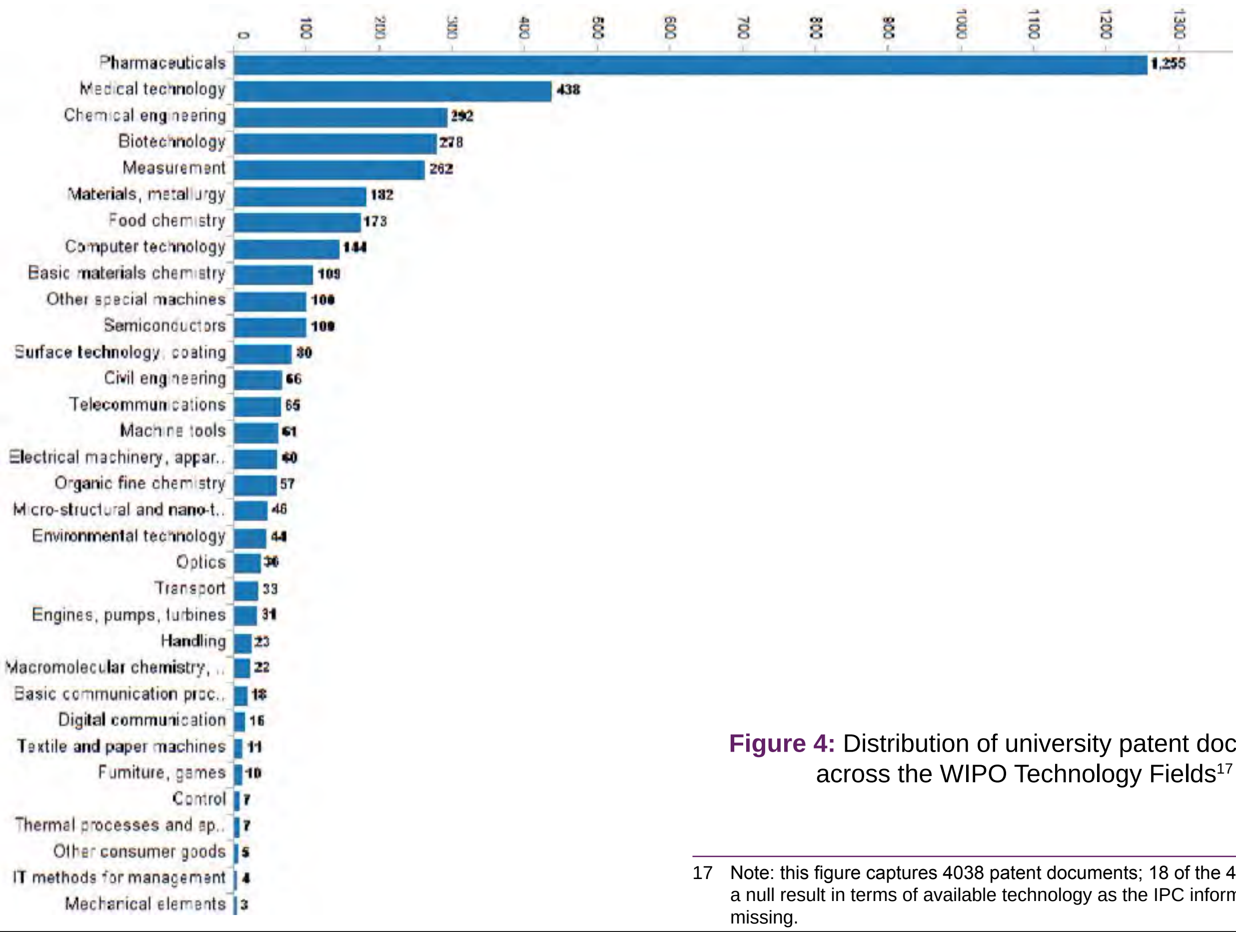


Figure 4: Distribution of university patent documents across the WIPO Technology Fields[17]

17 Note: this figure captures 4038 patent documents; 18 of the 4056 total had a null result in terms of available technology as the IPC information was missing.

Technology field / University	A	B	C	D	E	F	G	H	I	J	K	L	Total
Pharmaceuticals		26	63	34		15	41	137	436	403	7	92	**1255**
Medical technology		37	5	31	3	3	32	47	61	180	16	25	**438**
Chemical engineering		32	79	2	15	3	11	7	11	125	1	7	**292**
Biotechnology	1	6	10	11			4	36	57	129	8	16	**278**
Measurement		6	20		12		29	50	34	82	6	22	**262**
Materials, metallurgy		2					9	81	11	64		15	**182**
Food chemistry			6	16	1		27	16	38	66	3		**173**
Computer technology	5	30	4	5	1		9	24	22	40	1	3	**144**
Basic materials chemistry		2	22			1		26	20	28	6	4	**109**
Other special machines			10			6	4	14	32	27	4	3	**100**
Semiconductors				1				90	8	1			**100**
Surface technology, coating			6	1	14		3	27	6	17	3	3	**80**
Civil engineering		1	1					3	35	18		8	**66**
Telecommunications		15			1		35	5	3	2		6	**65**
Machine tools	9		13					1	26	12			**61**
Electrical machinery, apparatus, energy	23	1	5					24		3	3	1	**60**
Organic fine chemistry	1			1				26	9	18		3	**57**
Micro-structural and nano-technology		2	1				7	29	3	2		2	**46**
Environmental technology								5	1	31	6	1	**44**
Optics				2	4		1	13	13	3			**36**
Transport	4	1	1	4			9			9	2	3	**33**
Engines, pumps, turbines			14							17			**31**
Handling			9					9		2	3		**23**
Macromolecular chemistry, polymers							4		9	9			**22**
Basic communication processes							13	4				1	**18**
Digital communication	4	3					3		3	1		2	**16**
Textile and paper machines					1			10					**11**
Furniture, games			1				7			2			**10**
Control			1					1		5			**7**
Thermal processes and apparatus			1						5		1		**7**
Other consumer goods					3				2				**5**
IT methods for management		1				1				1	1		**4**
Mechanical elements										3			**3**
University total	**47**	**164**	**272**	**108**	**55**	**29**	**248**	**685**	**845**	**1300**	**71**	**216**	**4038**

Table 2: Distribution of university patent documents across the WIPO technology fields, by university

Note: This table captures 4038 patent documents; 18 of the 4056 total had a null result in terms of available technology as the IPC information was missing.

Metric 4 – Technology specialisation by visualisation of keywords

A ThemeScape map is a visual representation of a patent dataset.[18]

The map groups a vast number of patent documents (up to 60,000) into peaks according to the frequency of keywords occurring in the patent abstract or title. Documents which include specific technical words frequently are grouped together. By repeating this over all the words appearing in the chosen text fields, documents are grouped into separate peaks. These peaks represent areas of patenting where the activity is concentrated

The individual documents forming a part of the map can then be highlighted according to desired criteria. The documents are presented on the map as coloured dots.

The ThemeScape map below visualises patent documents originating from the 12 Australian universities. The map suggests patenting is concentrated in various areas, with the key ones being:

- **Peak 1** – Protein, Encode, Expression
- **Peak 2** – Device, Dopant, Atom, Substrate
- **Peak 3** – Tissue, Produced, Tissue Cell

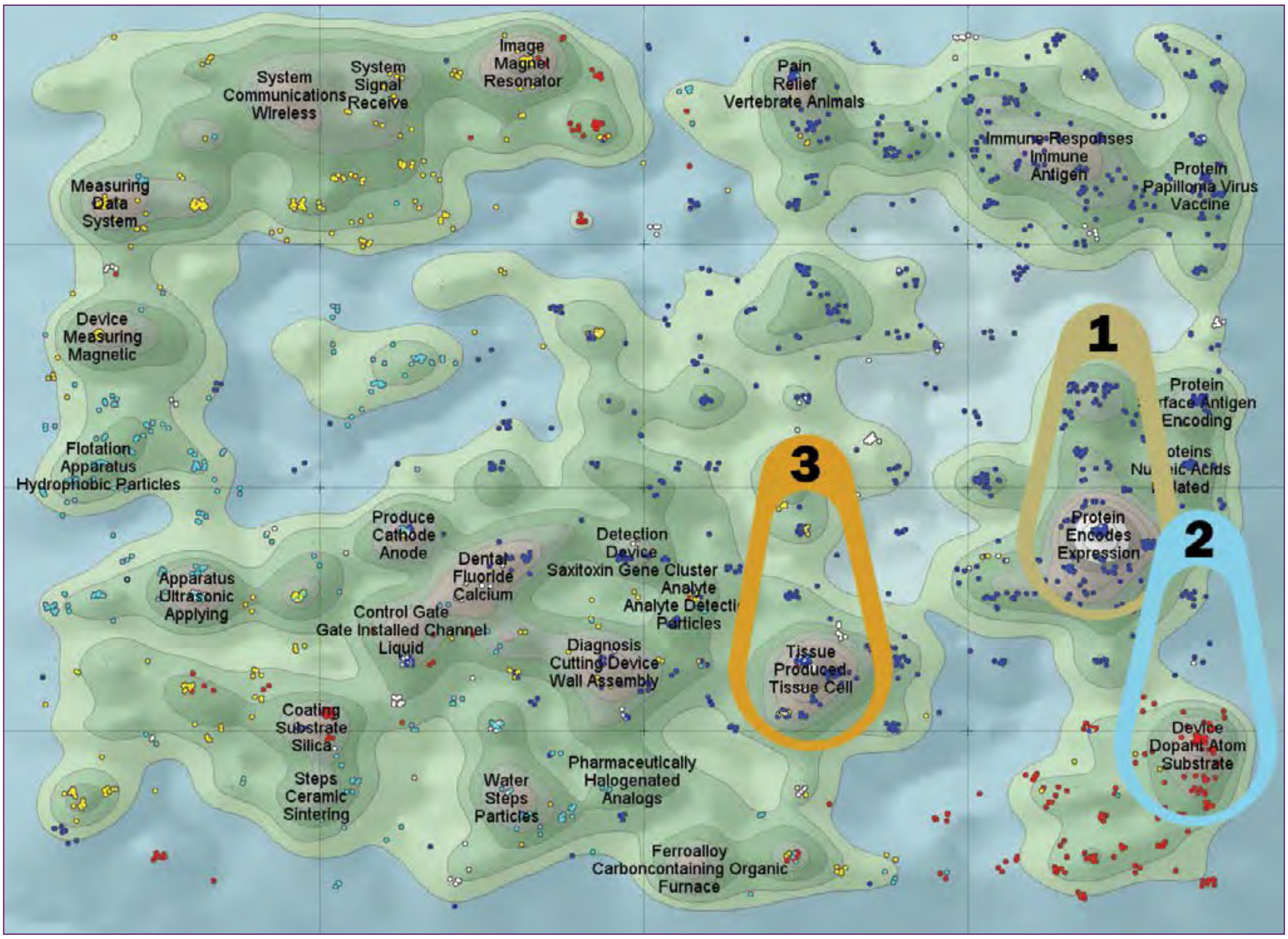


Figure 5: ThemeScape Map – Patents originating from 12 Australian universities, coloured by selected WIPO Technology Fields, namely semiconductors (red), control (yellow), biotechnology (dark blue), and chemical engineering (light blue)

Peak 1:
Protein, Encodes, Expression
There are many biotechnology patents concentrated in this peak, mostly in genetic engineering, plant reproduction, peptides and enzymes.

Universities represented among the top ten applicants are: J, I and H.

Peak 2:
Device, Dopant Atom, Substrate
Patent documents in the peak predominantly relate to semiconductors and nano-structures.

Universities represented in the 10 applicants are: H, I and K.

Peak 3:
Tissue, Produced, Tissue Cell
Patent documents in this peak primarily related to biotechnology.

Universities represented in this peak are: J, L, I and H.

18 A Themescape map is generated using Thomson Innovation software.

Metric 5 – Relative specialisation index

The relative specialisation index (RSI) is an indicator of technological specialisation adopted widely in patent analytics studies.[20]

RSI can be calculated at several levels – at an organisational level, country level or regional level.

In this report RSI was calculated for each of the 12 universities, relative to each other. The RSI measures a university's technological specialisation compared to the other 12 Australian universities.

The index is defined as the logarithm of the ratio of a university's share of patents in a particular technology field to the university's share of patents in all technology fields as follows:

Numerator	= University A's share of university patents in a particular technology
	= (# of University A patents in a particular WIPO technology field) / (# of patents from all 12 universities in the particular WIPO technology field)
Denominator	= University A's share of university patents
	= (total # of University A patents) / (total # of patents from all 12 universities)

RSI for University A in the technology of interest = Log10 {Numerator / Denominator}

The index is equal to zero when the university holds no patents in the technology of interest, or when the university's share in the technology of interest equals its share in all technologies (no specialisation). RSI is positive when the university's share in the technology of interest is greater than its share in all technologies and negative when the university's share in the technology of interest is less than its share in all technologies.

RSI calculations are independent of filing volumes. RSI accounts for the fact that some universities file more patent applications than others and that a relatively small number of patents may be highly specialised in a particular technology area. Such specialisation is revealed by positive RSI values.

The results

The RSI results for each university are presented in a heat map (Figure 6).

The RSI values are overlayed by colours with the positive values in green and the negative values in red. The technology areas are sorted by the RSI overall university average in descending order.

The results indicate that on the whole the areas with a positive relative specialisation are in audio-visual technology, consumer goods, IT methods for management, and textile and paper machines.

Similarly, the areas with a negative relative specialisation include semiconductors, civil and chemical engineering and micro-structural and nano-technologies.

Results vary across universities, for instance, Universities G and K tend to have relative strengths in a number of technologies, while other universities specialise in a few areas (e.g. University F in IT methods for management).

19 See, for example, OECD Science, Technology and Industry Outlook 2012, page 425.

	University											
	K	A	E	G	F	B	C	D	H	L	I	J
IT methods for management	1.15				1.55	0.79						-0.11
Transport	0.54	1.02		0.66		-0.13	-0.35	0.66		0.23		-0.09
Digital communication		1.34		0.49		0.66				0.37	-0.05	-0.71
Audio-visual technology						1.09				0.97		
Other consumer goods			1.64								0.28	
Thermal processes and apparatus	0.91						0.33				0.53	
Textile and paper machines			0.82						0.73			
Handling	0.87						0.76		0.36			-0.57
Basic communication processes				1.07					0.12	0.01		
Engines, pumps, turbines							0.83					0.23
Other special machines	0.36			-0.19	0.93		0.17		-0.08	-0.25	0.19	-0.08
Furniture, games				1.06			0.17					-0.21
Optics			0.91	-0.34				0.32	0.33		0.24	-0.59
Macromolecular chemistry, polymers				0.47							0.29	0.10
Measurement	0.13		0.55	0.26		-0.25	0.06		0.05	0.20	-0.20	-0.02
Electrical machinery, apparatus, energy	0.45	1.52				-0.39	0.09		0.37	-0.51		-0.81
Machine tools		1.11					0.50		-1.01		0.31	-0.21
Control							0.33		-0.07			0.35
Basic materials chemistry	0.49				0.11	-0.35	0.48		0.15	-0.17	-0.06	-0.10
Mechanical elements												0.49
Surface technology, coating	0.33		1.11	-0.21			0.05	-0.33	0.30	-0.16	-0.45	-0.18
Food chemistry	-0.01		-0.37	0.40			-0.29	0.54	-0.27		0.02	0.08
Organic fine chemistry		-0.12						-0.18	0.43	-0.01	-0.12	-0.02
Environmental technology	0.89								-0.17	-0.37	-0.96	0.34
Medical technology	0.32		-0.30	0.08	-0.09	0.31	-0.77	0.42	-0.20	0.02	-0.18	0.10
Computer technology	-0.41	0.48	-0.30	-0.01		0.71	-0.39	0.11	-0.01	-0.35	-0.14	-0.06
Telecommunications			-0.25	0.94		0.74			-0.34	0.20	-0.74	-1.02
Materials, metallurgy				-0.09		-0.57			0.42	0.19	-0.54	0.04
Pharmaceuticals	-0.50			-0.27	0.23	-0.29	-0.13	0.00	-0.19	0.13	0.22	0.00
Micro-structural and nano-technology				0.39		0.03	-0.49		0.57	-0.09	-0.51	-0.87
Civil engineering						-0.43	-0.65		-0.57	0.35	0.40	-0.07
Biotechnology	0.22	-0.50		-0.62		-0.27	-0.27	0.17	-0.12	0.03	0.00	0.16
Chemical engineering	-0.71		0.57	-0.21	0.16	0.43	0.60	-0.60	-0.88	-0.35	-0.77	0.13
Semiconductors								-0.43	0.73		-0.42	-1.51

Figure 6: Heat Map of the Relative Specialisation Index

3. Patent impact

This chapter provides insights into the impact of university patents on follow-on innovation.

- Metric 6 – Patent citation frequency by technology field
- Metric 7 – Relative citation impact by technology field
- Metric 8 – Patent citation frequency per patent family
- Metric 9 – Average citation frequency per year of publication

Patent citation frequency

Patent citation frequency is an indicator of technological impact. Patent examiners and innovators worldwide routinely cite patent documents relating to previous inventions. The frequency of these citations can be measured and this analysis provides insights into the impact of patents on follow-on innovation.

There are two types of patent citations: citations to previous documents (backward citations) and citations of a patent document after its publication (forward citations), as illustrated in Figure 7.

Backward citations can be indicative of the multi-disciplinary extent of a patent. For instance, multiple fields in the backwards citations (as is shown in this example) indicate a patent that draws on several disciplines.

Once a patent has been filed and is published, then others can cite it. Forward citations can thus be indicative of the impact a patent has had on follow on innovation (the higher the count of forward citations, the greater the impact the patent has had on follow on innovation).

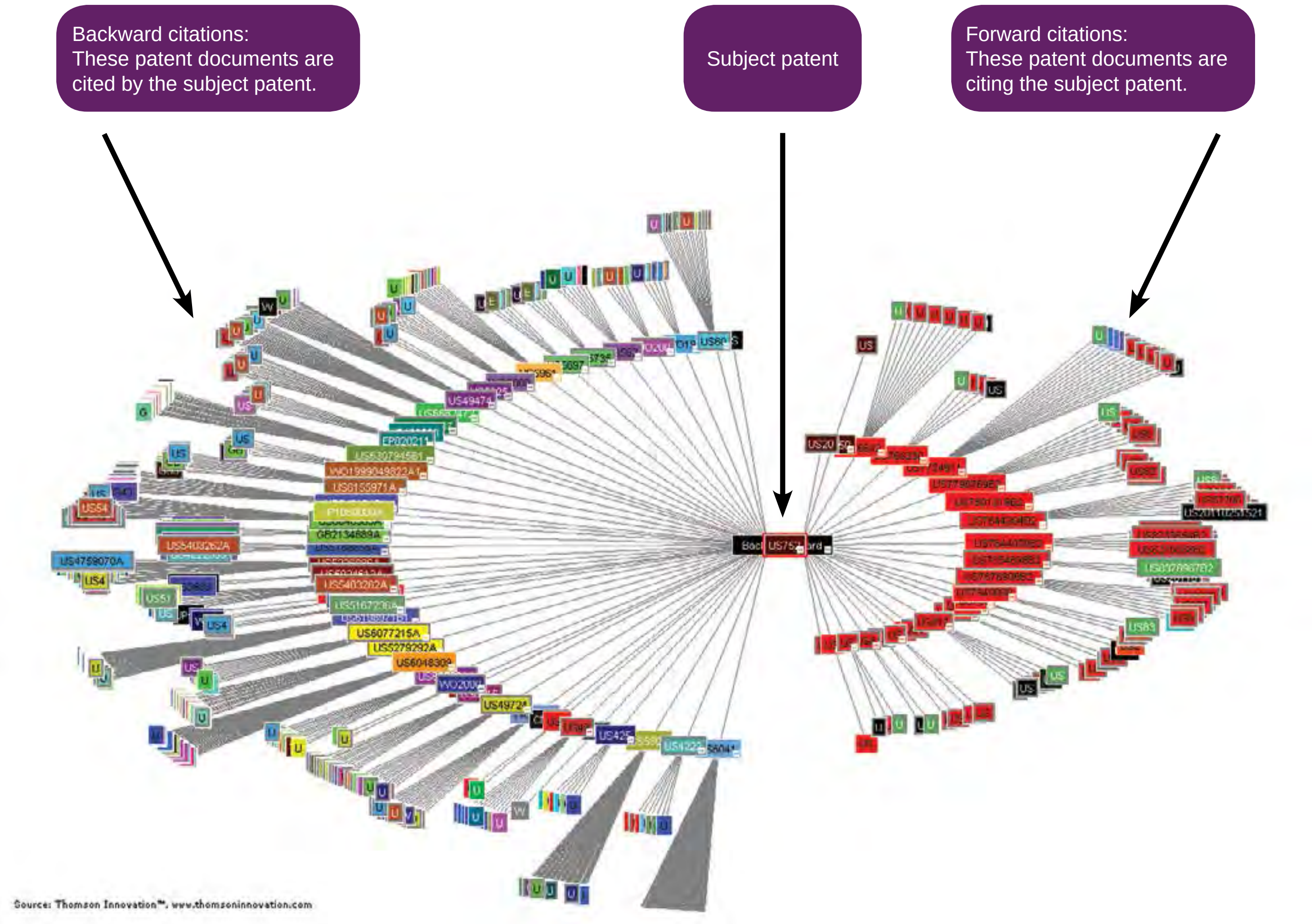


Figure 7: Illustration of patent citation analysis: An example of a patent citation tree with two generations of backward and forward citations relating to the subject patent. Entities are colour-coded.

Research has shown that the number of citations a patent receives is positively related to its economic value.[20] For this reason, analysis of forward patent citations is frequently used for the purposes of patent valuation. There is also evidence that indicates a positive correlation between the frequency of forward citations and company value.[21] Moreover, patents that receive more forward citations than the average are generally renewed for longer periods.[23]

Patent citation metrics in this study concentrate on the measurement of impact of university patents on follow on innovation, based on the counting of forward citations.

	University											
Technology Field	**H**	**B**	**I**	**G**	**J**	**C**	**L**	**A**	**D**	**E**	**F**	**K**
Medical technology	8.41	12.88	6.43	1.10	2.33	0.75	1.00		3.30	1.00	1.00	3.25
Electrical machinery, apparatus, energy	1.29	31.00			1.33	5.00	0.00	1.00				0.33
Computer technology	1.86	2.50	2.70	2.67	0.78	3.00	2.00	2.50	5.33	0.00		0.00
Measurement	3.33	0.00	3.31	5.50	2.03	0.60	1.88			3.50		0.33
Telecommunications	5.50	2.00	3.33	3.56	2.00		1.00			0.00		
Other special machines	2.00		1.11	3.00	0.70	0.20	2.00				6.00	1.00
Civil engineering	0.00	0.00	9.00		1.60	0.00	4.25					
Transport		0.00		1.20	1.50	0.00	1.00	9.00	1.50			0.00
Textile and paper machines	11.50									0.00		
Engines, pumps, turbines					1.33	9.00						
Chemical engineering	0.50	1.33	0.43	0.13	1.25	1.21	1.33		2.00	1.00	1.00	0.00
Digital communication		0.00	5.00	0.00	0.00		0.00	5.00				
Pharmaceuticals	1.07	1.40	1.15	0.71	1.02	1.38	2.21		0.46		0.17	0.00
Optics	3.75		3.00	0.00	0.33				0.00	1.50		
Surface technology, coating	1.67		0.75	1.00	2.00	1.00	0.00		0.00	2.00		0.00
Basic communication processes	0.00			8.00			0.00					
Basic materials chemistry	3.33	0.00	0.20		1.83	1.00	0.00				0.00	0.00
Food chemistry	0.38		0.60	2.50	0.74	0.00			0.33	0.00		1.00
Other consumer goods			0.00							5.00		
Materials, metallurgy	1.56	0.00	0.38	0.33	1.20		1.50					
Biotechnology	0.25	0.00	0.16	0.50	0.34	0.25	0.86	0.00	2.00			0.25
Furniture, games				0.00	3.00	1.00						
Organic fine chemistry	0.75		0.00		0.25		0.00	1.00	2.00			
Micro-structural and nano-technology	1.88	0.50	0.00	0.00	1.00	0.00	0.50					
Semiconductors	2.62		0.75		0.00				0.00			
Machine tools	0.00		0.55		0.50	0.00		1.00				
Environmental technology	0.00		0.00		2.00		0.00					0.00
Thermal processes and apparatus			0.00			2.00						0.00
Macromolecular chemistry, polymers			0.75	0.00	0.25							
Handling	0.00				0.00	0.75						0.00
Audio-visual technology												
Control	0.00				0.00	0.00						
IT methods for management		0.00			0.00						0.00	0.00
Mechanical elements					0.00							

Figure 8: Average citation counts per patent family per technology field

20 Harhoff D., Scherer F. M. and Vopel K. (2002), Citations, Family Size, Opposition and the Value of Patent Rights, *Research Policy* 32(8), 1343 – 63; see also Trajtenberg M. (1990), A Penny for Your Quotes: Patent Citations and the Value of Innovations, The *RAND Journal of Economics* 21(7), 172 – 187.

21 Hall B. H., Jaffe A. B and Trajtenberg M. (2005), Market Value and Patent Citations, The RAND Journal of Economics 36, 16 – 38.

22 Lanjouw, J. O, Parkes A. Putnam J. (1998), How to Count Patents and Value Intellectual Property: Uses of Patent Renewal and Application Data, *The Journal of Industrial Economics* (4), 405 -433.

Metric 6 – Patent citation frequency by technology field

This metric shows the average citation count received by university patents per technology fields. Only those patents which received more than 1 citation are included (Figure 8).

Patents with the highest counts of forward citations include:

- Medical technology patents by Universities B (31 citations), I (20 citations) H (12 citations)
- A pharmaceutical patent by University L (43 citations)
- An electrical machinery, apparatus and energy patent by University B (31 citations)
- Measurement patents by Universities J and G (22 citations)

Metric 7 – Relative citation impact per WIPO technology field

While the counting of forward patent citations provides some insights into the technological impact of university inventions, our understanding of the frequency of patent citations can be improved when these citations are used comparatively.

There is no natural scale associated with citation data, so whether a university patent has received 1 or 100 citations does not, on its own, indicate whether the patent is highly cited. The range of patent citations varies according to:

- **Publication date:** those patent documents published longer have had more chances to be cited.
- **Technology of patenting:** patent documents in certain technologies (e.g. pharmaceuticals and petrochemicals) tend to receive more citations than others.
- **Filing office:** different patent offices may have different citation practices which also impacts the count of forward citations.

To improve evaluation of university patent citation frequencies, IP Australia utilised a citation benchmark based on the counting of forward citations for all patents originating from Australia that have been published during the same period, i.e. 1 January 2006 to 30 June 2012.[23] This benchmark was then used to calculate a relative citation impact (RCI) of university patents.

The RCI is a ratio of the number of forward citations that university patents receive compared to the number of forward citations that an average Australian patent receives. For purposes of comparison, these calculations are based on forward citations in the same publication year range and in the same technology field.

The results

Figure 9 ranks the relative citation index for Australian universities relative to the Australian average by WIPO technology field.

Table 3 reports the average citations rates that are used to calculate the RCI. The citation rate for an average Australian patent is a benchmark of 1. A result of 2.11 (basic communication processes) indicates that university patents received 111% more citations than the average Australian patent. Similarly, an RCI of 0.40 (food chemistry) shows university patents received 60% fewer citations in this field than the average Australian patent.

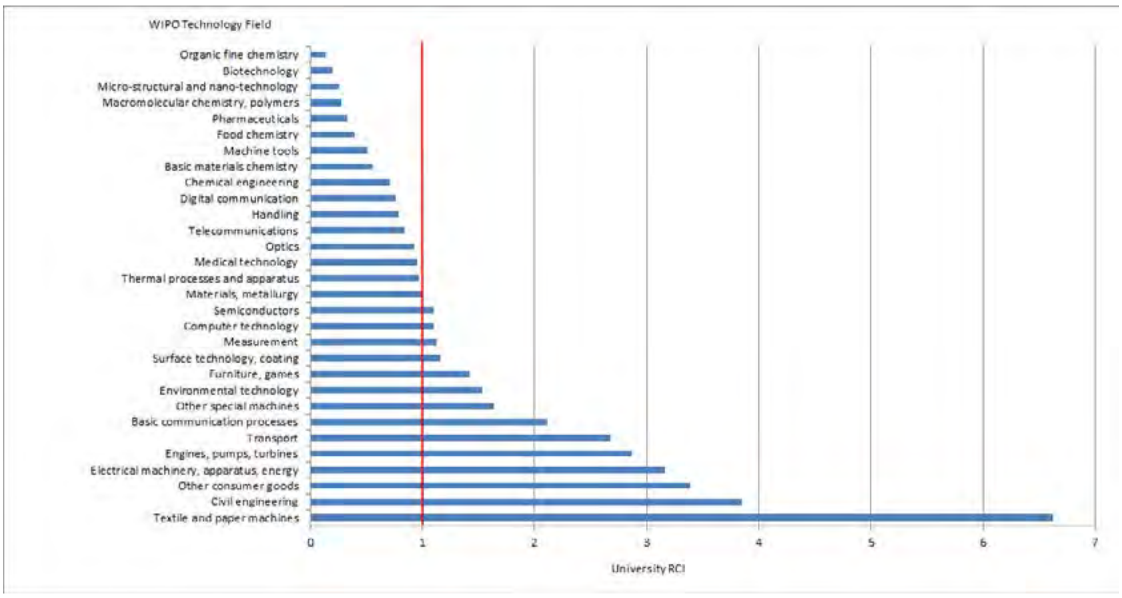


Figure 9: Relative citation index for Australian university patents relative to Australian patents, by WIPO technology field (in descending order)

23 Originating from Australia is defined as having an Australian priority document. A priority document, more specifically, the date of its filing, is used to establish the date of invention.

WIPO Technology Field	Average citation rate		University RCI	Percentage that university patents receive citations more (or less) than the national average
	All Australia	All Universities		
Textile and paper machines	1.16	7.67	6.62	562%
Civil engineering	0.45	1.73	3.85	285%
Other consumer goods	0.74	2.5	3.39	239%
Electrical machinery, apparatus, energy	0.85	2.7	3.16	216%
Engines, pumps, turbines	1.13	3.25	2.87	187%
Transport	0.54	1.45	2.68	168%
Basic communication processes	1.89	4	2.11	111%
Other special machines	0.7	1.14	1.64	64%
Environmental technology	0.65	1	1.53	53%
Furniture, games	0.94	1.33	1.42	42%
Surface technology, coating	1.08	1.26	1.16	16%
Measurement	1.77	2.01	1.13	13%
Computer technology	1.97	2.18	1.1	10%
Semiconductors	2.01	2.22	1.1	10%
Materials, metallurgy	1.18	1.18	1	0%
Thermal processes and apparatus	0.69	0.67	0.97	-3%
Medical technology	3.11	2.96	0.95	-5%
Optics	1.82	1.69	0.93	-7%
Telecommunications	3.8	3.19	0.84	-16%
Handling	0.42	0.33	0.79	-21%
Digital communication	2.48	1.88	0.76	-24%
Chemical engineering	1.52	1.07	0.71	-29%
Basic materials chemistry	2.43	1.35	0.55	-45%
Machine tools	0.87	0.45	0.51	-49%
Food chemistry	1.83	0.73	0.4	-60%
Pharmaceuticals	3.37	1.1	0.33	-67%
Macromolecular chemistry, polymers	1.89	0.54	0.28	-72%
Micro-structural and nano-technology	3.43	0.89	0.26	-74%
Biotechnology	1.92	0.37	0.2	-80%
Organic fine chemistry	2.92	0.4	0.14	-86%
Audio-visual technology	0.74	0	0	-
Control	0.85	0	0	-
IT methods for management	0.93	0	0	-
Mechanical elements	0.49	0	0	-

Table 3: Average citation rates and relative citation index (ranked by RCI in descending order)

University patents have received considerably more citations than the Australian average in the following technologies:

- Textile and paper machines
- Civil engineering
- Other consumer goods
- Electrical machines, apparatus, energy
- Engines, pumps, turbines
- Transport
- Basic communication processes

Metric 8 – Patent citation frequency per patent family

Metric 8 represents forward citations received by a group of university patent documents relating to the same invention. The results suggest that most patent families receive no citations, while a small share receive many.

The aggregate outcomes for the university data set are as follows:

- 35 families (3%) received 10 or more forward citations
- 87 families (7%) received 5 to 9 citations
- 184 families (14%) received 2 to 4 citations
- 163 families (13%) received 1 citation
- 824 families (64%) received 0 citations.

Average citation frequency per patent family

The results

Figure 10 shows that patent documents originating from University B are the most frequently cited (3.31 average citations per patent family), followed by University H (2.29 average citations) and University A (2.27 average citations). The average citation frequency for all universities stands at 1.64.

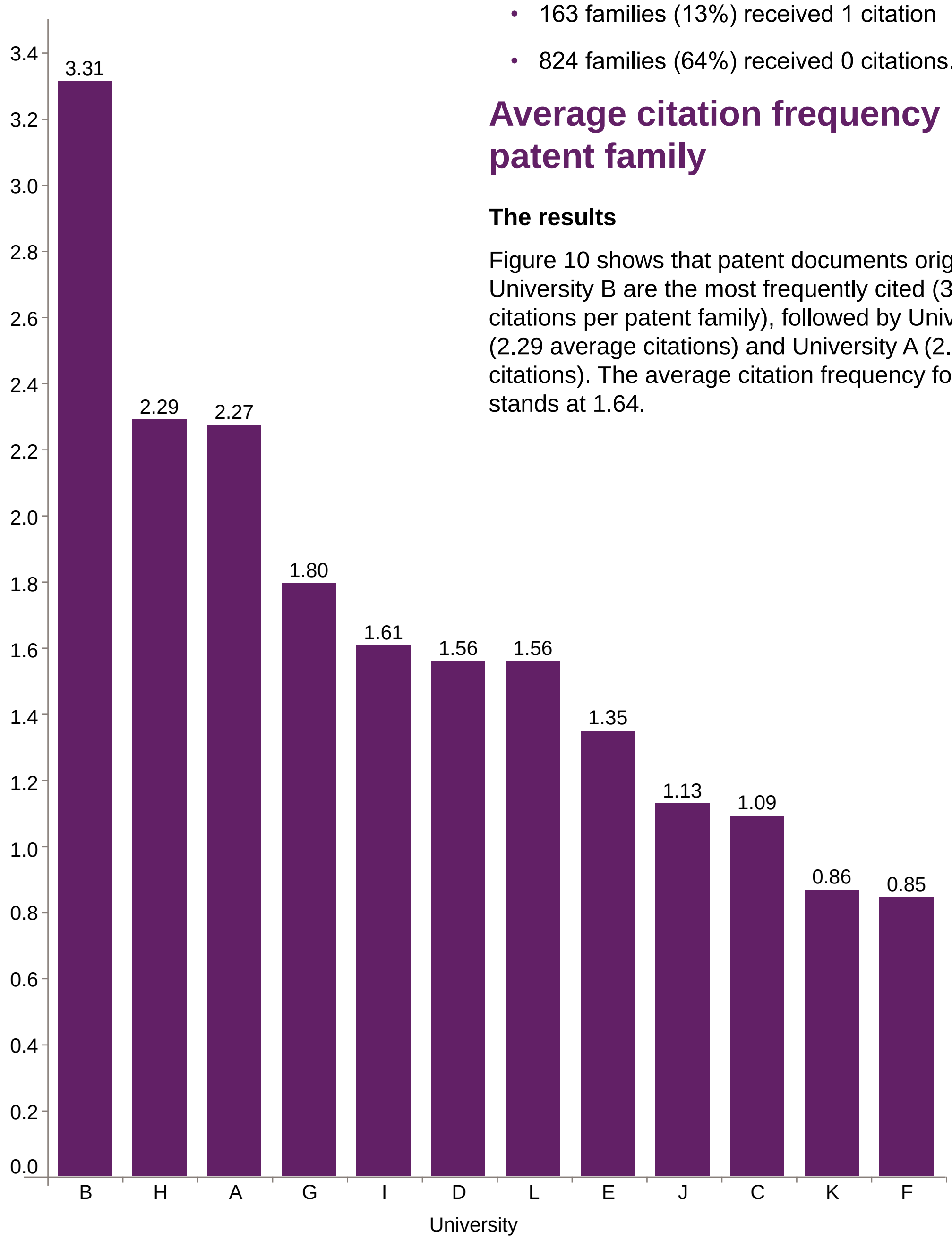


Figure 10: Average forward citations per university patent documents published from 1 January 2006 till 30 June 2012

Metric 9 – Average citation count per year of publication

This metric represents the sum of university forward citations per patent family divided by the number of years since publication.[24]

The results

Controlling for the age of a university's patent portfolio, Universities B and A have had the greatest impact in terms of the highest forward citation count per year (Figure 11).

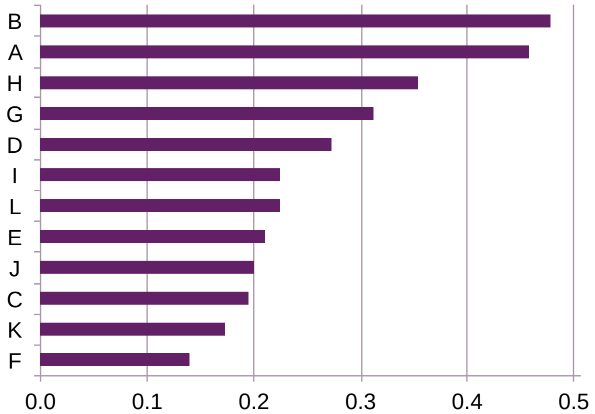


Figure 11: Average forward citations count per patent family per year of publication (data for 2012 only cover January – June)

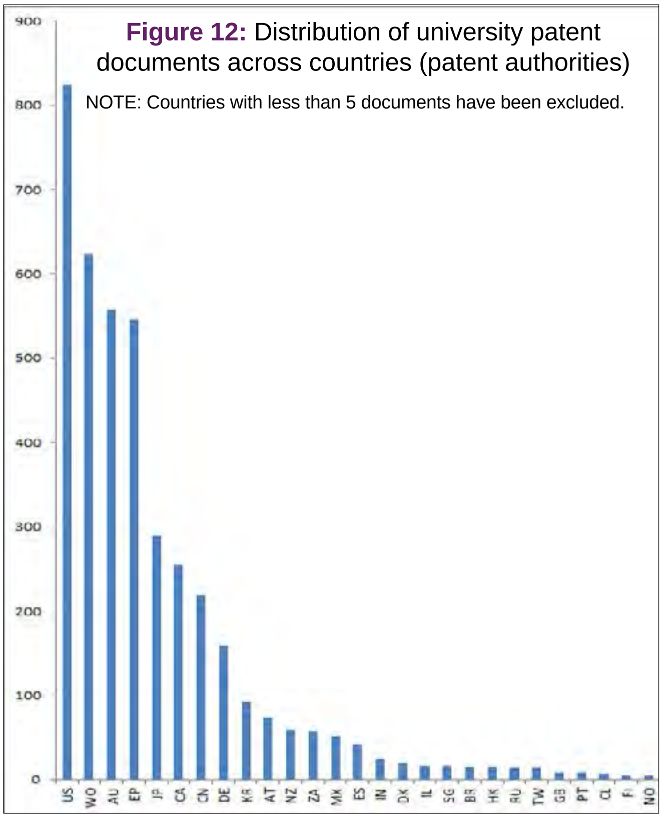
Metric 10 – Geographical filing breadth

The geographical filing breadth represents the number of filing countries (or 'jurisdictions' as some patent offices represent regions) in which a university entity filed applications for the same invention.

Patent applicants only receive patent protection in those jurisdictions where an application was filed. As such, geographical filing breadth is an indicator of commercialisation potential.

Figure 12: Distribution of university patent documents across countries (patent authorities)

NOTE: Countries with less than 5 documents have been excluded.



The results

University entities seek patent protection for the same invention in up to 3.14 jurisdictions.[25]

The top patenting destinations for patents originating from Australian universities are: the United States, Australia, the European Patent Office, Japan, Canada, China and Germany (Figure 12).

Figure 13 depicts the distribution of university patents across different patent authorities. The universities are sorted by total number of patents (in descending order). The figure reveals that the larger filers also file in a broader range of jurisdictions.

University	Country Code																										
	US	WO	AU	EP	JP	CA	CN	DE	KR	AT	NZ	ZA	MX	ES	IN	DK	IL	SG	BR	HK	RU	TW	GB	PT	CL	FI	NO
J	282	205	169	182	101	81	59	50	15	26	15	19	17	12	5	8	4	2	6	3	5	4	5	2	7		1
I	165	83	104	109	71	66	39	54	23	26	23	3	17	13	7	9	3	1	3	8	5			5		1	3
H	130	99	103	91	54	23	59	23	27	14	4	10	7	9	8	2	2	3	1	3		10	3				
C	55	51	51	26	9	20	9	9	2	5	3	13	5	2	2		0		2		2		1			4	
G	39	48	45	34	23	16	14	8	6	3	2	2	2	1			3	5		1	0						
L	53	40	38	23	9	14	10	4	3	1	4	4	2	3	1	1	2	4	1					1			
B	31	29	28	18	7	12	14	1	2		7	4		1	1		2	3	2		1						
D	29	26	1	26	4	11	0	2	8			0		1							0						
K	14	23		19	2	4		7	3																		
E	10	9	10	6	4	4	7	0	3			1	1				2										
A	14	5	4	6	5	1	7	1			1	1	1						1								
F	4	6	6	7	1	2			1		1												1				1

Note: Jurisdictions with less than 5 documents have been excluded; WIPO (WO) applications are PCT filings that may be used to enter the national phase.

Country codes are as follows: United States (US), WIPO (WO), Australia (AU), European Patent Office (EP), Japan (JP), Canada (CA), China (CN), Germany (DE), South Korea (KR), Austria (AT), New Zealand (NZ), South Africa (ZA), Mexico (MX), Spain (ES), India (IN), Denmark (DK), Israel (IL), Singapore (SG), Brazil (BR), Hong Kong (HK), Russia (RU), Taiwan (TW), United Kingdom (GB), Portugal (PT), Chile (CL), Finland (FI), Norway (NO).

Figure 13: Distribution of university patent documents across patent authorities, by total number of patent documents in descending order

24 For the purposes of this metric, the date of publication is the date when the first document in the patent family was published.

25 Patent applications filed with the European Patent Office (EPO) and with the International Bureau (WO documents) are each counted as 1 jurisdiction.

4. Commercialisation potential and collaboration

This section includes metrics that are indicative of the likelihood of a university patent being commercialised or used by third parties. The recorded level of collaboration between university entities and other partners is also assessed.

Metric 11 – Collaboration measured through co-applicants

The inventions disclosed in university patents often result from cumulative and collaborative work. Where multiple individuals from different universities, research centres or companies collaborate to invent, their respective employers may be listed on patent documents as co-applicants. Co-application is therefore an indicator of collaboration.

The Aduna cluster map (Figure 14) illustrates collaboration between the universities.[26] It is based on co-assignees listed in granted patents.

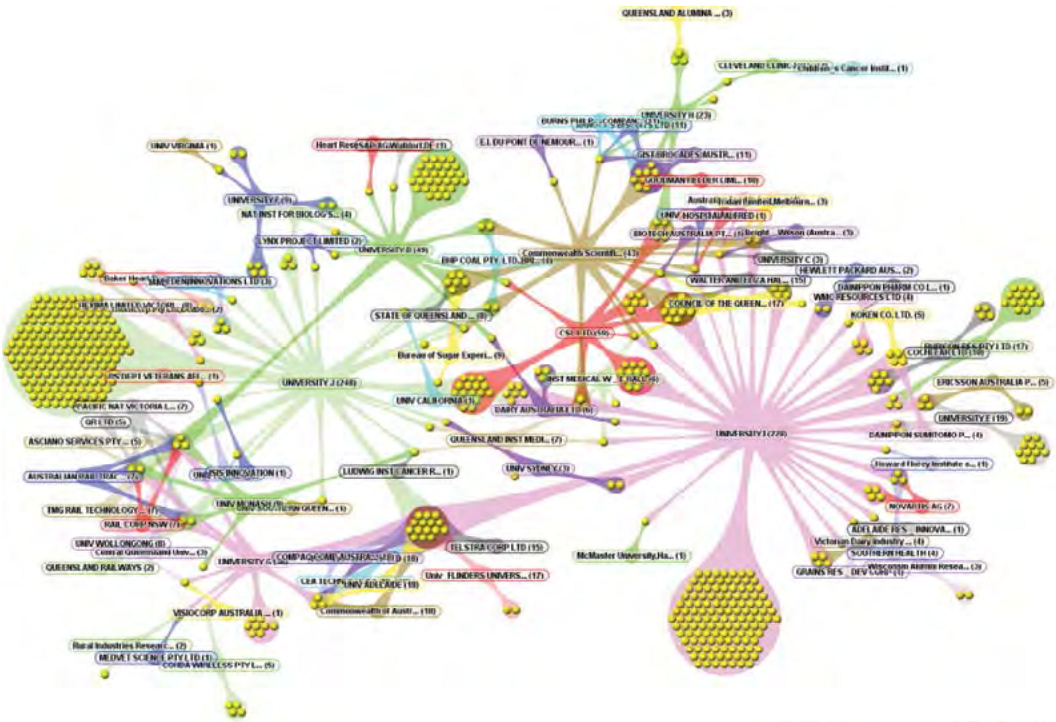
On the map, each patent is shown as a yellow sphere which sits in the coloured zones of the assignee to which it belongs. Where multiple assignees are listed, the sphere sits in between the assignees' respective zones and is connected to both. Where there is only one assignee, the sphere sits in a discrete circular zone, without any further connections.

The results

The map shows that Universities I, J, D and G are more active collaborators than the other universities.

The top non-university co-assignees in the university dataset include: CSL Ltd, CSIRO, Telstra and Walter and Eliza Hall Institute of Medical Research.

Co-assignee network of granted patents filed by Universities L, B and K are depicted in Figure 15.



(ABOVE) Figure 14: Aduna cluster map – Major co-assignee network of university patents

(RIGHT) Figure 15: Aduna cluster map – A smaller network of university patents

26 The Aduna cluster map contains information visualization technology developed by Aduna Software.

5. Lessons learned

Concluding remarks

This study demonstrates that patent metrics can be used to assess the scope and impact of inventions originating from university research. Such an assessment can be undertaken efficiently by relying on the identification, analysis, interpretation and visual representation of patent datasets.

The methodology presented here promises to be useful and will involve further consultations.

IP Australia welcomes feedback on this study from stakeholders. As work in patent analytics continues, and as new techniques and approaches to research impact assessment are developed, the analytical framework will be refined.

5.1 Linking ERA Fields of Research with International Patent Classifications

This project also considered linking the academic Fields of Research (FoR), used for ERA purposes, with the IPC, which relate to inventions. This did not prove to be feasible.

The linkages between academic research disciplines and patentable inventions are not straightforward. Unlike FoR, inventions involve the application of research and often span several technologies and research disciplines.

For example, the FoR code 230100 relates to mathematics. The subject matter of mathematics per se does not represent patentable subject matter. At the same time inventions which may arise from applying mathematics, such as new algorithms to control a computer processor, are patentable and could well fall within several WIPO technology fields.

The same applies to other FoR classes, such as physical sciences, chemical sciences, earth sciences, engineering disciplines and biological sciences.

Some FoR classes have no potential for generating patentable inventions and hence cannot be linked with WIPO technology fields (education, economics, language, commerce, politics, sociology, history, philosophy, law, journalism, literature, religion and the arts).

5.2 Data indexing

The identification of patents is wholly dependent on the search strategy. As a component of searching for each applicant, and in particular QUT, we conducted a search for the words ‘Queensland’, ‘University’ and ‘Technology’ in sequential order rather than a search for these words in any order so as to differentiate QUT from the University of Queensland.

Different search strategies may capture different patent documents. For instance, towards the end of the study it was discovered that DWPI had standardised the entries for two of the universities and as a result 215 patent documents were not captured in the original search (215 out of 4271 or 5.0% of the total). The missing patent documents are not insignificant for the two universities, but are inconsequential for the study overall as they were relatively small patent filers and the additional documents would not have altered the findings.

5.3 Guidelines for collecting ERA patent data

As per the current ERA guidelines, universities are required to report patents ‘registered’ to both universities and their researchers. The word ‘registered’ appears to be confusing.

In the context of the ERA guidelines, ‘registered’ is most likely meant to refer to ‘granted’ patents. However, some universities also reported patent applications yet to be granted. This interpretation may be based on the practice of patent offices which ‘register’ patent applications on the date of their filing.

Should patent data be collected within future iterations of ERA, it may be worthwhile providing guidelines to universities with regard to the scope and format of the data to be reported. It seems unclear what patents fall under the scope of ‘eligible university patents’ and whether these include all those filed by university commercialisation entities, spin-off companies or academics themselves.

Some patents in the ERA dataset did not include a country code or other identification of jurisdictions in which they have been filed. Other patents were reported to be registered in different countries or in countries where patent applications had not been filed.

These inconsistencies make it difficult to identify the patents and produce analyses of university patenting solely on the basis of the data reported for ERA. To avoid unfairly biasing the results due to these reporting issues, the ERA dataset was not incorporated in this study.

5.4 Relevant dates

The selection of priority (or filing) dates can be important in identifying patenting activity. Different dates may produce different results. Sensitivity analysis can be used to assess whether patenting activity varies greatly with different ranges of dates.

APPENDIX A

WIPO	Area, field	IPC code	Description Key: Advanced Materials, Manufacturing Processes
I	**Electrical engineering**		
1	Electrical machinery, apparatus, energy	F21#	Lighting (bulbs, mantles etc).
		H01B	Cables, conductors insulators.
		H01C	Resistors.
		H01F	Magnets; inductances; transformers; selection of materials for their magnetic properties.
		H01G	Capacitors; capacitors, rectifiers, detectors, switching devices, light-sensitive or temperature-sensitive devices of the electrolytic type.
		H01H	Electric switches; relays; selectors; emergency protective devices.
		H01J	Electric discharge tubes or discharge lamps.
		H01K	Electric incandescent lamps.
		H01M	Processes or means, e.g. batteries, for the direct conversion of chemical energy into electrical energy.
		H01R	Electrically-conductive connections; structural associations of a plurality of mutually-insulated electrical connecting elements; coupling devices; current collectors.
		H01T	Spark gaps; overvoltage arresters using spark gaps; sparking plugs; corona devices; generating ions to be introduced into non-enclosed gases.
		H02#	Generation, conversion, or distribution of electric power.
		H05B	Electric heating; electric lighting not otherwise provided for.
		H05C	Electric circuits or apparatus specially designed for use in equipment for killing, stunning, enclosing or guiding living beings.
		H05F	Static electricity; naturally-occurring electricity
		H99Z	Subject matter not otherwise provided for in this section.
2	Audio-visual technology	G09F	Displaying; advertising; signs; labels or name-plates; seals.
		G09G	Arrangements or circuits for control of indicating devices using static means to present variable information.
		G11B	Information storage based on relative movement between record carrier and transducer.
		H04N-003	Scanning details of television systems; Combination thereof with generation of supply voltages.
		H04N-005	Details of television systems.
		H04N-009	Details of colour television systems.
		H04N-013	Stereoscopic television systems; Details thereof.
		H04N-015	Stereoscopic colour television systems; Details thereof.
		H04N-017	Diagnosis, testing or measuring for television systems or their details.
		H04R	Loudspeakers, microphones, gramophone pick-ups or like acoustic electromechanical transducers; deaf-aid sets; public address systems.
		H04S	Stereophonic systems.
		H05K	Printed circuits; casings or constructional details of electric apparatus; manufacture of assemblages of electrical components.
3	Telecommunications	G08C	Transmission systems for measured values, control or similar signals.
		H01P	Waveguides; resonators, lines or other devices of the waveguide type.
		H01Q	Aerials.
		H04B	Transmission.
		H04H	Broadcast communication.
		H04J	Multiplex communication.
		H04K	Secret communication; jamming of communication.
		H04M	Telephonic communication.
		H04N-001	Scanning, transmission or reproduction of documents or the like, e.g. facsimile transmission; Details thereof.
		H04N-007	Television systems.
		H04N-011	Colour television systems.
		H04Q	Selecting.
4	Digital communication	H04L	Transmission of digital information, e.g. telegraphic communication.

5	Basic communication processes	H03#	Basic electronic circuitry.
6	Computer technology	(G06# not G06Q)	Computing; calculating; counting, not data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes.
		G11C	Static stores.
		G10L	Speech analysis or synthesis; speech recognition; audio analysis or processing.
7	IT methods for management	G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes, not otherwise provided for.
8	Semiconductors	H01L	Semiconductor devices; electric solid state devices not otherwise provided for.
		H01L-21#	Semiconductor manufacturing processes
		H01L-31#	Light sensitive semiconductors & optoelectronic components (photovoltaics)
II	**Instruments**		
9	Optics	G02#	Optics.
		G02C	Contact Lenses
		G03B	Photography; cinematography; analogous techniques using waves other than optical waves; electrography; holography.
		G03C	Photosensitive materials for photographic purposes; photographic processes, e.g. cine, x-ray, colour, stereo-photographic processes; auxiliary processes in photography.
		G03D	Apparatus for processing exposed photographic materials; accessories therefor.
		G03F	Photomechanical production of textured or patterned surfaces, e.g. for printing, for processing of semiconductor devices; materials therefor; originals therefor; apparatus specially adapted therefor.
		G03G	Electrography; electrophotography; magnetography.
		G03H	Holographic processes or apparatus.
		H01S	Devices using stimulated emission (eg; Lasers).
10	Measurement	G01B	Measuring length, thickness or similar linear dimensions; measuring angles; measuring areas; measuring irregularities of surfaces or contours.
		G01C	Measuring distances, levels or bearings; surveying; navigation; gyroscopic instruments; photogrammetry or videogrammetry.
		G01D	Measuring not specially adapted for a specific variable; arrangements for measuring two or more variables not covered by a single other subclass; tariff metering apparatus; transferring or transducing arrangements not specially adapted for a specific variable; measuring or testing not otherwise provided for.
		G01F	Measuring volume, volume flow, mass flow, or liquid level; metering by volume.
		G01G	Weighing.
		G01H	Measurement of mechanical vibrations or ultrasonic, sonic or infrasonic waves.
		G01J	Measurement of intensity, velocity, spectral content, polarisation, phase or pulse characteristics of infra-red, visible or ultra-violet light; colorimetry; radiation pyrometry.
		G01K	Measuring temperature; measuring quantity of heat; thermally-sensitive elements not otherwise provided for.
		G01L	Measuring force, stress, torque, work, mechanical power, mechanical efficiency, or fluid pressure.
		G01M	Testing static or dynamic balance of machines or structures; testing of structures or apparatus, not otherwise provided for.
		(G01N not G01N-033)	Investigating or analysing materials by determining their chemical or physical properties. (not biological materials).
		G01P	
		G01R	Measuring linear or angular speed, acceleration, deceleration, or shock; indicating presence, absence, or direction, of movement.
		G01S	Measuring electric variables; measuring magnetic variables.
		G01V	Radio direction-finding; radio navigation; determining distance or velocity by use of radio waves; locating or presence-detecting by use of the reflection or reradiation of radio waves; analogous arrangements using other waves.
		G01W	Geophysics; gravitational measurements; detecting masses or objects; tags.
		G04#	Meteorology.
		G12B	Horology (time measurement).
		G99Z	Details of instruments, or comparable details of other apparatus, not otherwise provided for. Subject matter not otherwise provided for in this section.
11	Analysis of biological materials	G01N-033	Investigating or analysing materials including biomaterials by specific methods not covered by groups G01N 1/00-G01N 31/00

12	Control	G05B	Control or regulating systems in general; functional elements of such systems; monitoring or testing arrangements for such systems or elements.
		G05D	Systems for controlling or regulating non-electric variables.
		G05F	Systems for regulating electric or magnetic variables.
		G07#	Checking-devices (cash registers, vending and ticket machines, toll machines, lottery machines, franking machines etc).
		G08B	Signalling or calling systems; order telegraphs; alarm systems.
		G08G	Traffic Control systems.
		G09B	Educational or demonstration appliances; appliances for teaching, or communicating with, the blind, deaf or mute; models; planetaria; globes; maps; diagrams.
		G09C	Ciphering or deciphering apparatus for cryptographic or other purposes involving the need for secrecy.
		G09D	Railway or like time or fare tables; perpetual calendars.
13	Medical technology	A61B	Diagnosis; surgery; identification.
		A61C	Dentistry; apparatus or methods for oral or dental hygiene.
		A61D	Veterinary instruments, implements, tools, or methods.
		A61F	Filters implantable into blood vessels; prostheses; devices providing patency to, or preventing collapsing of, tubular structures of the body, e.g. stents; orthopaedic, nursing or contraceptive devices; fomentation; treatment or protection of eyes or ears; bandages, dressings or absorbent pads; first-aid kits.
		A61G	Transport, personal conveyances, or accommodation specially adapted for patients or disabled persons; operating tables or chairs; chairs for dentistry; funeral devices.
		A61H	Physical therapy apparatus, e.g. devices for locating or stimulating reflex points in the body; artificial respiration; massage; bathing devices for special therapeutic or hygienic purposes or specific parts of the body.
		A61J	Containers specially adapted for medical or pharmaceutical purposes; devices or methods specially adapted for bringing pharmaceutical products into particular physical or administering forms; devices for administering food or medicines orally; baby comforters; devices for receiving spittle.
		A61L	Methods or apparatus for sterilising materials or objects in general; disinfection, sterilisation, or deodorisation of air; chemical aspects of bandages, dressings, absorbent pads, or surgical articles; materials for bandages, dressings, absorbent pads, or surgical articles.
		A61M	Devices for introducing media into, or onto, the body; devices for transducing body media or for taking media from the body; devices for producing or ending sleep or stupor.
		A61N	Electrotherapy; magnetotherapy; radiation therapy; ultrasound therapy.
		H05G	X-Ray techniques and apparatus.
III	**Chemistry**		
14	Organic fine chemistry	(C07B	{General methods of organic chemistry; apparatus therefor.
		C07C	Acyclic or carbocyclic compounds.
		C07D	Heterocyclic compounds.
		C07F	Acyclic, carbocyclic, or heterocyclic compounds containing elements other than carbon, hydrogen, halogen, oxygen, nitrogen, sulfur, selenium or tellurium.
		C07H	Sugars; derivatives thereof; nucleosides; nucleotides; nucleic acids.
		C07J	Steroids.
		C40B)	Combinatorial chemistry; libraries, e.g. Chemical libraries, in silico libraries.}
		not A61K	Not preparations for medical, dental, or toilet purposes.
		A61K-008	Cosmetics or similar toilet preparations.
		A61Q	Specific use of cosmetics or similar toilet preparations.
15	Biotechnology	(C07G	{Organic compounds of unknown constitution.
		C07K	Peptides.
		C12M	Apparatus for enzymology or microbiology.
		C12N	Micro-organisms or enzymes; compositions thereof.
		C12P	Fermentation or enzyme-using processes to synthesise a desired chemical compound or composition or to separate optical isomers from a racemic mixture.
		C12Q	Measuring or testing processes involving enzymes or micro-organisms; compositions or test papers therefor; processes of preparing such compositions; condition-responsive control in microbiological or enzymological processes.
		C12R	Micro-organisms.
		C12S)	Processes using enzymes or micro-organisms to liberate, separate or purify a pre-existing compound or composition; processes using enzymes or micro-organisms to treat textiles or to clean solid surfaces of materials.}
		not A61K	Not preparations for medical, dental, or toilet purposes.
16	Pharmaceuticals	A61K not	Preparations for medical, dental, or toilet purposes.
		A61K-008	Not Cosmetics or similar toilet preparations.

17	Macromolecular chemistry, polymers	C08B	Polysaccharides; derivatives thereof.
		C08C	Treatment or chemical modification of rubbers.
		C08F	Macromolecular compounds obtained by reactions only involving carbon-to-carbon unsaturated bonds.
		C08G	Macromolecular compounds obtained otherwise than by reactions only involving carbon-to-carbon unsaturated bonds.
		C08H	Derivatives of natural macromolecular compounds.
		C08K	Use of inorganic or non-macromolecular organic substances as compounding ingredients.
		C08L	Compositions of macromolecular compounds.
18	Food chemistry	A01H	New plants or processes for obtaining them; plant reproduction by tissue culture techniques.
		A21D	Treatment, e.g. preservation, of flour or dough for baking, e.g. by addition of materials; baking; bakery products; preservation thereof.
		A23B	Preserving, e.g. by canning, meat, fish, eggs, fruit, vegetables, edible seeds; chemical ripening of fruit or vegetables; the preserved, ripened, or canned products.
		A23C	Dairy products, e.g. milk, butter, cheese; milk or cheese substitutes; making thereof.
		A23D	Edible oils or fats, e.g. margarines, shortenings, cooking oils.
		A23F	Coffee; tea; their substitutes; manufacture, preparation, or infusion thereof.
		A23G	Cocoa; cocoa products, e.g. chocolate; substitutes for cocoa or cocoa products; confectionery; chewing gum; ice-cream.
		A23J	Protein compositions for foodstuffs; working-up proteins for foodstuffs; phosphatide compositions for foodstuffs.
		A23K	Feeding-stuffs specially adapted for animals; methods specially adapted for production thereof.
		A23L	Foods, foodstuffs, or non-alcoholic beverages; their preparation or treatment, e.g. cooking, modification of nutritive qualities, physical treatment; preservation of foods or foodstuffs, in general.
		C12C	Brewing of Beer.
		C12F	Recovery of by-products of fermented solutions; denaturing of, or denatured, alcohol.
		C12G	Wine; other alcoholic beverages; preparation thereof.
		C12H	Pasteurisation, sterilisation, preservation, purification, clarification, ageing of alcoholic beverages or removal of alcohol therefrom.
		C12J	Vinegar; its preparation.
		C13D	Production and purification of sugar juices.
		C13F	Preparation and processing of raw sugar, sugar, and syrup.
		C13J	Extraction of sugar from molasses.
		C13K	Glucose; invert sugar; lactose; maltose; other sugars.
19	Basic materials chemistry	A01N	Preservation of bodies of humans or animals or plants or parts thereof; biocides, e.g. as disinfectants, as pesticides or as herbicides; pest repellants or attractants; plant growth regulators.
		A01P	Biocidal, pest repellant, pest attractant or plant growth regulatory activity of chemical compounds or preparations.
		C05#	Fertilisers; manufacture thereof.
		C06#	Explosives; matches.
		C09B	Organic dyes or closely-related compounds for producing dyes; mordants; lakes.
		C09C	Treatment of inorganic materials, other than fibrous fillers, to enhance their pigmenting or filling properties.
		C09F	Natural resins; French polish; drying-oils; driers (siccatives); turpentine.
		C09G	Polishing compositions other than French polish; ski waxes.
		C09H	Preparation of glue or gelatine.
		C09K	Materials for applications not otherwise provided for; applications of materials not otherwise provided for.
		C09D	Coating compositions, e.g. paints, varnishes or lacquers; filling pastes; chemical paint or ink removers; inks; correcting fluids; woodstains; pastes or solids for colouring or printing; use of materials therefor.
		C09J	Adhesives; non-mechanical aspects of adhesive processes in general; adhesive processes not provided for elsewhere; use of materials as adhesives.
		(C10B, C10C, C10F, C10G, C10H, C10J, C10K, C10L, C10M, C10N)	Petroleum, gas or coke industries; technical gases containing carbon monoxide; fuels; lubricants; peat.

19	Basic materials chemistry	C11B	Producing, e.g. by pressing raw materials or by extraction from waste materials, refining or preserving fats, fatty substances, e.g. lanolin, fatty oils or waxes; essential oils; perfumes.
		C11C	Fatty acids from fats, oils or waxes; candles; fats, oils or fatty acids by chemical modification of fats, oils, or fatty acids obtained therefrom.
		C11D	Detergent compositions; use of single substances as detergents; soap or soap-making; resin soaps; recovery of glycerol
		C99Z	Subject matter not otherwise provided for in this section.
20	Materials, metallurgy	C01#	Inorganic Chemistry.
		C03C	Chemical composition of glasses, glazes, or vitreous enamels; surface treatment of glass; surface treatment of fibres or filaments from glass, minerals or slags; joining glass to glass or other materials.
		C04#	Cements; concrete; artificial stone; ceramics; refractories.
		C21#	Metallurgy of iron.
		C22#	Metallurgy; ferrous or non-ferrous alloys; treatment of alloys or non-ferrous metals.
		B22#	Casting; powder metallurgy.
21	Surface technology, coating	B05C	Apparatus for applying liquids or other fluent materials to surfaces, in general.
		B05D	Processes for applying liquids or other fluent materials to surfaces, in general.
		B32#	Layered products.
		C23#	Coating metallic material; coating material with metallic material; chemical surface treatment; diffusion treatment of metallic material; coating by vacuum evaporation, by sputtering, by ion implantation or by chemical vapour deposition, in general; inhibiting corrosion of metallic material or incrustation in general.
		C25#	Electrolytic or electrophoretic processes; apparatus therefor.
		C30#	Crystal Growth.
22	Micro-structure and nano-technology	B81B	Micro-structural devices or systems.
		B81C	Processes or apparatus specially adapted for the manufacture or treatment of micro-structural devices or systems.
		B82B	Nano-Structures.
		B82Y	Specific uses or applications of nano-structures; measurement or analysis of nano-structures; manufacture or treatment of nano-structures
23	Chemical engineering	B01B	Boiling; boiling apparatus.
		B01D-000#	Separation.
		B01D-01##	Evaporating.
		B01D-03##	Distillation or related exchange processes in which liquids are contacted with gaseous media, e.g. stripping.
		B01D-041	Regeneration of the filtering material or filter elements outside the filter for liquid or gaseous fluids.
		B01D-043	Separating particles from liquids, or liquids from solids, otherwise than by sedimentation or filtration.
		B01D-057	Separation, other than separation of solids, not fully covered by a single other group or subclass.
		B01D-059	Separation of different isotopes of the same chemical element.
		B01D-06##	Condensation.
		B01D-07##	Sublimation.
		B01F	Mixing, e.g. dissolving, emulsifying, dispersing.
		B01J	Chemical or physical processes, e.g. catalysis, colloid chemistry; their relevant apparatus.
		B01L	Chemical or physical laboratory apparatus for general use.
		B02C	Crushing, pulverising, or disintegrating in general; milling grain.
		B03#	Separation of solid materials using liquids or using pneumatic tables or jigs; magnetic or electrostatic separation of solid materials from solid materials or fluids; separation by high-voltage electric fields.
		B04#	Centrifugal apparatus or machines for carrying-out physical or chemical processes.
		B05B	Nozzles, spray heads or other outlets, with or without auxiliary devices such as valves, heating means.
		B06B	Generating or transmitting mechanical vibrations in general.
		B07#	Separating solids from solids; sorting.
		B08#	Cleaning.
		D06B	Treating textile materials by liquids, gases, or vapours.
		D06C	Finishing, dressing, tentering, or stretching textile fabrics.
		D06L	Bleaching, e.g. Optical bleaching, dry-cleaning, or washing fibres, threads, yarns, fabrics, feathers, or made-up fibrous goods; bleaching leather or furs.
		F25J	Liquefaction, solidification, or separation of gases or gaseous mixtures by pressure and cold treatment.
		F26#	Drying.

23	Chemical engineering	C14C	Chemical treatment of skins, hides or leather, e.g. tanning, impregnating, finishing; apparatus therefor; compositions for tanning.
		H05H	Plasma technique; production of accelerated electrically- charged particles or of neutrons; production or acceleration of neutral molecular or atomic beams.
24	Environmental technology	A62D	Chemical means for extinguishing fires; processes for making harmful chemical substances harmless, or less harmful, by effecting a chemical change; composition of materials for coverings or clothing for protecting against harmful chemical agents; composition of materials for transparent parts of gas-masks, respirators, breathing bags or helmets; composition of chemical materials for use in breathing apparatus.
		B01D-045	Separating dispersed particles from gases or vapours by gravity, inertia, or centrifugal forces.
		B01D-046	Filters or filtering processes specially modified for separating dispersed particles from gases or vapours.
		B01D-047	Separating dispersed particles from gases, air or vapours by liquid as separating agent.
		B01D-049	Separating dispersed particles from gases, air or vapours by other methods.
		B01D-050	Combinations of devices for separating particles from gases or vapours.
		B01D-051	Auxiliary pretreatment of gases or vapours to be cleaned from dispersed particles.
		B01D-053	Separation of gases or vapours; Recovering vapours of volatile solvents from gases; Chemical or biological purification of waste gases, e.g. engine exhaust gases, smoke, fumes, flue gases or aerosols.
		B09#	Disposal of solid waste; reclamation of contaminated soil.
		B65F	Gathering or removal of domestic or like refuse.
		C02#	Treatment of water, waste water, sewage, or sludge.
		F01N	Gas-flow silencers or exhaust apparatus for machines or engines in general; gas-flow silencers or exhaust apparatus for internal-combustion engines.
		F23G	Cremation furnaces; consuming waste or low grade fuels by combustion.
		F23J	Removal or treatment of combustion products or combustion residues; flues.
		G01T	Measurement of nuclear or x-radiation.
		E01F-008	Arrangements for absorbing or reflecting air transmitted noise from road or railway traffic.
		A62C	Fire-fighting.
IV	**Mechanical engineering**		
25	Handling	B25J	Manipulators; chambers provided with manipulation devices.
		B65B	Machines, apparatus or devices for, or methods of, packaging articles or materials; unpacking.
		B65C	Labelling or tagging machines, apparatus, or processes.
		B65D	Containers for storage or transport of articles or materials, e.g. Bags, barrels, bottles, boxes, cans, cartons, crates, drums, jars, tanks, hoppers, forwarding containers; accessories, closures, or fittings therefor; packaging elements; packages.
		B65G	Transport or storage devices, e.g. conveyers for loading or tipping; shop conveyer systems; pneumatic tube conveyers.
		B65H	Handling thin or filamentary material.
		B66#	Hoisting; lifting; hauling.
		B67#	Opening or closing bottles, jars or similar containers; liquid handling.
26	Machine tools	B21#	Mechanical metal-working without essentially removing material; punching metal.
		B23#	Machine tools; metal-working not otherwise provided for.
		B24#	Grinding; polishing.
		B26D	Cutting; details common to machines for severing, e.g. By cutting, perforating, punching, stamping-out.
		B26F	Perforating; punching; cutting-out; stamping-out; severing by means other than cutting.
		B27#	Working or preserving wood or similar material; nailing or stapling machines in general.
		B30#	Presses.
		B25B	Tools or bench devices not otherwise provided for, for fastening, connecting, disengaging, or holding.
		B25C	Hand-held nailing or stapling tools; manually-operated portable stapling tools.
		B25D	Percussive tools.
		B25F	Combination or multi-purpose tools not otherwise provided for; details or components of portable power-driven tools not particularly related to the operations performed and not otherwise provided for.
		B25G	Handles for hand implements.
		B25H	Workshop equipment, e.g. for marking-out work; storage means for workshops.
		B26B	Hand-held cutting tools not otherwise provided for.

27	Engines, pumps, turbines	F01B	Machines or engines, in general or of positive-displacement type, e.g. steam engines.
		F01C	Rotary-piston or oscillating-piston machines or engines.
		F01D	Non-positive-displacement machines or engines, e.g. steam turbines.
		F01K	Steam engine plants; steam accumulators; engine plants not otherwise provided for; engines using special working fluids or cycles.
		F01L	Cyclically operating valves for machines or engines.
		F01M	Lubricating of machines or engines in general; lubricating internal-combustion engines; crankcase ventilating.
		F01P	Cooling of machines or engines in general; cooling of internal-combustion engines.
		F02#	Combustion engines; hot-gas or combustion-product engine plants.
		F03#	Machines or engines for liquids; wind, spring, or weight motors; producing mechanical power or a reactive propulsive thrust, not otherwise provided for.
		F04#	Positive-displacement machines for liquids; pumps for liquids or elastic fluids.
		F23R	Generating combustion products of high pressure or high velocity, e.g. Gas-turbine combustion chambers.
		G21#	Nuclear physics; nuclear engineering.
		F99Z	Subject matter not otherwise provided for in this section.
28	Textile and paper machines	A41H	Appliances or methods for making clothes, e.g. for dress-making, for tailoring, not otherwise provided for.
		A43D	Machines, tools, equipment or methods for manufacturing or repairing footwear.
		A46D	Manufacture of brushes.
		C14B	Mechanical treatment or processing of skins, hides, or leather in general; pelt-shearing machines; intestine-splitting machines.
		D01#	Natural or artificial threads or fibres; spinning.
		D02#	Yarns; mechanical finishing of yarns or ropes; warping or beaming.
		D03#	Weaving.
		D04B	Knitting.
		D04C	Braiding or manufacture of lace, including bobbin-net or carbonised lace; braiding machines; braid; lace.
		D04G	Making nets by knotting of filamentary material; making knotted carpets or tapestries; knotting not otherwise provided for.
		D04H	Making textile fabrics, e.g. from fibres or filamentary material; fabrics made by such processes or apparatus, e.g. felts, non-woven fabrics; cotton-wool; wadding.
		D05#	Sewing; embroidering; tufting.
		D06G	Mechanical or pressure cleaning of carpets, rugs, sacks, hides, or other skin or textile articles or fabrics; turning inside-out flexible tubular or other hollow articles.
		D06H	Marking, inspecting, seaming, or severing textile materials.
		D06J	Pleating, kilting, or goffering textile fabrics or wearing apparel.
		D06M	Treatment, not provided for elsewhere in class D06, of fibres, threads, yarns, fabrics, feathers, or fibrous goods made from such materials.
		D06P	Dyeing or printing textiles; dyeing leather, furs, or solid macromolecular substances in any form.
		D06Q	Decorating Textiles.
		D99Z	Subject matter not otherwise provided for in this section.
		B31#	Making paper articles; working paper.
		D21#	Paper-making; production of cellulose.
		B41#	Printing; lining machines; typewriters; stamps.
29	Other special machines	A01B	Soil working in agriculture or forestry; parts, details, or accessories of agricultural machines or implements, in general.
		A01C	Planting; sowing; fertilising.
		A01D	Harvesting; mowing
		A01F	Threshing; baling of straw, hay or the like; stationary apparatus or hand tools for forming or binding straw, hay or the like into bundles; cutting of straw, hay or the like; storing agricultural or horticultural produce.
		A01G	Horticulture; cultivation of vegetables, flowers, rice, fruit, vines, hops, or seaweed; forestry; watering.
		A01J	Manufacture of dairy products.
		A01K	Animal husbandry; care of birds, fishes, insects; fishing; rearing or breeding animals, not otherwise provided for; new breeds of animals.
		A01L	Shoeing of animals.
		A01M	Catching, trapping or scaring of animals; apparatus for the destruction of noxious animals or noxious plants.
		A21B	Bakers' ovens; machines or equipment for baking.
		A21C	Machines or equipment for making or processing doughs; handling baked articles made from dough.

29	Other special machines	A22#	Butchering; meat treatment; processing poultry or fish.
		A23N	Machines or apparatus for treating harvested fruit, vegetables, or flower bulbs in bulk, not otherwise provided for; peeling vegetables or fruit in bulk; apparatus for preparing animal feeding-stuffs.
		A23P	Shaping or working of foodstuffs, not fully covered by a single other subclass.
		B02B	Preparing grain for milling; refining granular fruit to commercial products by working the surface.
		C12L	Pitching or depitching machines; cellar tools.
		C13C	Cutting mills; shredding knives; pulp presses.
		C13G	Evaporation apparatus; boiling pans.
		C13H	Cutting machines for sugar; combined cutting, sorting and packing machines for sugar.
		B28#	Working cement, clay, or stone.
		B29#	Working of plastics; working of substances in a plastic state in general.
		C03B	Manufacture or shaping of glass, or of mineral or slag wool; supplementary processes in the manufacture or shaping of glass, or of mineral or slag wool.
		C08J	Working-up; general processes of compounding; after-treatment.
		B99Z	Subject matter not otherwise provided for in this section.
		F41#	Weapons.
		F42#	Ammunition; blasting.
30	Thermal processes and apparatus	F22#	Steam generation.
		F23B	Methods or apparatus for combustion using only solid fuel.
		F23C	Methods or apparatus for combustion using fluid fuel or solid fuel suspended in air.
		F23D	Burners.
		F23H	Grates.
		F23K	Feeding fuel to combustion apparatus.
		F23L	Supplying air or non-combustible liquids or gases to combustion apparatus in general; valves or dampers specially adapted for controlling air supply or draught in combustion apparatus; inducing draught in combustion apparatus; tops for chimneys or ventilating shafts; terminals for flues.
		F23M	Constructional details of combustion chambers, not otherwise provided for.
		F23N	Regulating or controlling combustion.
		F23Q	Ignition.
		F24#	Heating; ranges; ventilating.
		F25B	Refrigeration machines, plants, or systems; combined heating and refrigeration systems; heat pump systems.
		F25C	Production, working, storing or distribution of ice.
		F27#	Furnaces; kilns; ovens; retorts.
		F28#	Heat exchange in general.
31	Mechanical elements	F15#	Fluid-pressure actuators; hydraulics or pneumatics in general.
		F16#	Engineering elements or units; general measures for producing and maintaining effective functioning of machines or installations; thermal insulation in general.
		F17#	Storing or distributing gases or liquids.
		G05G	Control devices or systems insofar as characterised by mechanical features only.
32	Transport	B60#	Vehicles in general.
		B61#	Railways.
		B62#	Land vehicles for travelling otherwise than on rails.
		B63B	Ships or other waterborne vessels; equipment for shipping.
		B63C	Launching, hauling-out, or dry-docking of vessels; life-saving in water; equipment for dwelling or working under water; means for salvaging or searching for underwater objects.
		B63G	Offensive or defensive arrangements on vessels; mine-laying; mine-sweeping; submarines; aircraft carriers.
		B63H	Marine propulsion or steering.
		B63J	Auxiliaries on vessels.
		B64#	Aircraft; aviation; cosmonautics.
V	**Other fields**		
33	Furniture, games	A47#	Furniture; domestic articles or appliances; coffee mills; spice mills; suction cleaners in general.
		A63#	Sports; games; amusements
34	Other consumer goods	A24#	Tobacco; cigars; cigarettes; smokers' requisites.
		A41B	Shirts; underwear; baby linen; handkerchiefs.
		A41C	Corsets; brassieres.
		A41D	Outerwear; protective garments; accessories.
		A41F	Garment fastenings; suspenders.
		A41G	Artificial flowers; wigs; masks; feathers.
		A42#	Headwear.

34	Other consumer goods	A43B	Characteristic features of footwear; parts of footwear.
		A43C	Fastenings or attachments for footwear; laces in general.
		A44#	Haberdashery; jewellery.
		A45#	Hand or travelling articles.
		A46B	Brushes.
		A62B	Devices, apparatus or methods for life-saving.
		B42#	Bookbinding; albums; files; special printed matter.
		B43#	Writing or drawing implements; bureau accessories.
		D04D	Trimmings; ribbons, tapes, or bands, not otherwise provided for.
		D07#	Ropes; cables other than electric.
		G10B	Organs, harmoniums or like wind-actuated musical instruments.
		G10C	Pianos, harpsichords, spinets or similar stringed musical instruments with one or more keyboards.
		G10D	Stringed musical instruments; wind-actuated musical instruments; accordions or concertinas; percussion musical instruments; musical instruments not otherwise provided for.
		G10F	Automatic musical instruments.
		G10G	Aids for music; supports for musical instruments; other auxiliary devices or accessories for music or musical instruments.
		G10H	Electrophonic musical instruments; instruments in which the tones are generated by electromechanical means or electronic generators, or in which the tones are synthesised from a data store.
		G10K	Sound-producing devices; methods or devices for protecting against, or for damping, noise or other acoustic waves in general; acoustics not otherwise provided for.
		B44#	Decorative arts.
		B68#	Saddlery; upholstery.
		D06F	Laundering, drying, ironing, pressing or folding textile articles.
		D06N	Wall, floor, or like covering materials, e.g. Linoleum, oilcloth, artificial leather, roofing felt, consisting of a fibrous web coated with a layer of macromolecular material; flexible sheet material not otherwise provided for.
		F25D	Refrigerators; cold rooms; ice-boxes; cooling or freezing apparatus not covered by any other subclass.
		A99Z	Subject matter not otherwise provided for in this section.
35	Civil engineering	E02#	Hydraulic engineering; foundations; soil-shifting.
		E01B	Permanent way; permanent-way tools; machines for making railways of all kinds.
		E01C	Construction of, or surfaces for, roads, sports grounds, or the like; machines or auxiliary tools for construction or repair.
		E01D	Bridges.
		E01F-001	Construction of platforms or refuge islands.
		E01F-003	Landing satges for helicopters.
		E01F-005	Draining the sub-base of roads or ballastway of railways by trenches, culverts or conduits.
		E01F-007	Devices affording protection against snow, sand drifts, side-wind effects, snowslides, avalanches or falling rocks; Anti-dazzle arrangements.
		E01F-009	Arrangement of road signs or traffic signals; Arrangements for enforcing caution, e.g. speed bumps.
		E01F-01#	Construction of roads, railways, or bridges.
		E01H	Street cleaning; cleaning of permanent ways; cleaning beaches; cleaning land; dispersing fog in general.
		E03#	Water supply; sewerage.
		E04#	Building.
		E05#	Locks; keys; window or door fittings; safes.
		E06#	Doors, windows, shutters, or roller blinds, in general; ladders.
		E21#	Earth or rock drilling; mining.
		E99Z	Subject matter not otherwise provided for in this section.

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