



National
Artificial
Intelligence
Centre

Australia's artificial intelligence ecosystem

Catalysing an AI industry

December 2023



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About this report

This report was prepared by CSIRO for the National Artificial Intelligence Centre. It presents information about companies and research institutes active in developing and applying artificial intelligence in Australia. This provides investors, customers, policy-makers, workers and students with information about Australia's capabilities, service offerings and research specialisations in artificial intelligence.

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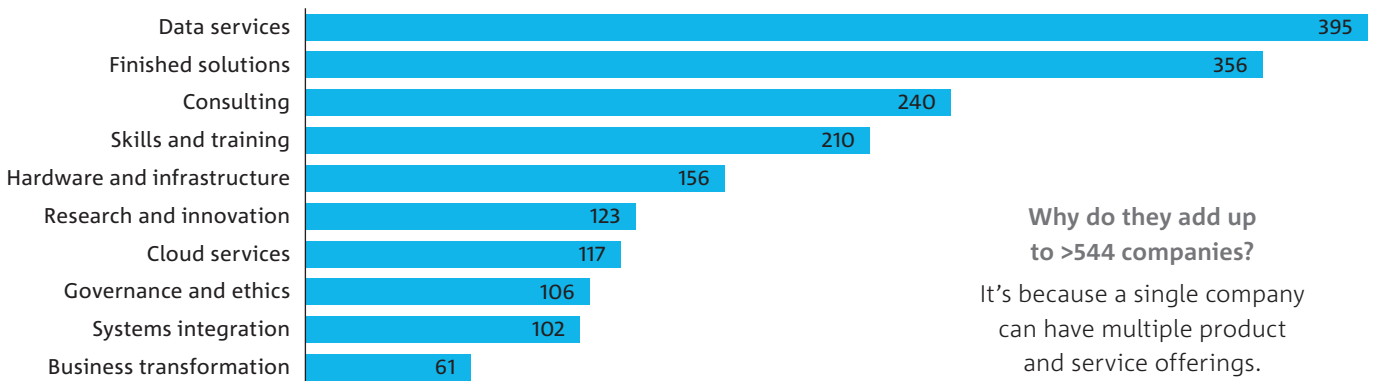
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Executive summary

Australia has a growing and diversified AI industry

We identified 544 companies in Australia whose main business activity is developing and selling AI products and services. These companies are nestled within a broader ecosystem of technology companies with >336,000 firms in the professional, scientific and technical services industry and close to 25,000 firms in information media and telecommunications.

Our initial search on company databases returned 1,606 AI companies. This was further screened, verified and validated down to 544 active AI companies. We developed a taxonomy to assign 10 AI product and service offering categories to each company as follows.



The number of AI companies in Australia has increased substantially over the past decade

396 Number of Australian AI companies opened for business in the past 10 years

204 Number of Australian AI companies opened for business in the past 5 years

7.7% Year-on-year growth of company count over the past 5 years

Australia's AI companies are showing patterns of geographic clustering

8 Number of tightly clustered hotspots (precincts) of AI companies across parts of Sydney, Melbourne, Brisbane, Adelaide and Perth

54% Share of Australia's 544 AI companies located in these 8 clusters (296 companies in total)

80 m Average straight-line distance between an AI company and its nearest neighbouring AI company within the same cluster

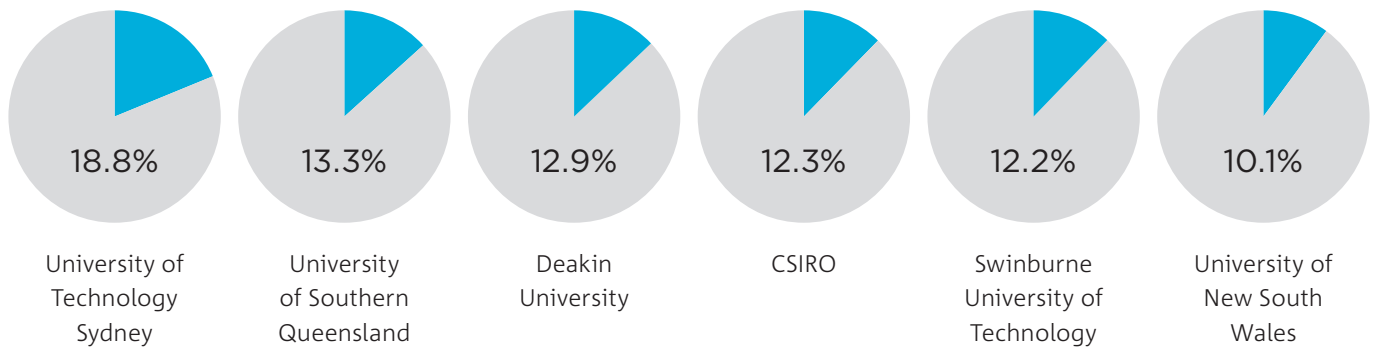
Australia's AI companies are young and nimble

6 yrs Median age of Australian AI companies

13 yrs Median age of Australian information and communications technology (ICT) sector companies

Australia's top 6 universities and research institutes by AI publishing intensity

The share of AI research published by Australian universities is rising, with >10% of the research published from the following six institutions being on AI topics in 2021.



Australia's share of AI publishing and product innovation

1.2%

Australia's share of global publishing on all topics

1.6%

Australia's share of global publishing on AI topics

0.2%

Share of global AI patent applications with an Australian inventor

Australia's top 3 AI application domains

Australia's R&D sector (public and private) is publishing research in AI application domains at a faster rate than the global average in these areas. The revealed technology advantage (RTA) scores show the rate at which we're publishing, where a value of 1 would be equal to the global rate.

4.8x

AI applications in livestock production

3.8x

AI applications in medical laboratory technologies

3.2x

AI applications in horticulture

Australia's top 3 AI technology sub-fields

Australia's R&D sector (public and private) is publishing research in AI technology types at a higher rate than the global rate in these areas. The RTA scores show we're publishing at 7.6 times the global average rate in the field of self-organising maps (a type of neural network).

7.6x

Self-organising map (a type of neural network)

5.3x

Ant colony optimisation (an algorithm inspired by ant colony behaviours)

5.2x

Gradient tree boosting (a machine learning technique used for prediction)

Stakeholder perspectives

We held interviews with 28 stakeholders across Australia's AI ecosystem including AI companies (startups and small, medium and large enterprises), academia and government agencies. These consultations explored current and emerging areas of competitive advantage across the Australian AI ecosystem, the unique value proposition of Australian-developed AI and opportunities to support the ecosystem in the future.

1

Challenge in separating the hype from reality.

Leaps forward by open-access tools like ChatGPT have accelerated interest in AI technologies. Business leaders can better visualise the potential benefits AI could bring to their organisations, but many remain risk-averse and apprehensive about AI technologies.

3

Deciding on what AI to build, buy or borrow.

To be globally competitive, Australia needs to set conditions that support AI adoption as well as create unique AI capabilities. This could include addressing the persisting challenge of scaling Australia's strong academic and research outputs into commercial innovations.

2

Need more awareness of local AI service providers.

Australian companies are opting for international AI service providers when the capabilities do not exist or cannot be identified locally. There are opportunities to expand platforms like the Australian AI Ecosystem Discoverability Platform to provide greater coverage and promote awareness of Australia's existing AI ecosystem.

4

Prioritising being an AI specialist over an AI generalist.

Acknowledging our population, market and funding size can limit Australia's capacity to compete in the global AI arena, there could be opportunities to grow world-leading capabilities in strategic areas of AI specialisation. These areas of AI specialisation should be based on domains where Australia has a strategic and/or comparative advantage.

5

An opportunity for safe and responsible AI.

There is a significant opportunity for Australia to be a global leader in the development and use of safe and responsible AI technologies. The ‘Australian brand’ is a trusted asset, which puts us in a strong position to drive future safe and responsible AI developments.

7

Strengthening linkages across the AI ecosystem.

Australia’s AI ecosystem requires strong leadership and improved connectivity across the sector. Doing so will maximise opportunities for Australia to define and strengthen its global reputation in AI and mature as an ecosystem.

6

The benefits of socio-cultural diversity.

Australia’s cultural and linguistic diversity provides a unique comparative advantage when it comes to developing novel AI technologies. Australia is well-placed to leverage this diversity in the creation of novel AI technologies, as well as position itself as an AI technology testbed.

8

Growing Australia’s AI talent and business ecosystem.

Talent shortages are a persisting struggle reported by Australian businesses, particularly when it comes to sourcing specialised technical skills. Australia could consider new approaches to inject talent into the AI ecosystem and reduce friction for professionals working in these areas.



Introduction

What is this report about?

This is the second report about Australia's artificial intelligence (AI) ecosystem with the first being published in 2022 (NAIC, 2022). It has been commissioned by the National Artificial Intelligence Centre (NAIC) and delivered by CSIRO. Australia's AI ecosystem is comprised of startups, small-to-large-sized companies, universities, research institutes, industry organisations and public sector agencies engaged in developing and applying AI technologies. This report aims to provide a snapshot of the current state of Australia's AI ecosystem and inform future strategy and policy decisions about its growth and development.

Why read this report?

This report contains information about companies, product innovation, investment, universities, research institutes and specialised capabilities relating to AI in Australia. It also contains information about the perceived challenges and opportunities for future growth and development of AI in Australia. The report aims to inform people in industry, academia, government and community spheres making decisions about AI capability uplift.

This report is useful to anyone wanting to understand and develop AI capability in Australia. It could be used by investors looking for opportunities in the Australian marketplace. It could be used by a company wanting to train and recruit AI talent. It could be used by someone starting or developing an AI company. It could be used by universities and research institutes planning for AI capability development. It could be used by Local, State/Territory and Federal government agencies aiming to support the AI industry and job growth. And it could be used by workers and students planning their AI careers.

What is the Australian AI ecosystem?

The AI ecosystem comprises companies (startups, small, medium and large enterprises), universities, education and training institutes, research institutes, industry bodies and professional associations concerned with the development and application of AI in Australia. Whilst practically all organisations use AI to some extent, this report focuses on companies and research institutes that have a primary or substantial focus on AI. We identify several sub-sectors within the AI ecosystem:

1. Small, medium, large and startup companies that make and sell AI products and services
2. Research institutes and universities significantly engaged in developing and applying AI
3. Venture capital and other investors who inject capital into the AI industry
4. Industry associations, professional bodies and community organisations
5. Education and training institutions¹
6. Government bodies that support and regulate the AI industry¹
7. Workers in AI occupations¹

¹ These sub-sectors were out of scope for the current report as we currently do not have datasets or standardised reporting frameworks for capturing information on these sub-sectors. We hope that future versions of this report will be able to shed light on these other parts of the Australian AI ecosystem.

Why is Australia's AI ecosystem significant?

Australia, along with most advanced economies, is grappling with an ongoing productivity slump (Australian Government, 2023). This causes lower rates of economic growth and a reduced growth rate in living standards. AI is a general-purpose technology that could turn things around. AI is impacting every policy sphere, industry sector and (practically) every career. This impact will intensify in the future.

When used well, AI allows people to do things faster, cheaper, safer and better. Just like electricity in the 1920s, AI has the capability to deliver an economy-wide productivity boost in the 2020s and beyond. Many new jobs, startups and corporations will be created through AI over the coming years. Many existing companies and workers will be impacted, which is part of the reason why AI is attracting so much attention. It is both a critical enabler of economic activity and a driver of disruption.

What's changing in the world of AI?

The year 2023 is considered by some as a new phase in the journey of AI. We've seen the rapid ascendancy of foundation AI models and generative AI such as ChatGPT, DALL-E 2 (OpenAI), GitHub Copilot, Imogen, Codey, Chirp (Google), Llama 2 (Meta AI) and others. Many more such models are likely to emerge over the coming months and years. Foundation models such as these are typically trained on vast quantities of data and can be used to perform a wide variety of tasks and solve problems across virtually all industries.

The global AI sector is racing to build new foundation models and plug-ins to existing models. This will be associated with the emergence and rapid scale-up of new AI companies. It will also change what's possible for existing companies with the prospect of a significant productivity uplift. There is much uncertainty about how the next generation of foundation AI models will play out, but a significant impact on Australia's economy and industry is certain. It's already happening.

Where does our information come from?

To describe the AI ecosystem, we draw upon large commercial databases which are often used by investors when searching for companies such as Crunchbase and PitchBook. These databases contain detailed industry classifications and wide-ranging company data. Our analysis of AI product innovation and research activity largely comes from The Lens, a comprehensive database on Australian and global scholarly publishing and patent applications. We also complemented these analyses with structured qualitative interviews with experts and stakeholders across the Australian AI ecosystem.

What's in this report?

The report is broken up into three main sections. The first section presents information on the AI industry in Australia through the lens of startups and small, medium and large companies whose primary business model involves making and selling AI products and services. We examine the temporal and spatial patterns of these AI companies and classify their AI offerings. The next section focuses on the research and development sector, examining patterns of AI research publishing and patent applications in Australia and areas of global specialisation. We also present information about the AI research activities of Australia's leading universities and research institutes. The final section presents insights from interviews with experts across Australia's AI ecosystem, shedding light on the opportunities and barriers facing the ecosystem.

1

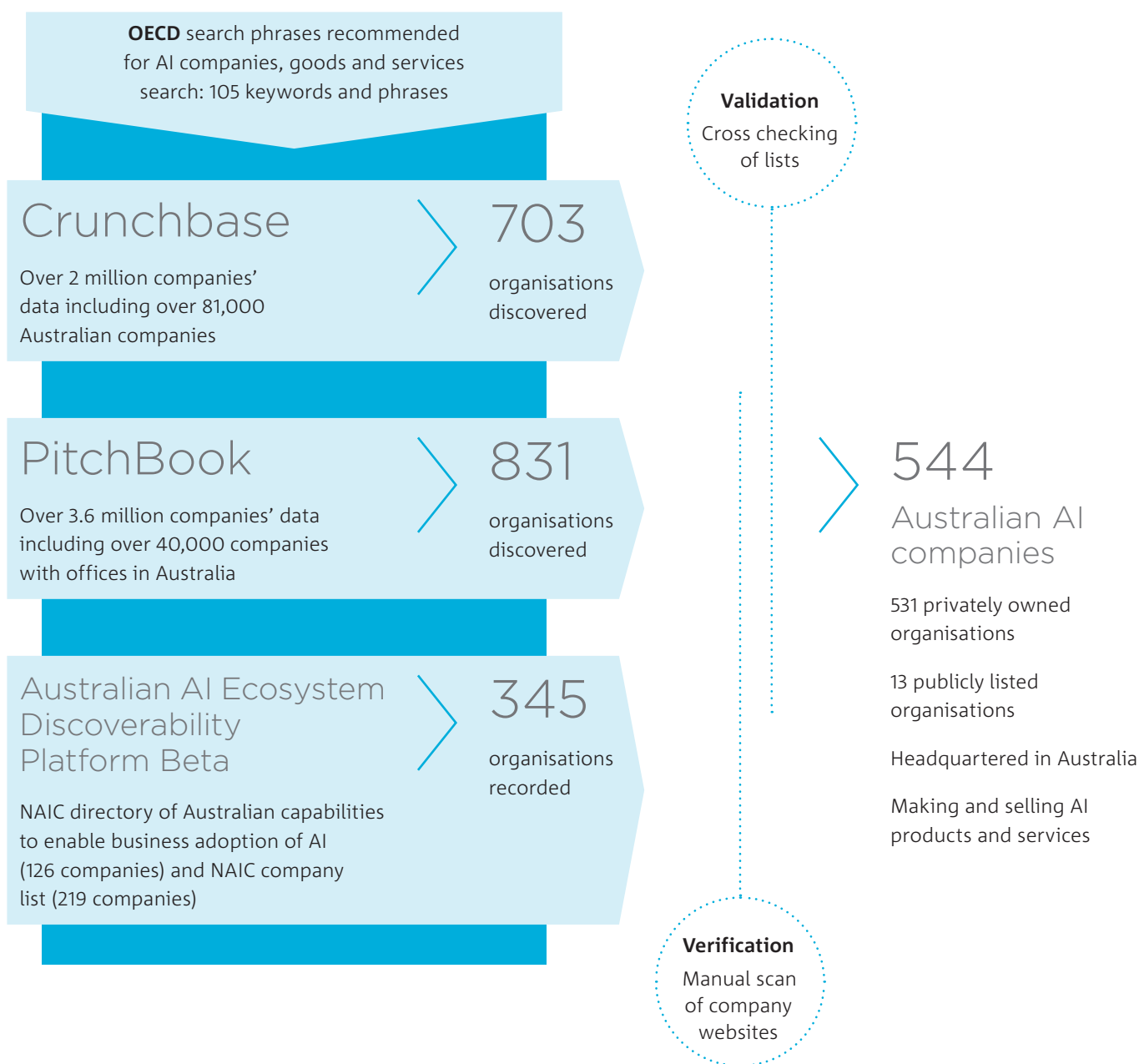
Artificial intelligence companies

Startups and small, medium and large Australian-headquartered companies whose primary business activity is making and selling AI products and services to customers.



How we identify and define an AI company

We define an Australian AI company as a privately owned or publicly listed company headquartered in Australia whose primary business activities involve making and selling AI products and services to customers. The list of Australian AI companies was constructed using three datasets: Crunchbase (Crunchbase, 2023a), Pitchbook (Pitchbook, 2023) and the Australian AI Ecosystem Discoverability Platform Beta (CSIRO, 2023).



We applied a set of 105 AI keywords developed by the OECD (Nakazato and Squicciarini, 2021) to search the descriptions of companies headquartered in Australia. Our aim was to identify companies whose main product or service offering was about AI. We recognise that many (arguably most) companies use AI; but in this analysis, we're after companies who make and sell AI products or services as their main business activity.

As a result of the search through three databases (Crunchbase, Pitchbook, NAIC AI Ecosystem Discoverability Platform Beta and company list), we identified a list of 1,606 Australian companies with unique names. The list of companies was further validated and verified by cross-checking datasets and manual screening of company web pages and LinkedIn profiles. Additional companies identified through the stakeholder consultations were also included in the final set, which totalled 544 Australian AI companies, including 531 privately owned companies and 13 publicly listed companies.

To put these findings in perspective, Australia is home to over 360,000 companies operating in the industries where most AI companies operate; namely, professional, scientific and technical services and information media and telecommunications. According to the Australian Bureau of Statistics (2023), at the end of June 2023, there were:

- 336,214 businesses in Australia in the professional, scientific and technical services industry. The industry demonstrated the third largest net increase in business count in the past year (an increase of 4,960 businesses) after healthcare and social assistance (10,721) and transport, postal and warehousing (5,040)
- 24,757 businesses in the information media and telecommunications industry in Australia. Compared with the year before, the number of businesses in the industry dropped by 0.3% or 75 companies.

Limitations of our data and methods

Identifying AI companies is a challenging task due to the nature of AI as a general-purpose technology and the range of ways it is used across all sectors of the economy. Technology companies also make a large and dynamic marketplace with company entries and exits occurring frequently. The following limitations of this analysis need to be considered when interpreting and using the results:

- We do not include overseas technology corporations with a presence in Australia because we cannot measure the nature and extent of their Australian (versus global) activity. However, they are likely to represent a significant share of Australia's AI activity.
- While best efforts were made to collect data on as many Australian AI companies as possible, the list is not exhaustive. The companies with more general descriptions of their activities on Crunchbase and Pitchbook platforms could have been overlooked in our search.
- The coverage of the datasets used (Crunchbase, Pitchbook) has been expanding over time, so trend data should be interpreted with caution.
- Data availability on the operations of private companies and publicly listed companies varies, so any comparison between these two groups should be performed with caution.
- The list of AI product and service offerings is sourced from NAIC and complemented by the analysis of Crunchbase industry classifications. This list is not exhaustive and the classification categories are not mutually exclusive.
- For industry analysis, we applied the Crunchbase industry taxonomy, which differs from the taxonomy used by the Australian Bureau of Statistics.

Overall, the number of AI companies is likely to change over time. Companies will grow, merge, enter and exit. Definitions of AI will change as the technology changes. Therefore, our estimate of AI companies in this report is a snapshot for the time of publication.

Product and service offerings

Working closely with the NAIC, we identified a set of product and service offering categories for Australian AI companies, noting that a company might provide multiple types of offerings. The categories are as follows:

Cloud services

Cloud services include software (an app or set of apps), application development platforms and infrastructure capabilities (memory, storage, networking). Cloud services enable businesses to develop and implement AI capabilities. Examples of AI cloud services capabilities include development and implementation for SaaS (Software as a Service), PaaS (Platform as a Service), IaaS (Infrastructure as a Service).

Consulting

Consulting services assist with strategy, organisational change processes and methods for optimal utilisation and application of AI technologies. Consulting services enable AI adoption and commercialisation and include services in innovation consultancy, legal and financial services.

Finished solutions

Finished solutions providers create ready to use AI applications, including platforms, enabling businesses to adopt and implement AI technologies. Finished solutions providers offer AI services to companies to help solve business challenges, including end-to-end design, implementation and maintenance of AI technologies for specific business use cases.

Hardware and infrastructure

Hardware and infrastructure vendors provide physical and network components of AI technologies to enable computational capabilities and automation. Key infrastructure for AI systems is high computing capacity (CPU, GPU-based computing), storage capacity, networking infrastructure (high bandwidth, low latency) and security. This group of AI capability providers also include developers of robotic solutions, communications and data centres infrastructure, applications of sensor technology.

Systems integration

Systems integration providers develop solutions that combine different computing operations components, including hardware and software for a more coherent and capable system. This includes developing software components, such as speech synthesisers and common-sense knowledgebases, that are interoperable with other components, and planning, coordinating, scheduling, testing and improving computing operations.

Data service

Data services provide resources and expertise for the utilisation of data to develop and optimise AI capabilities, including datasets, data analysis and management. This capability includes providers of DaaS (Data as a Service), and web-delivered services that perform various functions on data, such as data mining, visualisation, image and speech recognition and others.

Business transformation

The business transformation AI capability includes technology solutions and services in digitalisation, digital transformation and broader business integration. This category includes providers of business and management information systems, and contract and document management solutions.

Research and innovation

Research and innovation services provide expertise and technical capabilities to enable cutting-edge progress on emerging AI domains and solutions to complex challenges. This category encompasses organisations seeking to push the boundaries of knowledge and explore what is possible in terms of AI applications, including the pursuit of IP that can result in new products and services for commercialisation.

Governance and ethics

The governance and ethics capability group includes providers of advisory services that focus on the responsible and ethical adoption of AI technologies in accordance with ethical, privacy and security considerations and requirements. Companies promoting inclusion and diversity in the industry are also classified under this capability group.

Skills and training

Skills and training providers enable individuals and organisations to learn and build new workforce capabilities. This category includes companies that provide online training and courses along with tailored solutions for workforce adoption and upskilling.

Method for classifying companies

The table below shows the correspondences for the NAIC AI ecosystem taxonomy, Crunchbase Industry List and company descriptions keyword search.

AI ECOSYSTEM CAPABILITY CATEGORY	KEYWORDS	CORRESPONDING INDUSTRIES FROM CRUNCHBASE INDUSTRY LIST
Cloud services	Cloud technolog*, Cloud Comput*, Cloud Infrastructure, Platform Service, Platform Vendor, Software as a Service, SaaS, Platform as a Service, PaaS, Infrastructure as a Service, IaaS, cloud service*	Cloud Infrastructure, Private Cloud, Cloud Data Services, Cloud Management, Cloud Security, Cloud Security, Cloud Computing, SaaS
Finished solutions	AI application*, AI as a Service, Artificial Intelligence as a Service, Artificial Intelligence Development Service*, AI Development Service*, Artificial Intelligence Solution*, AI solution*, App*, platform*, game*, AI model*, software*	App Discovery, App, Consumer Application, Enterprise Application, Mobile App, Web App, Software
Hardware and infrastructure	AI Infrastructure, AI Hardware, Artificial Intelligence Infrastructure, Artificial Intelligence Hardware, GPU, CPU, GPU-based computing, networking infrastructure, FPGA*, on-chip memory, SRAM, automat*, robot*, sensor*	Application Specific Integrated Circuit, ASIC, Augmented Reality, Communication Hardware, Communications Infrastructure, Computer Vision, Data Center, Data Center Automation, GPS, GPU, Network Hardware, Sensor, Virtual Reality, IT Infrastructure, Network Security
Systems integration	Systems integrat*, speech synthesizer*, common sense knowledgebase*, AI system*, Artificial Intelligence system*, integrat*, design architect*, chatbot*, symbiosis, AI standard*	Data Integration
Business transformation	Business transform*, digital* transform*, digitali*, optim* process, business solution*, solv* business, digital product*, management tool*, business system*, growing business*, digital ecosystem, business intelligence	Business Information Systems, Contact Management, Document Management, Management Information Systems
Data services	data analy*, data management, Data as a service, DaaS, Training data, data aggregat*, data annotation, data architecture, data transit, data storage, data analysis, visuali*, voice*, speech*, vision*, data analy*, big data*, video analy*, conversation*, art*, music*, image recogni*, knowledge graph*, simulat*, interpret*	Application Performance Management, Business Intelligence, Data Mining, Data Visualization, Facial Recognition, Geospatial, Image Recognition, Intelligent Systems, Location Based Services, Predictive Analytics, Quantified Self, Speech Recognition, Text Analytics, Usability Testing, Big Data, Analytics
Consulting	Consulting Service*, Consult*, Innovation Consult*, innovation service, scal* up, legal*, decision*, insurance*, financial report*, report* servic*, financial servic*, business advis*, data-driven*, marketing	Consulting, Financial Services, FinTech, Trading Platform, Market Research, Advertising, Marketing
Research and innovation	research*, Innovation servic*, Artificial Intelligence research, AI research, knowledge broker*, research broker*, science, scientist*	
Governance and ethics	Governance, ethic*, privacy, female*, woman*, indigenous,*securit*, Data govern*, data privacy, cyber*	GovTech, Information Services, Cyber Security, Government, Military, National Security, Network Security
Skills and training	skills, training*, workforce*, learning, upskill, workforce capabilit*, educat*, employee assist*, recruit*	Continuing Education, Corporate Training, E-Learning, EdTech, Education, Edutainment, Higher Education, MOOC, Personal Development, Primary Education, Secondary Education, Skill Assessment, STEM Education, Training, Tutoring, Vocational Education

*Used as a common wildcard symbol to broaden the search to include the words that start with the same letters.

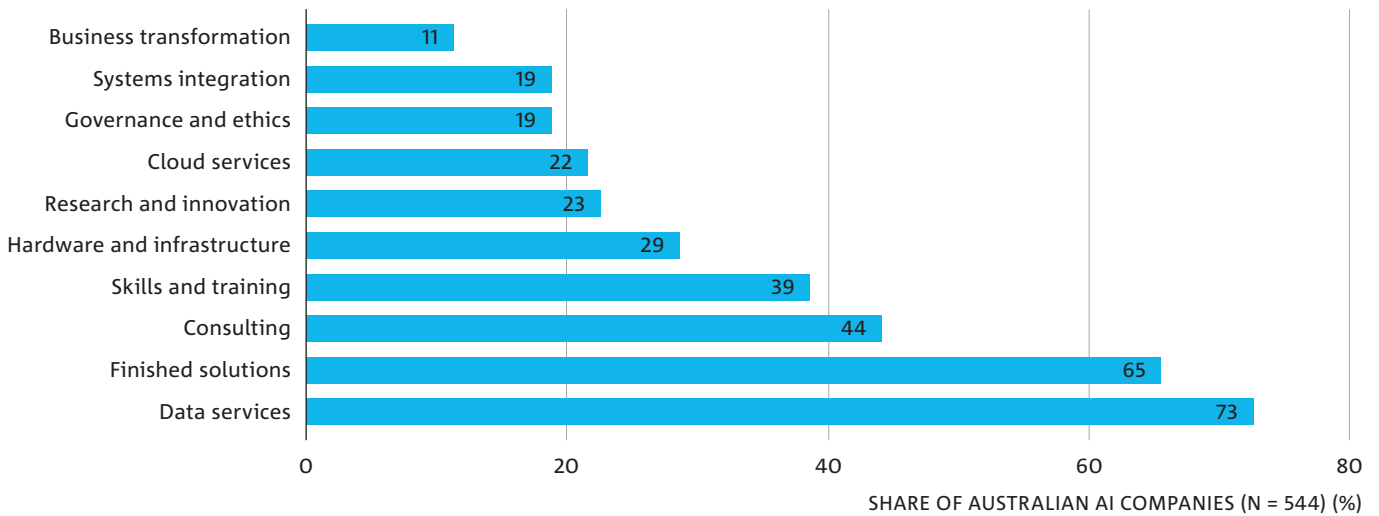
Product and service offerings of Australian AI companies

To understand the capabilities of the Australian AI ecosystem, we applied the NAIC taxonomy of AI product and service offering categories to the company descriptions. We incorporated the results of the NAIC survey (CSIRO, 2023) and the Crunchbase industry group classifications (Crunchbase, 2023b) to better define what capabilities each company contributes to the Australian AI ecosystem. Each Australian AI company was classified into at least one of the ten AI product and service offering categories.

Of the 544 Australian AI companies identified in this analysis, 395 (73%) provide capabilities in data services. Data services include expertise for the utilisation of data to develop and optimise AI capabilities, including data analysis and management. This component of AI capability includes providers of DaaS, data mining, visualisation and image and speech recognition, among others.

A large share of the companies (65%, 356 companies) are also classified as providers of finished solutions, which include ready to use AI applications (e.g., platforms) that enable businesses to adopt and implement AI technologies. Finished solutions providers also offer AI services to companies to help solve business challenges, including end-to-end design, implementation and maintenance of AI technologies for specific business use cases.

Roughly every two out of five AI companies are engaged in consulting and over 200 companies provide capabilities in skills and training. Skills and training providers enable individuals and organisations to learn and upskill for new workforce capabilities in AI-related domains. Another leading share of AI capabilities is in the domain of AI governance and ethics (19%), which includes companies actively promoting diversity and inclusion in the industry.

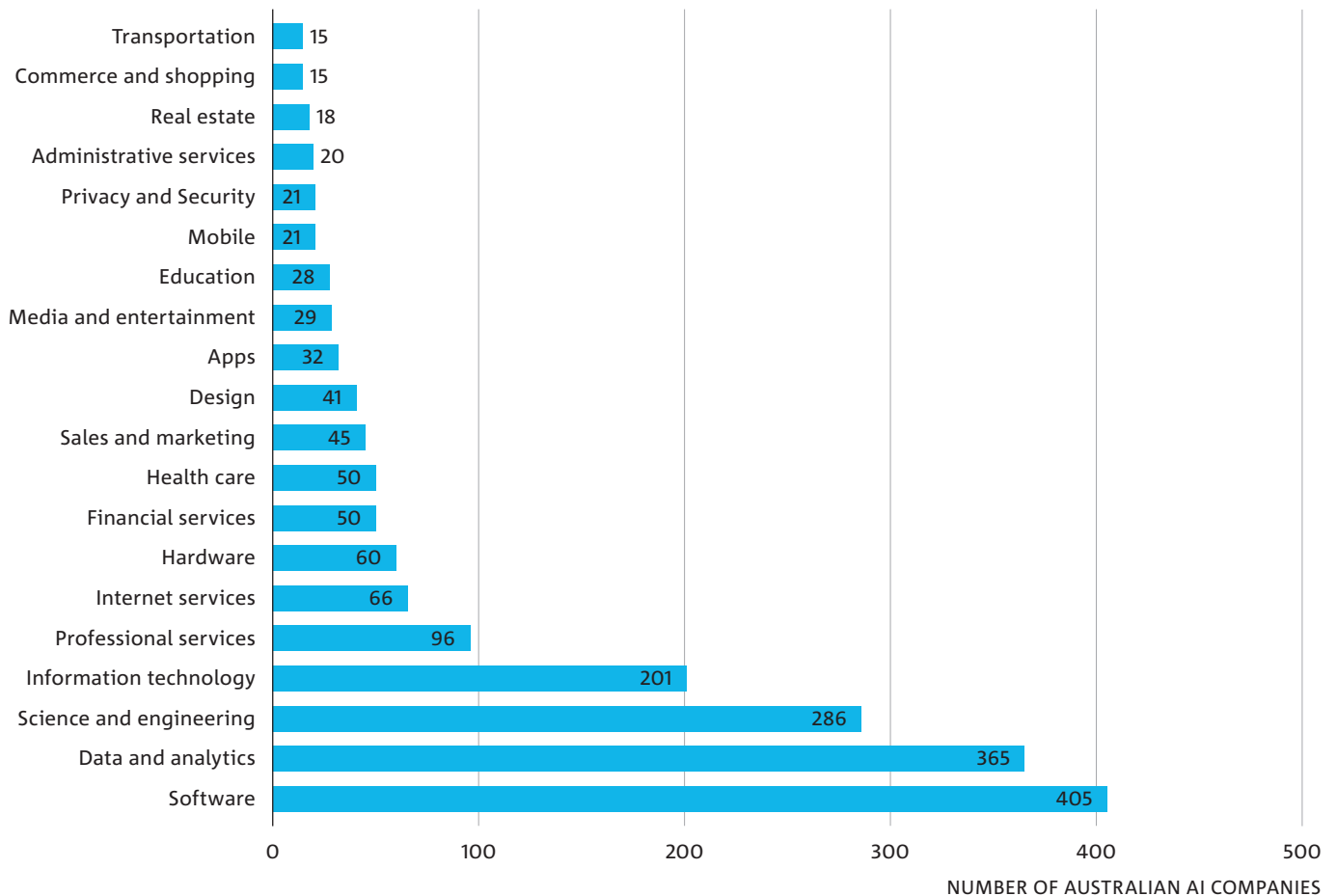


Capabilities each company contributes to the Australian AI ecosystem

AI companies by industry grouping

We used industry groupings available in commercial databases to map AI companies by industry group. Based on Crunchbase industry group taxonomy, 88% of Australian AI companies are classified as software providers and 79% of companies work in data and analytics.

This result is not surprising given the nature of AI development and adoption. Importantly, 62% of AI companies are also in the science and engineering domain, which might reflect innovation, research and development activities. Beyond this, the largest share of AI companies are working in information technology (IT), professional services, financial services and healthcare.

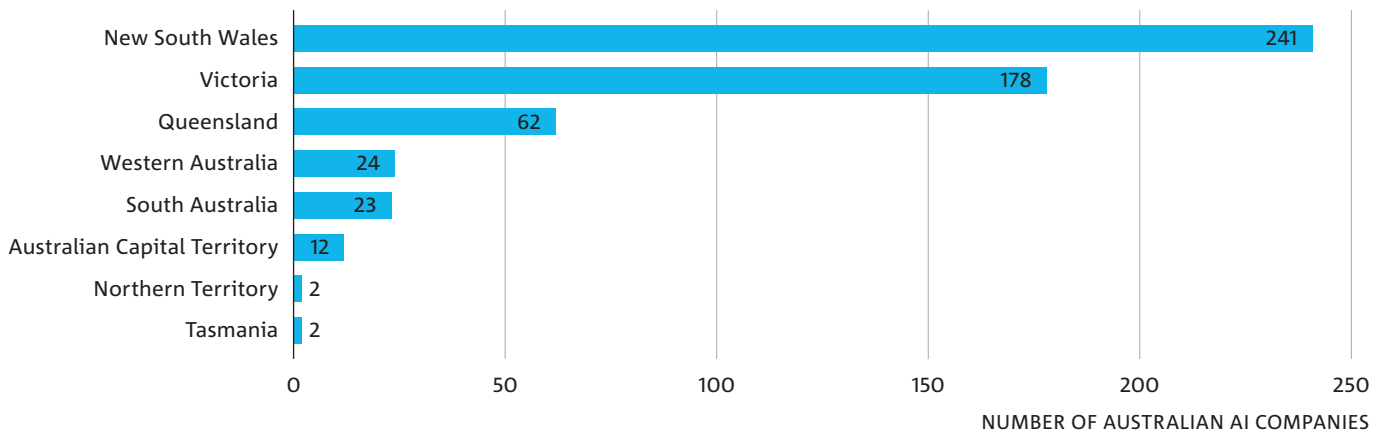


Top 20 industry groups for Australian AI companies (n = 461)

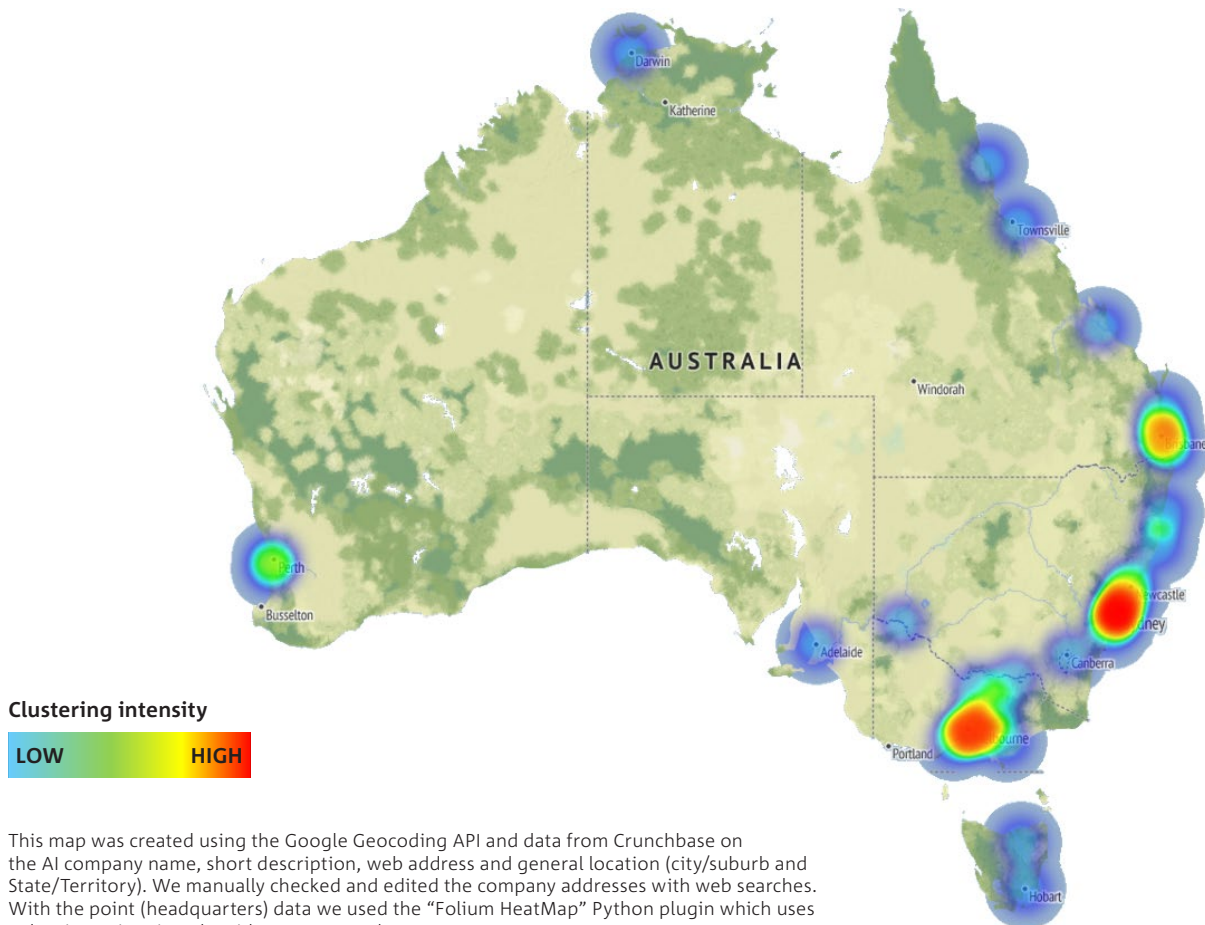
Note: A total of 461 Australian AI companies had available data on industry group classification and were included in this analysis. One company can have multiple industry groups, so it would be counted across multiple industry groups.

Geographic patterns of AI companies

We mapped the locations of AI company headquarters across Australia. Australian AI companies are located in all States and Territories, with the majority in New South Wales, Victoria and Queensland. The following heat maps show the intensity of clustering. While the most intense clusters are in Australia's capital cities, regional areas also feature.



Locations of AI company headquarters across Australia

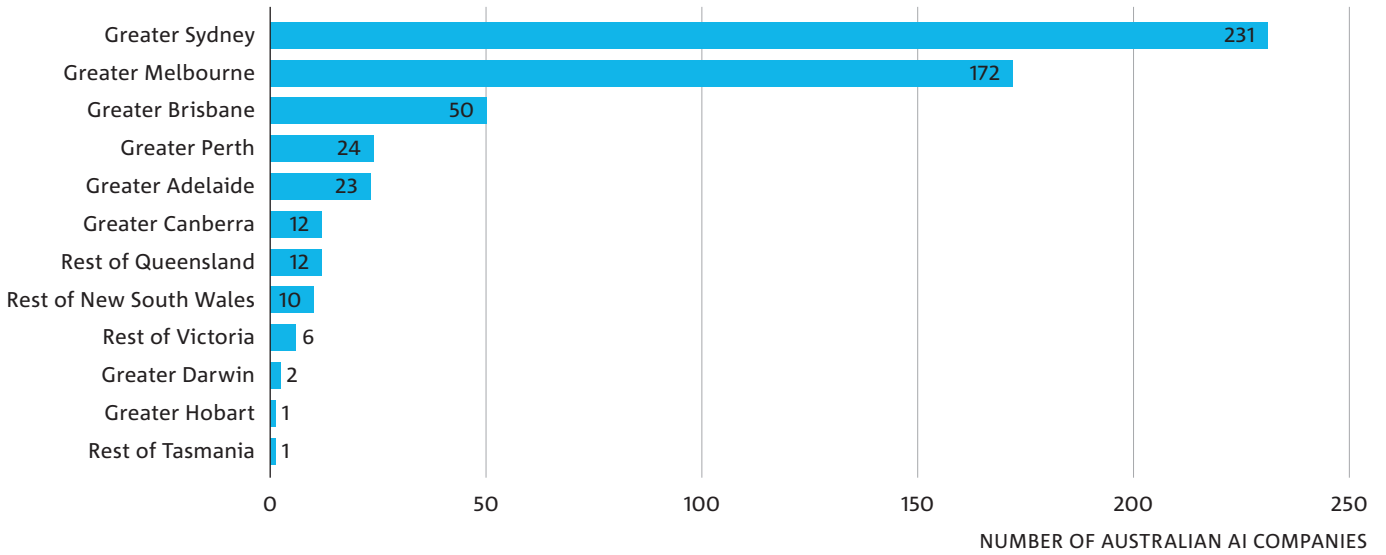


Clustering intensity
LOW HIGH

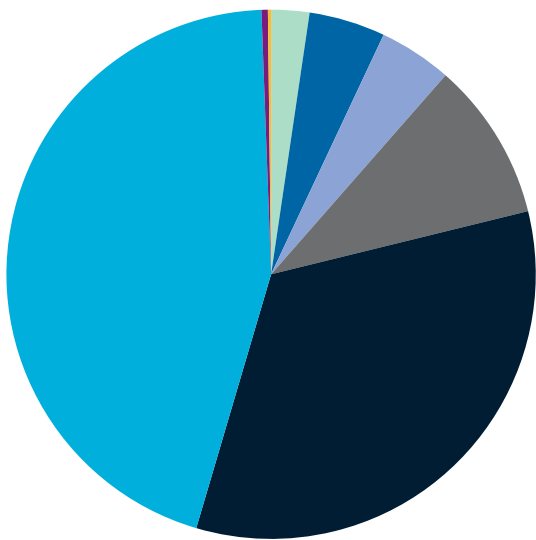
This map was created using the Google Geocoding API and data from Crunchbase on the AI company name, short description, web address and general location (city/suburb and State/Territory). We manually checked and edited the company addresses with web searches. With the point (headquarters) data we used the "Folium HeatMap" Python plugin which uses a density estimation algorithm to create a heatmap.

Map tiles by Stamen Design, under CC BY 3.0. Data by © OpenStreetMap, under CC BY SA.

While most Australian AI companies are located in greater capital cities areas, 29 are in regional areas.

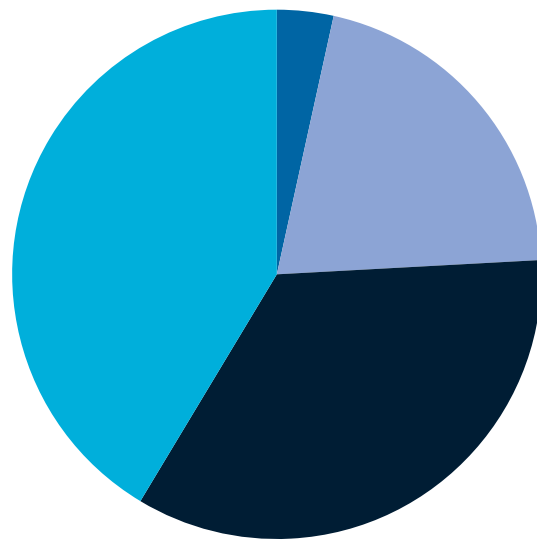


AI companies by location



- Greater Sydney (231)
- Greater Melbourne (172)
- Greater Brisbane (50)
- Greater Perth (24)
- Greater Adelaide (23)
- Greater Canberra (12)
- Greater Darwin (2)
- Greater Hobart (1)

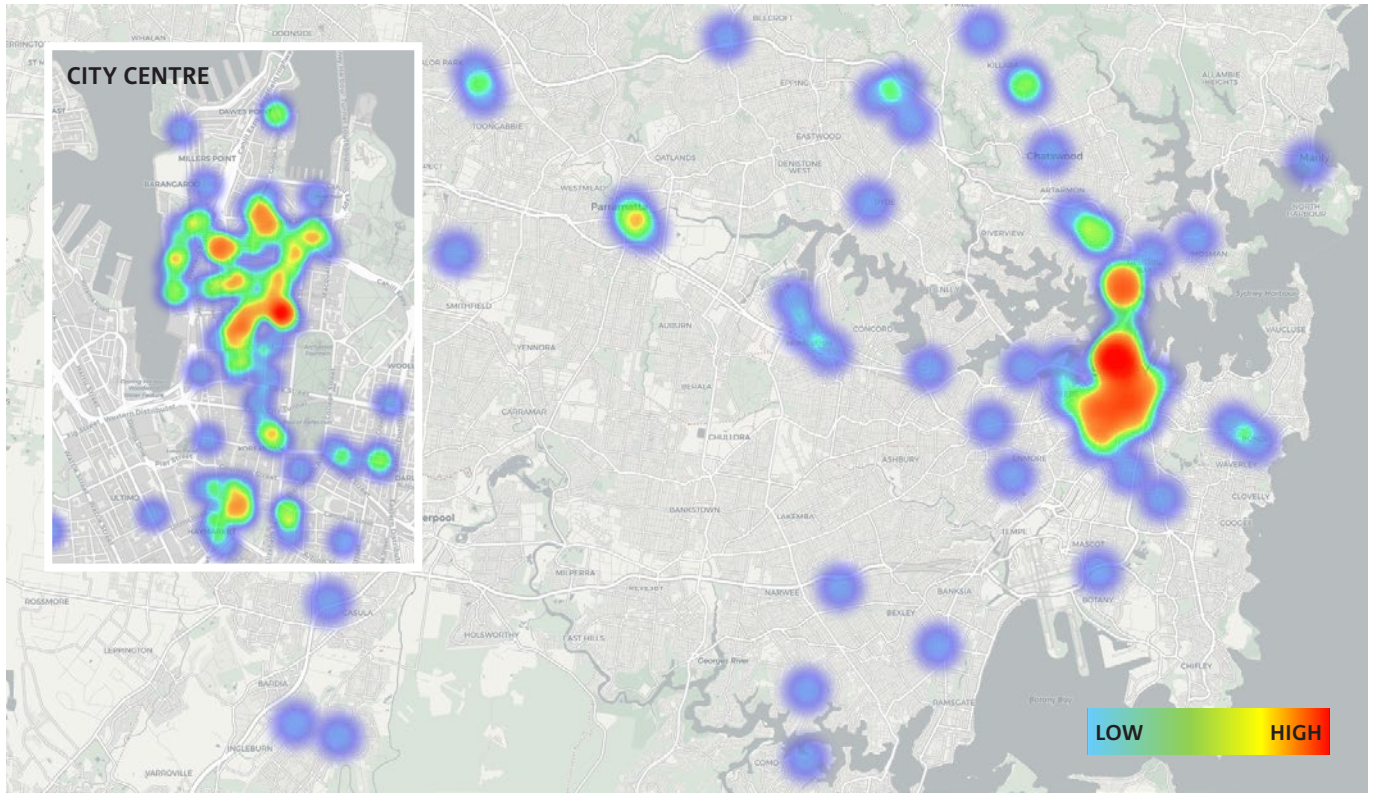
AI companies by greater capital city



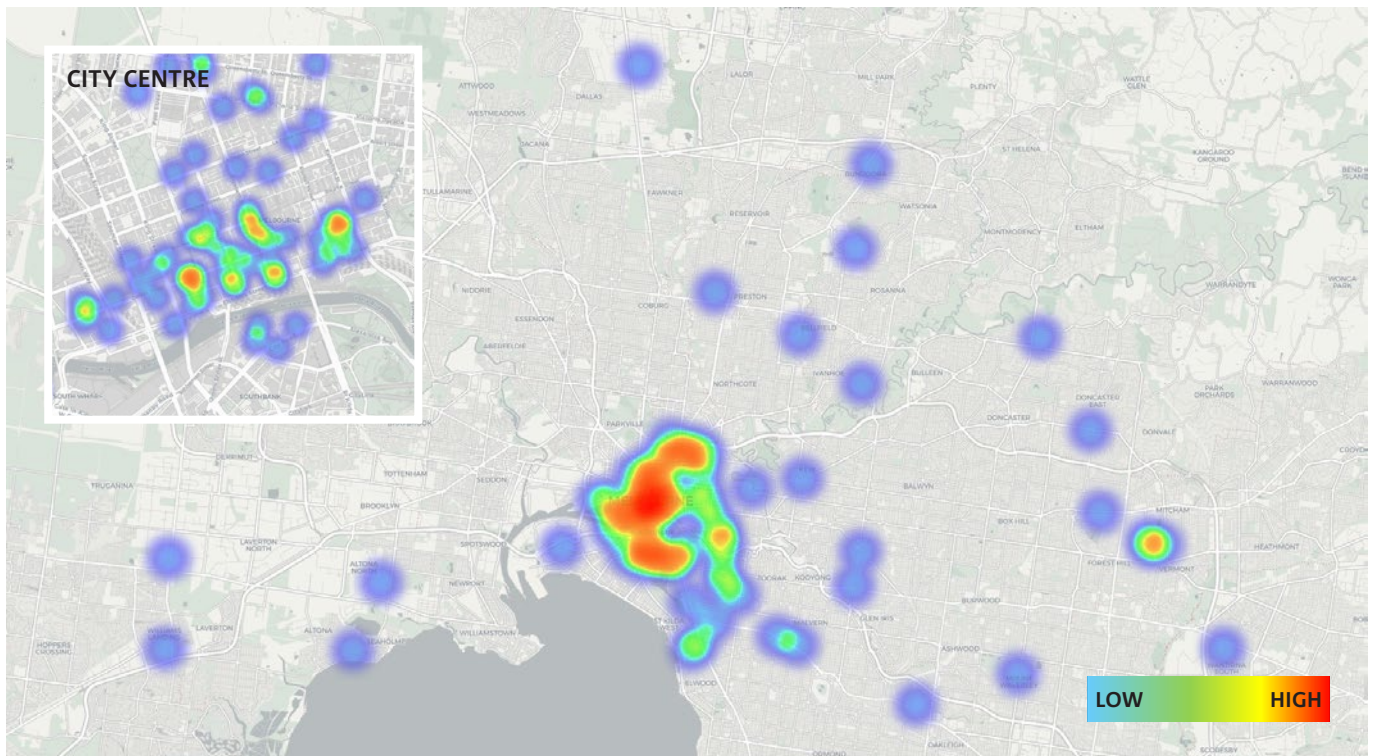
- Rest of Queensland (12)
- Rest of New South Wales (10)
- Rest of Victoria (6)
- Rest of Tasmania (1)

AI companies by regional areas

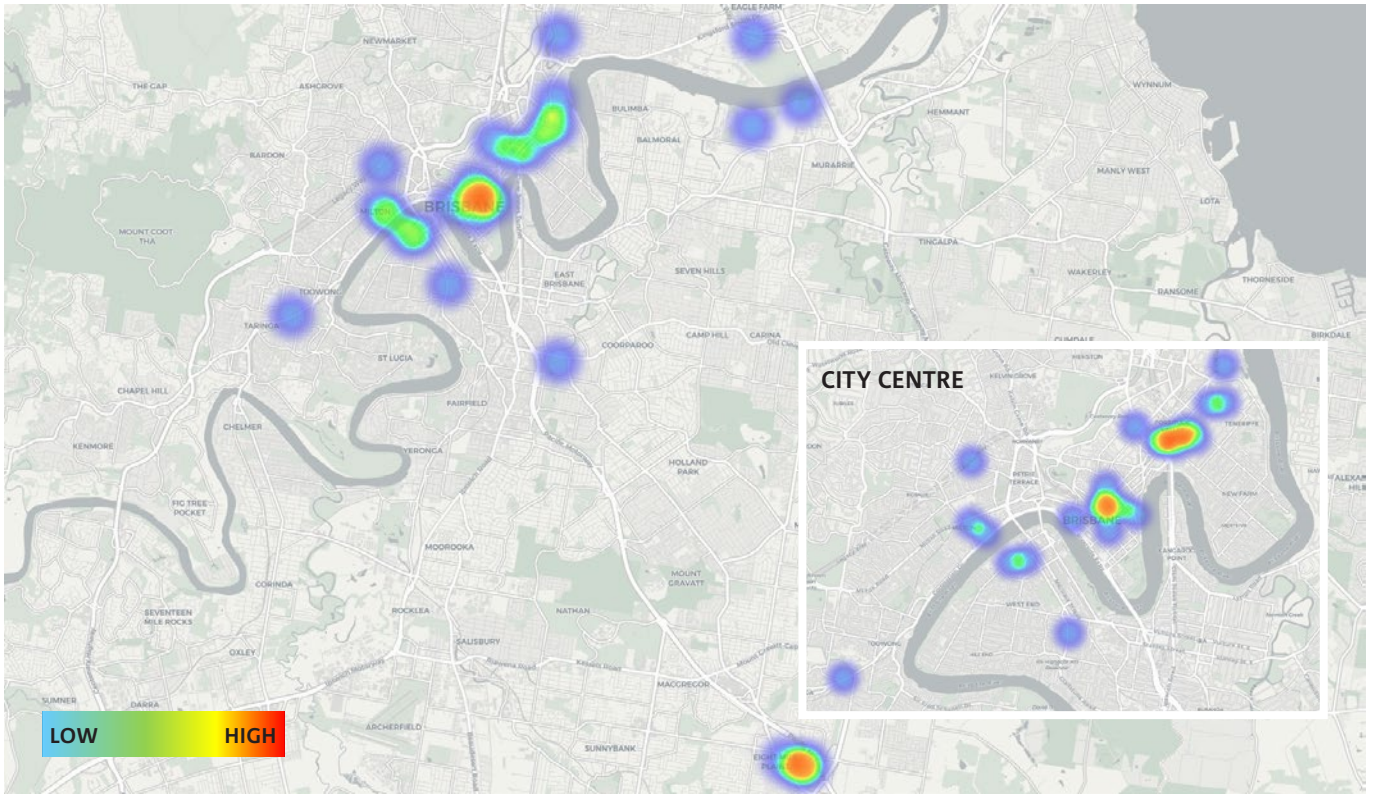
AI company heatmap – Greater Sydney



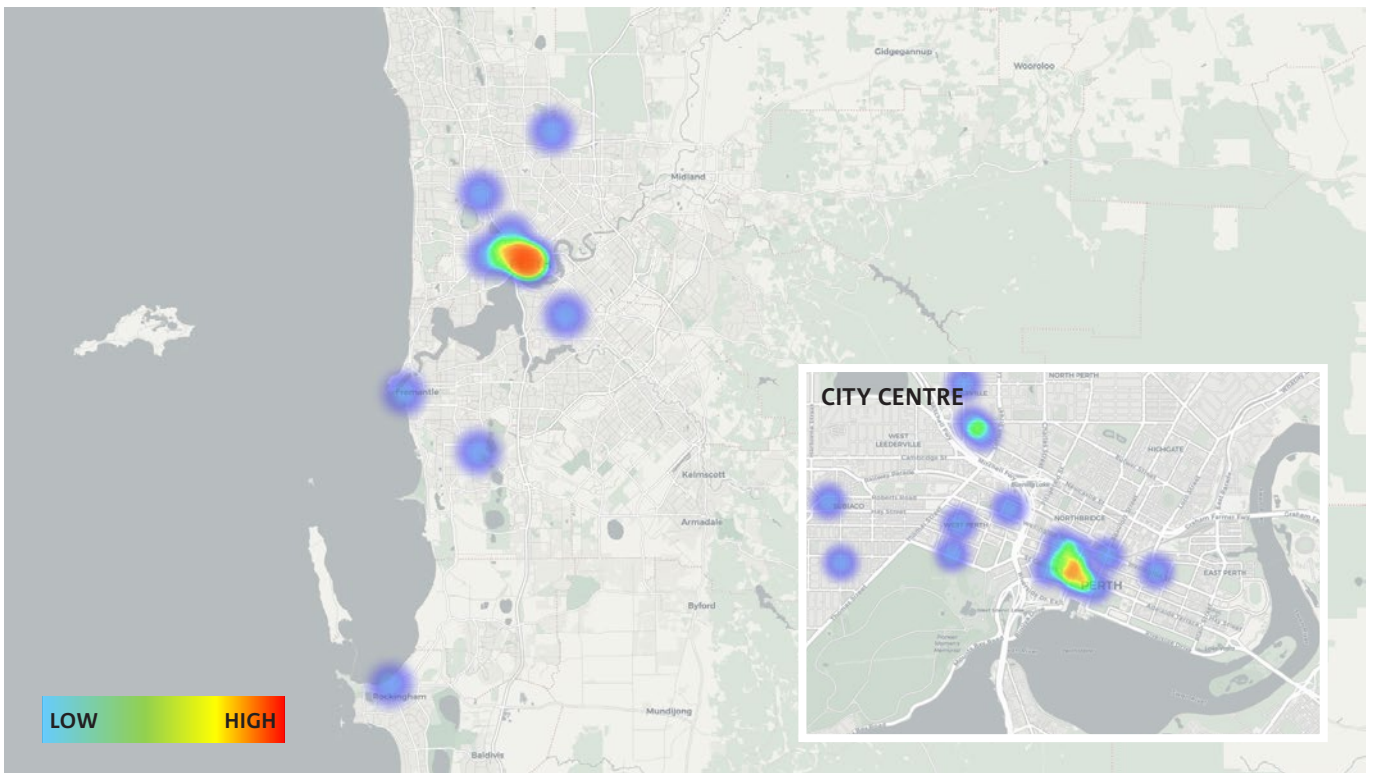
AI company heatmap – Greater Melbourne



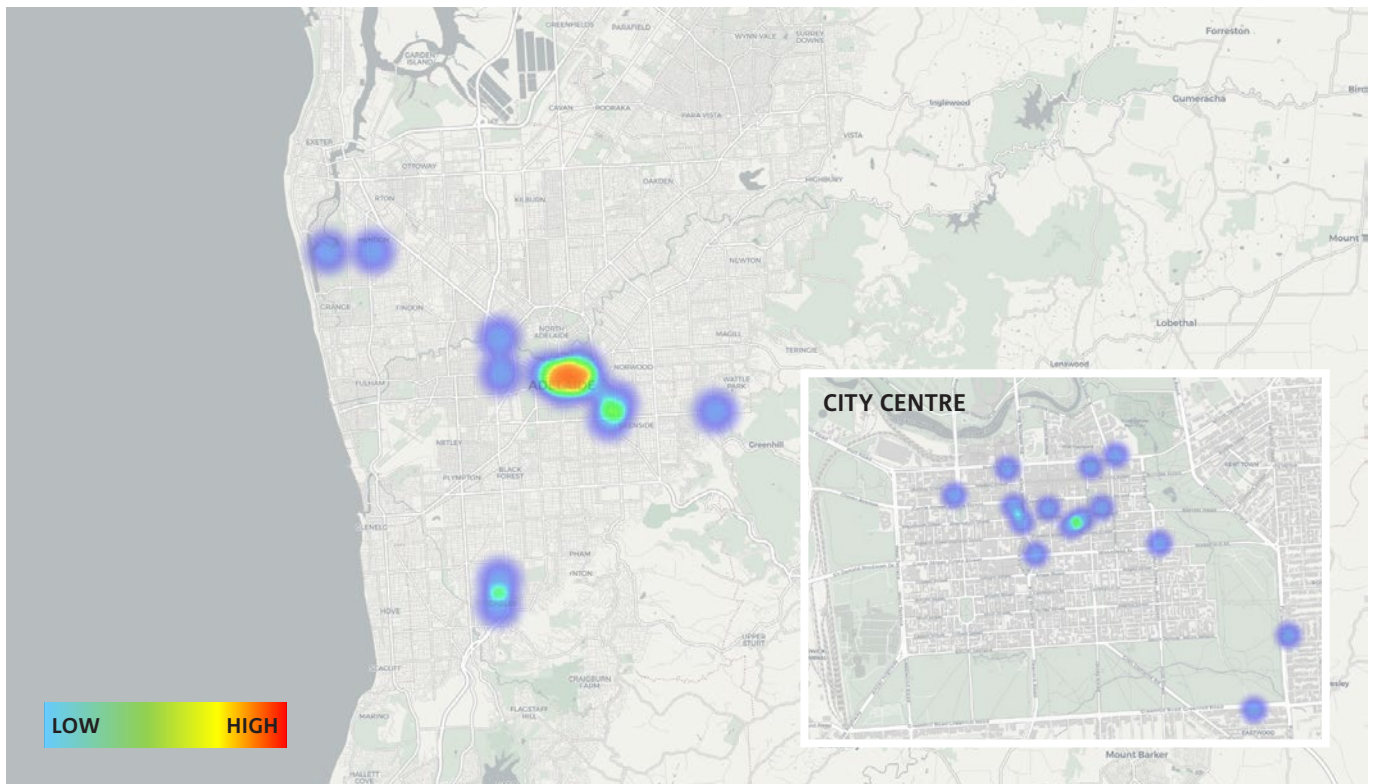
AI company heatmap – Greater Brisbane



AI company heatmap – Greater Perth

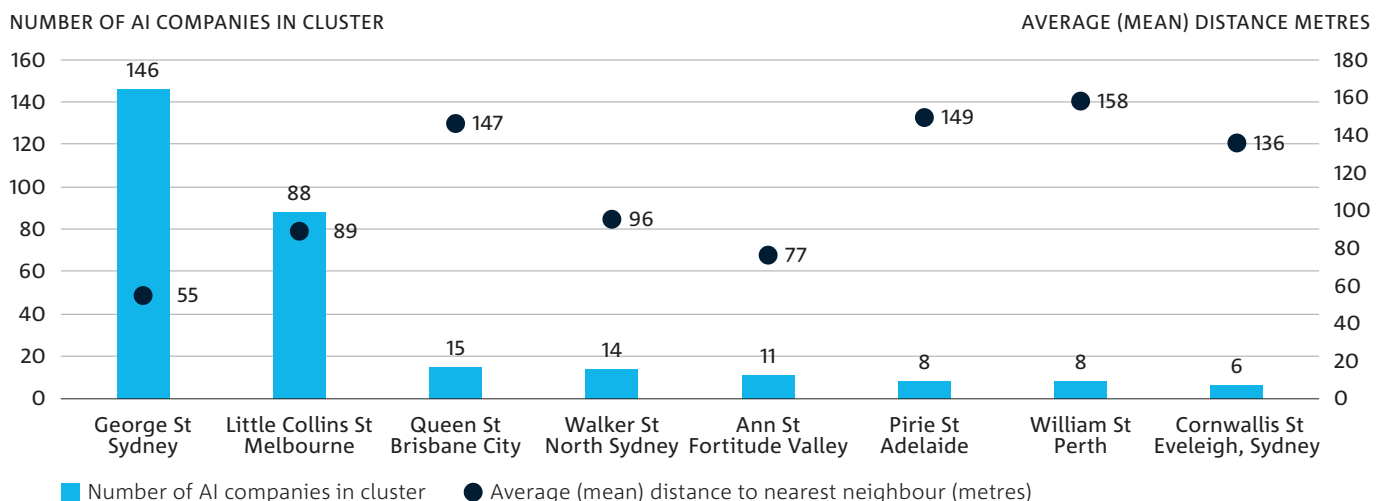


AI company heatmap – Greater Adelaide



Clustering intensity of AI companies in Australian cities – Nearest Neighbour Analysis

Clusters are hotspots of concentrated industry activity and have been shown to be important in the formation, growth and development of industries (Hajkowicz et al., 2023a; Cameron, 2022; Hajkowicz et al., 2021). We ran an unsupervised machine learning clustering algorithm² to identify locations in Australia where AI companies are geographically clustered. We found 8 clusters in Sydney, Melbourne, Brisbane, Perth and Adelaide containing 296 companies (54% of the total companies identified). The AI companies are located within proximity to each other, indicating tight clustering, with an average nearest neighbour distance of 80 m (range = 55 m to 158 m).



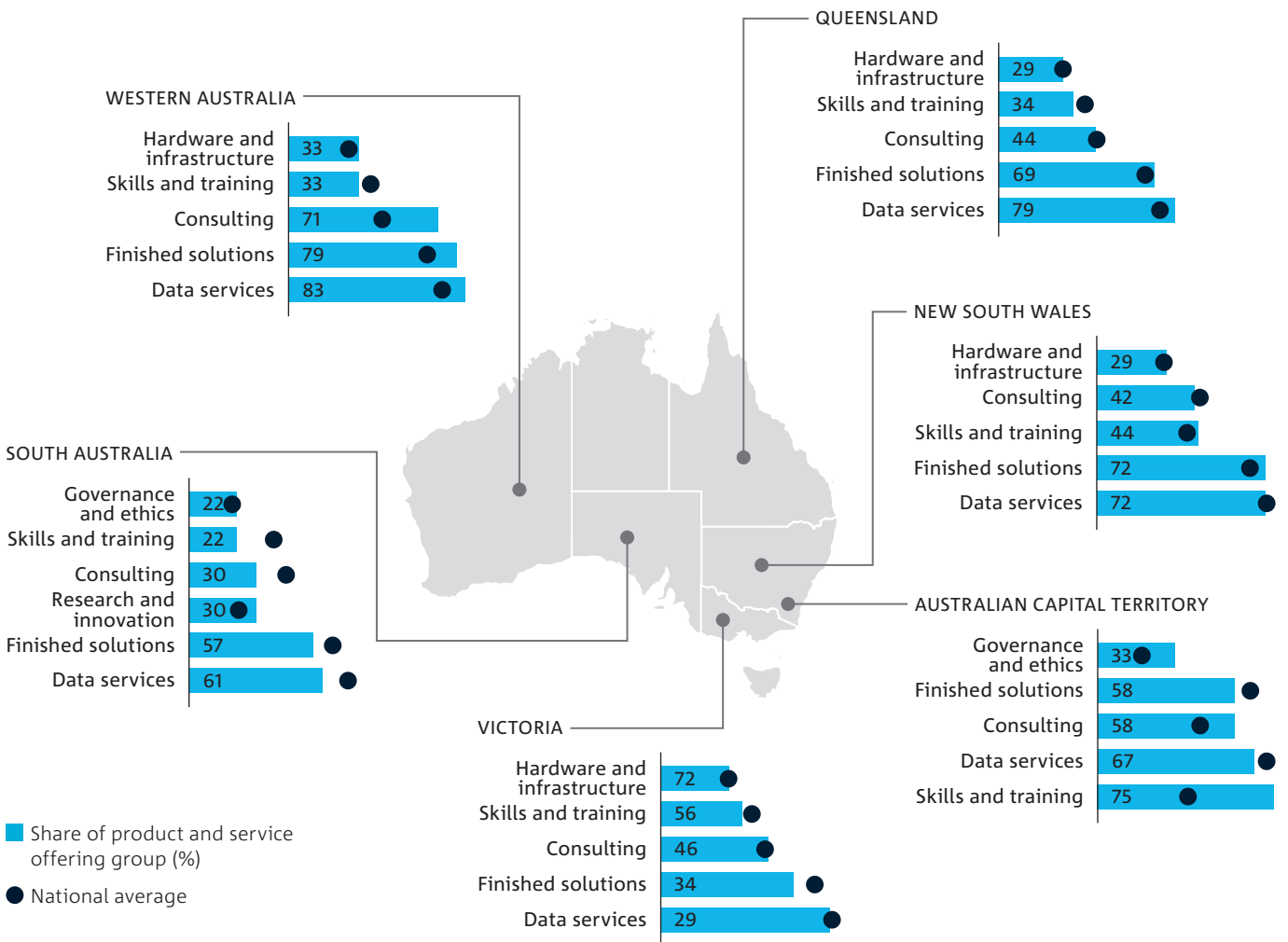
² The clusters are centred on these locations and were identified by an unsupervised machine learning algorithm called DBSCAN – density-based spatial clustering of applications with noise. We used DBSCAN input parameters of EPS at 400 metres and a minimum sample of 6.

Regional capability strengths

The graphs below show the top five capability categories for Australian States and Territories.³ Except for the Australian Capital Territory (ACT), the leading capability categories across states were data services and finished solutions.

In the ACT, 75% of AI companies had capabilities in skills and training, which was greater than the national average of 39%. The share of the companies contributing to AI capability in consulting was 58% – also above the national average. This is likely related to the service focus of ACT and a higher concentration of AI companies providing training and consulting for government and industry organisations.

South Australia had a higher than national-average concentration of research and innovation capabilities. This is likely related to the concentration of world-renown AI hub of research institutions in Adelaide, including Defence Science and Technology Group, the Australian Institute for Machine Learning, MITbigdata Living Lab by Massachusetts Institute of Technology, the Australian Research Centre for Interactive and Virtual Environments, and the Australian Cyber Collaboration Centre (Bratanova et al., 2022).



Product and service offerings by State and Territory³

³ The Northern Territory and Tasmania are not included in this analysis due to the limited number of companies.

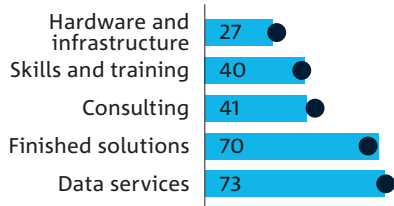
Capability strengths of eight AI clusters

The top five product and service offering categories for the eight identified AI company clusters are demonstrated below. Data services and finished solutions are among the top three categories across all eight clusters.

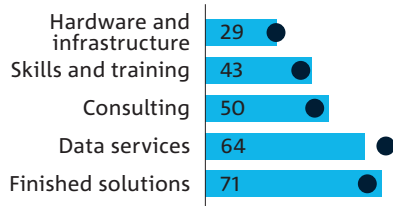
Consulting is relatively higher in Perth, Adelaide and Brisbane central business district clusters, while the Eveleigh cluster in Sydney has over half of member companies offering products and services in research and innovation.

Greater Sydney clusters

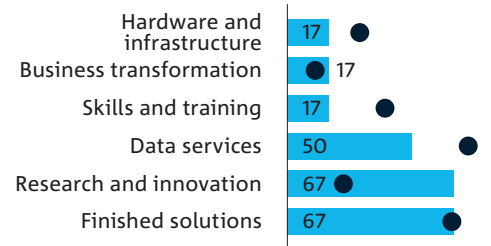
146 AI COMPANIES GEORGE ST, SYDNEY



14 AI COMPANIES WALKER ST, NORTH SYDNEY

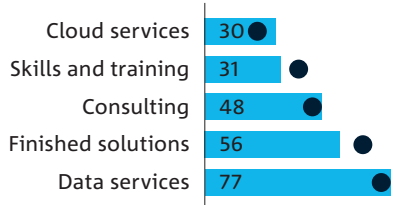


6 AI COMPANIES CORNWALLIS ST, EVELEIGH, SYDNEY



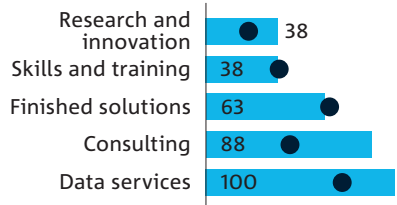
Greater Melbourne cluster

88 AI COMPANIES LITTLE COLLINS ST, MELBOURNE



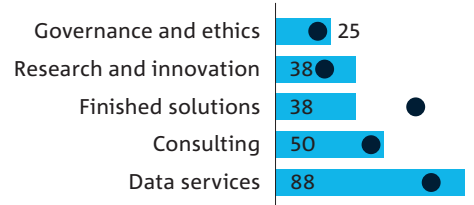
Greater Perth cluster

8 AI COMPANIES WILLIAM ST, PERTH



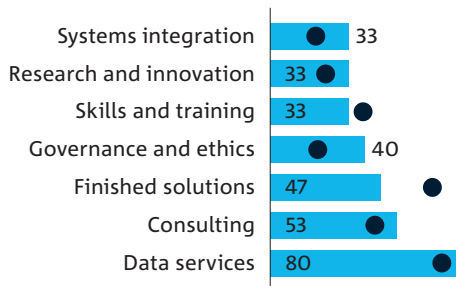
Greater Adelaide cluster

8 AI COMPANIES PIRIE ST, ADELAIDE

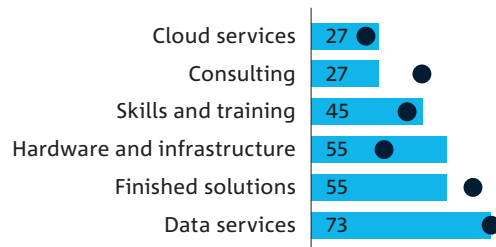


Greater Brisbane clusters

15 AI COMPANIES QUEEN ST, BRISBANE CITY



11 AI COMPANIES ANN ST, FORTITUDE VALLEY



■ Share of product and service offering group (%) ● National average

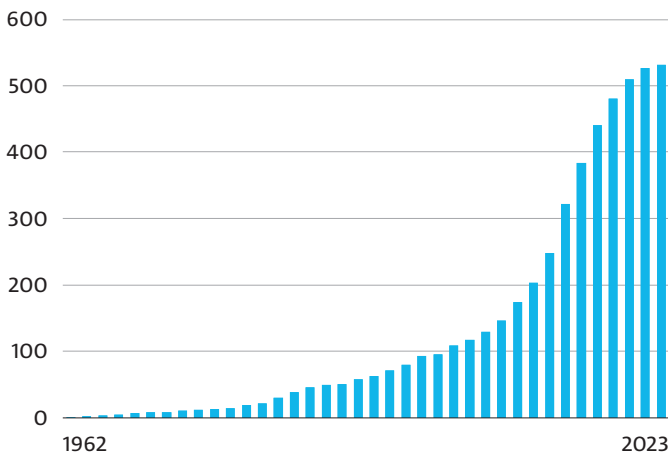
Product and service offerings by cluster

Company formation and maturity

Australia is home to 544 AI companies, which is comparable to other global leading AI countries. For example, having a larger population and economy, Canada recently reported 670 AI companies (University of Toronto, 2020). Until the last decade, the number of AI companies founded annually in Australia was growing at a slow pace, with an average of 5.5 companies added to the ecosystem annually between 1986 and 2013. This growth has since intensified, with 74 companies founded in 2017, 61 in 2018 and 57 in 2019. A similar pattern has been observed internationally, including the UK and Singapore.

The Australian AI business ecosystem is young, with 76% of companies (396 companies) founded in the last decade. The emerging nature of Australian AI companies is evident when compared to the broader Australian IT sector: the median company age is 6 years for AI companies and 13 years for IT companies. The Australian IT sector has been growing steadily, with growth intensifying in the last decade. Growth in AI companies is skewed more sharply towards the last 5 years, with 39.2% of Australian AI companies founded in 2018–2022, compared with 14.8% of Australian IT companies (Crunchbase, 2023a).

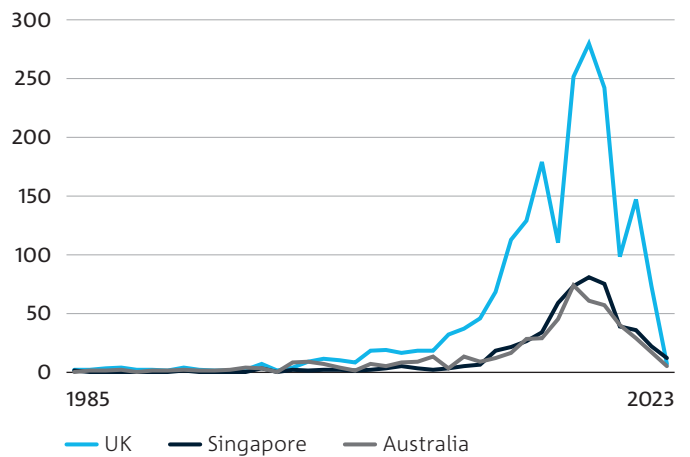
NUMBER OF AUSTRALIAN AI COMPANIES



The cumulative number of Australia AI companies has intensified in the last decade

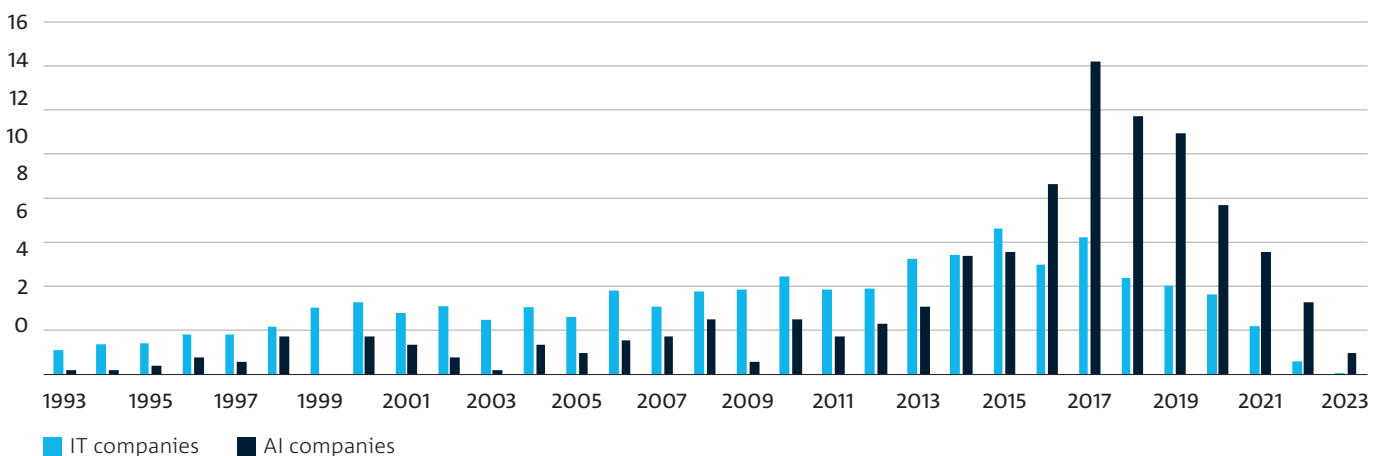
Note: Foundation year data was only available for 531 of the total 544 Australian AI companies identified in this analysis.

COUNT OF NEW AI COMPANIES



The United Kingdom and Singapore have shown similar temporal growth patterns to Australia

SHARE OF AUSTRALIAN COMPANIES IN EACH SECTOR (%)



Share of Australian IT and AI companies by founding year

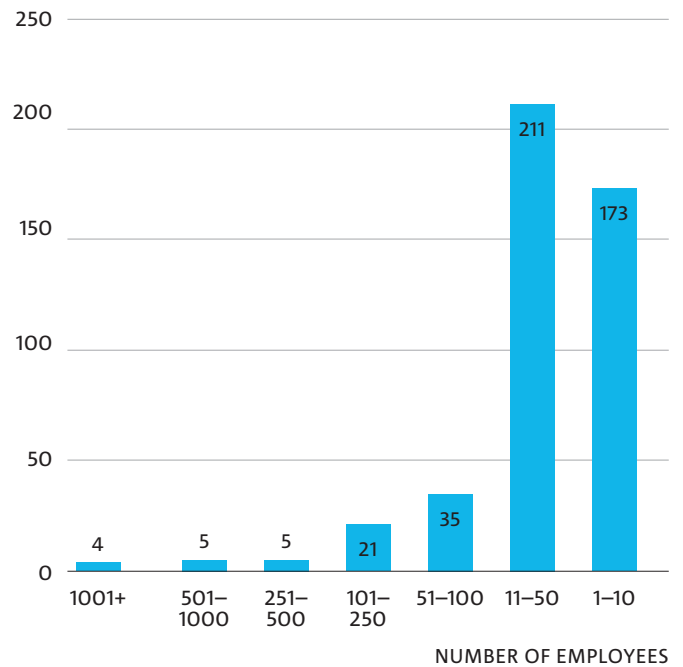
Note: The total count of Australian companies with data on the foundation year was 521 for AI companies and 6,772 for IT companies (1993–2023).

Publicly listed Australian AI companies

Our analysis revealed 13 Australian publicly listed AI companies trading on the Australian Stock Exchange and internationally (UK, USA). The total market capitalisation of these companies is approaching \$73 billion. All companies operate in the IT sector with a specific industry focus. Five out of 13 companies develop solutions for the healthcare industry, two operate in the fields of energy and the environment and one in transportation. While these companies operate across multiple Australian offices and internationally, their headquarters are in Victoria (6 companies), New South Wales (4), Western Australia (2) and the ACT (1).

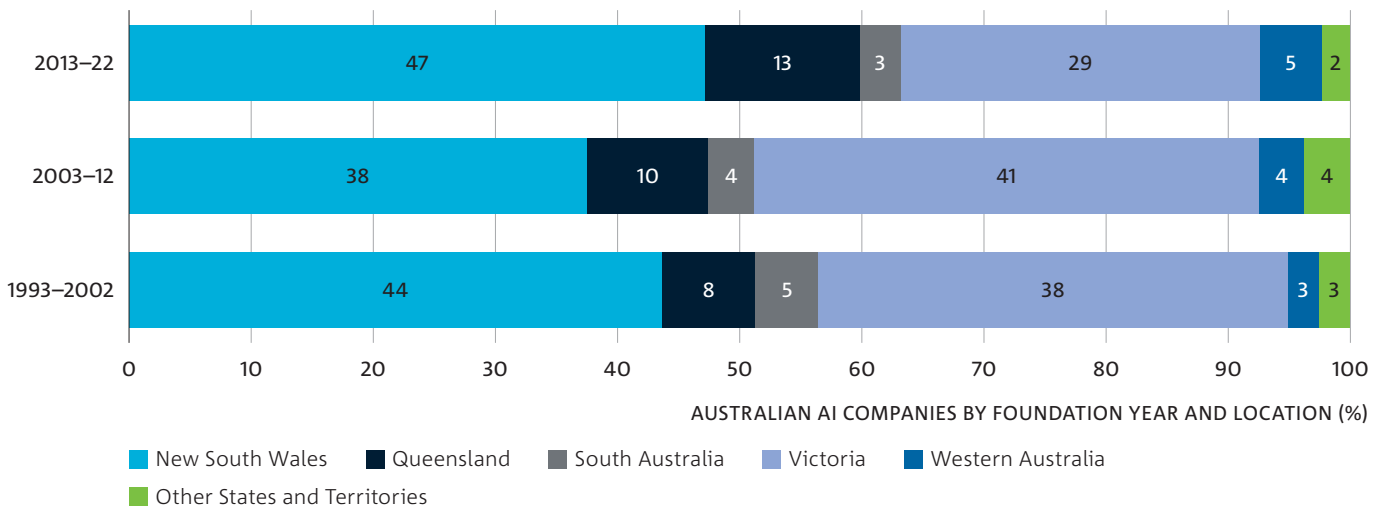
A large majority of Australian AI companies are headquartered in New South Wales, with almost every second AI company founded in 2013–22 located there. These companies are proportionally younger companies too. Victoria hosts a larger proportion of more mature AI companies, with 40% of Australian AI companies founded in 1993–2012 and operating today headquartered in Victoria.

NUMBER OF AI COMPANIES



Most Australian AI companies have 50 employees or less

Note: The total count of Australian AI companies with data on the number of employees was 454 (out of 544 companies included in this analysis).

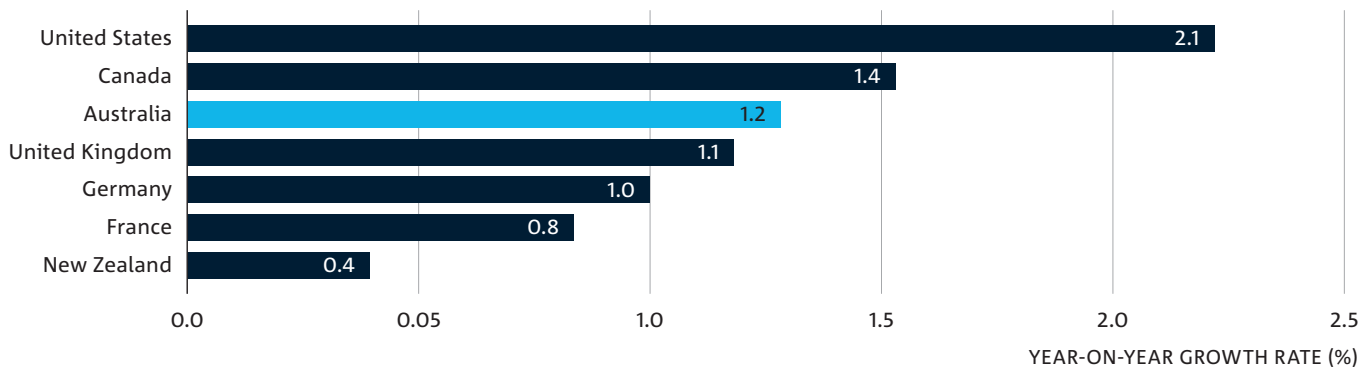


New South Wales has a larger share of younger AI companies, with Victoria home to more mature AI companies

Jobs and skills demand

The demand for AI-related skills is growing in Australia and internationally. In 2022, 2.1% of all job postings in the USA were AI-related (up from 1.8% in 2021). Australia is among the global leaders in terms of AI job postings, with 1.2% of all job postings in 2022 being AI-related.

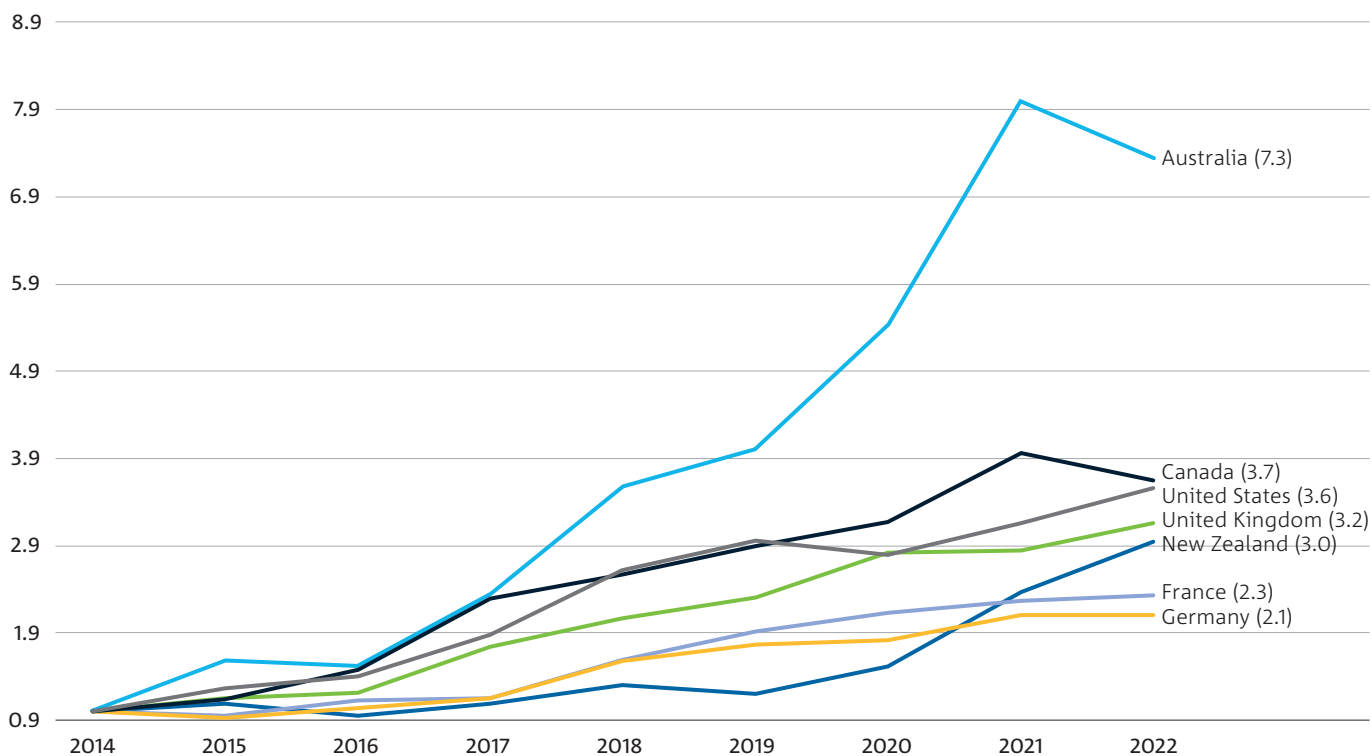
Demand for AI jobs has been going faster in Australia relative to international comparisons, with the share of AI-related job postings increasing by more than 7 times between 2014 and 2022.



Share of AI job postings as a percentage of all job postings (%), 2022

Data source: Stanford AI Index report 2023 (Maslej et al., 2023).

GROWTH RATE IN AI JOB POSTINGS (2014 = 1)

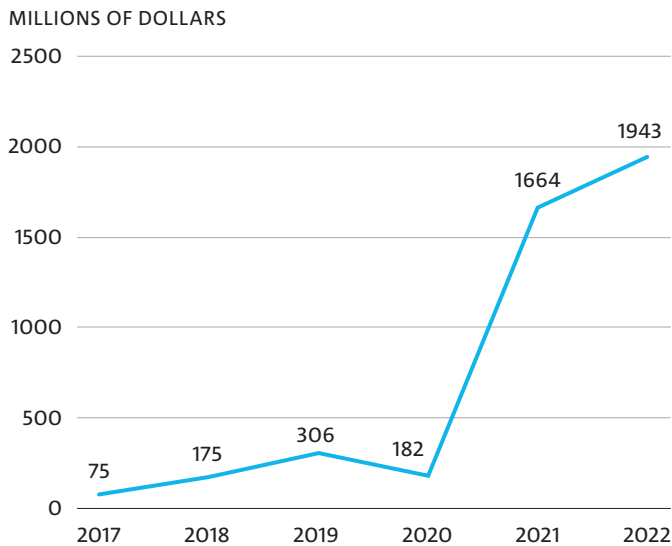


Growth rate in AI job postings relative as percentage of all job postings

Data source: Stanford AI Index report 2023 (Maslej et al., 2023).

Investment trends

AI investment has seen substantial growth over the past decade globally and in Australia. In 2022, private investment in AI globally was \$132.3 billion (US\$91.9 billion) – 18 times higher than it was in 2013 (Maslej et al., 2023). This growth dropped off for the first time in 2022, with global private investment in AI, declining by 26.7% from 2022 to 2021 (Maslej et al., 2023). Conversely, private investment in AI in Australia spiked in 2021 and remained high in 2022. Australia was ranked in 11th place for global ranking by private investment in AI in 2022, which reflected an improvement from 14th place over the period 2013–21.



Australian investment in AI

Data source: Stanford AI Index report 2023 (Maslej et al., 2023), Global AI Vibracy Tool (Stanford HCAI, 2023).

Venture capital (VC) investors in Australian AI companies

According to funding deals recorded on Crunchbase, the top five investors in Australian AI companies are as follows:

Flying Fox Ventures is a Victoria-based venture capital investment firm founded in 2021. The company invests in early-stage companies in technology, business-to-business and business-to-consumer sectors in Australia and New Zealand.

Artesian VC is a global company with offices in Sydney, Melbourne and Adelaide. The company was established in 2004 and specialises in public and private debt, VC and impact investment strategies.

Blackbird is a VC firm that incubates and invests in early-stage software technology companies.

Main Sequence is a Sydney-based VC firm co-founded by CSIRO and the Australian Government in 2017. The firm focuses on investment in deep tech and frontier technology companies and leveraging world-leading research from Australian institutions.

Carthona Capital is a VC investment firm that is based in Sydney and invests globally. The firm was founded in 2014 and focuses on pre-seed, seed and Series A companies.

2

Research and development

Information about research publishing by Australia's universities and research institutes working on AI and information about AI patent application trends.



Methods and source data

For our analysis of research publishing, intellectual property patents and Australian research institutes, we draw upon data from The Lens, Scopus by Elsevier and AI search phrases from the OECD. We use these datasets to identify AI-related scholarly publishing (peer-reviewed books, book chapters, journal papers and conference papers) using a bibliometric analysis approach. We apply a similar bibliometric analysis as approach used in Hajkowicz et al. (2023b).



Revealed technology advantage metric and statistical test

We adopt the revealed technology advantage (RTA) metric to assess the level of specialisation Australia has in application domains of AI. The RTA is a metric proposed by the OECD (2023) to measure technological specialisation and assess the comparative advantages a country or a jurisdiction might have in a particular technology. Countries/jurisdictions will typically seek to invest in technological capabilities where they have a comparative advantage (i.e., those denoted by a high RTA).

An illustration of how the RTA is calculated is given below for a hypothetical example where a country has 120 AI papers in research field X and 1,000 papers in research field X in total. This compares to the world which has 30,000 AI papers in research field X and 1,000,000 papers in research field X in total. This would yield a high RTA score of 4. The calculations are as follows:

$$\text{RTA} = \frac{\frac{\text{Number of AI papers in field_x in country}}{\text{Number of papers in field_x in country}}}{\frac{\text{Number of AI papers in field_x in world}}{\text{Number of papers in field_x in world}}}$$

$$\text{RTA} = \frac{\frac{120}{1000}}{\frac{30,000}{1,000,000}}$$

$$\text{RTA} = \frac{12\%}{3\%}$$

$$\text{RTA} = 4.0$$

While there is no clear cut-off about what represents a significant RTA, a value of 4 or greater would typically indicate an area of highly specialised technological capability. In this hypothetical case we would probably infer that the country has specialised AI capability in research field X. RTAs are similar to location quotients in economic geography where values above 1.2 to 1.5 are often considered evidence of significant specialisation (Crawley et al. 2013).

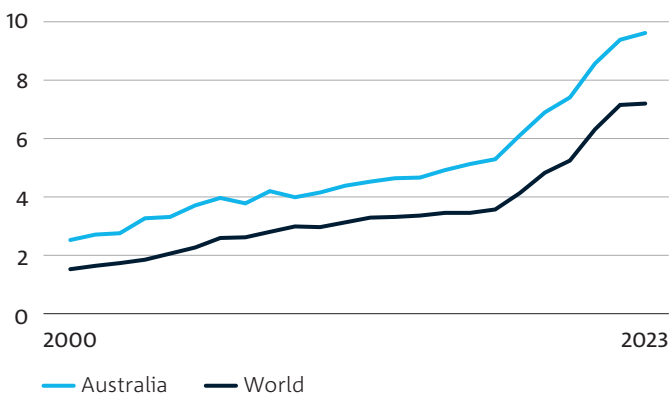
In our analysis, we apply a statistical technique developed by Crawley et al. (2013) to identify ranges above and below the estimated RTA score. Originally developed for use in the calculation of location quotients in economic geography, this statistical technique handles cases where a small number of publications might yield a high score but also carries high uncertainty and is therefore not significant.

Knowledge creation (research publishing trends)

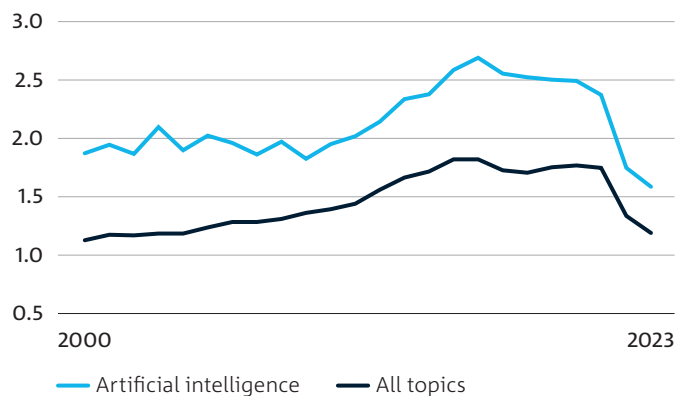
Since 2000, Australian researchers have published 92,940 peer-reviewed journal articles, conference papers, books and book chapters that refer to AI technologies in the title, abstract or keywords. This represents 5.5% of our total publishing. The intensity of AI publishing has increased over time, with AI publishing accounting for 9.6% of all publishing today compared with 2.5% in 2000.

Compared to other countries Australian researchers have higher AI adoption rates, with 9.6% of Australian research publications using or developing AI technology versus a global average of 7.2%. Since 2000, Australia created 2.2% of AI-related global publications, compared with 1.5% of global research publications on all topics, demonstrating Australia's above-average contribution to global AI research. While Australia's publications grew in absolute terms from 2021 to 2022, Australia's share of global publications declined due to a rapid increase in global publishing driven by other countries, such as China.

AI RESEARCH PUBLISHING INTENSITY (%)

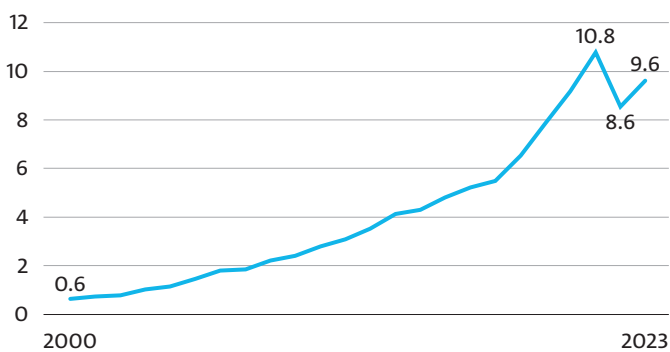


AUSTRALIAN SHARE OF GLOBAL PUBLISHED RESEARCH (%)



Share of all peer-reviewed publishing on the topic of AI

NUMBER OF AUSTRALIAN AI PUBLICATIONS ('000)

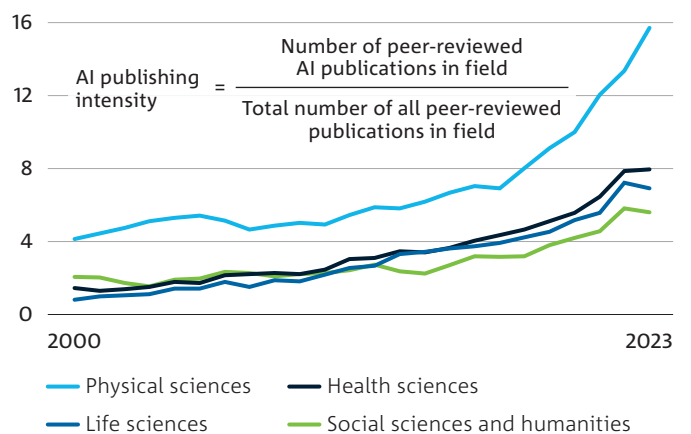


The volume of AI research publications with an Australian author has been growing, except for the pandemic when there was a downturn in publishing in most fields

Note: According to The Lens, overall publishing in all fields saw a slowdown during 2021–22 associated with the COVID-19 pandemic. Data for 2023 is an incomplete year with data up until June 2023.

Australia's share of global peer-reviewed publishing

SHARE OF AUSTRALIAN PUBLISHING ON THE TOPIC OF AI (%)



AI publishing intensity has increased across all fields of research (first-level categories) in Australia, with the strongest growth in physical sciences

Note: The last data point is for 2023 and is based on data only from January to June 2023.

The footprint of AI in Australia across more granular subject groups

Over the past two decades, AI has established a strong position in practically all research fields in Australia, suggesting that Australian researchers are making use of AI to further innovation and problem-solving in their own field. Across the second-level ASJC subject fields, the areas that had the highest level of AI research publishing in 2023 were computer science, mathematics, decision sciences, environmental science and engineering.

Whilst these are research fields, they're likely to have some connection to cutting-edge technology innovation within associated Australian industries. For example, the "health professions" field is likely to capture much AI activity within the healthcare sector in Australia.

Percent share of Australian research publishing by second-level ASJC field

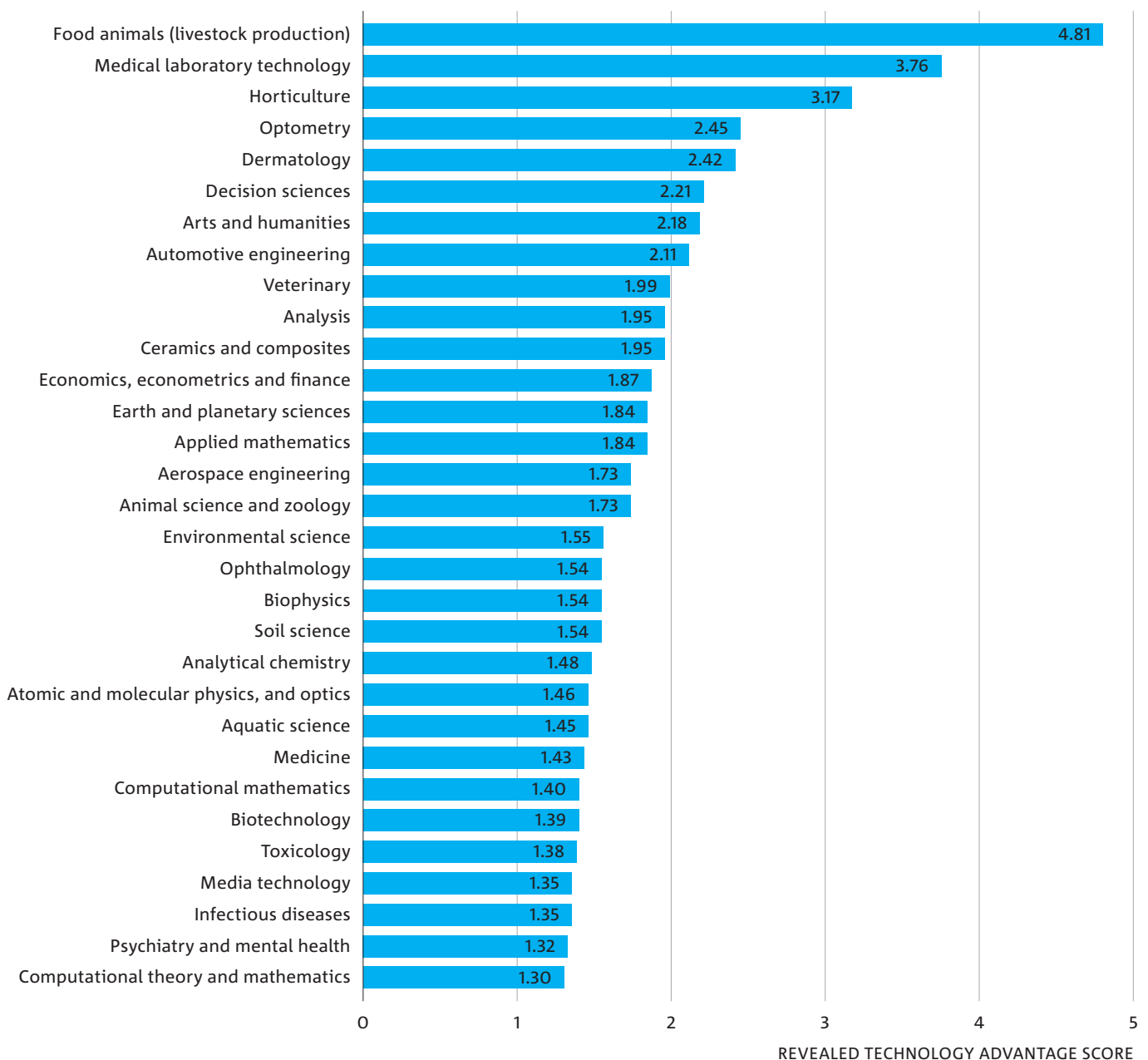
ALL SCIENCE JOURNAL CLASSIFICATION (LEVEL 2)	2000	2005	2010	2012	2014	2016	2018	2019	2020	2021	2022	2023*
Agricultural and Biological Sciences	0.9%	1.3%	1.7%	2.0%	2.5%	3.0%	3.6%	3.9%	4.3%	4.4%	6.6%	6.0%
Arts and Humanities	2.2%	1.6%	1.7%	2.1%	1.4%	1.8%	1.6%	2.5%	2.5%	2.6%	3.9%	2.8%
Biochemistry Genetics and Molecular Biology	0.7%	1.3%	2.2%	2.7%	3.6%	4.0%	4.4%	4.6%	5.4%	5.9%	7.5%	7.7%
Business Management and Accounting	2.9%	1.1%	2.9%	2.9%	2.5%	4.5%	4.6%	4.9%	5.4%	7.0%	6.4%	7.4%
Chemical Engineering	2.0%	1.9%	1.1%	1.5%	2.3%	2.6%	1.6%	2.3%	2.2%	2.7%	5.1%	5.5%
Chemistry	0.8%	1.4%	1.0%	1.4%	1.5%	1.7%	1.9%	2.3%	2.6%	3.6%	4.8%	4.6%
Computer Science	20.2%	22.7%	21.4%	24.1%	24.5%	27.0%	31.1%	32.7%	35.0%	39.5%	39.2%	40.3%
Decision Sciences	7.4%	7.4%	11.0%	11.8%	8.3%	12.7%	13.6%	12.6%	16.6%	18.7%	20.1%	21.3%
Dentistry	1.3%	3.2%	3.0%	2.0%	5.7%	2.3%	3.6%	3.4%	3.4%	8.7%	6.7%	4.0%
Earth and Planetary Sciences	0.9%	1.8%	1.7%	2.0%	2.9%	3.2%	3.9%	4.4%	4.8%	5.8%	8.0%	8.1%
Economics Econometrics and Finance	1.3%	2.1%	1.1%	1.0%	1.0%	1.2%	1.6%	2.5%	2.2%	3.1%	5.2%	4.3%
Energy	0.5%	3.1%	2.6%	3.1%	3.7%	4.5%	3.1%	4.5%	5.2%	5.9%	7.0%	9.5%
Engineering	5.1%	4.8%	5.3%	6.9%	7.0%	7.8%	8.5%	10.8%	11.8%	14.0%	15.0%	19.8%
Environmental Science	1.5%	2.2%	2.0%	2.2%	2.8%	3.1%	4.1%	4.4%	4.5%	5.1%	6.3%	6.3%
Health Professions	2.3%	0.7%	1.8%	2.3%	3.5%	3.6%	4.1%	5.5%	5.5%	7.5%	9.4%	10.7%
Immunology and Microbiology	0.5%	1.1%	2.0%	2.4%	2.9%	3.0%	2.7%	4.1%	3.9%	4.5%	5.4%	3.3%
Materials Science	0.8%	0.7%	0.8%	1.1%	1.1%	1.6%	1.8%	3.8%	3.9%	4.2%	4.7%	5.3%
Mathematics	8.7%	13.5%	12.9%	13.8%	12.8%	15.4%	16.2%	17.7%	18.9%	20.7%	24.1%	25.1%
Medicine	1.4%	1.8%	2.5%	3.1%	3.5%	4.1%	4.7%	5.2%	5.7%	6.5%	8.0%	8.1%
Neuroscience	1.6%	2.8%	3.5%	4.9%	5.4%	6.0%	6.4%	6.5%	7.6%	8.2%	10.1%	10.4%
Nursing	1.6%	0.9%	2.3%	3.2%	2.8%	3.7%	4.6%	4.5%	4.7%	5.0%	6.3%	6.2%
Pharmacology Toxicology and Pharmaceutics	0.7%	1.1%	1.5%	1.6%	2.3%	1.5%	3.9%	3.5%	4.3%	4.7%	5.8%	4.4%
Physics and Astronomy	1.4%	1.5%	1.4%	1.4%	1.9%	2.3%	3.6%	4.8%	5.4%	7.6%	8.1%	10.1%
Psychology	2.8%	3.6%	3.6%	5.6%	4.1%	5.4%	4.9%	5.1%	5.3%	4.9%	6.1%	6.2%
Social Sciences	1.1%	1.5%	1.5%	1.8%	1.7%	2.3%	2.4%	3.2%	3.5%	3.6%	5.4%	5.2%
Veterinary	0.4%	1.0%	1.8%	3.7%	3.4%	4.8%	3.3%	4.2%	4.0%	5.1%	7.5%	3.9%

*Includes data for January to June 2023.

Application domain specialisations

Of the 333 third-level ASJC research fields where AI is being applied, we identified 31 fields that reflect areas of significant specialisation for Australia and likely areas of comparative advantage. Areas of significant specialisation were identified as research fields with Australian research publishing RTA of 1.3 or greater and a lower bound of the uncertainty range of 1.1 at the 95% confidence interval.

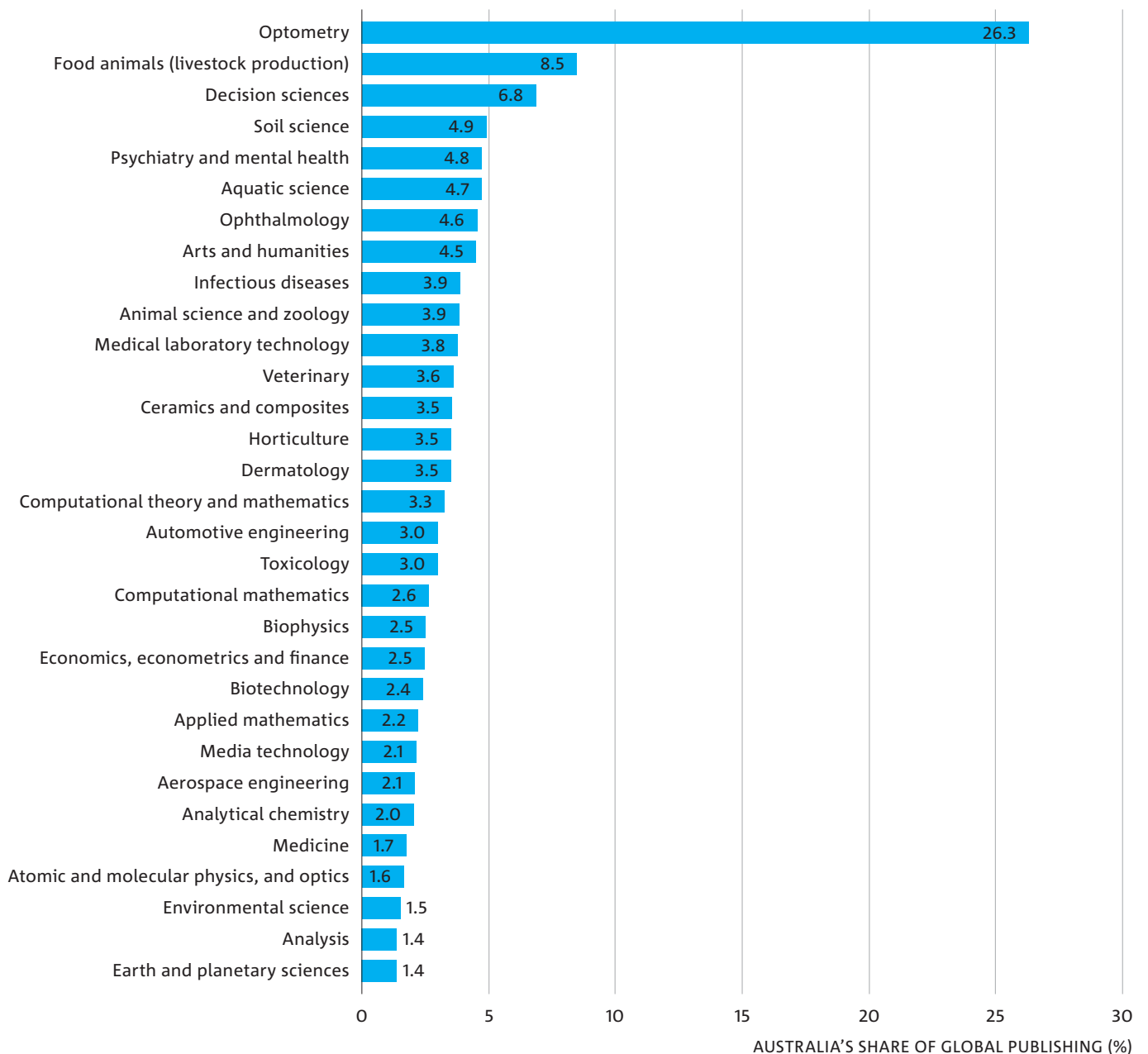
We note the cut-offs are assumed; in reality, the level of specialisation is a continuously graded scale from high to low. We use the cut-offs to create a shortlist of areas of higher specialisation. There were 31 application domains with an RTA score that met the criteria for significant specialisation (above 1.3) and had statistical significance at the 95% confidence interval.



Specialisation in AI application domains in 2022

For the 31 application domains with significant specialisation for Australia, we calculated the share of research in this field globally that is driven by an Australian author. Australian authors account for approximately 26% of global AI publications in optometry, 8.5% in livestock production and 6.8% in the decision sciences, which is greater than the average Australian share of global research publishing across all fields (1.3%).

Optometry, livestock production and decision sciences therefore reflect AI application domains where Australian research is highly represented.



Australia's share of global AI publishing in application domains in 2022

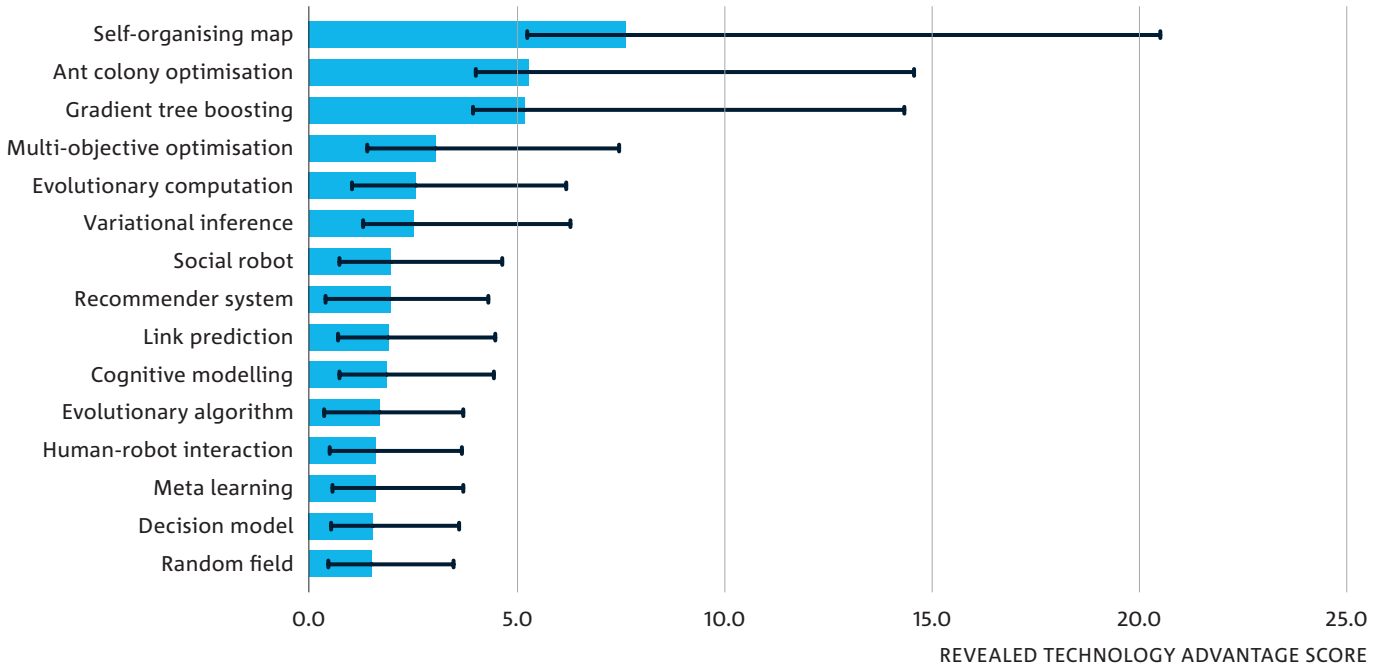
Artificial intelligence technology specialisations

We find numerous AI technologies where Australia has specialised capability on the global stage. Here we show AI technologies with an RTA > 1.5 and lower bound above 1.0 at 95% Confidence Interval. Data is for the year 2022.

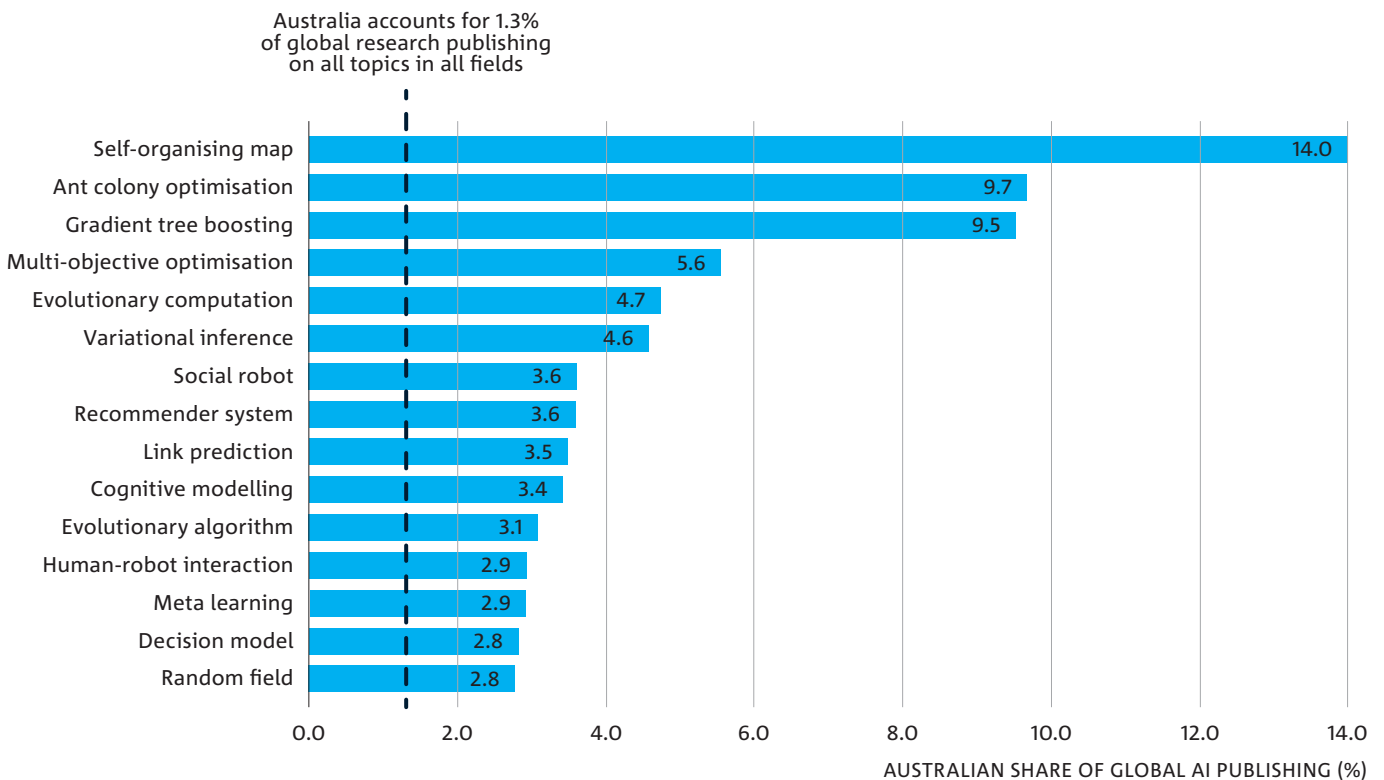
AI TECHNOLOGY	DESCRIPTION (TEXT IN THIS FIELD WAS INITIALLY GENERATED BY CHATGPT 4 AND THEN CHECKED AND EDITED BY THE LEAD AUTHOR)	RTA	AUSTRALIAN SHARE OF GLOBAL PUBLISHING (%)
Self-organising map	A type of artificial neural network trained using unsupervised machine learning to produce a low-dimensional representation of the input space, typically a 2D grid.	7.63	14.0
Ant colony optimisation	A type of optimisation inspired by the behaviour of ant colonies. It is mainly used to find optimal paths through maps or charts.	5.27	9.7
Gradient tree boosting	A machine learning technique that produces a prediction model in the form of an ensemble of weak prediction models, typically decision trees.	5.19	9.5
Multi-objective optimisation	An area of multiple criteria decision analysis concerned with mathematical optimization problems involving more than one objective function to be optimized simultaneously.	3.03	5.6
Evolutionary computation	A family of algorithms for optimization inspired by biological evolution, such as genetic algorithms, evolutionary strategies, genetic programming, etc.	2.58	4.7
Variational inference	A method in machine learning that uses optimization techniques to estimate the true probability distribution of data.	2.50	4.6
Social robot	A type of autonomous robot that interacts and communicates with humans or other autonomous physical agents by following social behaviours and rules.	1.96	3.6
Recommender system	This is a type of machine learning that uses information provided by a user to predict and/or prioritise the products/items they're seeking.	1.95	3.6
Link prediction	A problem in network science and social network analysis to predict the existence of a link between two nodes, given a snapshot of a network.	1.89	3.5
Cognitive modelling	A method used in AI to simulate human problem-solving and mental task processes in a computerized model.	1.86	3.4
Evolutionary algorithm	A subset of evolutionary computation, a generic population-based metaheuristic optimization algorithm.	1.68	3.1
Human-robot interaction	A field of study dedicated to understanding, designing and evaluating robotic systems for use by or with humans.	1.59	2.9
Meta learning	These are models that learn how to learn. The learning algorithm is adjusted and improved in each iteration of problem solving. It helps identify which algorithms perform best for a given problem.	1.58	2.9
Decision model	This captures a wide range of AI-based tools and technologies which are designed to help a decision model choose from a set of competing alternatives.	1.54	2.8
Random field	Random fields are used to infer the joint distribution of a set of variables based on their interactions and dependencies. They're used in image processing, language processing and computational biology.	1.51	2.8

Artificial intelligence technology specialisations – error margins

This graph shows the data on AI technology specialisation in Australia from the previous table but with error margins around the RTA scores at the 95% confidence interval.



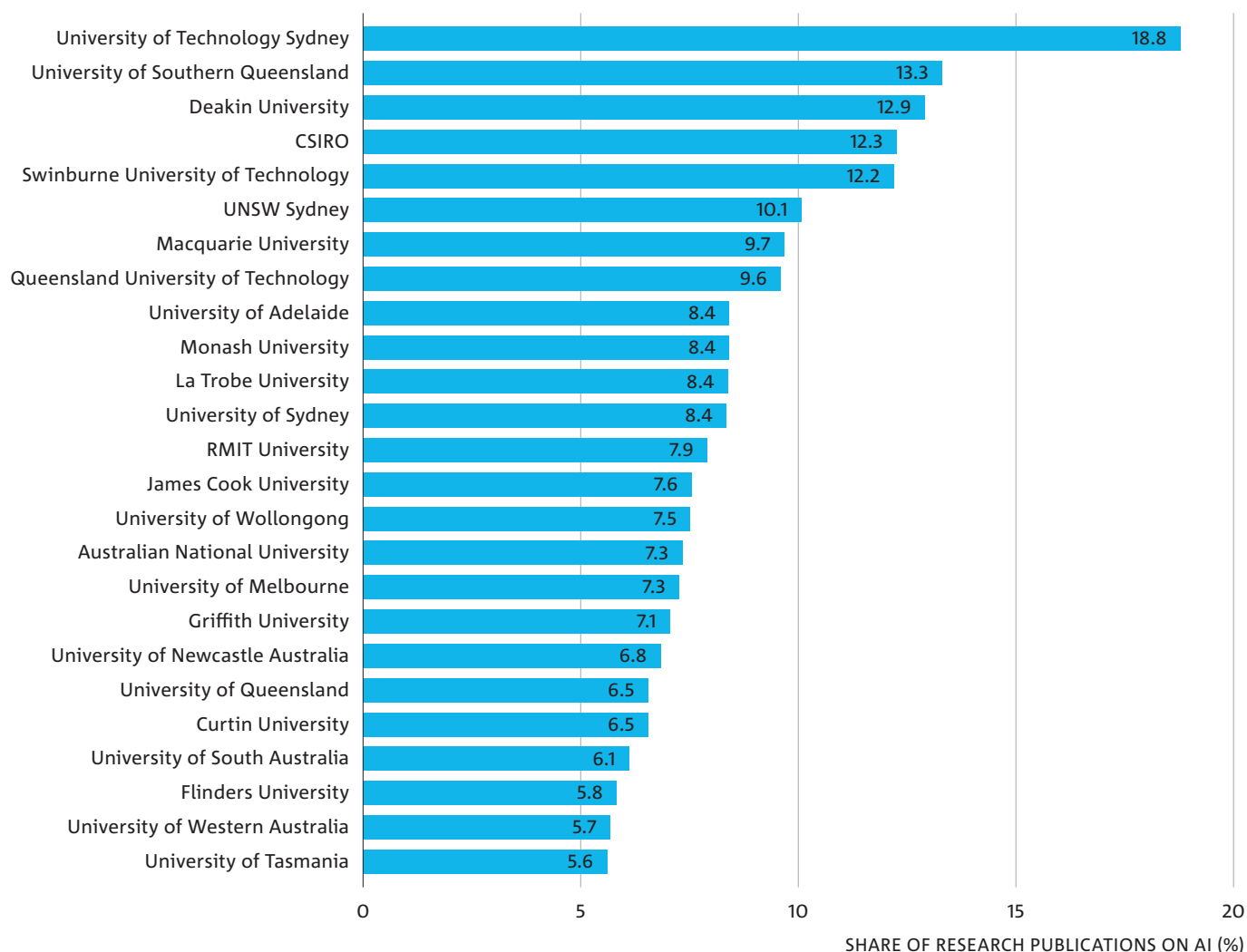
Error margins at 95% confidence interval for AI technology specialisations in 2022



Australia has an above-average share of global AI publishing in AI technologies where it has significant specialisation, 2022

Universities and research institutes

Our datasets identify 167 research institutes in Australia with a unique global Research Organisation Registry (ROR) code. Twenty-five of these institutes had published over 100 peer-reviewed journal papers, books, book chapters or conference proceedings on AI in 2021. Moreover, six institutes referred to AI technologies in over 10% of publications, including the University of Technology Sydney, which had the highest AI publishing intensity among Australian universities and research institutes.



Intensity of AI publishing by research institute as indexed by the share of total publishing on AI, 2021

Note: This analysis was based on 2021 data from The Lens due to declines observed across many institutes in 2022, which was likely associated with the COVID-19 pandemic. We assume that 2021 is a more representative year of AI publishing activity than 2022.

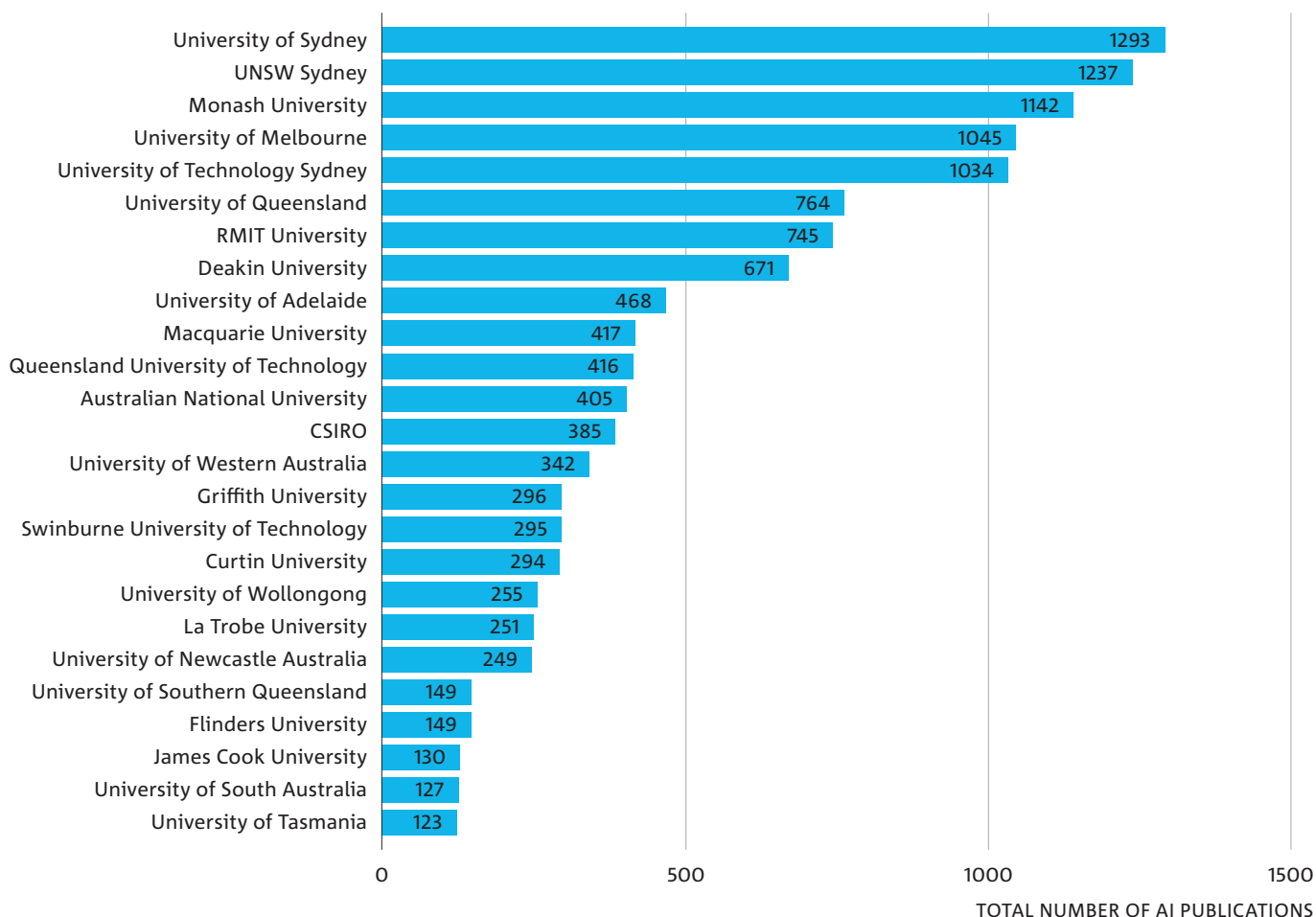
When listed in descending order of volume of AI publishing the ranking of institutes (with over 50 AI papers in 2021) changes. The University of Sydney, University of New South Wales, Monash University, University of Melbourne and the University of Technology Sydney all contributed over 1000 peer reviewed AI publications in the year 2021.

University research centres, industry and community groups in the Australian AI ecosystem

Australian universities have research departments and groups dedicated to AI research, many of which were founded in partnerships with the Australian Government, regional governments and industry organisations.

Research, innovation and commercialisation activities by the Australian universities contribute to the development and expansion of the AI ecosystem. The table below provides examples of the university research groups and departments that specialise in AI.

Australia is home to multiple industry and community groups that actively contribute to the AI ecosystem, especially in relation to skills and training, research and innovation. The table below provides some examples.



Total number of AI publications in 2021 by research institute (institutes with over 100 AI publications)

Note: This analysis was based on 2021 data from The Lens due to declines observed across many institutes in 2022, which was likely associated with the COVID-19 pandemic. We assume that 2021 is a more representative year of AI publishing activity than 2022.

University research groups and departments that specialise in AI

UNIVERSITY	DEPARTMENT OR RESEARCH GROUP
University of Western Australia	UWA Data Institute
Monash University	Department of Data Science and Artificial Intelligence
Australian National University	Intelligent Systems
University of Adelaide	Australian Institute for Machine Learning
University of Melbourne	Artificial Intelligence Assurance Lab and AI and Autonomy Lab (School of Computing and Information Systems)
University of New South Wales	UNSW AI Institute
University of Queensland	UQ AI Collaboratory
The University of Sydney	Sydney Artificial Intelligence Centre Sydney Institute for Robotics and Intelligent Systems Australian Centre for Field Robotics
Macquarie University	Centre for Applied Artificial Intelligence
Deakin University	Centre for AI and Future of Business
La Trobe University, CISCO	AI & Machine Learning at La Trobe University
RMIT	Centre for Industrial AI Research & Innovation
University of Technology Sydney	Australian Artificial Intelligence Institute
Torrens University Australia	Centre for Artificial Intelligence Research and Optimisation

Industry and community groups that actively contribute to the AI ecosystem

NAME OF ORGANISATION OR INITIATIVE	HEAD ORGANISATION OR FOUNDING ORGANISATIONS	ESTABLISHED
National Artificial Intelligence Centre	CSIRO, Google, Committee for Economic Development of Australia	2021
AcademicID	CSIRO	2022
Artificial intelligence Ethics Committee	Australian Computer Society	NA
ARC Centre of Excellence for Automated Decision-Making and Society	Australian Research Council, Australian Government	2020
Advanced Robotics for Manufacturing Hub	Queensland University of Technology, Urban Art Projects	2019
Australian Urban Research Infrastructure Network	University of Melbourne	2022
Australian Council of Learned Academies	Five Learned Academies	2010
Artificial Intelligence Laboratory	University of Adelaide	2017
Advanced Analytics and AI Platform	Intersect Australia	NA
Gradient Institute	IAG, The University of Sydney, CSIRO	2018
Queensland AI Hub	Queensland Government, University of Queensland, Queensland University of Technology	2020
Data Science and Ai Association of Australia	NA	2018

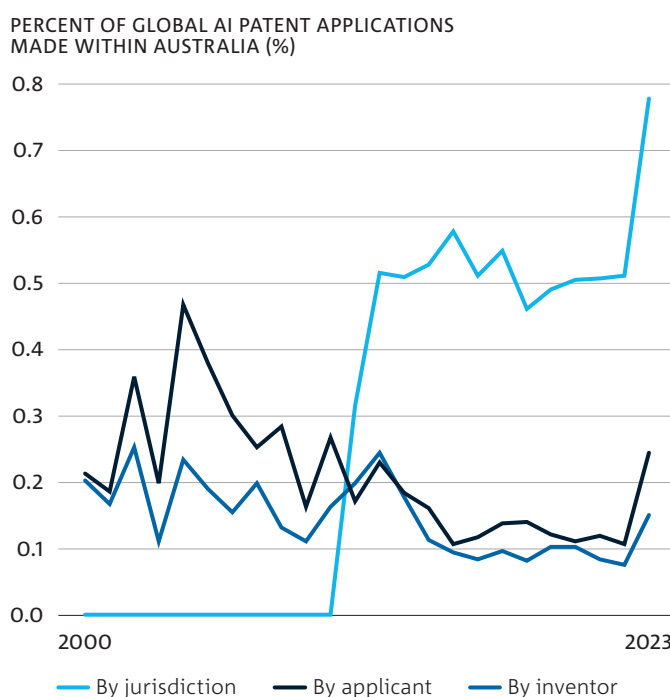
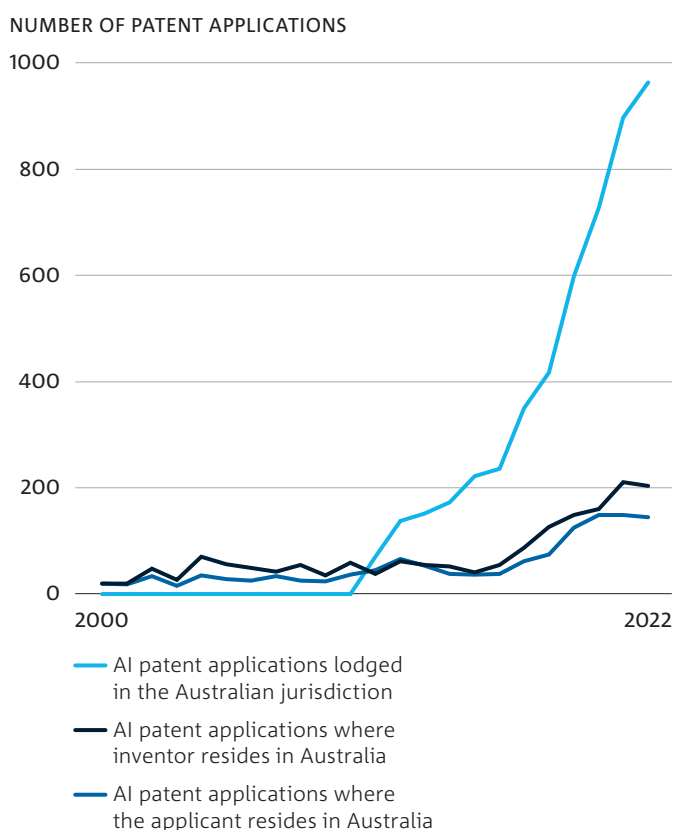
Product innovation and patent applications

Intellectual property patent applications can be used as an indicator that the applicant – an individual, company or organisation – believes they have discovered a novel technology with commercial value. Patent applications are costly and time-consuming, so they have to be worth the effort. Analysing AI patents provides insights into the creation of cutting-edge commercially valuable inventions in Australia.

However, we note that patents only capture part of what’s happening. Research has shown that 36% of product innovations result in patent applications (Arundel and Kabla, 1998). So, whilst patent analyses provide some insight into AI and product innovation, they likely do not capture the bulk of activity, nor is there an alternative comprehensive and consistent measure of product innovation.

With these caveats in mind, patents can still provide insights into AI product innovation trends. In this section, we analyse patent data relating to AI for Australia. The headline graph on the number of AI patents by Australian jurisdiction, applicant and inventor shows the bulk of Australian AI patents had an overseas applicant or inventor. All three trends show growth patterns, with more rapid growth since 2016.

The share of global AI patent applicants and inventors in Australia has fallen over time. This trend is likely to be largely driven by increases in global patenting activity, rather than a decline in patenting activity in Australia. However, the number of global AI patent applications in the Australian jurisdiction has grown sharply since 2010, which is likely to be associated with the increasing presence of overseas technology companies based in Australia.



There has been a sharp increase in the share of global AI patent applications submitted in the Australian jurisdiction

Note: The last data point is for 2023 and is based on data only from January to June 2023.

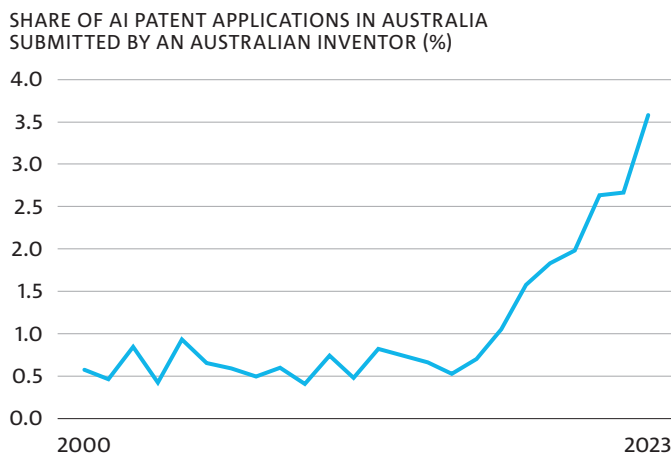
AI patent applications in Australia

There were 379 AI patent applications in the Australian jurisdiction in 2022 (the last full year of data in The Lens), compared with 73 submitted by Australian applicants and 119 by Australian inventors. The companies filing for the largest number of AI patent applications in Australia have their global headquarters in other countries. The top 10 companies submitting AI patent applications in Australia account for 32% of all AI patent applications filed in the Australian jurisdiction from 2000–22.

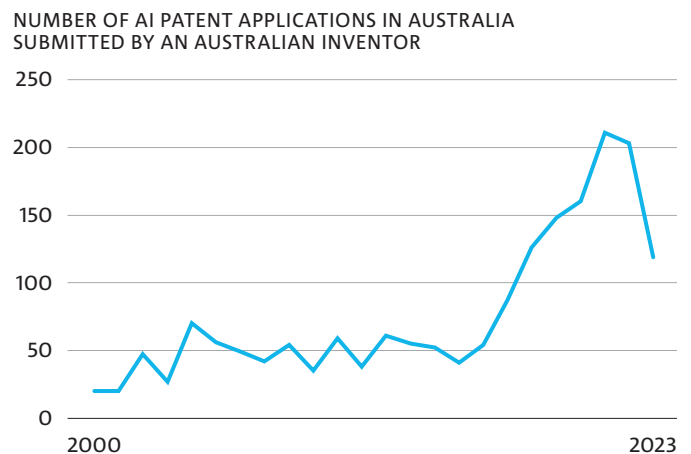
Examining AI patent applications by inventors (as opposed to by applicant or jurisdiction) provides insights into the AI product innovations being created by Australian inventors. The data show a sharp rise in relative and absolute terms since around 2015. In 2023, 3.6% of patents invented by an Australian resident were about AI and 203 AI patents were invented by Australians in 2022 (2.7% patents). These temporal patterns show that AI technology is playing an increasingly important role in Australian product innovation.



Top 10 companies that submitted AI patent applications in the Australian jurisdiction during 2000–22, all of which have international headquarters



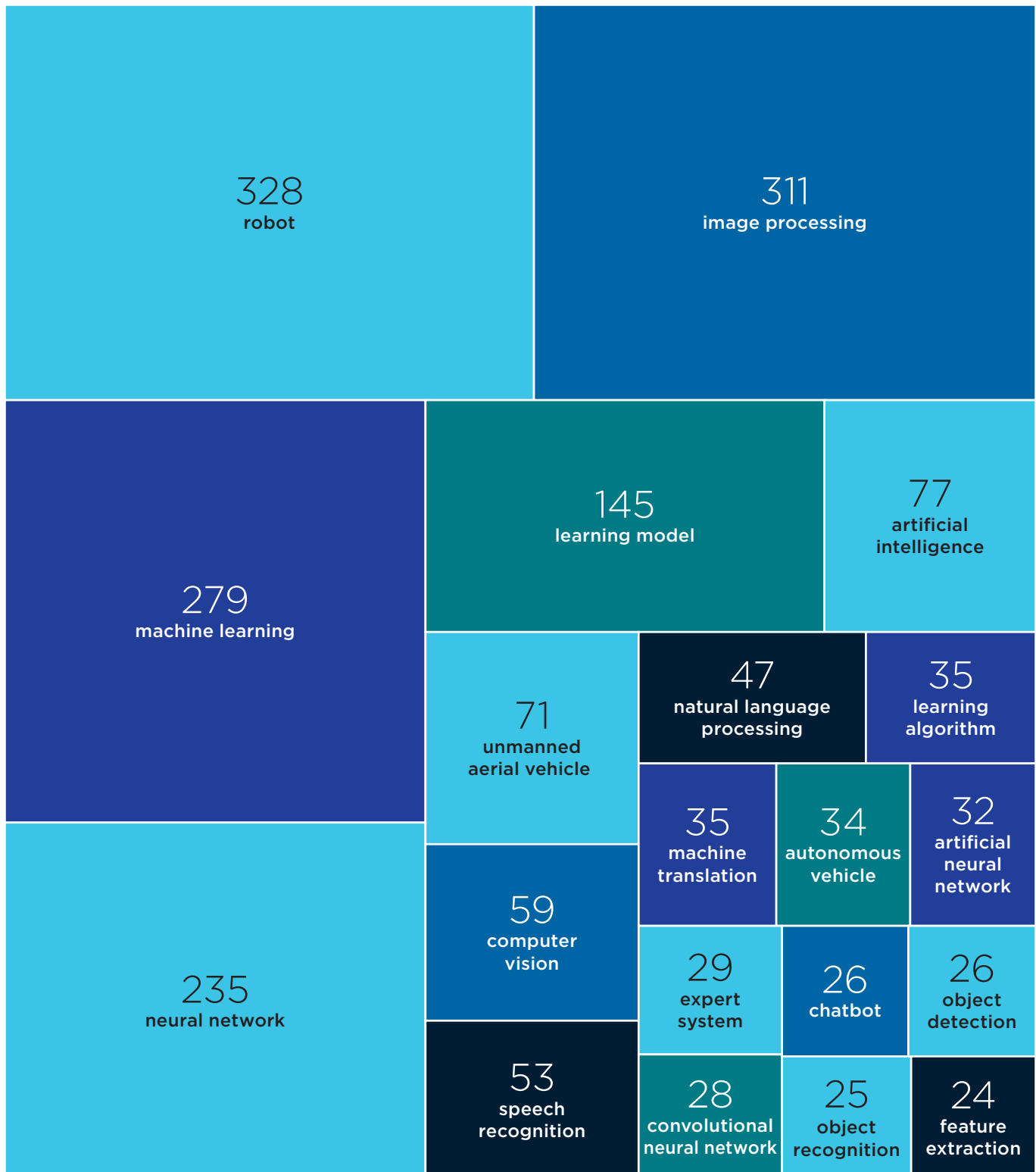
Australian product innovation is increasingly incorporating AI technology



Overall volume of AI product innovation has risen sharply since 2015

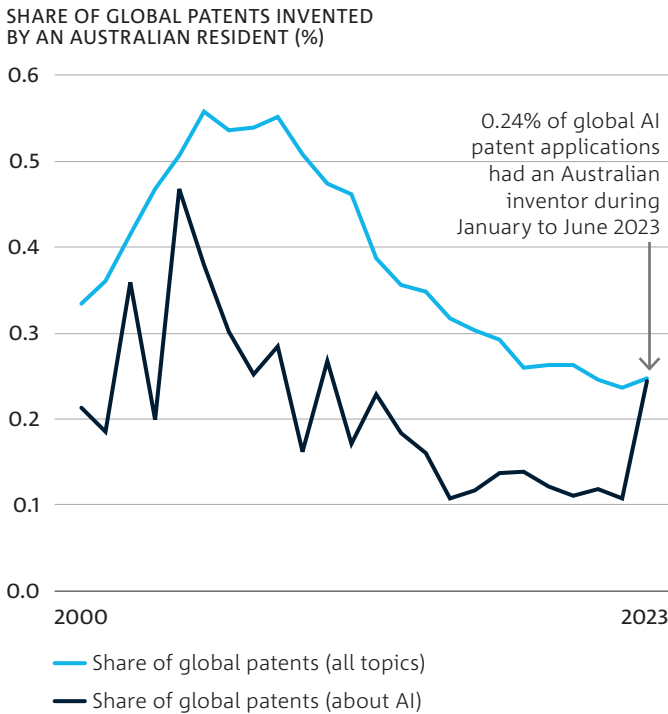
Note: The last data point is for 2023 and is based on data only from January to June 2023.

We analysed which of the 225 AI phrases identified by the OECD as relating to AI technologies occurred most frequently in AI patent applications in Australia. Terms such as “robot”, “image processing”, “machine learning”, “neural network” and “learning model” were most frequently used in patent descriptions in patent applications with an Australian inventor. The chart below shows the top 20 AI technology phrases that featured in patent applications with an Australian inventor occurring during 2000 to 2023.

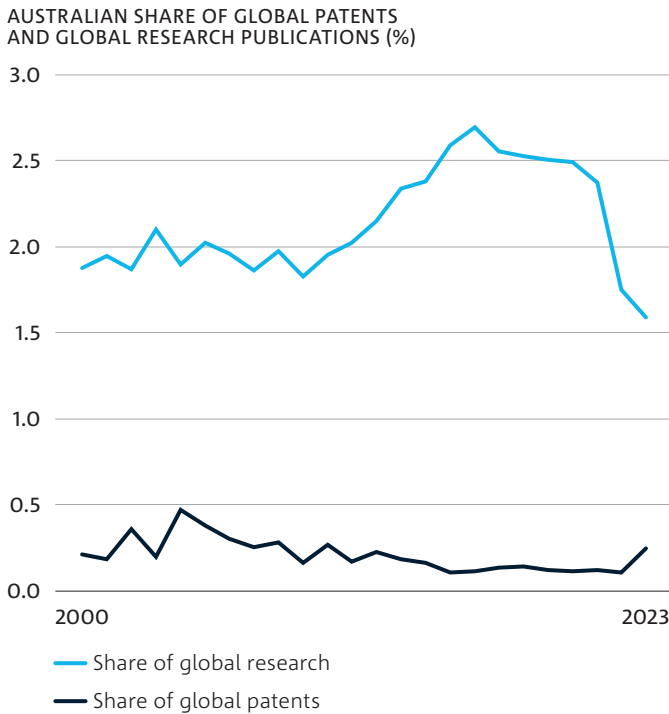


The share of global AI patents with an Australian inventor has risen strongly in the last year, increasing from 0.11% in 2022 to 0.24% in 2023. This last data point captures only January to June 2023; whether it's an aberration or longer term trend is unclear. This share of global AI patents is on par with the share of global patents covering all topics that have an Australian inventor. Australia's share of global patents (on all topics) has been on the decline due to the rapid growth of patent production, especially from emerging economies such as China.

Australia's contribution to global AI patent applications remains well below our contribution to AI research publishing. From January to June 2023, Australia contributed 1.6% of the world's peer-reviewed AI research publishing but only 0.24% of global AI patent applications (with an Australian inventor). This discrepancy suggests that we are not converting AI research into AI product innovations and commercialisation opportunities at the same rate as other countries. We create much more knowledge about AI for the world than we do commercial AI products.



Share of global patents invented by Australian residents



Australia makes up a larger share of global research outputs than patent applications

Note: The last data point is for 2023 and is based on data only from January to June 2023.

3

Industry stakeholder and expert perspectives

Qualitative analysis of interviews conducted by the research team about opportunities and challenges for Australia's AI ecosystem.



Insights from our interviews

We conducted consultations with 28 stakeholders across the AI ecosystem in Australia, including representatives from companies developing and adopting AI technologies and supporting services, government agencies and academic institutions. These engagements sought to better understand current and emerging areas of competitive advantage across the Australian AI ecosystem, the unique value proposition of Australian-developed AI and opportunities to grow and support the ecosystem in the future. This section details the key themes emerging from these consultations and their implications for future directions across the AI ecosystem in Australia.

The hype versus the reality around AI

Interest in AI technologies has been accelerated by the release of tools like OpenAI's ChatGPT, Google's Bard and Microsoft's Bing and there is a sense that we are still in the beginning stages of the current AI hype cycle. These developments have made it easier for business leaders to visualise the potential benefits that AI technology could provide for their organisations and Australian AI service providers are routinely using ChatGPT as a useful reference point in discussing AI opportunities with clients.

Despite this interest, there is a reasonable degree of apprehension across government and businesses about adopting and experimenting with AI technologies, with some organisations more risk-averse than others. Moreover, even if a business is open to implementing AI technologies, many are held back due to fragmented data systems and/or the investment needed to resolve these data issues. Further work is needed to educate decision-makers about the types of problems that AI can address or are best suited to and the level of investment and development required to reach an optimal solution.

The perceived value of local AI service providers

When it comes to deciding whether to outsource AI capabilities to an Australian or international provider, there are several considerations. A key factor is access to capabilities, with many companies opting for an international AI service provider if the appropriate capabilities do not exist or cannot be identified locally.

The NAIC has established the Australian AI Ecosystem Discoverability Platform, a directory of Australian capabilities that support the adoption of AI technologies and a useful starting point in connecting local AI service providers with businesses (CSIRO, 2023). There could be future opportunities to expand the platform's coverage of the Australian AI ecosystem and awareness of the platform.

There are natural proximity advantages to doing business with Australian AI service providers. These include operating in the same time zone, having access to face-to-face support and an appreciation for the local industry context. There is also an innate trust associated with Australian-developed AI technologies (see *An Opportunity for safe and responsible AI*). On the other hand, there is a tendency to assume that AI models that have been developed by larger international companies are more reliable or scalable by virtue of being developed in bigger markets or with greater resources. This perception, along with existing business relationships with international suppliers, can sway Australian companies to do business with an international AI service provider.

Deciding on what AI to build, buy or borrow

Will Australia be a leading creator of AI technologies or adopt technologies developed elsewhere? There is a general perception across the AI ecosystem that Australian businesses will likely be a consumer of internationally developed AI technologies. Despite being the 13th most advanced economy, Australia is currently ranked as the 82nd most complex economy (Observatory of Economic Complexity, 2023) and has low rates of adoption of AI and data analytics relative to other OECD countries (Productivity Commission, 2022). To be globally competitive, Australia needs to set the conditions that support AI adoption as well as create unique AI capabilities.

Australia has a strong network of universities and research institutes working on AI technologies, but there is a persisting challenge in commercialising and scaling innovations. There are likely to be cases where it is advantageous to outsource or adapt existing AI technologies when there are cost and capabilities barriers to developing from scratch. But there could be areas where there is an imperative to develop sovereign foundational AI models and technologies (e.g., applications based on data resources that cannot be used to train international models due to privacy restrictions). Some stakeholders were supportive of using open-source models as a starting point for building these foundational AI capabilities.

Australia's modest culture and low appetite for risk were also highlighted as factors that are holding the AI ecosystem back from developing novel AI technologies. This was exemplified in expatriates who had returned to Australia after spending a substantial period working in international technology clusters like Silicon Valley. Showcasing AI success stories of innovative AI technologies and applications across the Australian AI ecosystem, such as those featured in this report, could help to create a cultural shift around opportunities for the Australian AI ecosystem to drive future technology developments.

Prioritising being an AI specialist over an AI generalist

Australian businesses felt the current national AI approach is too broad and aspirations to position Australia as a global leader in AI technologies could be misplaced. This sentiment is based on the acknowledgement that we do not have the population, market or economy size and level of investment in AI needed to compete with large multinational technology companies. Instead, a more desirable approach could be to focus on building and growing our AI capabilities and reputation in specialised areas where Australia has a strategic and/or comparative advantage. Deciding on areas of AI specialisation could take different forms.

For example, there could be opportunities to leverage existing industry strengths in heavy industries, such as mining and agriculture, where there are clear benefits for the role of automation, computer vision and advanced decision support tools. There could also be opportunities to leverage Australia's rich renewable energy resources to sustainably power AI technologies. Australia's large, open spaces suitable for testing novel autonomous technologies could also be attractive for international companies looking to develop and test in a smaller market. Finally, in line with the Australian Government's ambition for Australia to be a global leader in trusted, secure and responsible AI (DISR, 2023a), stakeholders acknowledged the unique advantage of Australia in developing trusted AI technologies (see An Opportunity for safe and responsible AI).

An opportunity for safe and responsible AI

Ensuring safe and responsible AI practices is important for Australian businesses to mitigate potential risks associated with AI, including legal and reputational risks (Reid et al., 2023). It is acknowledged across the Australian AI ecosystem that there is a significant opportunity for Australia to be a global leader in the development and use of safe and responsible AI technologies. This ambition aligns with the Australian Government's latest consultation on safe and responsible AI in Australia which aims to identify the optimal regulatory and policy approach to ensure AI developed and used in Australia is done so in a safe and responsible manner (DISR, 2023b).

Australia is not alone in its desire to be a global leader in safe and responsible AI. Other countries, including Singapore, the United States, the United Kingdom and the European Union, are among a suite of jurisdictions that are exploring both voluntary and regulatory approaches safeguarding future AI developments and applications (DISR, 2023b). Stakeholders across the Australian AI ecosystem emphasised the need for a balanced, risk-based approach to regulating AI to ensure such policies do not unnecessarily slow or disrupt future AI uptake and developments.

The 'Australian brand' is a trusted asset, which puts the nation in a strong position to drive future safe and responsible AI developments. There is a current disconnect, however, between best practice approaches to responsible AI and actual business practices: the 2023 Responsible AI Index found that

82% of Australian organisations believed they were practising AI responsibly but only 24% had measures in place to ensure this was the case (Fifth Quadrant, 2022). To support Australian businesses in implementing AI safely and responsibly, the NAIC and the Gradient Institute have released a guide on implementing the Australian Government's eight AI ethics principles (Reid et al., 2023).

Finding our strength through our diversity

With every 3 in 10 people living in Australia born overseas, Australia is one of the most culturally and linguistically diverse countries in the world (AIHW, 2023). This provides a unique comparative advantage when it comes to developing novel AI technologies: AI models that are trained on representative Australian data are likely to be less vulnerable to population biases and be fit for purpose as an exportable AI product or service in other countries. This data diversity could be particularly powerful when developing AI health applications or designing technologies to mitigate biases against marginalised populations.

Conversely, a lack of diversity in training data used in developing international AI technologies can be a challenge for Australian businesses looking to apply these technologies locally given they might not perform well in an Australian context. There is an opportunity for the Australian AI ecosystem to leverage this diversity in the creation of novel AI technologies, as well as position itself as the testbed for international companies looking to improve the quality and representativeness of the training data their models are built upon.

Strengthening linkages across the AI ecosystem

Across the AI ecosystem in Australia, there is a perceived lack of strong leadership and connectivity. In some cases, this can lead to duplicated efforts across academia and industry, with parallel streams of AI development on similar technologies. In other cases, Australian businesses can struggle to identify the right AI capabilities they need and resort to sourcing these capabilities internationally. While these barriers likely reflect the nascent nature of Australia's emerging AI sector, it nonetheless requires attention to maximise opportunities for Australia to define and strengthen its global reputation in AI and mature as an ecosystem.

Some stakeholders pointed to opportunities to leverage various national and state-based AI hubs and networks across Australia as a mechanism for improving connectivity across the ecosystem. Example AI hubs across Australia include the NAIC (and its Responsible AI Network), the Queensland AI Hub, and the university and research institutions listed in this report (see Universities and research institutes).

Partner programs offered by large technology companies, such as Amazon Web Services Partner Programs and Google's Cloud Partner Advantage Program, were also acknowledged as a useful channel for increasing the reach of Australian AI service providers, particularly startups and smaller providers.

Growing Australia's AI talent and business ecosystem

Talent shortages are a persisting struggle reported by Australian businesses, particularly when it comes to sourcing specialised technical skills. While it can be challenging for Australian businesses to offer globally competitive salary packages, the liveability benefits of Australia can be attractive for skilled workers looking to stay in Australia or relocate here. Beyond these lifestyle perks, the stakeholders consulted in this project suggested other potential mechanisms for growing Australia's AI talent pipeline and attracting and retaining AI companies in Australia.

For instance, countries such as Singapore have introduced several top-down measures designed to grow their AI sector as part of their national AI strategy, including streamlining its process for patenting AI technologies, boosting research and development investment into AI and fostering an attractive AI startup ecosystem (Goode et al., 2023). Australian expatriate technology workers can also face challenges returning home to work remotely for an international technology company, with stakeholders acknowledging the need to reduce the friction in this process. Australia could also consider new approaches for injecting talent into the AI ecosystem, such as hybrid academic-industry positions, which could also help to improve connectivity across sectors.



Australia's AI ecosystem case studies

The following case studies provide examples of Australian companies at the coal-face of developing AI solutions for industry.

Streamlining the management of critical infrastructure

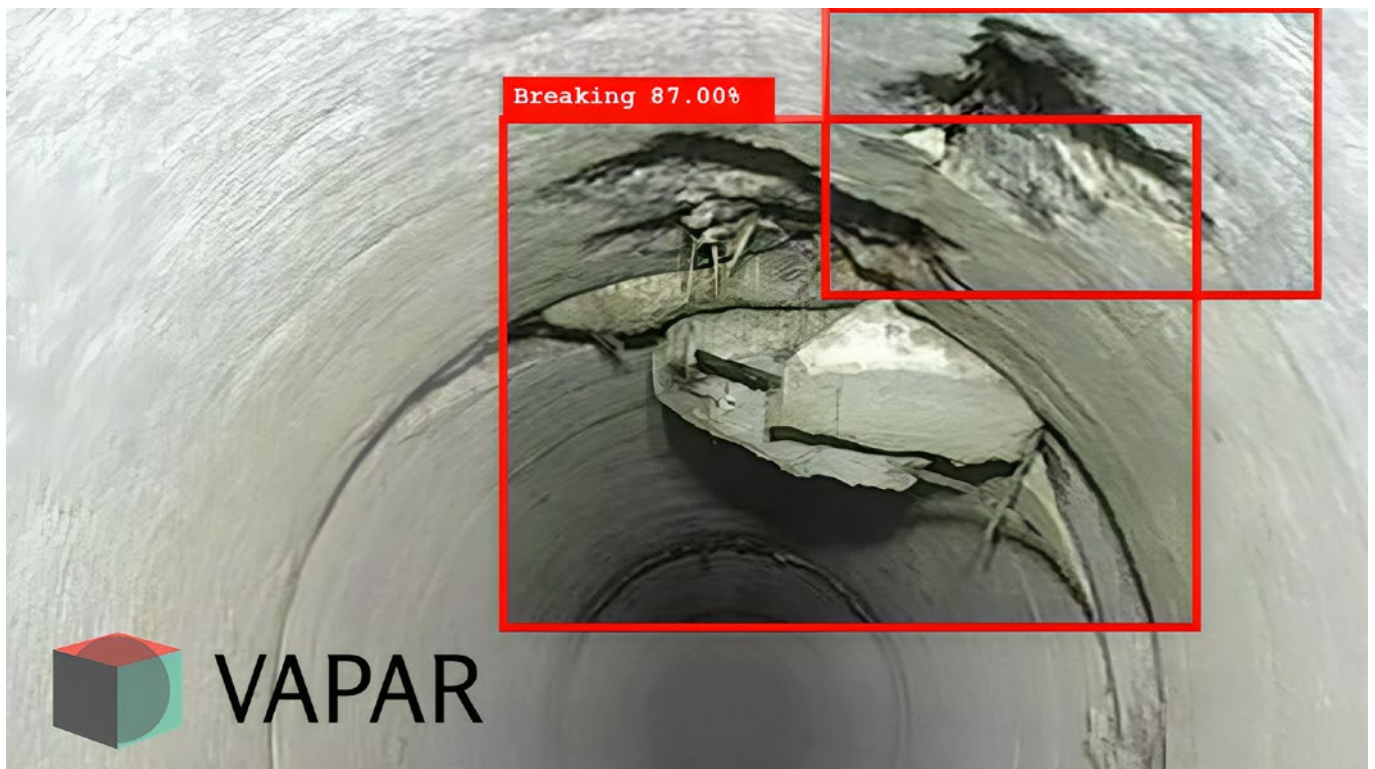


Image source: VAPAR.Solutions

There are thousands of kilometres of wastewater pipelines beneath us that need to be regularly inspected for maintenance or repair issues. Traditionally, engineers would inspect the condition of these pipes manually using CCTV footage, which is extremely challenging and costly for utilities, councils and organisations. Sydney-based VAPAR uses AI to eliminate the repetitive and manual requirements of infrastructure management (VAPAR, 2023). Its cloud-based platform uses machine learning to automatically assess the condition of pipes and identify defects from CCTV footage.

The VAPAR platform improves the accuracy and timeliness of pipe condition assessments, generates cost savings and strengthens the consistency across assessments. VAPAR processes over 200,000 metres of wastewater infrastructure across Australia, New Zealand and the United Kingdom. This case study highlights Australia's ability to develop AI solutions that solve tangible problems improving the safety and efficiency of critical infrastructure.

Helping clinicians detect conditions better and faster

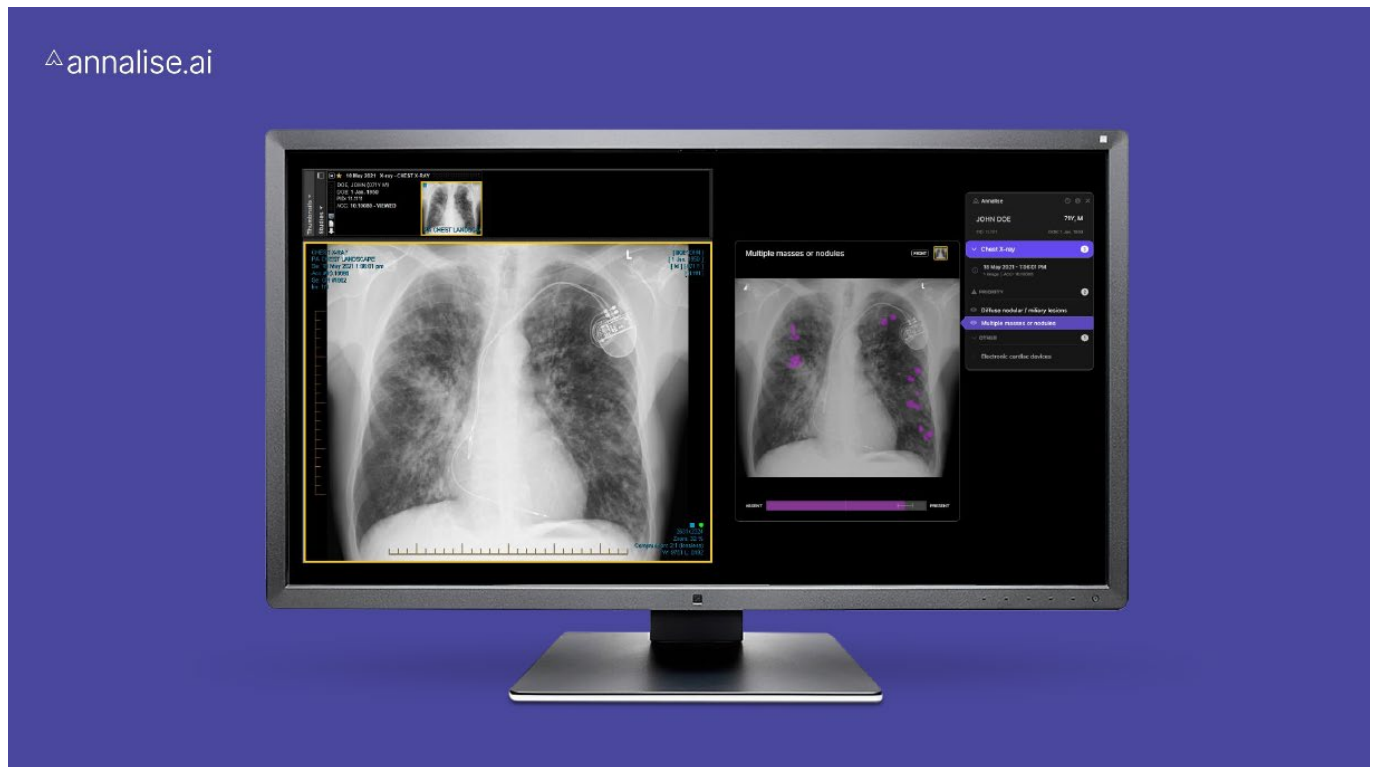


Image source: harrison.ai

Sydney-based harrison.ai uses AI to address the healthcare system's wicked problem – the need to provide quality, equitable and timely care in the face of growing workforce shortages (Harrison AI, 2023). Already caring for over one million patients a year in Australia, their goal is to raise the standard of healthcare for one million patients a day by 2025 and make equitable healthcare a reality for all. harrison.ai is developing technologies that combine the strengths of human intelligence and AI and equip clinicians with decision-support tools that can improve their capacity and quality of care.

In partnership with I-MED, harrison.ai launched annalise.ai in 2020, a decision-support solution for chest X-rays. The first product, Annalise CXR, provides decision support for radiologists to detect conditions quickly and accurately from chest X-rays (CXR). This solution outperforms similar CXR systems and can detect more clinical findings (124) than the next most comprehensive CXR product (75). A peer-reviewed study of Annalise CXR also found a significant improvement in radiologist reporting, with the AI model matching a radiologist's decision in 86.5% of cases (Jones et al., 2021). franklin.ai, a joint venture between Sonic Healthcare and harrison.ai, aims to similarly augment and improve pathologists' decision-making using AI.

Taking a human-first approach to AI in recruitment

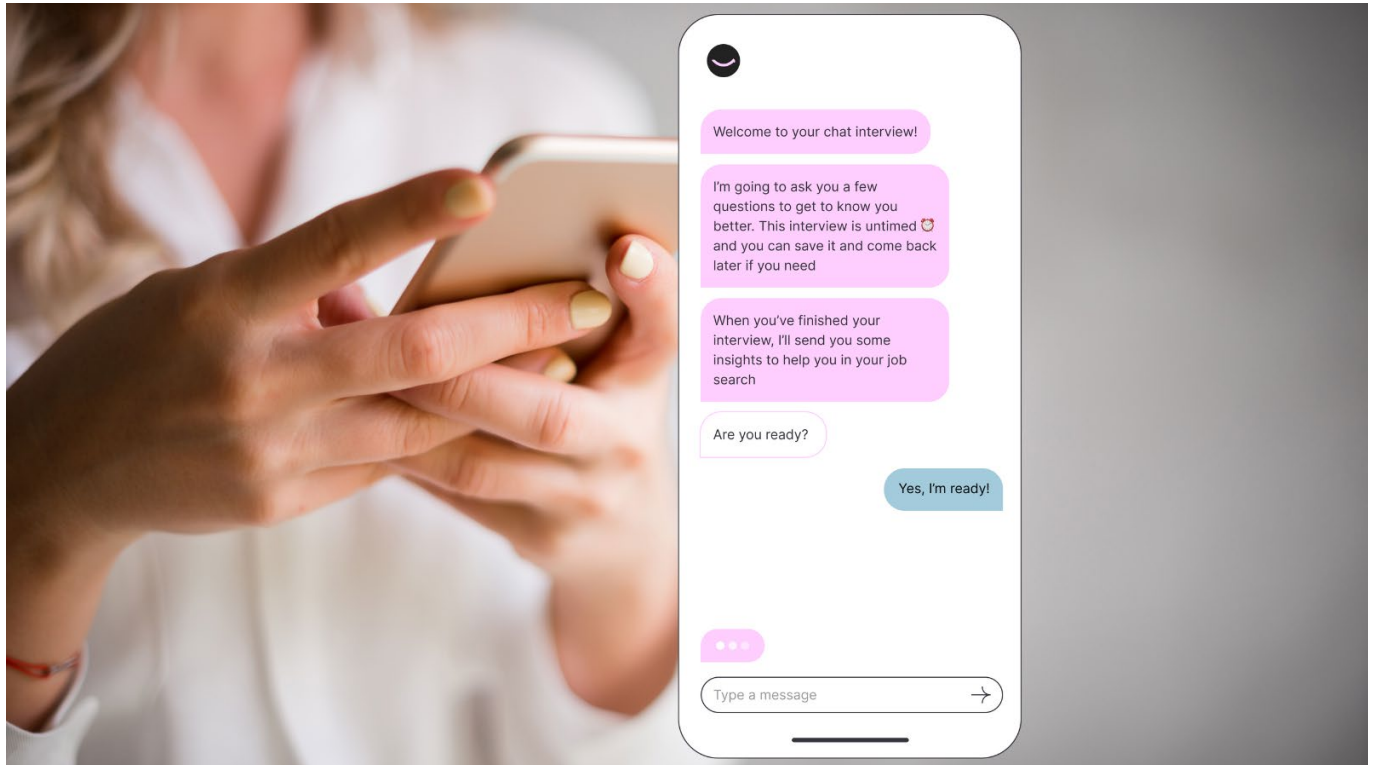


Image source: Sapia.ai

Melbourne-based Sapia.ai has developed an AI-enabled recruitment tool that aims to make hiring more inclusive, efficient and effective (Sapia, 2023). Sapia.ai uses proprietary algorithms and data to automate elements of the hiring process, reducing time-to-hire for large organisations, interrupting bias in hiring and enhancing the candidate experience.

One of Sapia.ai's key tenets is that the end-to-end system, including the algorithms, must be fair and explainable. Their platform was built to minimise bias in the hiring process and excludes the use of video data, data scraped from the web, metadata or any other third-party data. The algorithms only use data provided by the candidate with consent. They have also developed and published a FAIR AI for Recruitment (FAIR) framework, which presents a set of guidelines for fair, transparent and trustworthy applications of AI in recruitment.

The platform has been used to interview more than 3 million people in 47 countries, including candidates from industries such as retail, insurance, financial services, healthcare and aviation. Sapia's national and international success provides an exemplar of the value of fair, trusted and responsible AI technologies and lays the groundwork for future opportunities to position Australia as a leader in this domain.

Mining data for new mineral opportunities

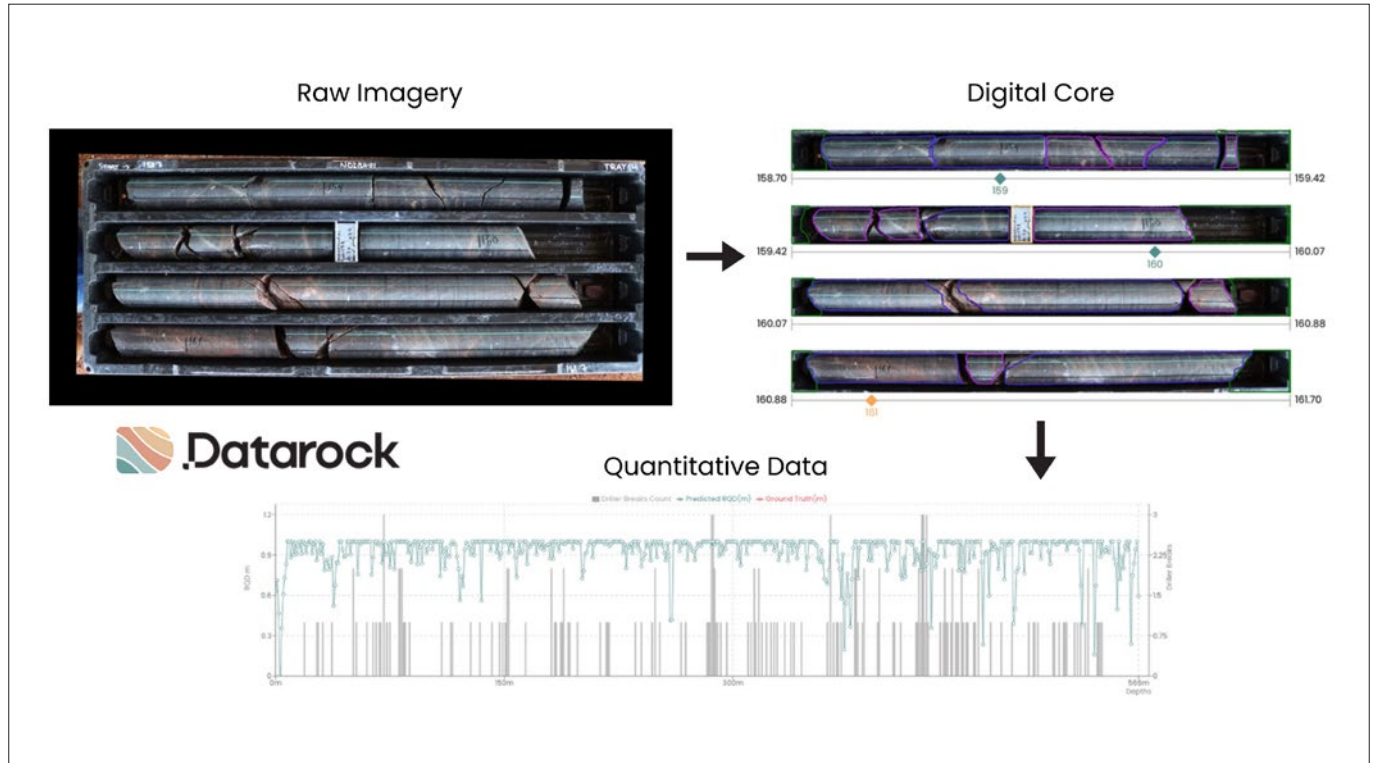


Image source: DiUS and Datarock

Australia's renowned mining sector is poised to harness the potential of technological advancements, with AI playing a central role. In 2018 an Australian technology company and Solve Geosolutions, an Australian data science consultancy, came together to create Datarock (DiUS, 2023). They saw an opportunity to leverage AI technology and provide the industry with a solution that transforms core imagery into actionable data and delivers reliable insights (Datarock, 2023; DiUS, 2023).

Traditionally, drill core is logged by manual inspection by a geologist or geotechnical engineers, a labour-intensive approach susceptible to inconsistencies and errors. Datarock technology – which utilises deep learning models and computer vision – enables core imagery to be processed via a cloud-hosted platform, automating drill core analysis and extracting geoscientific insights that are consistent, auditable, and can surpass the quality and quantity of traditional human-based observations.

The platform eliminates mundane human effort, empowering the user to focus on data interpretation and making informed, data-rich decisions that add additional value to mining operations. Datarock has been embraced by many of the world's largest mining companies across the globe.

Connecting remote communities with essential supplies and services



Swoop Aero has developed the world's first end-to-end drone logistics platform that is working to bridge the tyranny of distance across Australia and beyond (Swoop Aero, 2023). Using digital twins, sensor technologies, machine learning and computer vision, Swoop Aero's drones are plugged into an integrated logistics network to seamlessly deliver products of up to 5 kg, including medical supplies, with a range of 130 km at speeds of 200 km/h. This technology has also been used to map and respond to disaster-prone areas, patrol coastal environments for incidents and monitor wildlife and flora for conservation purposes.

In 2018, Swoop Aero was awarded the world's first commercial contract to provide medical drone logistics services in Vanuatu. Healthcare workers previously transported vaccinations in iceboxes and would have to navigate difficult terrain to deliver these medical supplies. Swoop Aero successfully piloted an integrated drone network for delivering vaccines and other medical supplies to remote locations across Vanuatu and has since operated over 70 flights and delivered more than 25 kg of medical supplies. Similar successful healthcare projects have been conducted in Malawi, the Democratic Republic of Congo and Mozambique, providing timely access to medical supplies for communities living in remote locations.

Key takeaways

1

Australia's AI companies have grown rapidly in the last five years

Until the last decade, the number of AI companies founded annually in Australia was growing at a slow pace. An average of 5.5 companies were added to the ecosystem per year between 1986 and 2013. The last decade saw intensified growth in the number of newly registered Australian AI companies, with a spike of 74 companies founded in 2017 followed by 61 and 57 over 2018–19. We now have 544 AI companies, which is on par with other global AI leaders. For example, with a larger population and economy, Canada recently reported 670 AI companies (University of Toronto, 2020).

2

Australia's AI companies are young, vibrant and nimble

Three-quarters of Australia's AI companies have been operating for less than 10 years. This is comparatively younger than both economy-wide companies and IT sector companies. For example, around 40% of Australian AI companies were founded in 2018–22 compared to roughly 15% of Australian IT companies. Our AI companies are also small, often employing 50 staff or less. However, the youth and size of Australian AI companies could be an advantage, enabling companies to pivot quickly to changing market conditions and respond to early-stage AI technology developments.

3

Geographic hotspots and clusters are forming – AI companies like to be near other AI companies

We examined spatial clustering patterns of AI companies in Australian cities and found that they are tightly clustered. We identified eight clusters in Sydney, Melbourne, Brisbane, Adelaide and Perth, with more forming in other cities and regions. We found that 54% of AI companies were in one of the clusters and that the average distance from an AI company to its nearest neighbour AI company was 80 m. This suggests we are likely to see the emergence of place-based AI hubs in Australia in the future.

4

Australia's R&D sector has higher (and growing) rates of AI adoption compared to global averages

Australia has higher intensity of AI research than the global average. In Australia, 9.6% of all R&D publications in 2022 referred to AI technologies compared to 7.2% globally. The rate of research publications has also been increasing. In 2023, AI R&D publishing by public and private sector organisations accounted for 9.6% of all R&D publishing which is up from 9.4% the year before, 4.9% in 2015 and 2.5% in the year 2000. Since 2000, the Australian R&D sector has published 92,940 peer-reviewed books, book chapters, conference papers and journal papers about AI.

5

Australia creates much AI knowledge but relatively few commercial products

We found that Australia contributes 1.6% of global peer-reviewed research publishing on AI. By comparison, we found that Australia contributes only 0.2% of global AI patent applications where the inventor resides within Australia. This shows that we are not converting our knowledge and understanding of cutting-edge AI science into commercial products at the same rate as other countries. Essentially, we give the world more knowledge about AI than commercial AI products. This sentiment was echoed in consultations with stakeholders across the Australian AI ecosystem.

7

Australia is recognised as a place for trusted and responsible AI innovation

The Australian brand is a key asset that can be leveraged when it comes to the development of safe and responsible AI. In addition to focusing on specialised areas of strategic advantage, stakeholders from the AI ecosystem identified the strength of Australia's reputation as a comparatively trustworthy and appropriately regulated country. This global positioning, combined with Australia's diverse population which is beneficial when developing AI technologies that are generalisable to diverse markets, could be used to position Australia as a global leader in the development and use of safe and responsible AI technologies.

6

Australia has a mature AI ecosystem with clear specialisations in AI technology and applications domains

Stakeholders across Australia's AI ecosystem identified a desire to focus on specialised areas for AI development, rather than positioning Australia as a "jack of all" AI capabilities. Our analysis highlighted current areas of AI specialisation when it comes to specific AI technologies (e.g. self-organising maps, ant colony optimisation, gradient tree boosting) and application domains (e.g. optometry, livestock production and decision sciences). Beyond these R&D-driven strengths, stakeholders also highlighted opportunities for Australia to take a world-leading role in areas complementary to existing industry and geographical strengths, or AI technologies that emphasise Australia's trusted brand.

Planned improvements

Future AI ecosystem reports

This is the second AI ecosystem report released by CSIRO's National Artificial Intelligence Centre. It captures a broader range of source data compared to last year's report. And there are plans to expand and improve the metrics captured and communicated in future reports. In this section we explore some of the main planned improvements for future versions.

1. Improved data on the AI workforce (workers and skills demand profile)

We know that most of Australia's AI workforce is not in one of the AI companies we identified. They're in banks, mining companies, software companies, supermarkets and a wide range of other companies that are developing AI capabilities to achieve improved business processes. At the current time, there is no formal classification of an AI worker in the Australian and New Zealand Standard Classification of Occupations (ANZSCO). This means we can't get statistics from formal government sources (e.g. The Australian Bureau of Statistics) on the number of, and types of, AI workers in Australia. However, it may be possible to use alternative online data about AI jobs (e.g. job adverts). By meshing ANZSCO data from the census with online data, we could build a more detailed picture of Australia's AI workforce.

2. Improved data on AI training and education providers

Australia's schools, universities and technical colleges provide extensive education and training on AI-related topics. These include skills and knowledge areas such as machine learning, computer vision, natural language processing, robotics, mathematics, statistics, software engineering, computer coding and data science. It also covers skills and knowledge such as AI business strategy, technology foresight, government policy and planning, ethics, user experience/design, human-computer interfaces and organisational transformation. The AI training ecosystem is likely to be expanding and diversifying in Australia to meet the demand for these skills and knowledge. Future versions of this report could examine the size and structure of Australia's AI training and education sector.

3. Analysis of AI adoption patterns and productivity impacts

There is an increasing body of evidence about productivity uplift associated with AI adoption. For example, a recent study by Stanford University (Brynjolfsson et al., 2023) found that customer support staff were able to solve 14% more complex customer questions per hour when they used generative AI chatbots. It was also found to increase customer satisfaction and the productivity gains were more than double for new and inexperienced staff. However, not all AI adoption stories are about success. There is much complexity and challenge about how AI is adopted, which tools are used and how they are applied (Hajkowicz and Whittle, 2023). Future versions of the AI Ecosystem report could explore the extent of adoption, patterns of adoption and productivity impacts.

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