ACIL ALLEN

Securing Prosperity: Unlocking Australia's Robotics Potential

A strategic study

March 2026

About ACIL Allen

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Our purpose is to help clients make informed decisions about complex economic and public policy issues.

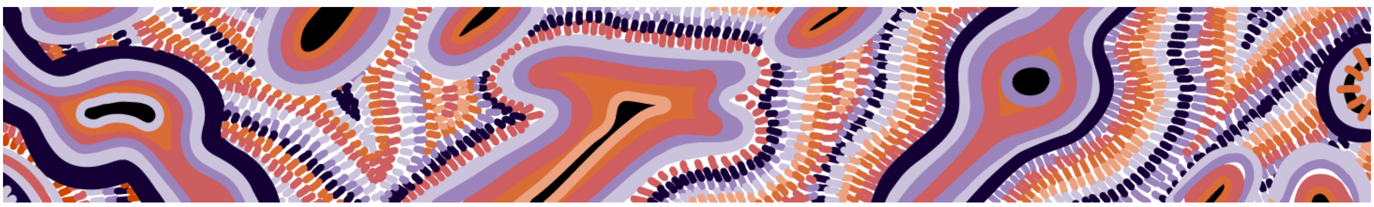
Our vision is to be Australia's most trusted economics, policy and strategy advisory firm. We are committed and passionate about providing rigorous independent advice that contributes to a better world.

Report to:

Amazon Commercial Services

All data in this report is current as of August 2025.

ACIL Allen acknowledges Aboriginal and Torres Strait Islander peoples as the Traditional Custodians of the land and its waters. We pay our respects to Elders, past and present, and to the youth, for the future. We extend this to all Aboriginal and Torres Strait Islander peoples reading this report.



Goomup, by Jarni McGuire

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Glossary of terms

Term	Definition
Adoption of robotics	The integration of robotics technologies by individuals, businesses or sectors into their operations or daily activities.
Artificial intelligence (AI)	The field of computer science focused on creating systems or machines that can perform tasks that typically require human intelligence. These tasks include learning, reasoning, problem-solving, perception, and language understanding.
Autonomy	The performance of tasks without human intervention.
Cobots	Collaborative robots designed to work safely alongside humans in shared spaces, often in manufacturing, healthcare, or logistics settings.
Companion robots	Robots designed to provide emotional support, interaction, or companionship, often used in aged care, disability support, or therapeutic contexts.
Enabling technologies	Technologies that are used within robotics, like sensors, computing vision and AI.
Field robots	Robots designed to operate in outdoor or unstructured environments such as farms, mines, construction sites, or disaster zones.
Industrial robots	Fixed in place or mobile robots used in industrial application processes. For example, fixed robots used on the conveyor belts for car manufacturing, or mobile robots used to move goods in a warehouse.
Integrators	Specialists or companies that design, configure, and implement robotic systems tailored to specific industry needs by combining hardware, software, and processes.
Mesh network	A type of local area network where each node (such as a sensor, device, or robot) is connected to multiple other nodes, allowing data to be transmitted across the network via many possible paths.
Production of robotics	The process of designing, manufacturing, assembling, and testing robots and robotic systems for deployment in various sectors.
Productivity	A measure of how efficiently inputs (such as labour, capital, or materials) are converted into outputs (goods or services).
Robots	Machines that function with a certain level of independence, enabling them to navigate their surroundings and interact with objects. They are defined by four fundamental attributes: the ability to sense their environment, move, utilise energy, and operate autonomously.
Robotics	The design, manufacturing and use of robots.
Robotics cluster:	Broadly refers to a geographic concentration of robotics and automation organisations and capabilities united under a common goal to increase the adoption capability and capacity of Australia's robotics sectors. A robotics cluster is similar to a hub or centre in that it is a geographical concentration of robotics capabilities and capacities all working to a common goal(s).
Robotic population density	The number of industrial robots in operation per 10,000 manufacturing employees, adjusting for workforce size and economic scale.
Service robots	Robots that can perform tasks for humans or equipment in non-industrial applications. For example, agricultural drones and mobile units used in precision farming. Service robots include field robots.

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Summary Report

Executive Summary

Investment in robotics offers significant economic benefits by driving productivity improvements and supporting the creation of high-quality jobs. Advanced robotics systems can enhance efficiency across various industries, leading to cost savings, higher output, and improved product quality. This, in turn, fosters economic growth by stimulating innovation and wealth creation across the economy.

The advantages of adopting robotics more widely across the economy are both evident and extensive. Robotics can boost the strength and sophistication of Australia's manufacturing sector by supporting more advanced, efficient, and accurate production methods, helping local firms stay competitive on the global stage. In sectors like agriculture, mining, and healthcare, where skilled labour is often in short supply, robots offer a practical and scalable solution to the many labour market challenges facing those sectors. Supporting the growth of robotics will help build stronger industries and lay the foundation for a more innovative and resilient economy.

Australia's first National Robotics Strategy (the Strategy), released in May 2024, identifies the future economic potential of robotics for the country. It sets out a clear and shared vision to develop and adopt robotics solutions, and outlines pathways to build a strong, unified robotics sector in Australia. The Strategy suggests that automation, including robotics, can increase annual productivity growth in Australia by between 50% to 150%. The Strategy also argues that a 1% increase in robotics could lead to a 0.8% increase in productivity across the whole of the economy, including by automating high-value manufacturing and enabling production at scale. Given the Government's focus on boosting productivity, robotics offers a promising way forward.

Yet, this opportunity is not being fully realised. While Australia's record in robotics research is world-class, the country trails its global counterparts in production and adoption. Compared to leading nations, Australia lags in terms of the number of robotics-related jobs, economic contributions from automation, domestic capability in robotics development, and overall adoption rates.

Our strength in research and development (R&D) is not translating into widespread commercialisation and adoption within the country. While Australian universities and research institutions are at the forefront of robotics innovation, there is a significant gap in translating these advancements into scalable, industry-ready solutions that will drive the productive capacity of the economy. This disconnect highlights the need for stronger links between technology developers and end users — the businesses that could benefit most from these innovations.

There are several reasons for Australia not fully realising its potential, including:

- **Access to capital is a major obstacle**. Australia's smaller firms that have limited markets struggle to meet the large upfront costs associated with commercialisation, while large firms prefer to either develop their own solutions or purchase in technology developed overseas.
- **Insufficient linkages between the business and research sectors**, which means that research is not always focussed on addressing the specific problems that businesses have identified.
- **The transition from R&D to a market-ready product is challenging**, with barriers to successful commercialisation that include access to facilities for prototyping, testing and scaling up.
- **Sub-scale and fragmented robotics concentrations** that do not attract the investment needed to increase the production and adoption of robotics across Australia's economic sectors.

The opportunity

Australia has a strong history of innovation in robotics, underpinned by world-class research institutions and a healthy industrial base. As global demand for automation accelerates, and as enabling technologies like AI and quantum technologies continue to evolve, Australia is ideally-positioned to build on our existing strengths. The country's vast and varied landscape presents unique opportunities for testing and deploying advanced robotic systems, with industries such as mining and agriculture leading the way in adoption.

With strategic and well-targeted investment, Australia can make the most of this foundation to grow a globally competitive robotics industry. By scaling proven capabilities, strengthening collaboration between research and industry, and supporting commercialisation pathways, Australia can shift from being a niche developer to a recognised leader in robotics innovation. This approach will not only drive productivity and competitiveness across key sectors but also create high-value jobs and future-proof the economy in an increasingly automated world.

This report presents an analysis of the potential economic benefits that could emerge from expanded robotics adoption (i.e. use of robots) and production (i.e. manufacturing of robots) across Australia. The analysis quantifies the prospective economic benefits that could arise from strengthening Australia's robotics sector by achieving a set of aspirational targets. The targets modelled in this analysis are:

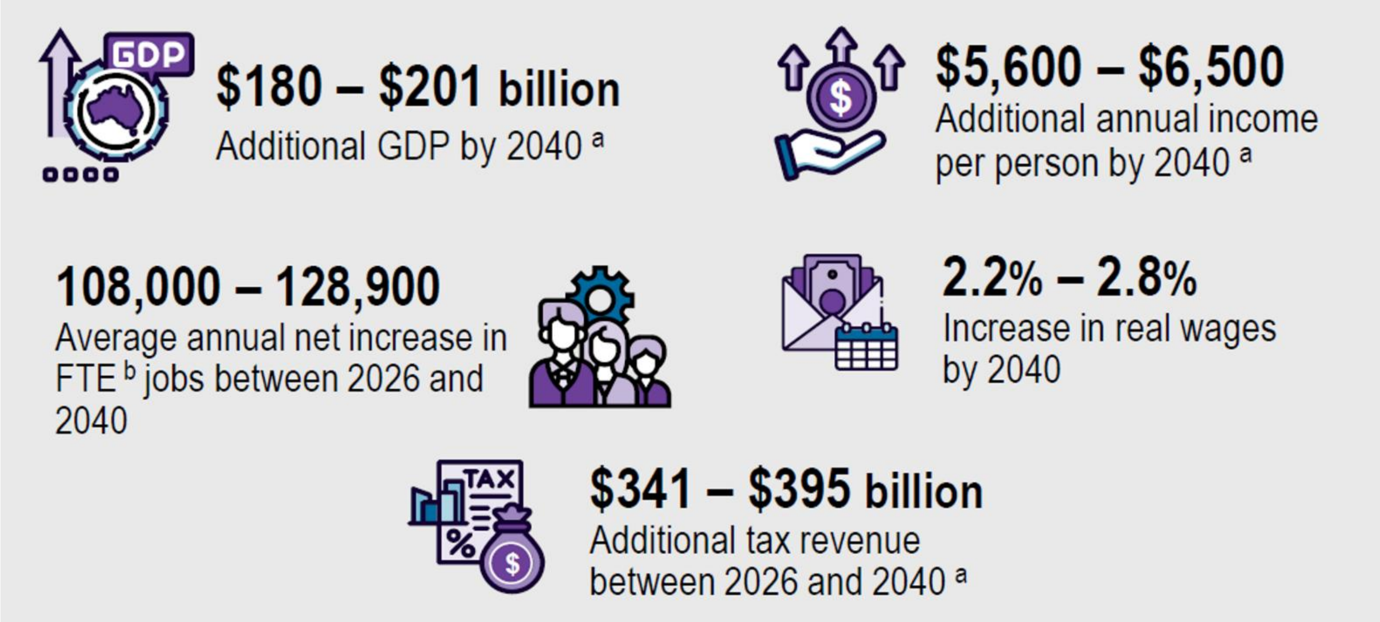
— Doubling Australia's industrial robot density by 2040.
— Increasing Australia's productivity growth by 15% by 2040 through greater adoption of service robots in non-manufacturing industries.
— Achieving robotics industry revenue growth that is 50% higher than under the reference case.

The economic potential of Australian robotics

Our analysis of the potential economic benefits associated with strengthening Australia's robotics sector through the achievement of key aspirational targets indicates that increased adoption and production of robotics could deliver significant national gains.

Our whole-of-economy modelling suggests that achieving our set of aspirational targets can significantly increase Australia's GDP, increase real wages, and generate additional tax revenue by 2040, as well as provide a significant boost to full-time equivalent employment.

Figure ES 1 Economic modelling outcomes of a robotics future for Australia



[a] In 2024 dollars, [b] Full time equivalent. Further explanation and methodological details of these economic estimates are provided in Section 3 and Appendix A.

Source: ACIL Allen

Possible next steps for Australia

Australia has the potential to be more than a passive participant in the global robotics landscape. We must decide whether to invest in developing these technologies and capture the economic and societal benefits, or to let the wave pass us by and simply become consumers rather than pioneers and early adopters. The choices we make now will determine whether we lead in automation or fall behind as others set the pace.

We can be a builder, a leader, and an exporter of next-generation solutions. With the right ambition and investment, Australia could develop and adopt homegrown robotics technologies that solve real-world challenges across industries, from precision agriculture to resource extraction, advanced manufacturing to healthcare. A strong robotics sector would not only drive local innovation but also enhance Australia’s position as a trusted provider of robotics expertise and technology on the world stage.

Our research and feedback collected from stakeholders for this study suggest a range of viable options for the future. These options cover a broad spectrum of approaches, ranging from ‘do nothing/minimal intervention’ to ‘significant’ public and private investments in robotics clusters and commercialisation funds.

The future for Australian robotics is exciting and complex. That robotics will change the nature of our economy and the way we live is undoubted. The opportunities are clear but so too are the risks, and seizing this opportunity will require courage and vision. Now is the moment to push beyond proof-of-concept and for investors to back bold, scalable ventures. This is more than a technology bet: it’s an investment in Australia’s productivity, resilience and future prosperity.

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Main Report

1 Introduction

This section outlines the background, scope, and interpretation of this report.

1.1 Australia's robotics moment

The vision

Australia stands at the threshold of a transformative era in which robotics and automation will reshape the nation's industrial and social landscapes. Robotics and automation technologies are crucial for Australia's future, offering transformative potential across various sectors. They can significantly enhance productivity, address labour shortages, reduce international supply chain vulnerabilities, help revitalise the manufacturing sector and support the transition to a net-zero economy.

We are already seeing changes in how Australian businesses are using robotics technologies. In the next decade, collaborative robots (cobots) will change. Under human supervision, these robots will handle loading, unloading, and precision tasks guided by computer vision. This shift will enable factories to adapt quickly to market changes and maintain high safety standards. Mining operations will also benefit, as cobots assist in sorting, monitoring conditions, and transporting materials.

On farms, robotics will revolutionise how we grow and harvest food. Autonomous tractors and drones equipped with computer vision will inspect fields, identify crop health issues, and relay data over mesh networks spanning vast properties. Small "agri-bots" will navigate between rows to perform targeted weeding, pollination assistance, or selective harvesting. Farmers will use real-time dashboards that integrate soil moisture readings, weather forecasts, and crop visuals to optimise irrigation and harvesting schedules. Together, these insights help them decide exactly when to irrigate, fertilise, or harvest, boosting yields and cutting waste.

Robotics will redefine what is possible in surgery, rehabilitation, and aged care. In operating theatres, robotic arms guided by surgeons will perform minimally invasive procedures with millimetre-level accuracy. Patients will benefit from smaller incisions, faster recoveries, and lower complication rates. Rehabilitation centres will use robotic exoskeletons and sensor-laden prosthetics to assist individuals recovering from stroke or spinal injury. In aged-care facilities, companion robots will remind residents to take medication, monitor vitals, and alert staff if someone falls or shows concerning symptoms.

None of this works without the right digital backbone. Rather than isolated machines, future deployments will be built on adaptive networks of robots, sensors, and edge-computing nodes. If a computer-vision inspection bot in a factory notices a sudden spike in defects, AI algorithms can reroute cobots to perform extra checks even before an engineer arrives. Across remote mine sites or sprawling agricultural properties, mesh networks ensure that data flows seamlessly between every device. In this way, real-time information and cobots come together to reduce downtime, boost efficiency, and cut costs.

Shaping our robotics destiny

This is a promising vision, and in many cases, Australia has already started to put these ideas into practice. We have begun to recognise that investing in robotics yields substantial economic gains by boosting productivity and generating high-quality employment. Advanced robotic systems improve efficiency in multiple sectors, resulting in cost reductions, increased output, and better product quality. These improvements drive economic growth by spurring innovation and creating new wealth throughout the economy.

Yet we stand at a crossroads. To date, Australia's adoption of robotics and automation in manufacturing has been relatively limited, which has constrained the sector's progress. We must decide whether to invest in developing these technologies and capture the economic and societal benefits, or to let the wave pass us by and simply become consumers rather than pioneers and early adopters. The choices we make now will determine whether we lead in automation or fall behind as others set the pace.

The Australian Government has recognised this imperative. In 2024, the Government released the National Robotics Strategy (the Strategy), the first of its kind in Australia. The Strategy sets a clear and shared vision to develop and adopt robotics solutions, and outlines pathways to build a strong, unified robotics ecosystem in Australia. It focuses on four main themes:

— **National Capability**, which aims to build a strong, collaborative robotics and automation ecosystem that delivers world-leading research and has clear pathways to market and global exports.
— **Increasing Adoption**, which aims to support the integration of robotics and automation technologies into the operations of Australian industries.
— **Trust, Inclusion, and Responsible Development**, aimed at ensuring that robotics and automation solutions designed and deployed in Australia do so in a responsible, secure, ethical, and inclusive manner.
— **Skills and Diversity**, which aims to support Australians from all backgrounds to contribute to and benefit from the robotics and automation industry.

While the Strategy recognises Australia's strong robotics expertise, renowned academic institutions and local capability in areas such as field robotics, it also acknowledges the lack of a mature and well-coordinated supply chain for locally made solutions (which limits the commercialisation and scaling up of innovations) and the barrier this presents to realising the benefits of these technologies. The Strategy identifies several challenges that need to be addressed to take full advantage of Australia's leading research capability, including:

— High upfront costs needed to develop robotic solutions.
— Immature supply chains and geographic isolation.
— Low levels of industry-research collaboration.
— Skills and infrastructure deficits.
— Limited awareness of Australia's robotics and automation success.

1.2 This study

Recognising the robotics opportunity, Amazon Australia engaged ACIL Allen to conduct an economic and strategic study of how to support the further development of a robotics industry in Australia. The study assessed the importance of Australia's robotics and automation capabilities and the opportunities to amplify them with strategic investment, policy coordination and industry-research collaboration.

1.2.1 How to interpret this report

The purpose of this report is to provide a foundation for discussions on how to advance the development and deployment of robotics technologies in Australia.

The report analyses the opportunities, challenges, and potential economic impacts of the growth of the robotics industry in Australia. It can be used to inform policy development, guide funding decisions, and support strategic partnerships. It offers evidence-based insights that can be leveraged to advocate for government support, attract investment, and align research and industry priorities. Additionally, it provides a framework for assessing the viability of different models of robotics investment, ensuring that decision-makers have a well-rounded understanding of the landscape before committing resources.

The report was informed by a comprehensive desktop review, targeted stakeholder consultations, and analysis of best practice models. The economic modelling was undertaken using ACIL Allen's computable general equilibrium (CGE) model of the Australian economy, Tasman Global (see Appendix D).

1.2.2 Key definitions

This report focuses on robotics as a distinct form of automation, emphasising its transformative role in modern industry rather than the broader automation concept. This report has adopted the definitions outlined by the Strategy and summarised below.

— **Robots:** machines that function with a certain level of independence, enabling them to navigate their surroundings and interact with objects. They are defined by four fundamental attributes: the ability to sense their environment, move, utilise energy, and operate autonomously.

— **Robotics:** the design, manufacturing and use of robots.

— **Autonomy:** the performing of tasks without human intervention.

— **Enabling technologies:** technologies that are used within robotics, like sensors, computing vision and AI.

— **Robotics and automation technologies:** refers to all technologies listed above.

— **Robotics cluster:** broadly refers to a geographic concentration of robotics and automation organisations and capabilities united under a common goal to increase the adoption capability and capacity of Australia's robotics sectors. A robotics cluster is similar to a hub or centre in that it is a geographical concentration of robotics capabilities and capacities all working to a common goal(s).

Robots are usually divided into two types:

— **Industrial robots:** fixed in place or mobile robots used in industrial application processes. For example, fixed robots used on the conveyor belts for car manufacturing, or mobile robots used to move goods in a warehouse.

— **Service robots:** robots that can perform tasks for humans or equipment in non-industrial applications. For example, agricultural drones and mobile units used in precision farming. Service robots include field robots.

A complete list of definitions can be found in the Glossary.

1.2.3 Report structure

— Chapter 2: This chapter provides a brief picture of where we stand with respect to adoption and investment in robotics.

— Chapter 3: This chapter shows the broad economic impact of increased robotics use and production in Australia.

— Chapter 4: This chapter outlines international best practice for a robotics cluster, exploring the lessons from leading robotics nations. It provides a list of critical success factors and a blueprint for success, and outlines a set of next possible steps.

2 Robotics adoption and economic growth

This chapter explores the benefits of a strong robotics industry, places Australian investment and adoption in the global context.

2.1 The need for a robust robotics industry

Investment in robotics can offer significant economic benefits by driving productivity improvements and supporting the creation of high-quality jobs. Advanced robotics systems can enhance efficiency across various industries, leading to cost savings, higher output, and improved product quality. This, in turn, fosters economic growth by stimulating innovation and wealth creation across the economy.

Australia's first National Robotics Strategy was released in May 2024 and suggested that automation, including robotics, can increase annual productivity growth in Australia by between 50% to 150%.[1] The Strategy also argues that a 1% increase in robotics could lead to a 0.8% increase in productivity across the whole of the economy, including by automating high-value manufacturing and enabling production at scale.

However, to date, Australia's uptake of robotics and automation in the manufacturing industry has been relatively limited, and this has held the sector back. The Strategy notes that Australia's productivity growth has slowed to 1.2% per year in the 20 years to 2021–22 – the lowest level in 60 years. Both the Productivity Commission and the Treasury have identified the need for investment in new technology to improve productivity.[2] [3]

Of course, it is not just manufacturing that can benefit from the adoption of robotic technologies. Service sectors such as aged care and health could also realise considerable benefits from the increased adoption of robot technologies, particularly as the Australian population ages and the anticipated skills shortages in those sectors increase over the coming decades. The National Skills Commission has forecast that worker shortages in the care and support sector (aged care, disability, veteran and mental health) are projected to increase to 211,000 by 2050.[4] The Strategy highlights the use of companion robots in aged care facilities, where robots can help reduce labour shortages by contributing to improved care quality, staff efficiency and overall quality of life.[5]

Robotic and remote surgical technologies also offer a solution to workforce shortages in the health sector. By enabling surgeons to perform robot-assisted or remotely controlled procedures from a distance, healthcare facilities (especially in rural or underserved areas) can access specialist expertise without requiring on-site specialists, alleviating staffing shortages and expanding surgical capacity. This is already starting to happen in Australia, with facilities like the Peter MacCallum Cancer Centre[6] and Epworth Hospital[7] in Melbourne (among others) making use of robots in their surgical practice.

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[1] *National Robotics Strategy*, Australian Government Department of Industry, Science and Resources. Pg 12

[2] *Advancing Prosperity - 5-year Productivity Inquiry report*, Productivity Commission, 2023.

[3] *Intergenerational Report 2023 - Australia's future to 2063*, https://treasury.gov.au/sites/default/files/2023-08/p2023-435150.pdf accessed 1 April 2025.

[4] *Care Workforce Labour Market Study,* National Skills Commission, 2021.

[5] *National Robotics Strategy*, Australian Government Department of Industry, Science and Resources. Pg 22

[6] *Robotic Surgery,* Peter MacCallum Cancer Centre. https://www.petermac.org/patients-and-carers/treatments/surgery/robotic-surgery

[7] *20 years of robotic surgery revolution in Australia,* Epworth Hospital, https://www.epworth.org.au/newsroom/epworth-celebrates-20-years-of-robotic-surgery-revolution-in-australia

Recent advancements in AI, particularly its use in training robots (i.e., enabling robots to learn new tasks through machine-learning algorithms), enabling technologies (e.g., visual recognition and sensing), and robotic design are likely to increase not only the rate at which robotic technologies are developed and adopted, but also the size of the benefits that such adoption will bring.

In today's uncertain global environment, developing a strong domestic robotics production industry will reduce Australia's reliance on imported technologies and external supply chains. Building local manufacturing and R&D capabilities enhances technological self-sufficiency and bolsters our economic and strategic resilience against global instabilities. Proactively attracting foreign direct investment, through incentives for joint ventures, R&D partnerships, and infrastructure development, can accelerate the growth of local capacity, bring in new expertise, and foster innovation within Australia's robotics sector. A strong robotics industry is therefore crucial for Australia to remain competitive in a rapidly evolving global economy. It can address national challenges, productivity demands, and the need for advanced manufacturing. Investing in robotics will help secure Australia's future prosperity, sustainability, and technological independence.

2.2 Where are we now?

Australia has a strong history of innovation in robotics, underpinned by world-class research institutions and a healthy industrial base. As global demand for automation accelerates, Australia is well-positioned to leverage its expertise, particularly in field and service robotics. The country's vast and varied landscape presents unique opportunities for testing and deploying advanced robotic systems, with industries such as mining and agriculture leading the way in adoption.

However, understanding Australia's current robotics landscape is challenging due to significant data gaps. While the International Federation of Robotics (IFR) publishes reasonably good data on the use of industrial robots, comprehensive data on service robots in Australia is virtually non-existent. The analysis presented in this report therefore relies on the best available data sources for Australia, supplemented by comparisons with relevant international markets and industry estimates. This data limitation means that Australia's actual robotics footprint may be larger than captured in official statistics.

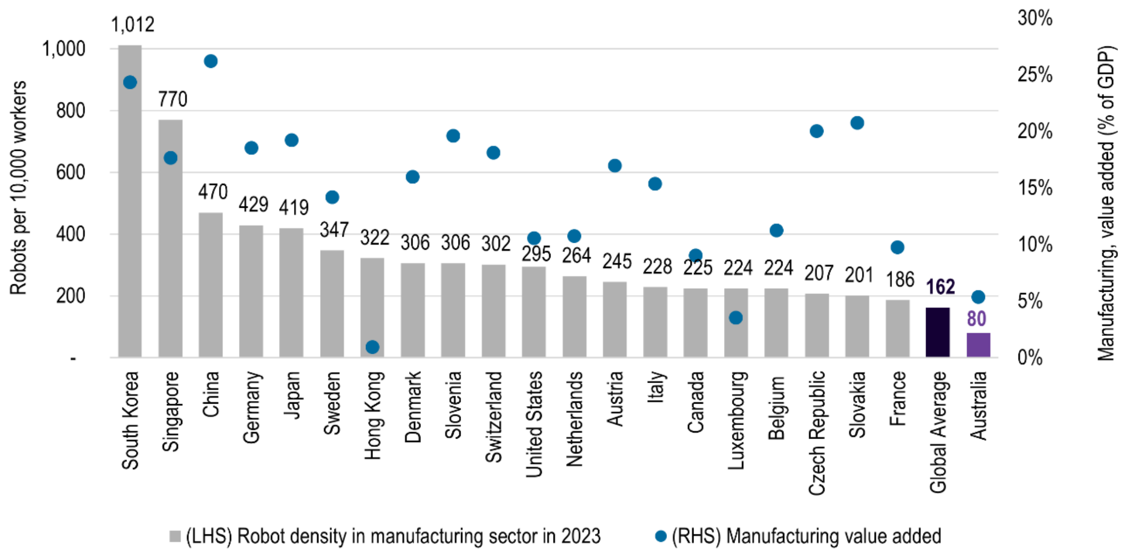
2.2.1 Adoption of robots in Australia

Industrial robots

Australia is lagging behind other countries in its use of industrial robots. A helpful way to compare the level of adoption between countries is through robot population density. This calculation accounts for the number of multipurpose industrial robots in operation per 10,000 manufacturing employees, adjusting for workforce size and economic scale to enable meaningful analysis. Compared to nations with similar manufacturing output, Australia is currently using fewer robots, and its robot density is less than half the global average (see Figure 2.1). Since 2014 Australia's industrial robot density has been declining (see Figure 2.2), which has caused it to drop from a ranking of 18th to 35th (of 37) in the world in robot density in the manufacturing industry.[8]

[8] Lundström, Elías 2023, *Robotics in Australia: From "immature" to national priority*, HowToRobot, August, https://howtorobot.com/expert-insight/robotics-australia-immature-national-priority, Accessed 7 May 2025.

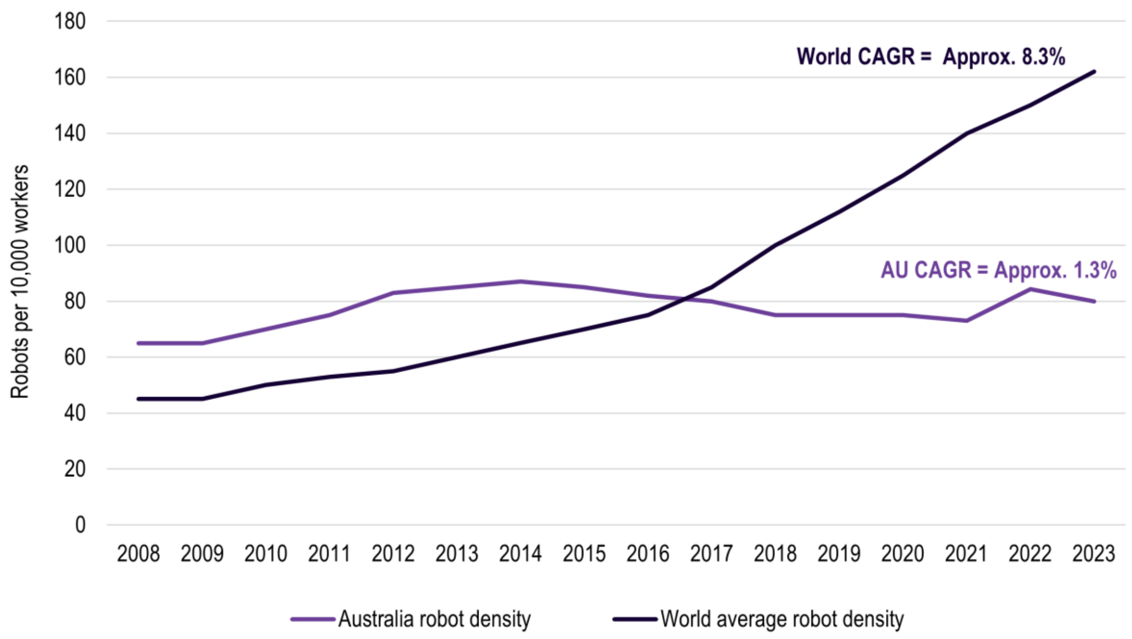
Figure 2.1 Industrial robot density and manufacturing value added in selected countries, 2023



Notes: Manufacturing value added refers to the 2023 year, except for Japan (2022), US (2021) and Canada (2020). Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.

Source: IFR 2024, Presentation of World Robotics 2024, September; World Bank 2025, World Development Indicators, April.

Figure 2.2 Australia's industrial robot population density, 2008 - 2023



Note: CAGR stands for compound annual growth rate.
Source: ACIL Allen based on data from Keay, Sue 2024, Why Australia has such a low robot population density, January and IFR 2024, Presentation of World Robotics 2024.

A country's industrial robot density reveals much about the structure of its economy. In Australia, the relatively low density of industrial robots is largely due to the limited presence of industries that typically benefit most from automation—such as automotive manufacturing (which has historically accounted for a significant share of global robot installations) and the electronics sector (where Australia has a comparatively modest footprint).

Australia's industrial robots are primarily deployed in the metal industry (20%), food and beverage sector (18%), chemical products (9%), and, to a lesser extent, the automotive industry (2%).[9] In terms of application, the predominant use is for handling tasks (66%), followed by welding (9%), processing (4%), assembly (2%), and dispensing (2%). The IFR estimates that 14% of Australia's industrial robot stock is classified as 'unspecified', suggesting that a significant portion may be operating outside traditional manufacturing sectors, in applications that have yet to be systematically categorised or measured.

There is little to no manufacturing of industrial robots in Australia, with Australia heavily reliant on importing industrial robots.[10]

Service Robots

As mentioned in Chapter 1, service robots are robots that can perform tasks for humans or equipment in non-industrial applications and include field robots.

As a country with vast geography and few people, Australia has developed a special expertise in field robotics (which can operate in challenging, unstructured environments) in many sectors not traditionally served by robotics companies in other markets. For example, Australia's deployment of autonomous production drills, autonomous haulage systems, and autonomous vehicles in the mining sector is said to be world-leading.[11] Many of the stakeholders consulted for this report noted that Australia's robotics R&D is regarded as being leading edge. Specific areas of expertise identified included:

- Robot vision.
- Robot sensor technology.
- Robot software.
- Localisation and mapping.[12]

There are a range of significant innovations in field robotics, many of which have seen successful applications both domestically and internationally. Notable examples include GeoSLAM's advanced 3D SLAM (Simultaneous Localization and Mapping) technology, which enables precise real-time mapping of complex indoor and outdoor environments without GPS, used extensively in surveying, mining, and construction.

Australian companies have led the development of automated mining technologies, including autonomous haul trucks, drilling equipment, and underground robots that improve safety, operational efficiency, and productivity on mine sites globally. In agriculture, Australian-developed robots such as SwarmFarm's modular robotic platforms[13], or Wildlife Drones, a Canberra-based company that has developed drone-mounted radio telemetry systems for tracking wildlife in challenging terrains.

Obtaining accurate statistics on service and field robotics in Australia, however, is a persistent challenge. Unlike industrial robotics, where data is more readily captured through manufacturing and trade reporting, service robotics span a wide range of sectors, including agriculture, healthcare, logistics, and public services, many of which do not systematically report robotics usage. In Australia, much of this activity occurs

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[9] Cited in Keay, Sue 2024, *Why Australia has such a low robot population density*, January, https://www.linkedin.com/pulse/why-australia-has-low-robot-population-density-sue-keay-id7xc, Accessed 7 May 2025.

[10] Robotics Australia Group 2025, *A Robotics Roadmap for Australia 2025.*

[11] Ibid

[12] Stakeholder communications.

[13] SwarmFarm Robotics. https://www.swarmfarm.com/

in fragmented or early-stage deployments, making it difficult to capture through existing industry classifications or surveys. As a result, there is a limited evidence base to quantify uptake, measure impact, or benchmark Australia's performance internationally in these growing and strategically important areas.

2.2.2 Australia's robotics industry

The previous section discussed the use or adoption of industrial and service robots in Australia. This section discusses the size of the Australia robotics industry, which encompasses the design, manufacturing, and installation of robots and robotic systems (i.e. companies supplying industrial and service robots). The industry also includes companies and institutions involved in robotics software, hardware, integration, and maintenance services.

A recent stocktake of Australia's robotics and automation industry conducted by HowToRobot in collaboration with Robotics Australia Group, identified 466 companies active in the sector. These companies specialise in automation for *both manufacturing and field robotics across industries*, including sectors not traditionally served by robotics companies in other markets (including mining, construction and agriculture).

- Non-manufacturing industries (using service robots) that are served by Australian robotics suppliers include[14]:
  - Mining (29% of suppliers).
  - Energy (24% of suppliers).
  - Construction (20% of suppliers).
  - Agriculture and forestry (19% of suppliers).
  - Recycling (17% of suppliers).
- The top manufacturing industries (using industrial robots) served by most Australian robotics suppliers include:
  - Metal and machinery (47% of suppliers).
  - Logistics (42% of suppliers).
  - Food and beverage (30% of suppliers).

According to the report, robotics companies in Australia most commonly focus on automating tasks that are found across a range of industries, such as handling and picking items (covered by 51% of robotics suppliers), inspection and quality control (37% of suppliers), logistics and storage functions (33% of suppliers), and packing and palletising (28% of suppliers).[15]

Of the 466 Australian robotics companies (see Figure 2.3):[16]

- 57% are integrators specialising in designing, programming and implementing customised robotic solutions for businesses, primarily believed to support the manufacturing industry.
- 19% are robot manufacturers (including the production of service robots and drones).
- 15% are component suppliers.
- 7% operate as distributors.
- 3% primarily offer advisory services.

In 2021 local robotics companies were worth about $18 billion in annual revenue (up from $12 billion in 2018) and provided employment to over 50,000 people.[17] This represents a compound annual growth rate

[14] HowToRobot 2023, *First overview of Australian robotics industry published,* November, https://howtorobot.com/expert-insight/first-overview-australian-robotics-industry-published, Accessed 7 May 2025.

[15] Ibid.

[16] Ibid.

[17] Robotics Australia Group (2022). *A Robotics Roadmap for Australia 2022.*

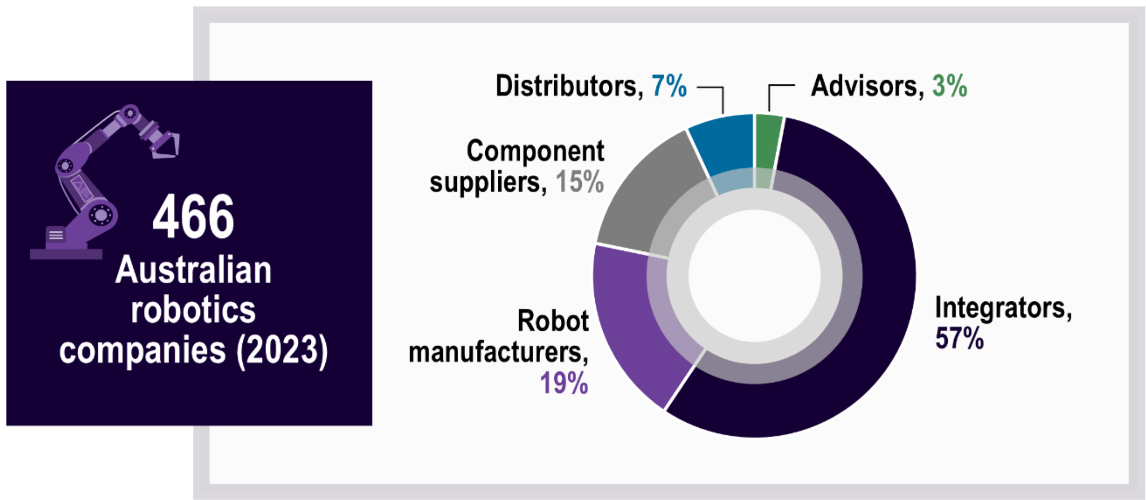
(CAGR) of approximately 14.5%, which appears significantly higher than Australia's relatively low industrial robot density metrics in Figure 2.2 would suggest.

This apparent discrepancy between strong revenue growth from Australian robotics companies and low industrial robot intensity may reflect several factors:

- Increased robot sophistication and value: the robots being deployed may be significantly more advanced and expensive than previous generations, driving higher revenue per unit.
- Service robot growth: the revenue figures may capture growth in service robotics and software solutions that are not reflected in traditional industrial robot density measures.
- Export activity: some of the revenue growth may reflect Australian robotics companies expanding internationally rather than just domestic adoption.
- Data measurement differences: robot density typically measures industrial robot installations per manufacturing worker, while revenue figures capture the broader robotics ecosystem including software, services, and maintenance.
- Productivity gains: as suggested by the revenue growth, the robots currently deployed in Australia may be delivering exceptional productivity improvements, justifying higher investment levels.

These factors highlight the complexity of measuring Australia's robotics landscape and suggest that traditional metrics may not fully capture the sector's economic impact.

Figure 2.3 Overview of robot and automation companies in Australia, 2023



Source: HowToRobot 2023, First overview of Australian robotics industry published, November.

2.2.3 Investment in robotics

Public research and investment

Australia is behind many countries in relation to new investment into robotics. For example, according to research undertaken by Robotics Australia Group, over the past four years, public investment in Canada in AI and robotics has been 25 times greater than in Australia.[18] Public funding for Australian robotics is available through the National Reconstruction Fund (NRF), which has put $1 billion towards “critical technologies” which include robotics. The Industry Growth Program provides advice for startups and SMEs undertaking innovative commercialisation and/or growth projects that are within the priority areas of the

[18] Robotics Australia Group (2025). *A Robotics Roadmap for Australia 2025.* Pg. 10

NRF. The government also supports core research through funding for the CSRIO and other research institutions. There are also a range of tax incentives and sector specific support initiatives (e.g. space and defence) to encourage research and development generally. However, these funding sources do not provide dedicated funding towards robotics, unlike in other jurisdictions.

The table below provides examples of government funding for robotics and automation in a selection of countries with a history of strong robotics innovation and adoption. While not exhaustive, it demonstrates the commitments many governments are making to supporting the development and deployment of robotics technologies.

Table 2.1 Public funding and strategies for robotics and automation – selected international comparison

Country	Funding
Japan	From FY 2026 onwards, the Japanese government will significantly escalate its robotics commitment. The total budget for semiconductors and AI is now A$12.6 billion (J¥1.23 trillion) in FY 2026.[19] Within this, A$3.97 billion (J¥387.3 billion) is specifically allocated for "physical AI" (robots and machinery control systems). Additionally, Japan has committed A$10.3 billion (J¥1 trillion) over five years for domestic AI development. This represents a substantial increase from the 2020-2025 Moonshot program (A$532 million) and the A$1 billion invested in 2023.
South Korea	South Korea announced in 2025 that it would scale up its National Growth Fund from A$100 billion to A$150 billion (₩100 trillion to ₩150 trillion) with dedicated robotics and humanoid robot programs.[20] Within this envelope, A$2 billion (₩2.1 trillion) is allocated specifically for robotics (distinct from AI and semiconductors, which have been allocated A$30 billion and A$21 billion respectively). This represents a dramatic expansion from the 2023-2024 announcements (A$250 million plus A$200 million planned) to support intelligent robotics.
Germany	Germany has committed A$580 million (€350 million) through the High-Tech Strategy 2025 until 2026, as well as a series of other, smaller public investments in innovation clusters and enabling technologies.
United Kingdom	The UK has significantly expanded its advanced manufacturing investment commitment, allocating A$4.95 billion (£2.8 billion) to R&D over five years under the Advanced Manufacturing Sector Plan.[21] Specifically, A$78million (£40million) is dedicated to establishing a Robotics Adoption Hubs network, comprising approximately five regional hubs.
China	In 2023 and 2024, the Chinese government allocated A$72 million (CN¥329 million) in general funding and an additional A$71 million (CN¥324 million) specifically for the Key Special Program on Intelligent Robots. In March 2025, China announced plans for a state-backed venture capital fund focused on robotics, AI, and innovation. The fund is expected to attract A$200 billion (C¥1 trillion) in from local governments and the private sector.[22]Other programs are not included due to limited access to official government data.

Source: Various

[19] Japan Times (December 2025). Japan to quadruple spending support for chips and AI in budget. Accessed at: https://www.japantimes.co.jp/business/2025/12/26/economy/ai-budget-support/

[20] Korea Economic Daily (September 2025). S.Korea to scale up National Growth Fund to $110 bn with high-tech focus. Accessed at: https://www.kedglobal.com/business-politics/newsView/ked202509100010

[21] UK Government (August 2025). Advanced Manufacturing Sector Plan. Accessed at: https://assets.publishing.service.gov.uk/media/68920a3366bdd4490c61098f/industrial_strategy_advanced_manufacturing_sector_plan_accessible.pdf

[22] The Robot Report (March 2025). China to invest $137B in robotics and high-tech industries, reports IFR. Accessed at: https://www.therobotreport.com/china-invests-137b-robotics-high-tech-industries-reports-ifr/

Private research and investment

The strength of venture capital investment in a sector offers a clear signal of its current health and future growth potential, reflecting market confidence and emerging commercial opportunities.

Australia's early-stage venture capital investment (for all investments, not just in robotics) lags behind that of many other countries. In the 2023-24 financial year, the total committed early-stage venture capital in Australia was $5,622 million, with a total investment amount of $412 million.[23] The median investment size was just $0.38 million.[24] By contrast, the United States saw a median deal size of $5.5 million for early-stage investments during Q3 2024,[25] while globally, the median early-stage deal size was $3.2 million.[26]

Patent activity in robotics is a valuable indicator of innovation and technological advancement, highlighting where breakthroughs are occurring and which areas are attracting sustained research and development efforts. Between 2017 and 2021, Australia filed 841 patent families related to autonomous systems, robotics, positioning, timing and sensing technologies, a small fraction compared to China's 89,997 and the United States' 38,489.[27] Research undertaken by Citi Global Perspectives and Solutions noted that China makes up the bulk of new robotics patents, accounting for 78% of all robotics patents between 2003 and 2024, highlighting the shifting epicentre of new research and investment.[28] Between 2018 and 2022, Australian institutions produced 17,130 publications related to these technologies ranking 11th globally.[29] Comparatively, China and the United States led the world with 170,579 and 127,391 publications, respectively, underscoring the substantial scale of investment and activity in these countries.

2.2.4 Existing research centres and robotics clusters

The current Australian robotics community features a multiplicity of stakeholders who drive innovation and change. These stakeholders include universities, existing robotics clusters, incubators and accelerators, industry, peak bodies, and state and federal governments. In many ways, these organisations interact and rely upon each other, sharing expertise, advanced equipment and funding.

One of Australia’s key strengths lies in its research capabilities, particularly within the university sector. These institutions are centres of knowledge, acting as launchpads for emerging technologies. They offer collaborative opportunities, technical resources, and a steady pipeline of skilled graduates who contribute to the ongoing advancement of robotics in Australia.

Our universities were the birthplaces for many of the existing robotics and automation clusters today. Most of these clusters are either embedded within universities or maintain strong partnerships with them. In fact, nearly all Australian universities host some form of research centre, testing facility, or collaboration space focused on robotics. These clusters differ in their approach to industry engagement and commercialisation. Some operate purely as academic research facilities under faculty governance, while others serve as a conduit between research and real-world application, aiming to turn academic innovation into industry-ready solutions. A few are governed by independent boards, maintaining looser ties to the university while still drawing on academic expertise.

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[23] Australian Government Department of Industry, Science and Resources (2024). *Venture Capital Dashboard FY 2023/24.*

[24] Ibid.

[25] KPMG (2024). *Venture Pulse Q3 2024.* https://kpmg.com/kpmg-us/content/dam/kpmg/pdf/2024/venture-pulse-q3-2024.pdf

[26] Ibid.

[27] Australian Government Department of Industry, Science and Resources. *Autonomous systems, robotics, positioning, timing and sensing.* https://www.industry.gov.au/publications/list-critical-technologies-national-interest/autonomous-systems-robotics-positioning-timing-and-sensing. Accessed January 2025.

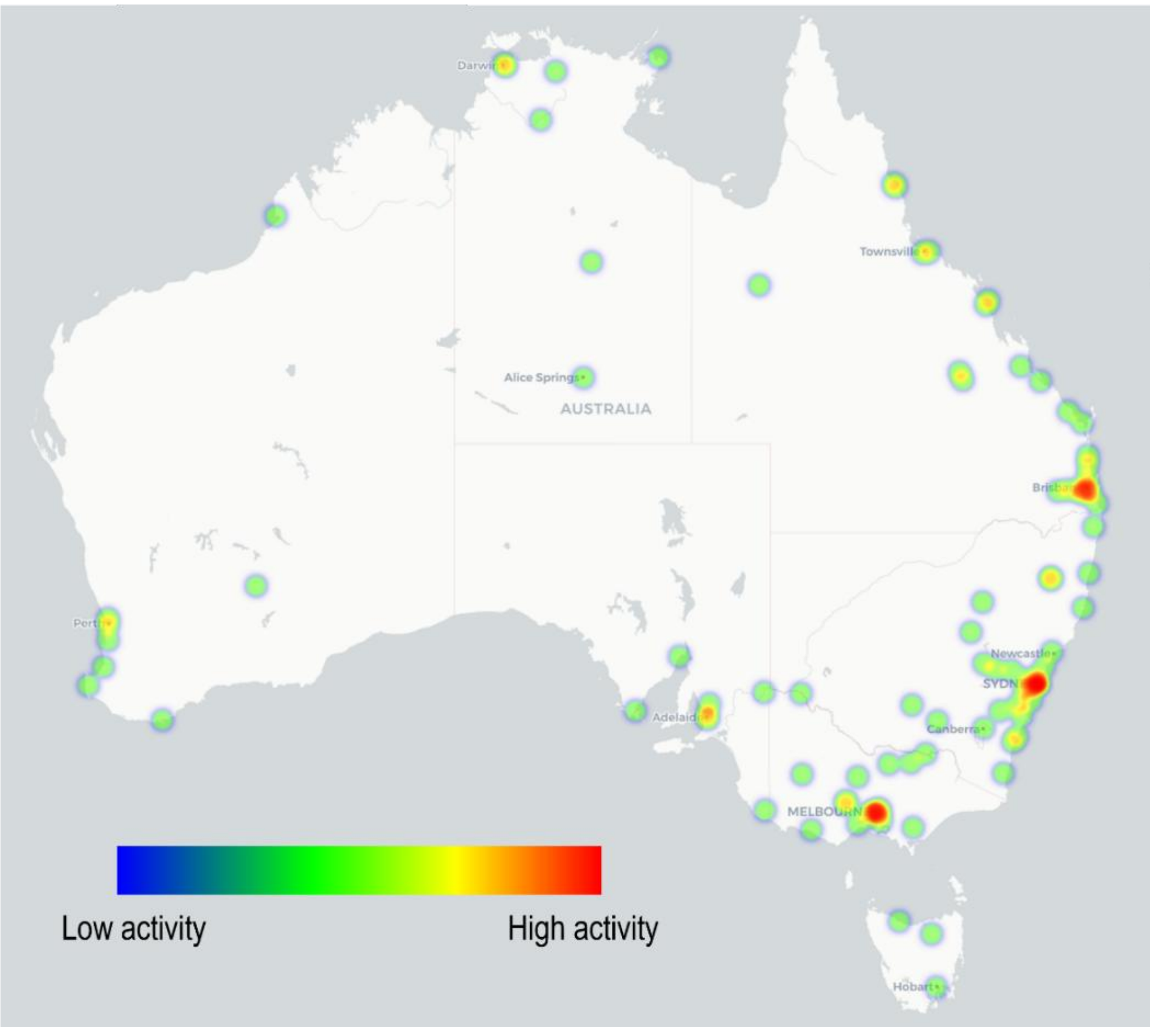
[28] Citi Global Perspectives and Solutions (2024). *The Rise of AI Robots*. https://www.citifirst.com.hk/home/upload/citi_research/rsch_pdf_30297368.pdf

[29] Australian Government Department of Industry, Science and Resources. *Autonomous systems, robotics, positioning, timing and sensing.* https://www.industry.gov.au/publications/list-critical-technologies-national-interest/autonomous-systems-robotics-positioning-timing-and-sensing. Accessed January 2025.

These clusters also vary in their size, sectoral focus, and institutional arrangements. Some, like the Advanced Robotics for Manufacturing (ARM) Hub in Brisbane, operate as collaborative ventures between universities, CSIRO, and government, with a strong emphasis on commercialisation and industry support. Others, such as the Australian Automation and Robotics Precinct (AARP) near Perth, are government-led and provide large-scale test environments for industrial and mining automation. In Sydney, the Australian Centre for Robotics has long been a leader in field robotics research, while the newer ARC Research Hub in Intelligent Robotics Systems (ARIAM Hub) focuses on applying autonomous systems to hazardous asset inspection. Both are embedded within the university system but with differing degrees of external engagement. Similarly, CSIRO's Robotics Innovation Centre in Queensland supports applied robotics research in areas such as autonomous mapping and UAV systems.

The heatmap below (Figure 2.4) gives an overview of Australia's university campuses and existing robotics clusters, and an indicative list of clusters can be found in Appendix B.

Figure 2.4 Heatmap illustrating Australia's university campuses and existing robotics clusters



Source: ACIL Allen

It was noted by many stakeholders consulted for this study that Australia's existing robotics clusters are world-leading in research, particularly in field robotics. It was noted that while Australia might not play the lead role in the whole chain of robotics development, we have unique capabilities that feed into it. However, they also pointed out several recurring challenges:

— A fragmented landscape with limited national coordination and low visibility of existing capabilities.

- University-based structures that, while research-rich, are not always geared toward solving practical, real-world problems.
- An overreliance on government funding, with limited sustained private investment.
- A difficult middle ground where large industry players demand immediate, proven solutions, while smaller firms often lack the capital or risk appetite to invest in emerging technologies.

2.2.5 Peak bodies, industry associations and other players

Outside of universities and robotics hubs, there are several organisations that play a role in supporting, coordinating, and representing Australia's robotics community across research, industry, and policy. These organisations vary in scope and focus, but collectively contribute to building national capability, aiding collaboration, and promoting the development and adoption of robotics technologies. Key examples include:

- **Robotics Australia Group (RAG)**: RAG is the peak body for Australian robotics. They are a not-for-profit organisation whose aim is to support the development of a sustainable and globally competitive robotics industry in Australia. It advocates for the robotics industry by raising its visibility, commenting on government policy, lobbying on relevant issues, and promoting the adoption of robotics technologies. RAG has developed a series of Robotics Roadmaps for Australia, the latest of which was released in 2025. The Roadmap explores the use of robotics in a range of industry sectors and aims to highlight gaps in developing a sustainable robotics industry in Australia.
- **Australian Robotics and Automation Association (ARAA)**: the ARAA is a professional society spanning Australia and New Zealand, focused on robotics, their applications, implications, and related automation technologies. The ARAA facilitates collaboration through conferences and events.
- **Australian Remote Operations for Space and Earth (AROSE)**: AROSE is a not-for-profit that aims to bring together remote operations expertise across industry and academia to drive new innovations, build national capability, and secure Australia's role in the space sector.

There is also a range of other actors who contribute to the capability and capacity of Australia's robotics ecosystem. They include, but are not limited to:

- **Australian Research Council (ARC):** The ARC is an entity of the Australian government. The ARC supports applied research and research training through competitive grants awarded to individuals, teams and large-scale centres. Many existing robotics hubs and university robotics research teams have benefited from ARC funding.
- **State and federal government:** state and territory governments, as well as the federal government, offer a range of grants, subsidies, and other supports to help grow Australian industry generally. While they may not be focussed on robotics specifically, many state governments also have designated 'innovation precincts' where active funding, infrastructure, and regulatory support is being used to drive research and commercialisation within their jurisdictions.
- **Individual businesses:** there are a range of individual businesses which fund and participate in the sector; however, we have observed that this participation is at relatively low levels compared to other countries.

It is important to note that while the current robotics ecosystem faces a series of growth challenges and opportunities, there is a broad range of actors within the system who could champion (either on their own or in collaboration with others) its development over time. Our analysis of other robotics concentrations overseas suggests that a champion or group of champions who apply sustained pressure on these challenges is key to unlocking the development potential of a nation's robotics capabilities.

2.3 Unrealised potential

The benefits of increased robotics adoption are clear and far-reaching. By enhancing the capacity and capability of the manufacturing sector, robotics can enable more advanced, efficient, and precise production processes, helping Australian manufacturers remain globally competitive. Robots also provide a practical solution to the labour shortages faced by industries such as agriculture, mining, and healthcare, where finding skilled workers can be an ongoing challenge. Embracing robotics will strengthen industries and contribute to a more innovative and resilient economy.

Yet, this opportunity is not being fully realised. While Australia’s robotics research record in robotics is world-class, the country trails its global counterparts in deployment. Compared to leading nations, Australia lags in terms of the number of robotics-related jobs, economic contributions from automation, domestic capability in robotics development, and overall adoption rates.

Our strength in R&D is not translating into widespread commercialisation and adoption within the country. While Australian universities and research institutions are at the forefront of robotics innovation, there remains a significant gap in translating these advancements into scalable, industry-ready solutions. This disconnect highlights the need for stronger links between technology developers and end users — the businesses that could benefit most from these innovations.

There are several reasons for this, including:

— Access to capital is a major obstacle — Australia's smaller firms that have limited markets struggle to meet the large upfront costs associated with commercialisation, while larger firms prefer to either develop their own solutions or purchase in technology developed overseas.

— Insufficient linkages between the business and research sectors, which means that research is not always focussed on addressing the specific problems that businesses have identified.

— The transition from R&D to a market-ready product is challenging, with barriers to successful commercialisation that include access to facilities for prototyping, testing and scaling up.

— Sub-scale and fragmented robotics concentrations that do not attract the investment needed to increase the production and adoption of robotics across Australia’s economic sectors.

3 The economic opportunity for robotics in Australia

It is essential to demonstrate that change is worth pursuing. This chapter presents an economy-wide analysis of the potential impacts of increased robot adoption and production on the Australian economy.

This chapter presents an analysis of the potential economic benefits that could emerge from expanded robotics adoption (i.e. use of robots) and production (i.e. manufacturing of robots) across Australia. The analysis quantifies the prospective economic benefits that could arise from strengthening Australia's robotics ecosystem by achieving a set of aspirational targets, rather than evaluating any specific intervention (such as creating a robotics cluster).

The aspirational targets are ambitious but necessary to achieve transformative productivity and economic gains. Although aspirational, the targets are grounded in the reality that Australia currently lags well behind global peers in robot adoption, and represent that which can be achieved with deliberate and strategic investment. The aspirational targets were developed through:

— Comprehensive analysis of publicly available data, including comparative robot adoption metrics from international markets and findings from relevant academic literature.

— In-depth consultations with key industry stakeholders engaged throughout this project.

The aspirational targets modelled in this analysis are:

— Doubling Australia's industrial robot density (i.e. for manufacturing industries) by 2040.

— Increasing Australia's productivity growth by 0.17 percentage points by 2040 through greater adoption of service robots in non-manufacturing industries.[30]

— Achieving robotics industry revenue growth that is 50% higher than under the reference case.

A fulsome discussion of these targets and their development is detailed in Appendix A.3.1 and A.3.2.

A core assumption underpinning this analysis is that strategic, deliberate investment in the robotics ecosystem will enable the achievement of these targets.

The results presented in this chapter should be interpreted as indicative, intended to highlight the broad magnitude and nature of the impacts of increased robot adoption and production on the Australian economy. Due to the unique assumptions and data inputs specific to this project, the findings are not directly comparable to modelling conducted for other technological or industrial transitions.

3.1 Exploring the opportunity: approach to measuring impact

This section provides a high-level overview of the approach used in this report to measure the potential impacts of increased robotics adoption on the Australian economy. More detail of this methodology is provided in Appendix A.

[30] Growth of approximately 15% from a baseline of 1.1%

3.1.1 Analytical framework for the economic impact analysis

The analytical framework used to assess the potential impacts of increased robotics adoption and production on the Australian economy is ACIL Allen's computable general equilibrium (CGE) model of the Australian economy, *Tasman Global*.

Tasman Global is a large-scale, dynamic CGE model of the world economy developed in-house by ACIL Allen that allows for economic analysis to be conducted at the regional, state, national and global levels. The rationale to use a CGE model for this analysis is discussed in **Box 3.1**, and additional details on *Tasman Global* are provided in Appendix D.

Box 3.1 Why use a CGE model to evaluate economic impact?

Why CGE modelling was selected for the impact analysis of robotics?

CGE modelling was chosen for this analysis due to several factors specific to robotics adoption in Australia:

— Limited granular data availability: as outlined in the previous chapter, comprehensive data on robotics adoption, production, and economic impacts across Australian industries remains limited. This data scarcity makes bottom-up analytical approaches impractical, as they would require detailed sector-by-sector and firm-level data that is not readily available. CGE modelling can work effectively with the aggregate economic data that is available.

— Economy-wide transformation: robotics adoption represents a significant technological and economic shock that affects multiple industries simultaneously rather than being confined to a single sector. This cross-industry transformation is exactly the type of structural economic change that CGE models are designed to analyse, as they can capture the complex interdependencies between sectors.

— Indirect and flow-on effects: the economic impact of robotics extends far beyond the immediate users - it affects supply chains, labour markets, productivity levels, and competitiveness across the entire economy. These indirect effects are difficult to quantify using partial equilibrium approaches but are naturally captured in a CGE framework.

Why CGE modelling is appropriate for this analysis?

Evaluating industry changes requires understanding what would happen without those changes (i.e. 'the counterfactual'). Since this cannot be directly observed, it must be inferred. CGE models are well-suited for this, as they can simulate a 'no change' scenario (i.e. a world without the industry changes being assessed, in this case, without increasing robot adoption/production), offering a more accurate and comprehensive approach than simple cost-benefit analysis.

Furthermore, a CGE model can estimate the impacts of industry changes on key macroeconomic aggregates such as GDP, exports, imports, consumption and investment and can provide valid measures of changes in consumer welfare or living standards so that the impacts of change can be correctly evaluated in terms of public interest.

The use of CGE models in policy and program analysis imposes a discipline in which model structures can be easily compared and contrasted, and model results can be interpreted using a well-understood and rigorously developed theoretical framework. In addition, as mentioned above, the use of a CGE framework allows capturing both the direct and indirect impacts of the increased robot adoption/production. A CGE model is a high-level representation of the Australian economy that allows measuring the wider effects of changes in economic activity in key industries and regions. To the extent that economic activity is interlinked, a CGE model will capture any flow-on effects that arise from increased use and production of robots in Australia, including upstream and downstream impacts.

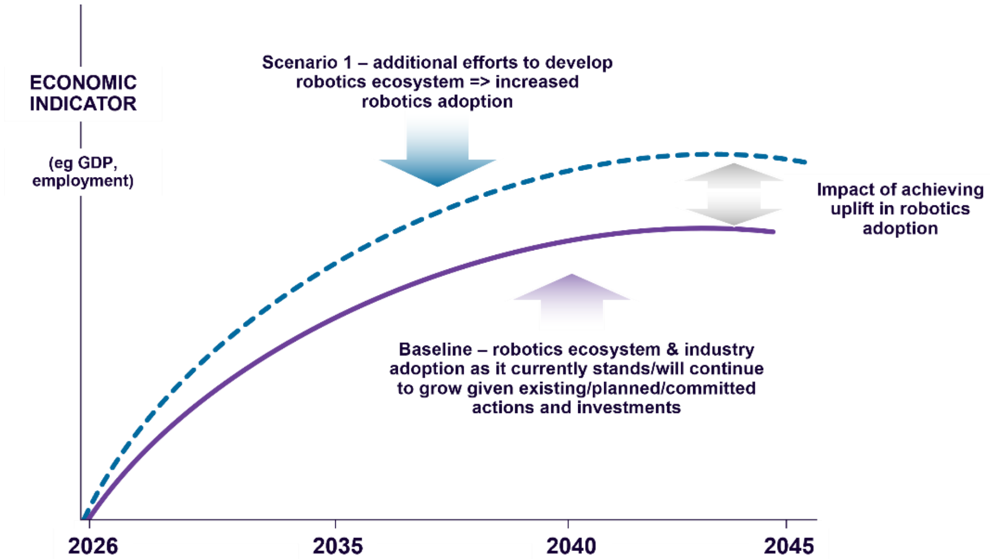
CGE models are widely used by government, industry and academics to evaluate the worth of policy actions, programs and projects. This means that CGE modelling results are well understood and accepted by a wide range of stakeholders.

Source: ACIL Allen

CGE models mimic the workings of the economy through a system of interdependent behavioural and accounting equations linked to an input-output database. These models provide a representation of the whole economy, set in a national and international trading context, starting with individual markets, producers and consumers, and building up the system via demand and production from each component. When an economic shock is applied to the model, each market adjusts according to the set of behavioural parameters, which are underpinned by economic theory. An economic shock refers to any significant change that affects economic activity. For example, a major trade disruption (like new tariffs on key exports), a policy change (such as a carbon tax), a natural disaster, or in this case, increased robotics adoption across industries. These shocks ripple through the economy, affecting prices, employment, production, and trade patterns.

In applications of the *Tasman Global* model, a reference case simulation forms a 'business-as-usual' basis with which to compare the results of various simulations (herein referred to as the Base Case or Business as Usual - BAU). The Base Case provides projections of growth in the absence of the project/change being analysed (such as Gross Domestic Product (GDP), population, labour supply, industry output, etc.) and provides projections of endogenous variables[31] such as productivity changes and consumer preferences. The project case assumes all productivity improvements, tax rates, and consumer preferences change as per the Base Case projections, but also includes the project or policy being evaluated (in this case, an increase in robot adoption and manufacturing). The 2 scenarios give projections of the economy, and the net impact of the change is then calculated as deviations from the Base Case (see Figure 3.1).

Figure 3.1 Illustrative scenario analysis using *Tasman Global*



Note: In reality, impacts could be negative, positive, neutral or a mixture.

Source: ACIL Allen

3.1.2 Simulation design

The following scenarios were simulated in the *Tasman Global* model to measure the potential impacts of increased robotics adoption and production on the Australian economy:

[31] Endogenous variables are economic factors that are determined within the model itself based on the interactions and relationships built into the model's structure (such as wages, prices, and employment levels), as opposed to exogenous variables which are set externally by the model user (such as population growth rates or government policy settings).

- *Base Case scenario* — a scenario projecting the future development of the economy under business-as-usual assumptions about macroeconomic variables and structural trends. This scenario reflects a state of the world where there are no additional investment/activities to grow the robotics ecosystem and industry adoption (other than existing/planned/committed policies, actions and investments). This was used as a benchmark with which to compare the results of simulating the increased robotics adoption scenarios.
- *Scenario 1: increased adoption of robots in Australia* — this scenario refers to a case where additional efforts are made to grow the Australian robotics ecosystem and increase robot adoption (both of industrial and service robots). In particular, this scenario assumes that:
  - Australia's industrial robot density doubles by 2040.
  - Australia's productivity growth increased by 0.17 percentage points by 2040 through greater adoption of service robots in non-manufacturing industries.
- *Scenario 2: increased adoption and production of robots in Australia* — this scenario refers to a case where additional efforts are made to increase robot adoption <u>and</u> production in Australia (both of industrial and service robots). In particular, this scenario assumes that:
  - Australia's industrial robot density doubles by 2040.
  - Australia's productivity growth increased by 0.17 percentage points by 2040 through greater adoption of service robots in non-manufacturing industries.
  - The revenue of Australia's robotics industry revenue grows at an annual rate 50% higher than under the reference case.

Differences in economic outcomes between the baseline and change scenarios are calculated to determine the potential economic benefits of increased robot adoption and production.

The direct benefits of increased robot adoption and production are estimated using existing data on robot density and use in Australia, estimates of the elasticity of robot adoption on productivity from national and international literature, and a number of other assumptions. Based on this information, ACIL Allen estimated the shocks that are introduced into *Tasman Global*. The timeframe covered by the economic modelling spans from 2026 to 2040. Details of the assumptions used to derive the modelling inputs for the robotics scenarios are provided in Appendix A.

3.2 Strengthening Australia's robotics ecosystem: unlocking economic value

When assessing the impacts of a change on the economy, a range of key macroeconomic variables are commonly evaluated, including the following.

- *Gross Domestic Product (GDP)* — one of the most commonly quoted macroeconomic variables at a national level is real GDP, which is a measure of the aggregate level of economic activity (output) generated by an economy over a given period of time (typically a year). The term 'economic output' has been used in the discussion of the relevant results presented in this report.
- *Real income* — indicates changes in economic welfare (wellbeing) of the residents of Australia. This indicator measures the ability to purchase goods and services (adjusted by inflation).
- *Employment* — shows how job numbers change across the Australian economy at large.
- *Wages* — refer to money that is paid or received for work or services. Real wages refer to wages adjusted for the effect of prices (inflation).
- *Government revenue* — measures the distribution of impacts of increased robotics adoption on Commonwealth and State Government revenues.

How robots increase productivity

SPEED AND EFFICIENCY	▪ Faster task completion ▪ Material efficiency ▪ Fuel and energy efficiency ▪ Reduced human supervision	▪ Businesses are able to produce more goods and services using the same or fewer inputs	▪ Lower operational costs ▪ Workers freed to focus on higher-value tasks
PRECISION AND ACCURACY	▪ Micro-level precision ▪ Reduced human error ▪ Standardised quality	▪ Increased product quality ▪ Reduced waste and errors	▪ Lower operational costs ▪ Increased quality and consumer satisfaction
CONSISTENCY AND RELIABILITY	▪ 24/7 operation ▪ Consistent performance ▪ Predictable outcomes	▪ Increased production capacity ▪ Reduced variations in finished products	▪ Increased output, profits and competitiveness
SAFETY AND RISK MITIGATION	▪ Elimination of human exposure to dangerous machinery, toxic environments, or repetitive strain	▪ Ability to operate in hazardous environments ▪ Reduced workplace injuries	▪ Lower operational costs (including insurance and liability costs)

The sections below discuss the impacts of increased adoption and production of robots on these key macroeconomic variables for the Australian economy.

All of the economic impacts in this section are reported in Australian dollars (in 2024 dollars unless noted) and the net present valuations (NPV)[32] are calculated using a central 7% real discount rate[33] (with sensitivity analysis for a 3%, 5% and 10% discount rate presented in tables).

3.2.1 Economic output

Increased adoption of robotics enhances productivity across industries by automating repetitive, physically demanding, and precision-intensive tasks that human workers may perform more slowly or inconsistently. Robots typically operate with higher levels of speed, accuracy, and consistency, helping to reduce errors and waste while maintaining high quality standards. Robots can function continuously enabling 24/7 production cycles, particularly in manufacturing settings.

This automation effect acts as a productivity multiplier: businesses are able to produce more goods and services using the same or fewer inputs. At the same time, workers are freed to focus on higher-value tasks that complement automated systems. The resulting productivity gains reduce production costs, which can lead to lower prices for consumers, greater capital availability for business investment, and higher wages for workers in newly created, higher-skill roles that emerge alongside robotic technologies.

Lower consumer prices, in turn, stimulate demand, prompting businesses to expand production and directly boosting Australia’s economic output (GDP).

Domestic robot production creates direct economic value by generating high-skilled jobs in engineering, programming, and advanced manufacturing that typically command higher wages. This manufacturing process also stimulates extensive domestic supply chains for components, materials, electronics, and specialised services, effectively keeping capital within the national economy rather than sending it overseas through imports. The expertise developed through domestic robot production also generates valuable knowledge spillovers that benefit adjacent industries, as specialised skills in automation, artificial intelligence, and advanced manufacturing become transferable across sectors. Over time, a robust domestic robotics industry can mature into an export sector, bringing additional revenue into the economy from international markets.

Table 3.1 summarises the estimated impacts on real economic output of increased robot adoption and production, measured as deviations from the Base Case scenario. All figures represent additional economic activity above what would occur under business-as-usual. Notably, following standard CGE modelling practice, **all results are presented as increases relative to the Base Case**, which assumes continued economic growth without enhanced robotics adoption. For context, Australia's real GDP in the Base Case is projected to grow from approximately $2.7 trillion in 2025 to $3.8 trillion by 2040 (in 2024 dollars). The scenarios below show the additional economic activity generated on top of this baseline growth.

— **Scenario 1** (increased adoption of industrial and service robots) could generate an additional $180.3 billion in economic output by 2040, contributing to a cumulative $1.32 trillion increase in Australia’s real GDP over 15 years.[34]

— **Scenario 2** (expanded robot adoption and production) could generate an additional $201.3 billion in economic output by 2040, contributing to a cumulative $1.44 trillion increase in Australia’s real GDP over 15 years.

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32 Net Present Value (NPV) is a financial metric that calculates the difference between the present value of cash inflows and outflows over time, helping to assess whether an investment will generate a net gain or loss.

33 See Section A.4 in Appendix A for further discussion about the discount rate used in the presentation of results in the report.

34 The cumulative increase is the summation of the difference between the base case and scenario for every year from 2025-2040.

To place these projected impacts in perspective, the discounted present value (using a 7% discount rate) of the national output increase under:

- **Scenario 1** is:
  - Equivalent to around 25% of Australia's current GDP.
  - Nearly equivalent to the combined economies of Queensland and South Australia—Queensland's Gross State Product (GSP) was $515.9 billion and South Australia's GSP was $152.2 billion as of June 2024 (current prices).
- **Scenario 2** corresponds to approximately 90% of New South Wales's economy ($788.6 billion as of June 2024).

These represent transformative economic impacts.

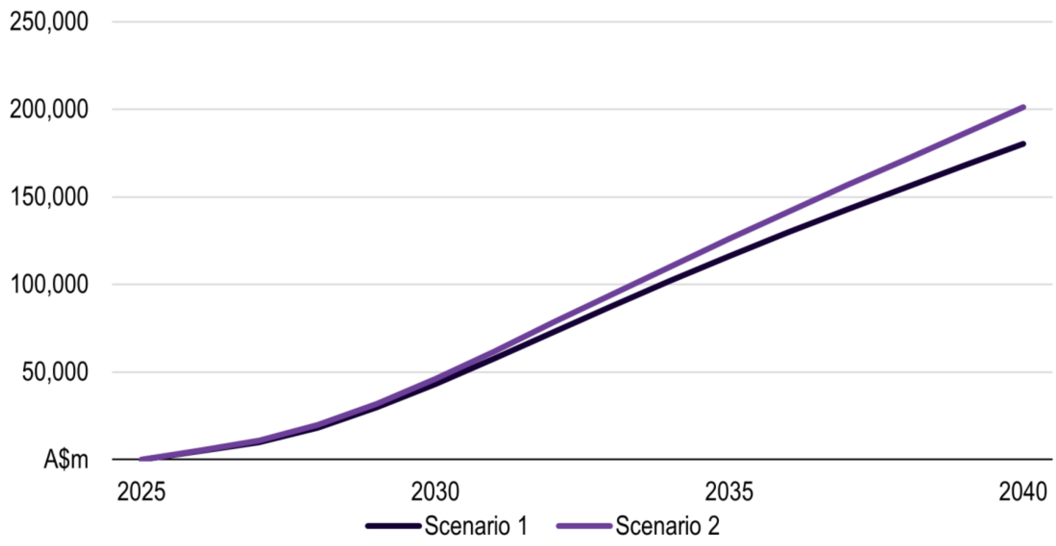
Figure 3.2 illustrates how increased robot adoption and production progressively enhance Australia's real economic output, with benefits accumulating as robot stock and production capacity expand over time.

Table 3.1 Estimated impacts on economic output from 2026 to 2040 associated with the modelled scenarios (relative to the Base Case), $ billion (2024 dollars)

	Total (2026-2040)	Annual average	Net Present Value (7%)
Scenario 1: increased adoption of robots in Australia	1,318.6	87.9	651.0
Scenario 2: increased adoption and production of robots in Australia	1,441.5	96.1	709.5

Source: ACIL Allen

Figure 3.2 Estimated impacts on economic output from 2026 to 2040 associated with the modelled scenarios (relative to the Base Case), $ million (2024 dollars)



Source: ACIL Allen

3.2.2 Real income impacts

Real income measures the ability to purchase goods and services, adjusted for inflation. A rise in real income indicates a rise in current consumption capacity and an increased ability to accumulate wealth in the form of financial and other assets.

In global CGE models such as *Tasman Global*, the change in real income is equivalent to the change in consumer welfare using the equivalent variation measure of welfare change resulting from exogenous shocks. Hence, it is valid to say that the projected change in real income (from *Tasman Global*) is also the projected change in consumer welfare.

The estimated changes in real income associated with increased use and production of robots are shown in Table 3.2 and Figure 3.3.

Table 3.2 illustrates that increased robot utilisation and production could significantly increase Australia's real income over the 2026-2040 period (relative to the Base Case):

— **Scenario 1** projects an annual average increase of $89.5 billion in real income, accumulating to $1.34 trillion over the forecast period compared to the Base Case.

— **Scenario 2** could deliver a more substantial $1.52 trillion cumulative increase in real income over the 15-year horizon. This translates to an average annual income boost of $101.5 billion.

To place these estimated changes in income in perspective, the value today of 15 years of increased income (from 2026 to 2040)[35] is equivalent to increasing the average income of all current Australian residents (relative to the Base Case):

— By $24,400 per person under Scenario 1.

— By $27,500 per person under Scenario 2.

Table 3.2 Estimated impacts on real income from 2026 to 2040 associated with the modelled scenarios (relative to the Base Case), $ billion (2024 dollars)

	Total (2026-2040)	Annual average	Net Present Value (7%)
Scenario 1: increased adoption of robots in Australia	1,342.8	89.5	665.9
Scenario 2: increased adoption and production of robots in Australia	1,522.9	101.5	751.6

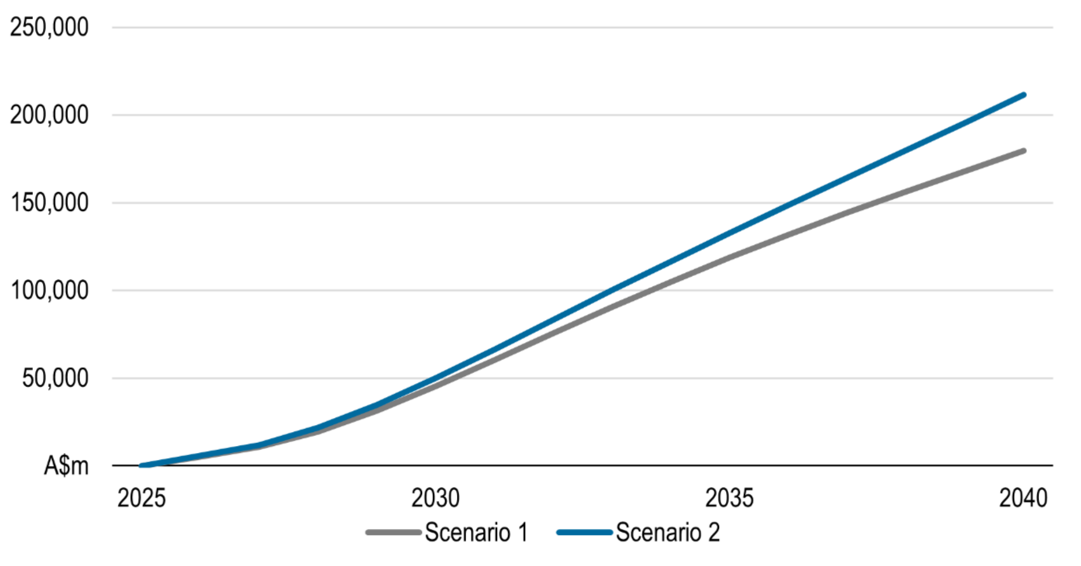
Source: ACIL Allen

Another way to conceptualise these projected real income increases is to consider the additional annual income per person in 2040, which is estimated at $5,500–$6,500 under the two scenarios. These figures are derived from modelled projections of the increase to total real national income under the two scenarios. In Scenario 1, the additional real income above the Base Case in 2040 is projected at $179.5 billion, while Scenario 2 projects $211.5 billion abvoe the Base Case for real income in 2040 (see Figure 3.3). These values are divided by the projected Australian population in 2040 of 32,308,944, based on the Australian Bureau of Statistics medium-series population forecast.

Overall, as shown in Figure 3.3, the pattern of annual changes in real income is similar to the pattern of changes in real economic output. This is because there are only minor terms of trade and foreign income transfer effects as a result of the modelled increases in robot utilisation and production.

[35] That is, the discounted present values of the projected changes in real income using a 7% real discount rate.

Figure 3.3 Estimated impacts on real income from 2026 to 2040 associated with the modelled scenarios (relative to the Base Case), $ million (2024 dollars)



Source: ACIL Allen

3.2.3 Labour market impacts

Employment

The increased adoption of robotics is expected to significantly reshape workforces across the economy. As robots take over routine, predictable, and physically demanding tasks, the nature of work will evolve, leading to a shift in the skills required across many occupations.

In the short term, this transition will cause some job changes within certain sectors and between industries. However, the widespread adoption of robotics will likely enhance the productive capacity of our economy and thus generate new employment opportunities for Australians. Over time, these enhancements will also generate positive second-order effects on income and consumption, reinforcing a cycle of longer-term economic growth.

Employment dynamics are closely tied to economic activity and investment. As firms become more productive through increased use of robotics, and as domestic demand for robots grows, businesses can expand operations, invest in capital, and increase output. These developments, in turn, shift the demand for labour. As a result, employment trends tend to mirror changes in economic output.

The figures presented below represent net employment impacts that fully account for both job transition caused by robotics automation and new job creation from productivity gains, economic expansion, and emerging industries. The CGE model captures the complete adjustment process, including workers transitioning between sectors and the economy's return to equilibrium employment levels.

The economic modelling indicates that the productivity and output gains from increased adoption and domestic production of robotics will lead to a net increase in employment across Australia (see Table 3.3 and Figure 3.4). These figures account for all job transition effects from robotics automation. Specifically, between 2026 and 2040, it is estimated that, relative to the Base Case:

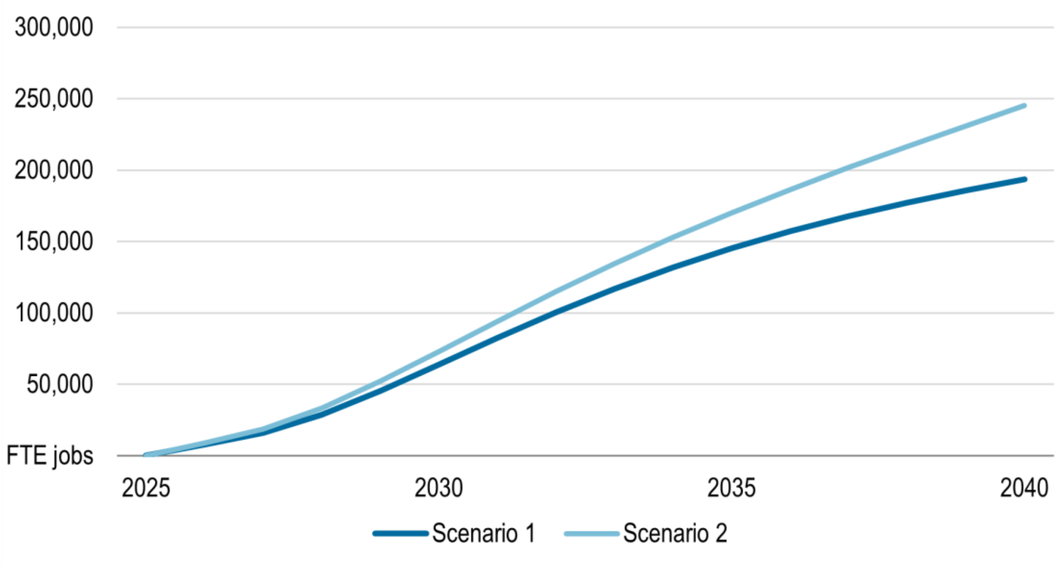
- 1.6 million employee years[36] of full-time equivalent employment (FTE) net additional direct and indirect jobs will be created in Australia under Scenario 1 (implying an average annual net increase of 108,029 FTE jobs).
- 1.9 million employee years under Scenario 2 (an average annual net increase of 128,946 FTE jobs).

Table 3.3 Estimated change in employment from 2026 to 2040 associated with the modelled scenarios (relative to the Base Case, FTE jobs across the whole Australian economy)

	Annual average	Total (2026-2040)
	FTE	Employee years
Scenario 1: increased adoption of robots	108,029	1,620,429
Scenario 2: increased adoption and production of robots	128,946	1,934,194

Source: ACIL Allen

Figure 3.4 Projected change in total (direct and indirect) employment from 2026 to 2040 associated with the modelled scenarios (relative to the Base Case, FTE jobs across the whole Australian economy)



Source: ACIL Allen

A key issue when estimating the impact of an industry change is determining how the labour market will clear.[37] In general, increases in the demand for labour from the productivity gains enabled by increased use and production of robots can be met by some combination of three mechanisms: increasing participation rates and/or average hours worked; increasing migration; and reducing the unemployment rate. In the model framework, the first two mechanisms are driven by changes in the real wages paid to workers while the third is a function of the additional labour demand relative to the Base Case. Given the low unemployment rate assumed throughout the projection period, changes in the real wage rate account for the majority of the additional labour supply in the modelled scenarios relative to the Base Case.

[36] An employee year is employment of one full time equivalent (FTE) person for one year or one 0.5 FTE person for 2 years.

[37] As with other CGE models, the standard assumption within *Tasman Global* is that all markets clear (i.e., demand equals supply) at the start and end of each time period, including the labour market. CGE models place explicit limits on the availability of factors and the nature of the constraints can greatly change the magnitude and nature of the results. In contrast, most other tools used to assess economic impacts, including I-O multiplier analysis, do not place constraints on the availability of factors. Consequently, non-CGE methods tend to overestimate the impacts of a project/change.

It should be noted that this analysis does not assume any changes in net foreign migration because of the increased use or production of robots in Australia.[38]

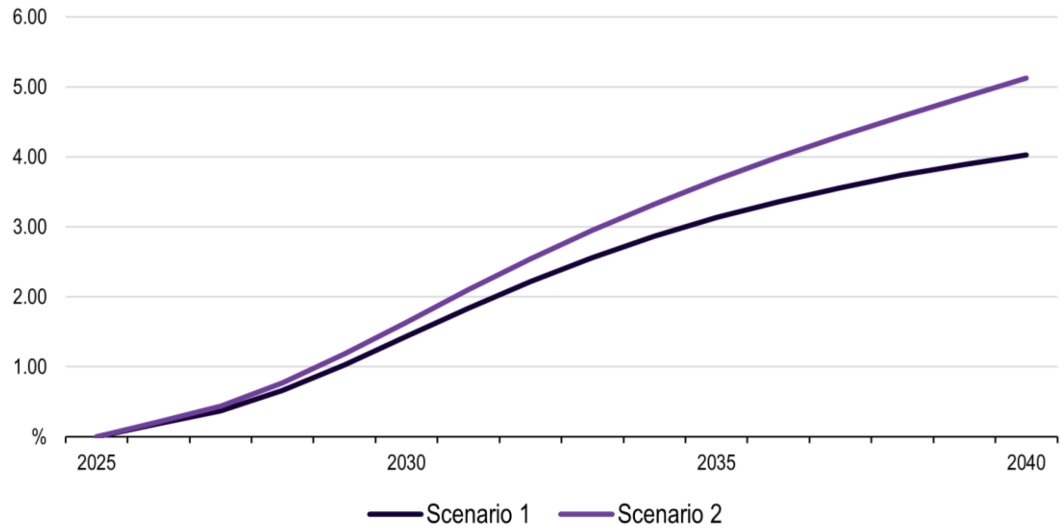
Wages

Figure 3.5 shows the projected changes in real wages under each of the modelled scenarios. The projected changes in real wages follow the changes in labour demand, with wages acting to balance demand and supply in each year. In addition, the magnitude of the projected changes in real wages is a function of the relative size of the demand and supply imbalance with respect to the overall size of the labour market (that is, large percentage increases in labour demand relative to the reference case will tend to result in large percentage increases in real wages relative to the reference case).

As can be seen from Figure 3.5, there is a significant increase in the average real wages in Australia as a result of the increase in utilisation and production of robots. As would be expected, the wages' profile follow the profile of changes in employment.

Over the period 2026 to 2040, real wages in Australia are projected to increase by an average of 2.2% under Scenario 1 and 2.8% under Scenario 2 (relative to the reference case). This is a sizeable increase in the context of CGE models.

Figure 3.5 Projected change in real wages by scenario, relative to the reference case



Source: ACIL Allen

3.2.4 Government revenue

The growth in the Australian economy driven by the increased adoption and manufacturing of robots will generate greater taxation payable to governments in Australia. It is estimated that over the 15 years of the scenarios analysed in this report, total taxation payable to Australian governments will increase by approximately $341 billion under Scenario 1 and by approximately $395 billion under Scenario 2. As can be seen from Table 3.4, just over half of the total revenues are expected to come from higher personal income taxes driven by the higher real wages. This is followed by higher company income taxes and additional GST revenues, each accounting for around 13%-16% of the additional revenues.

[38] The underlying logic for this assumption is that these changes do not have any significant effect on the Australian Government's immigration policy.

Table 3.4 Impact of total taxation revenues, relative to the reference case, 2025 to 2040 (in real 2024 terms)

	Total	Net present value			
	(2026-2040)	3%	5%	7%	10%
	A$ billion	A$ billion	A$ billion	A$ billion	A$ billion
Scenario 1					
State payroll taxes	22.5	16.5	13.6	11.3	8.6
Federal personal income taxes	182.8	134.3	110.5	91.7	70.3
Federal company income taxes	55.8	40.3	32.7	26.8	20.2
GST	45.2	33.1	27.1	22.4	17.1
Other State and Federal Government taxes	34.4	25.5	21.2	17.7	13.7
Total Australia	340.7	249.7	205.2	169.9	130.0
Scenario 2					
State payroll taxes	26.6	19.5	16.0	13.3	10.1
Federal personal income taxes	216.5	158.6	130.2	107.8	82.5
Federal company income taxes	55.2	39.8	32.4	26.5	19.9
GST	51.3	37.4	30.7	25.3	19.3
Other State and Federal Government taxes	45.5	33.5	27.6	22.9	17.6
Total Australia	395.2	288.9	236.9	195.9	149.4

Source: ACIL Allen

4 Unlocking the potential of robotics in Australia

This chapter explores the key lessons to be learned from successful robotics nations, outlining critical success factors and a blueprint for success.

4.1 International best practice: lessons from leading robotics nations

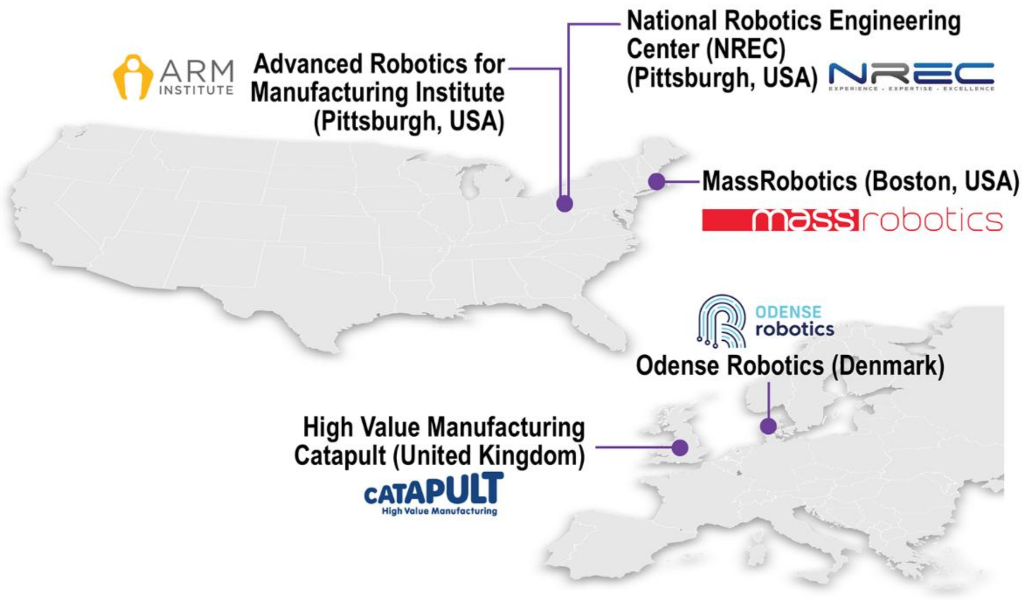
While earlier sections of this report have examined the outputs of a strong robotics industry, such as patent activity, commercial success, and workforce growth, this section turns to the underlying conditions that enable that success in the first place.

It is clear from the research that robotics clusters play a critical role in strengthening a nation's robotics industry. When looking at some of the world's leading robotics countries, it was found that they all had strong, well-supported clusters at the heart of their ecosystems. While this is not to say that Australia lacks robotics clusters, examining international examples offers valuable insight into how such ecosystems can be more deliberately structured, supported, and scaled to drive national competitiveness. By reviewing these clusters, we gained insights into how physical proximity, shared infrastructure, and coordinated support mechanisms can accelerate robotics capability and competitiveness. We found that clusters are not just a by-product of a strong robotics industry, but are often the engine that drives it.

A range of international robotics clusters is driving the development and adoption of robotics technology globally. These clusters foster innovation, support commercialisation, and facilitate collaboration between industry, government, and academia. They vary in their focus, funding models, and approaches to project selection, but they share a common goal: to accelerate the commercialisation and adoption of robotics across different sectors.

Below is an overview of some important international robotics clusters, highlighting their objectives, activities, and impact. These clusters were chosen for their demonstrated leadership in robotics research and strong engagement with a large number of start-ups. They also illustrate the diverse governance and funding models, spanning multiple regions. Together, they offer comparable insights into best practices and challenges in scaling robotics innovation. A more fulsome analysis of each can be found in Appendix E.

Figure 4.1 International best practice clusters



Source: ACIL Allen

MassRobotics (Boston, USA)

MassRobotics is a non-profit robotics hub based in Boston's Innovation District. It is positioned near more than 400 robotics companies and world-class universities. Established in 2015, its mission is to accelerate innovation and adoption in robotics by providing infrastructure, funding opportunities, and networking support for startups and industry stakeholders. The centre offers a comprehensive ecosystem, including shared prototyping facilities, industrial automation labs, and an accelerator program that provides US$100,000 in non-dilutive funding.

MassRobotics has been instrumental in supporting over 200 startups, which collectively have raised over US$1 billion and hired more than 600 people. Through initiatives such as the International Immersion Program and custom industry challenges, MassRobotics fosters global collaboration and ensures that new robotics ventures have access to the resources and guidance that are necessary to succeed in both U.S. and international markets.

Advanced Robotics for Manufacturing (ARM) Institute (Pittsburgh, USA)

The ARM Institute was founded in 2017 by Carnegie Mellon University as a key part of the U.S. government's Manufacturing USA initiative. It focuses on strengthening U.S. manufacturing by advancing robotics, automation, and AI solutions. ARM operates a membership-based model, bringing together over 400 stakeholders from industry, academia, and government.

It facilitates the commercialisation of robotics solutions through competitive Project Calls (competitive funding mechanism used to solicit proposals for targeted research, development, or commercialisation activities), targeting technology readiness levels (TRL) 4-7. The institute also plays a role in workforce development, and maintaining the RoboticsCareer.org database to connect workers with training opportunities. ARM supports small and medium-sized manufacturers through the Robotics Manufacturing Hub, providing no-cost prototyping and proof-of-concept demonstrations.

National Robotics Engineering Center (NREC) (Pittsburgh, USA)

Operating as part of Carnegie Mellon University's Robotics Institute since 1996, NREC specialises in developing customised robotics solutions from concept to commercialisation. It follows an eight-step process that includes problem assessment, technology invention, prototyping, and commercialisation support. NREC works across multiple sectors, including agriculture, defence, energy, and logistics, with funding from both public and private sources.

A 2021 evaluation highlighted its role in workforce development, with 64% of its alumni remain in the Pittsburgh robotics sector, and over 20 firms with a combined valuation exceeding US$25 billion were founded by former NREC personnel. NREC's intellectual property has been widely adopted around the world, with around 450 technology licenses for robotics solutions in 31 countries, demonstrating its global influence. The centre has also played a significant role in the economic transformation of the Lawrenceville neighbourhood in Pittsburgh, driving job creation and regional development.

High Value Manufacturing Catapult (HVMC) (United Kingdom)

Part of the UK's Catapult Network, HVMC focuses on enhancing manufacturing productivity by providing R&D expertise and technological infrastructure to businesses. Unlike other robotics-specific hubs, HVMC supports a broad range of manufacturing innovations, including robotics.

It offers tailored support for startups, SMEs, and large enterprises, helping businesses scale their operations and integrate new technologies. HVMC engages in collaborative R&D, connecting manufacturers with academia and government to accelerate commercialisation. In 2022-23, it worked with 5,810 companies, of which 3,496 were SMEs, and generated £275 million in R&D and commercial income. The UK government plays a central role in HVMC's funding, ensuring that firms can access initial support at no cost.

Odense Robotics (Denmark)

Odense Robotics is Denmark's national robotics, automation, and drone cluster, with regional hubs across the country. Its mission is to drive innovation and sustainable development in the robotics sector by fostering collaboration between private companies, research institutions, and government agencies.

The organisation provides early-stage startups with financial and technical support through the Odense Robotics Start-Up Fund, which has a total capital of DKK 18.4 million (around A$4.4 million). Companies in the incubator program benefit from mentorship, business coaching, and collaboration with leading researchers. The now-closed Odense Robotics Start-Up Hub, which operated from 2015 to 2022, had an 80% success rate, with its alumni securing over €30 million in external investment and employing more than 170 people. The cluster continues to support hardware startups and aims to strengthen Denmark's position as a global leader in robotics.

4.2 Critical success factors

While the number of international robotics hubs examined here was relatively small, there were a number of trends in the approaches they adopted to grow the robotics sector. These included:

— All centres **recognised the importance of robotics** for improving the performance, productivity and competitiveness of industry more broadly.

— All centres place a **strong emphasis on supporting the commercialisation of robotics** technologies. Hence there is a focus on supporting startups. For three of the centres, supporting startups is a major objective. The other two centres are focussed on developing and commercialising robotic solutions to solve specific problems that industry have identified. The selection of problems that the centre seeks to find solutions for is generally based on applications by either those seeking support or members requesting support to address a specific problem. The support provided by centres often includes providing the hardware facilities to develop and construct prototypes of new robot technologies and the space to test their operation.

— All centres have a **strong collaboration** ethos that is central to their operations. Allowing regular and easy contact between participants in the centre is seen as crucial to ensuring that industry is aware of the capabilities that researchers have developed and that researchers understand the problems for which industry are seeking solutions.
— **Education and training** of the next generation of workers with robotics-related skills is recognised as important to develop and maintain local capacity, and longer-term sustainability of the local robotics sector.
— Most centres are **quite broad in the sectors that they support**. Notably, several include an interest in supporting the development and adoption of robot technologies for defence purposes (either direct or dual use robotics).
— Funding by **government tends to play a role** in most centres, particularly in the early stages of a centre. However, several of the centres have transitioned to a **funding model that relies heavily on the income from membership fees and or fees for services** to support their ongoing operations. To the extent that any government support is provided it tends to be largely for one off capital injections to fund the purchase of new equipment or building additional facilities.
— Centres tend to be **located close to existing educational institutions and industry** with an interest in researching, developing and adopting robotics. Several stakeholders spoke of the importance of ensuring that the centres had strong transport links and that participants had easy (often walkable) access to each other’s organisations. This was important for allowing students and researchers at universities to come to the centre and make use of its facilities.
— Support provided by centres often include providing the facilities to develop and test robot technologies

In summary, this review of international robotics centres has identified a number of critical elements for success, namely:

— Ensuring a strong and collaborative partnership between industry, research and government participants in the centre.
— The importance of locating the cluster in close proximity to research institutions. This includes ensuring that the cluster is accessible to both industries that are likely to be end users of the technologies developed and firms that supply goods to robot manufacturers.
— Adopting a flexible approach to the sectors that robotics can assist and having the option to grow the cluster over time as its operations expand.
— Recruiting the right sort of leadership and having one or more champions that are committed to growing the robotics sector. These should be people who want to grow the pie for everybody rather than capture a bigger share of the existing (or smaller) pie.
— The cluster needs to have a laser sharp strategic focus on commercialisation and training. Stakeholders generally agreed that this strongly suggests that the leadership should not come from a research institution.
— The cluster should have a suite of programs, activities and facilities that it makes available to its participants. It should be a physical space with access to testing facilities, equipment, workshops, product demonstrations and investor functions.

Figure 4.2 Critical success factors for a robotics hub

COMMERCIALISATION FOCUS

- Provide industry-led pathways to commercialisation
- Comprehensive support framework for emerging startups that provides direct linkages to end markets

LOCATION

- Proximity to university talent pools
- Accessible by public transport
- Livable and attractive location for a highly educated and entrepreneurial community
- Concentrated innovation environment

SPACE AND SUPPORT

- Purpose-built facilities for robotics development and testing
- Dedicated spaces for startup incubation
- Multifaceted training programs (academic and entrepreneurial)
- Industry showcase opportunities

COLLABORATIVE ECOSYSTEM

- *Meaningful* engagement from industry, research, and government stakeholders
- Direct access to potential customers and market channels

STRONG LEADERSHIP

- Independent sector champion driving the robotics vision
- Industry-focused governance
- Diverse advisory board representing key stakeholders (industry, academia and government)

FLEXIBILITY FOR GROWTH

- Scalable testing infrastructure/facilities allowing for staged growth
- Strategic expansion across diverse sectors, technologies, and markets

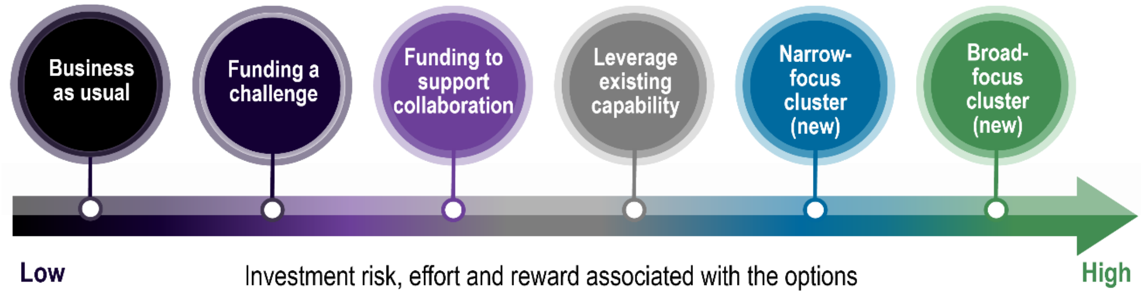
Source: ACIL Allen

4.3 Possible next steps for Australia

Our research and feedback from stakeholders collected for this study suggest a range of viable options for the future. These options cover a broad spectrum of approaches, ranging from 'do nothing/minimal intervention' to 'significant' public and private investments.

We have conceptualised these options as a spectrum shown in the figure below.

Figure 4.3 Investment spectrum based on practice in other jurisdictions



Source: ACIL Allen

This spectrum recognises that it is an option not to do anything in this space or to provide minimal public and industry investment in Australian robotics. In other words, just let the existing capabilities and clusters grow organically. However, as Chapter 3 has highlighted, this would represent a significant lost opportunity to the economy, as it does not deal with the scale and fragmentation issues that currently constrain the adoption of robotics in Australia.

Table 4.1 Investment spectrum description

Investment option	Description
Business as usual	Maintain current investment levels and strategies, relying on organic growth and existing policy measures without additional targeted interventions.
Funding a challenge	Initiate a DARPA-style robotics challenge to stimulate innovation and competition, attracting national and international talent.
Funding to support collaboration	Create or support an existing entity to coordinate industry, research, and government collaboration, facilitate commercial partnerships, and actively promote investment in Australian robotics. Government oversight, possibly through the Department of Industry, Science and Resources, could ensure strong cross-sectoral linkages.
Leverage existing capability	Strategically invest to enhance and expand an established robotics cluster, maximising existing strengths and infrastructure.
New, narrow-focus cluster	Establish a new robotics cluster from the ground up, developed with targeted support from commercial and strategic partners, focused specifically on a key industry (e.g., agriculture or mining).
New, broad-focus cluster	Establish a new robotics cluster from the ground up, developed with broad support from commercial and strategic partners, and designed to be technology and industry agnostic, fostering innovation across multiple sectors.

Source: ACIL Allen

The spectrum also recognises that the opportunities to undertake significant investment in Australian robotics that could (if appropriately constructed and funding is provided) accelerate the benefits of robotics to the Australian economy. It is our view, and the view of many stakeholders consulted for this report, that as the investment profile increases for a cluster, so do the risks that it will guarantee a suitable return on investment.

It is important that an investment in a robotics is based on best practice. This study has identified the key ingredients to delivering a cluster that is connected domestically and internationally, grows our capabilities and delivers impact that endures. However, to operationalise these ingredients, an enhanced robotics capacity need support from the government and key industry partners.

For most paths forward, the framing of the value proposition is critically important. Stakeholders consulted for this report have observed that robotics is often seen to be a lower priority in an investment climate dominated by the buzz of AI and quantum computing. Framing of any investment opportunity must therefore elevate robotics by emphasising its real contributions to economic growth while also highlighting its compatibility with emerging technologies.

The future for Australian robotics is exciting and complex. It is undoubted that robotics will change the nature of our economy and the way we live. The opportunities are clear, but so too are the risks, and seizing this opportunity will require courage and vision. Now is the moment to push beyond proof-of-concept and for investors to back bold, scalable ventures. This is more than a technology bet: it's an investment in Australia's productivity, resilience, and future prosperity.

Appendices

A Detailed modelling approach

The potential impacts of increased robotics adoption and production on the Australian economy were estimated using a Computable General Equilibrium (CGE) model of the Australian economy, the *Tasman Global* model. The sections below provide more details about these assumptions, the simulation design and the inputs used for the economic modelling. Additional details about *Tasman Global* are provided in Appendix D.

A.1 Why use a CGE model to evaluate economic impact?

An impact evaluation of industry changes requires an understanding of what would happen in the absence of the outputs that are attributed to the change under examination. This 'without change' scenario (the 'counterfactual') cannot, of course, be observed, so it must be inferred.

Establishing the 'without change' baseline is fundamental to assess the extent to which the aims of an industry intervention (like increasing robot adoption) are being achieved. A CGE model is capable of providing an accurate reflection of the world without policy intervention or industry change (that is, without the industry changes being assessed, in this case, without increasing robot adoption/production). In that sense, it is a much more useful tool than a comparative cost-benefit analysis approach. Furthermore, a CGE model can estimate the impacts of industry changes on key macroeconomic aggregates such as GDP, exports, imports, consumption and investment and can provide valid measures of changes in consumer welfare or living standards so that the impacts of change can be correctly evaluated in terms of public interest.

The use of CGE models in policy and program analysis imposes a discipline in which model structures can be easily compared and contrasted, and model results can be interpreted using a well-understood and rigorously developed theoretical framework. In addition, the use of a CGE framework allows capturing both the direct and indirect impacts of the increased robot adoption/production. A CGE model is a high-level representation of the Australian economy that allows measuring the wider effects of changes in economic activity in key industries and regions. To the extent that economic activity is interlinked, a CGE model will capture any flow-on effects that arise from increased use and production of robots in Australia, including upstream and downstream impacts.

CGE models are widely used by government, industry and academics to evaluate the worth of policy actions, programs and projects. This means that CGE modelling results are well understood and accepted by a wide range of stakeholders.

A.2 Modelled scenarios

As noted before, the modelling examines the potential economic impact of increased robotics adoption and production in Australia (rather than evaluating any specific intervention - such as a robotics cluster). Our approach quantifies the prospective economic benefits that would result from strengthening Australia's robotics ecosystem through achievement of specific aspirational targets. These targets were formulated based on:

— publicly available data, including comparative robot adoption metrics from international markets and relevant academic literature

— consultations with Amazon and key industry stakeholders engaged during this project.

The following scenarios were simulated in the *Tasman Global* model to measure the potential impacts of increased robotics adoption and production on the Australian economy:

— *Base Case scenario* — a scenario projecting the future development of the economy under business-as-usual assumptions about macroeconomic variables and structural trends. This scenario reflects a state of the world where there are no additional investment/activities to grow the robotics ecosystem and industry adoption (other than existing/planned/committed policies, actions and investments). This was used as a benchmark with which to compare the results of simulating the increased robotics adoption scenarios.

— *Scenario 1: increased adoption of robots in Australia* — this scenario refers to a case where additional efforts are made to grow the Australian robotics ecosystem and increase robot adoption (both of industrial and service robots).

— *Scenario 2: increased adoption and production of robots in Australia* — this scenario refers to a case where additional efforts are made to increase robot adoption and production in Australia (both of industrial and service robots).

Differences in economic outcomes between the baseline and change scenarios are calculated to determine the potential economic benefits of increased robotics adoption.

The inputs used to model the change scenarios are discussed in more detail below.

A.3 Parameters and assumptions used for developing aspirational targets

A.3.1 Scenario 1: increased adoption of robots in Australia

As noted above, this scenario refers to a case where additional efforts are made to increase use of both industrial and service robots.

Three sets of shocks were applied to *Tasman Global* to simulate this scenario, one related to the benefits of increased use of industrial robots (which only affects the manufacturing sector), one related to the benefits of increased use of service robots (which affects other non-manufacturing industries), and one related to the costs of these additional robots. These are explained in more details in the sections below.

Industrial robots target

Estimating the direct benefits of increased use of industrial robots requires the following:

— data on the current number of robots in use in Australia (robot density)

— information on the main users of industrial robots within the Australian manufacturing sector

— estimates of the expected growth in the use of robots under the base case (the business as usual, BAU)

— setting a target for increased adoption of industrial robots under Scenario 1 (including defining which manufacturing sectors would benefit from this increased number of robots)

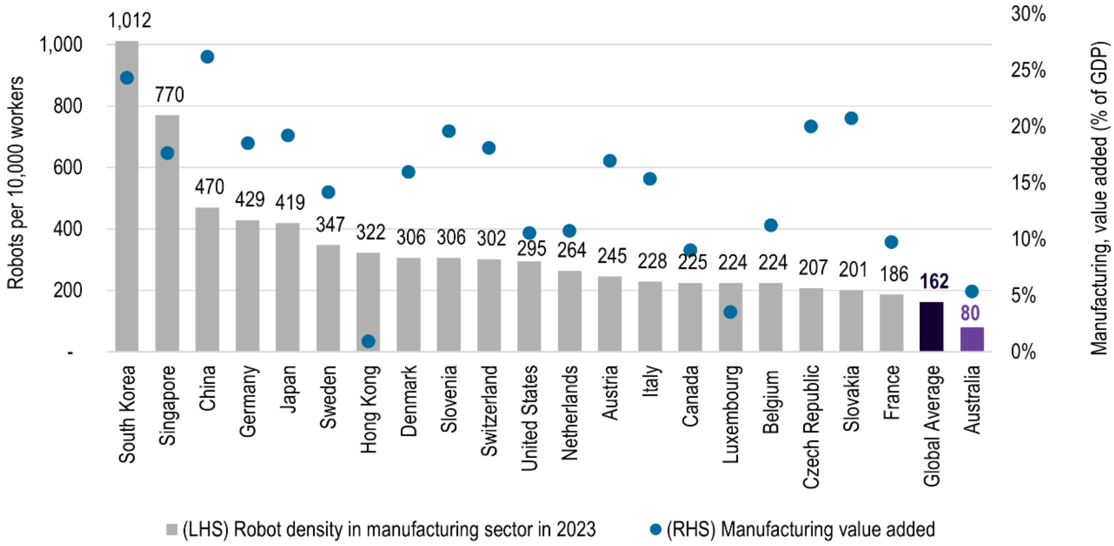
— estimating the benefits of these additional robots using estimates of the elasticity of robot adoption on productivity from national and international literature.

More details about these inputs are provided in following sections.

Australia's robot stock, density and main users

As discussed in Chapter 2, the IFR's most recent report indicates a density of 80 robots per 10,000 employees in Australia[39]. This compares to a global average density of 162 robots per 10,000 employees (see Figure A.1).

Figure A.1 Industrial robot density vs manufacturing value added in selected countries, 2023



Notes: Manufacturing value added refers to the 2023 year, except for Japan (2022), US (2021) and Canada (2020). Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.

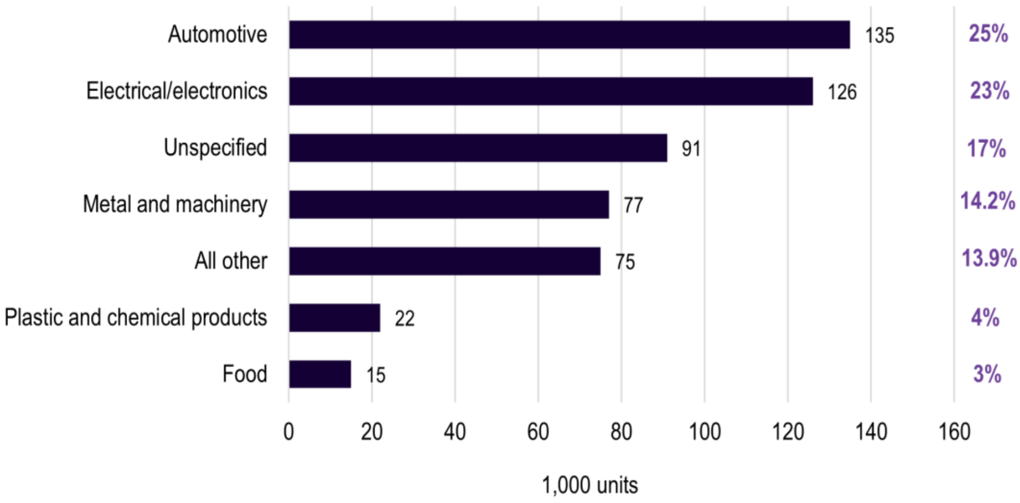
Source: IFR 2024, Presentation of World Robotics 2024, September; World Bank 2025, World Development Indicators, April.

In 2022, the IFR estimated that Australia had 8,154 operational industrial robots, corresponding to a density of 84 robots per 10,000 employees. Most were deployed in the metal industry (20%), food and beverage sector (18%), and chemical products (9%), with a smaller share in the automotive sector (2%).[40] Since data on robot deployment in other manufacturing subsectors is not publicly available, we developed approximate estimates based on global patterns (see Figure A.2). We assumed the remaining robots are distributed as follows: 23% in electrical/electronics and machinery and equipment manufacturing, and 28% across all other manufacturing subsectors.

[39] IFR 2024, *Presentation of World Robotics 2024*, September.

[40] Cited in Keay, Sue 2024, *Why Australia has such a low robot population density*, January, https://www.linkedin.com/pulse/why-australia-has-low-robot-population-density-sue-keay-id7xc, Accessed 7 May 2025.

Figure A.2 Annual installations of industrial robots by customer industry - World, 2023



Source: IFR 2024, Presentation of World Robotics 2024, September.

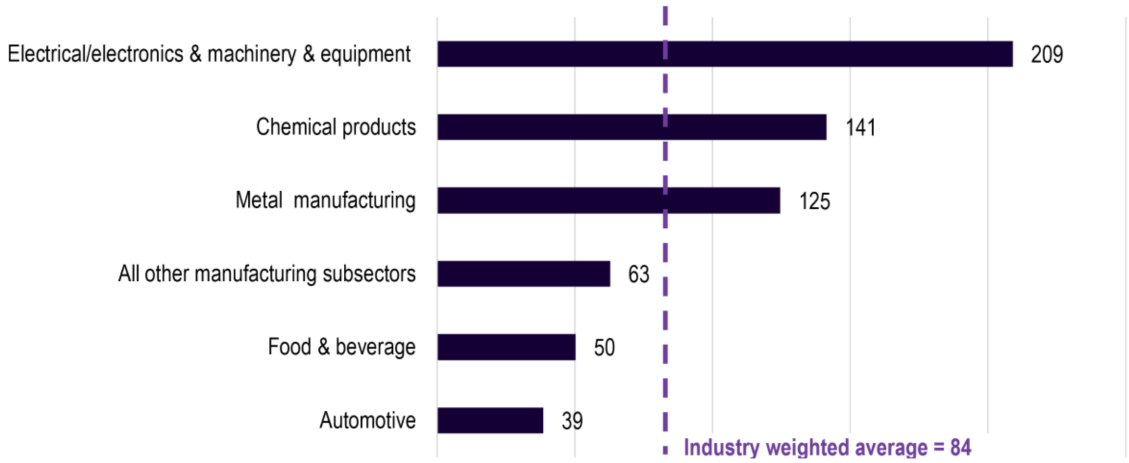
Our approximate estimates of robots' stock and density by different manufacturing subsectors in Australian in 2022 are outlined in Table A.1 and Figure A.3.

Table A.1 Approximate estimates of robot stock and density in Australia by main users, 2022

Main users within manufacturing industry	% of total robots	Robot units (No.)	Total employment	Estimated robot density
Electrical/electronics & machinery & equipment	23%	1,899	90,846	209
Metal manufacturing	20%	1,631	130,913	125
Food & beverage	18%	1,468	291,678	50
Chemical products	9%	734	51,888	141
Automotive	2%	163	42,219	39
All other manufacturing subsectors	28%	2,259	359,424	63
All manufacturing sectors	100%	8,154	966,967	84

Source: ACIL Allen based on information from IFR 2024, Presentation of World Robotics 2024, September; Keay, Sue 2024, Why Australia has such a low robot population density, January; and ABS 6291.0.55.001 Labour Force, Australia, Detailed.

Figure A.3 Approximate estimates of robot density across different manufacturing sectors in Australia in 2022

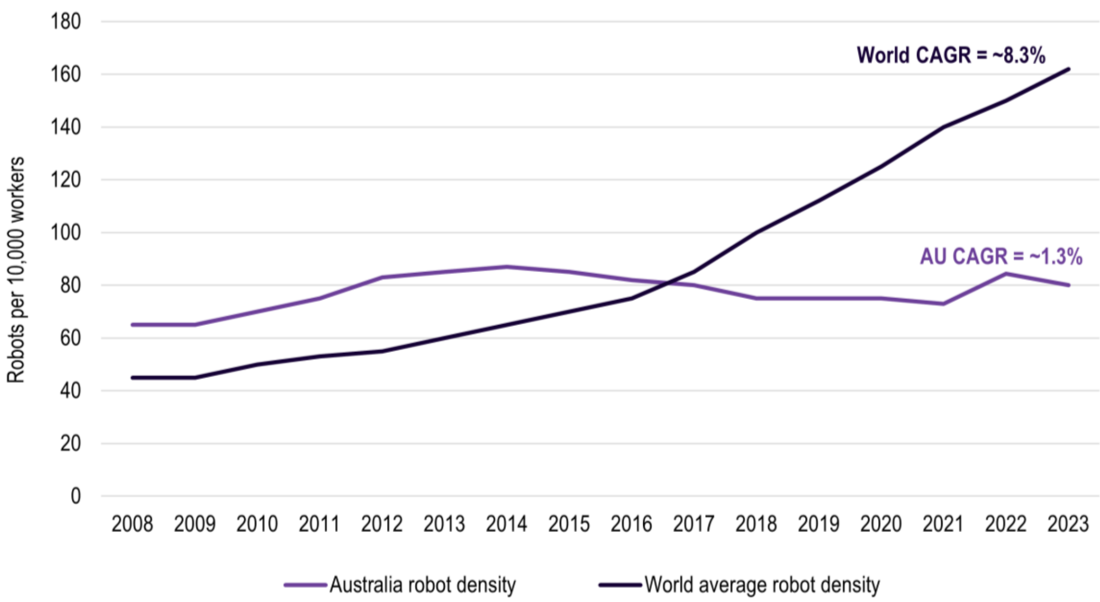


Source: ACIL Allen based on information from IFR 2024, Presentation of World Robotics 2024, September; Keay, Sue 2024, Why Australia has such a low robot population density, January; ABS 6291.0.55.001 Labour Force, Australia, Detailed.

Growth in Australia's robot stock under the BAU

Based on Australia's historical data on industrial robot population density (Figure A.4) and IFR's forecast of annual installations of industrial robots across different regions (Figure A.5), we have assumed that Australia's robot stock under the BAU would grow at a Compound Annual Growth Rate (CAGR) of 2% per annum. This assumption translates into a robot density of 112 robots per 10,000 employees by 2040 (see Figure A.6).

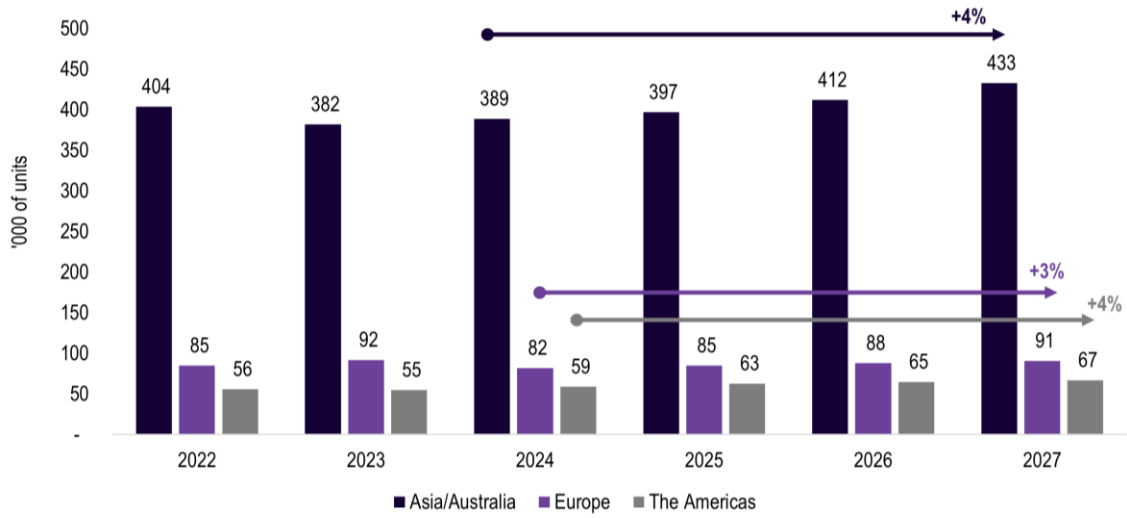
Figure A.4 Australia's industrial robot population density, 2008 - 2023



Note: CAGR stands for compound annual growth rate.

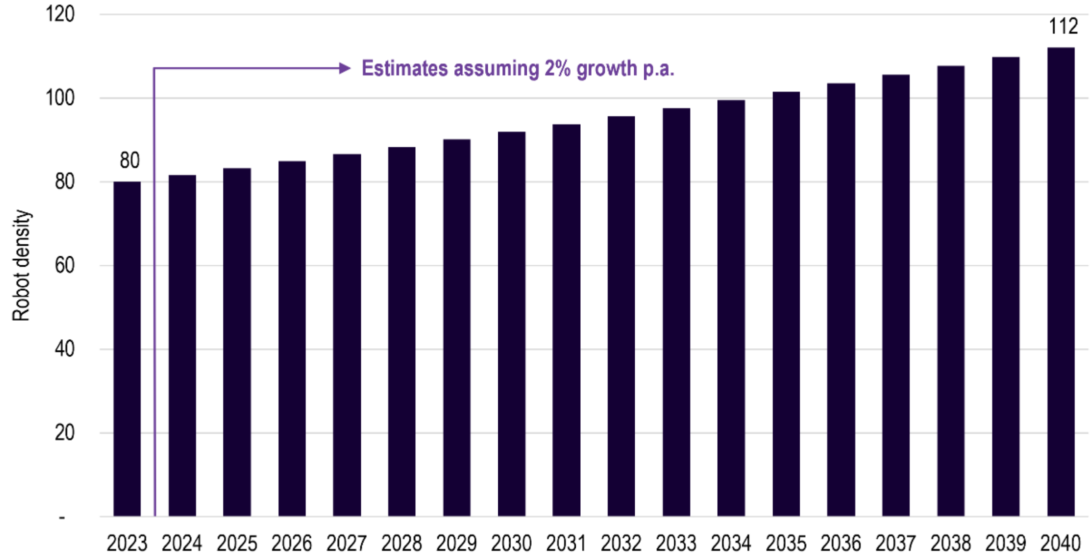
Source: ACIL Allen based on data from Keay, Sue 2024, Why Australia has such a low robot population density, January and IFR 2024, Presentation of World Robotics 2024.

Figure A.5 IFR forecast of annual installations of industrial robots (2024 -2027)



Source: IFR 2024, Presentation of World Robotics 2024, September.

Figure A.6 Assumed Australia robot density under BAU

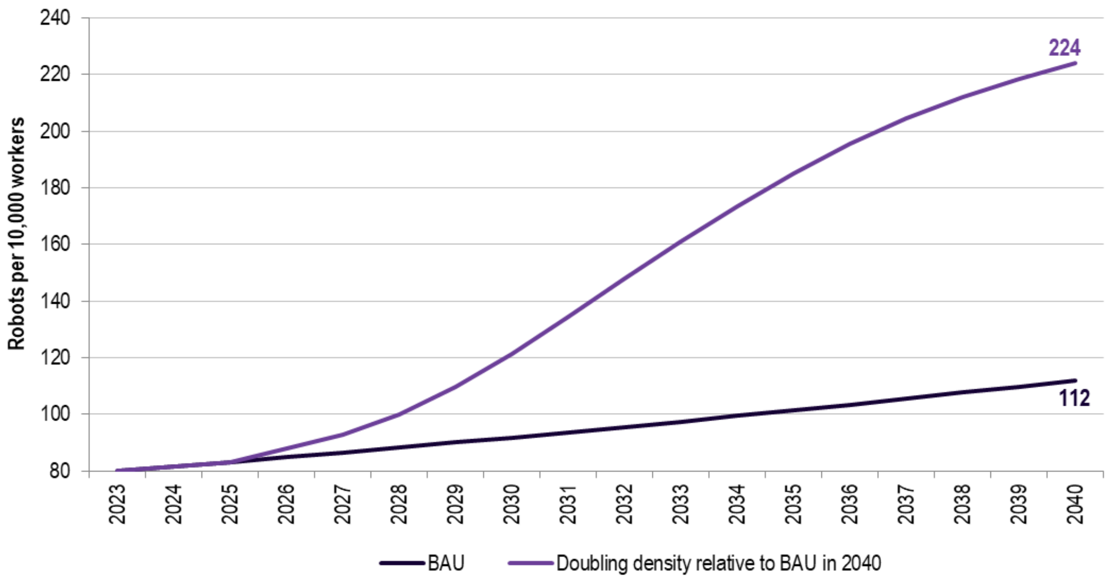


Source: ACIL Allen.

Increased robot adoption target

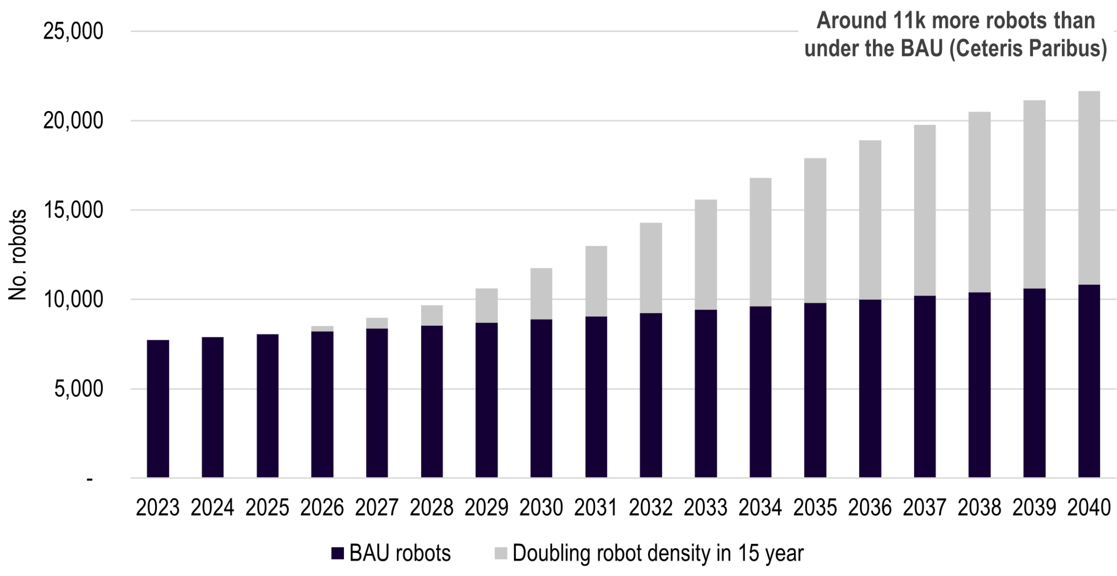
Under Scenario 1, we assume that Australia achieves an aspirational target of doubling its robot density by 2040 compared to the BAU trajectory. This implies reaching 224 robots per 10,000 employees by 2040 (see Figure A.7), which equates to approximately 11,000 additional robots relative to the BAU scenario, assuming all other factors remain constant (see Figure A.8). This target robot density is similar to the *current* density of other countries with similar manufacturing output (e.g. Canada and Luxemburg).

Figure A.7 Projected robot density under Scenario 1



Source: ACIL Allen

Figure A.8 Additional industrial robots under Scenario 1



Source: ACIL Allen

Beneficiaries of increased robot adoption

Both the Strategy and the 2025 Roadmap highlight the growth potential in robotics in the advanced manufacturing (AM) sector, 'particularly in niche areas like aerospace, medical devices, renewable energy technology, and value-added food products – where Australia has become a world leader.'[41]

[41] Robotics Australia Group (2025). *A Robotics Roadmap for Australia 2025.* Pg. 117.

The Australian Bureau of Statistics (ABS) defines AM as a sector that:

> *includes any manufacturing process that takes advantage of high-technology or knowledge-intensive inputs as an integral part of its manufacturing process. It includes chemical and medicinal manufacturing, vehicle and transport manufacturing, professional and scientific equipment manufacturing, computer and electronic manufacturing and specialised machinery and equipment manufacturing.*
>
> *ABS 2015, 8166.0.80.001 - Summary of IT Use and Innovation in Selected Growth Sectors, Australia, 2013-14, June*

The Australian and New Zealand Standard Industrial Classification (ANZSIC) Classes that ABS includes in this definition of the AM sector are outlined in Table A.2.

Table A.2 ANZSIC Classes within advanced manufacturing sector

ANZSIC Class Code	Description
	Chemical and medicinal manufacturing
1811	Industrial gas manufacturing
1812	Basic organic chemical manufacturing
1813	Basic inorganic chemical manufacturing
1821	Synthetic resin and synthetic rubber manufacturing
1829	Other basic polymer manufacturing
1831	Fertiliser manufacturing
1832	Pesticide manufacturing
1841	Human pharmaceutical and medicinal product manufacturing
1842	Veterinary pharmaceutical and medicinal product manufacturing
1851	Cleaning compound manufacturing
1852	Cosmetic and toiletry preparation manufacturing
1891	Photographic chemical product manufacturing
1892	Explosive manufacturing
1899	Other basic chemical product manufacturing n.e.c.
	Vehicle and transport manufacturing
2311	Motor vehicle manufacturing
2312	Motor vehicle body and trailer manufacturing
2313	Automotive electrical component manufacturing
2319	Other motor vehicle parts manufacturing
2391	Shipbuilding and repair services
2392	Boatbuilding and repair services
2393	Railway rolling stock manufacturing and repair services
2394	Aircraft manufacturing and repair services
2399	Other transport equipment manufacturing n.e.c.
	Professional and scientific equipment manufacturing
2411	Photographic, optical and ophthalmic equipment manufacturing
2412	Medical and surgical equipment manufacturing
2419	Other professional and scientific equipment manufacturing

ANZSIC Class Code	Description
	Computer and electronic manufacturing
2421	Computer and electronic office equipment manufacturing
2422	Communication equipment manufacturing
2429	Other electronic equipment manufacturing
2431	Electric cable and wire manufacturing
2432	Electric lighting equipment manufacturing
2439	Other electrical equipment manufacturing
	Specialised machinery and equipment manufacturing
2441	Whiteware appliance manufacturing
2449	Other domestic appliance manufacturing
2451	Pump and compressor manufacturing
2452	Fixed space heating, cooling and ventilation equipment manufacturing
2461	Agricultural machinery and equipment manufacturing
2462	Mining and construction machinery manufacturing
2463	Machine tool parts and parts manufacturing
2469	Other specialised machinery and equipment manufacturing
2491	Lifting and handling equipment manufacturing
2499	Other machinery and equipment manufacturing

Note: n.e.c. stands for nowhere else classified.

Source: ABS 2015, 8166.0.80.001 - Summary of IT Use and Innovation in Selected Growth Sectors, Australia, 2013-14, June.

For Scenario 1 it has been assumed that the additional robots are adopted across the above AM sectors according to the percentages in Table A.3.

Table A.3 Increased adoption of industrial robots under Scenario 1 – who benefits?

Subsectors	Share of robot increase	Key drivers for robot adoption
Chemical and medicinal manufacturing	30%	– Workplace safety (reduced human exposure to hazardous chemicals and materials) – Precision requirements (including batch consistency) – Quality control and inspection (strict regulatory compliance) – Skills shortages and ageing workforce
Vehicle and transport manufacturing	10%	– Competitive pressures (automation needed to remain viable against international manufacturers) – Complex assembly requirements suited to robotic assistance – Quality standards (precision welding and component assembly) – Workplace safety (reduction of worker exposure to hazardous environments)

Subsectors	Share of robot increase	Key drivers for robot adoption
Professional and scientific equipment manufacturing	20%	– Micro-precision requirements (production of components requiring extremely tight tolerances – e.g. optical components) – Complex assembly processes suited to robotic assistance (e.g. alignment of multiple precision components, assembly of multi-component systems with electronic elements) – Quality control and inspection (strict regulatory compliance for medical and surgical equipment) – Skills shortages and ageing workforce
Computer and electronic manufacturing	20%	– Production complexity, miniaturisation trends (assembly of increasingly smaller components more suitable to robots) and precision assembly requirements (exact placement of small components) – Competitive pressures (pressure to match international productivity and quality standards) – Skills shortages and ageing workforce
Specialised machinery and equipment manufacturing	20%	– Fabrication complexity – Competitive pressures – Meeting stringent quality standards and consistency – Skills shortages and ageing workforce

Source: ACIL Allen

Benefits of additional robot adoption

The direct benefits of increased adoption were calculated using estimates of the elasticity of robot adoption on productivity from national and international literature.

The elasticity of robot adoption measures the responsiveness of productivity growth to changes in robot density within an industry or economy. This metric quantifies how a percentage increase in robot adoption translates into percentage changes in productivity outcomes. For example, an elasticity of 0.15 would indicate that a 10% increase in robot density corresponds to a 1.5% increase in productivity.

A summary of the studies found in the literature that examine the impact of increased robot adoption on productivity is presented in Table A.4. As shown in this table, elasticity estimates vary significantly, ranging from 0.02% to 5.1%.

For modelling purposes, we apply an elasticity value of 0.94 (the average across all studies examined), which aligns with the central tendency observed in the literature where estimates typically approximate 0.1. This parameter indicates that a 1% increase in robot density would yield approximately a 0.1% increase in productivity.

Table A.4 Selection of literature studying the impact of increased robot adoption on productivity

Study	Industry	Relevant estimates	Summary and notes
Zhao, Y. et al (2024)[42]	Manufacturing (China)	A 1% increase in robot density raises labour productivity by approximately 0.018%. Labour productivity is defined as the ratio of value added for the year divided by the average number of employees in an industry.	This paper analyses the impact of industrial robots on labour productivity using panel data from 17 Chinese industries from 2006 to 2021. The key findings include: – Industrial robot adoption improves labour productivity - a 1% increase in robot density raises labour productivity by approximately 0.018%. – The impact varies across industry types, with low-density robotics industries showing larger productivity gains compared to high-density robotics industries (i.e. there may be diminishing marginal returns from industrial robots in promoting labour productivity). – Human capital serves as an intermediary between robot adoption and productivity improvement, suggesting robots contribute to productivity by optimising human capital structure. The paper does not explicitly calculate the costs of achieving the estimated productivity uplift (i.e., the direct costs of increased robot density). It focuses primarily on establishing the relationship between industrial robot adoption and labour productivity, finding that every 1% increase in industrial robot application density increases labour productivity by 0.018% on average. The paper does mention that capital inputs and material inputs are included as control variables in the econometric models used, but it does not specifically quantify the investment required to achieve specific robot density levels or conduct a cost-benefit analysis of robot adoption.
Investment Research SelectUSA (2020)[43]	Slow robot adopters: – Agriculture, Forestry, Fishing – Mining and Quarrying – Textile Manufacturing	A 1% increase in robot density raises productivity by 5.1%. Productivity is defined as output per unit of labour and is calculated by taking the ratio of growth in value added to growth in hours.	The report examines the relationship between industrial robot adoption and economic outcomes across industries globally from 2003-2017 using data from the International Federation of Robotics (IFR) on single industrial robot installations and industrial robot stock by industry and country. Key findings include: – A positive relationship between industrial robot density and productivity - an increase in industrial robot density of 1% is correlated with an increase in productivity of 0.76%, all else equal. – Industries slower to adopt robots saw greater productivity gains - these industries experienced a 5.1% productivity increase with each 1% increase in robot density, suggesting diminishing marginal returns in heavily roboticized sectors. – An inverse relationship exists between robot density and hours worked - a 1% increase in robot density correlated with a 1% decrease in hours worked overall, with slower-adopting industries seeing a larger 2.7% decrease. The report does not explicitly quantify the costs of achieving the estimated productivity uplift through increased robot density. There is no detailed cost-benefit analysis that shows the investment required to implement industrial robots against the productivity gains.
	Middle robot adopters: – Construction – Education – Utilities	A 1% increase in robot density raises productivity by 0.84%	
	Fast robot adopters: – Automotive and Other Transportation Manufacturing – Chemical Manufacturing – Food and Beverage Manufacturing – Metal and Electrical/Electronic Manufacturing – Wood and Paper Manufacturing	A 1% increase in robot density raises productivity by 0.49%	
	Manufacturing overall	A 1% increase in robot density raises productivity by 0.76%	

42 Yantong Zhao, Rusmawati Said, Normaz Wana Ismail, Hanny Zurina Hamzah, 2024, *Impact of industrial robot on labour productivity: Empirical study based on industry panel data*, Innovation and Green Development, Volume 3, Issue 2, 2024, 100148, ISSN 2949-7531, https://doi.org/10.1016/j.igd.2024.100148.

43 Investment Research Select USA 2020, *Robots and the Economy: The Role of Automation in Driving Productivity Growth*.

Study	Industry	Relevant estimates	Summary and notes
Oxford Economics (2019)[44]	Manufacturing (sample of various countries)	A 1% increase in the stock of robots per worker in the manufacturing sector leads to a 0.1% boost to Gross Value Added (GVA) per worker across the wider workforce	The report analyses the global impact of industrial robots on jobs and productivity. Key findings include: – Each new industrial robot displaces about 1.6 manufacturing workers, with a disproportionate impact on lower-income regions (displacing nearly twice as many jobs compared to higher-income regions). – Despite job displacement, robotics creates a significant economic dividend - a 1% increase in robot density in manufacturing boosts overall worker productivity by 0.1%. This productivity impact was calculated using a dynamic panel approach that controlled for factors such as skill levels and other capital investment across 29 of the world's most advanced economies. – Accelerated robot adoption could add $4.9 trillion to the global economy by 2030. The report does not explicitly calculate the costs of achieving the estimated productivity uplift through increased robot density. Instead, the authors use Oxford Economics' Global Economic Model (GEM) to simulate different scenarios of robot adoption rates, comparing a baseline projection with "high" and "low" scenarios that are 30% above or below the baseline respectively.
Jungmittag and Pesole (2019)[45]	Transport equipment (12 countries)	A 1% increase of the 2014 robot stocks would increase labour productivity on average by 0.105%. Labour productivity is defined as real value added divided by total hours worked.	This paper examines the impact of industrial robots on labour productivity using panel data from 9 manufacturing industries across 12 EU countries from 1995 to 2015. The authors used a Cobb-Douglas production function approach to analyse how robot density (measured as robots per 1 million euros of non-ICT capital input) affects labour productivity. Their key findings include: – Robot density has a significant positive effect on labour productivity - stocks of robots contribute substantially to productivity growth beyond what would be expected from traditional capital investment. – The impact varies by industry, with the largest productivity gains observed in transport equipment manufacturing, followed by rubber and plastic products, metals and metal products, and machinery and equipment. – The productivity impact of robots increased over time, being stronger in the 2008-2015 period than in 1995-2007, suggesting robots may need to reach a critical mass to achieve their full productivity benefits. – The researchers concluded that industrial robots represent an evolution of long-term automation rather than a breakthrough innovation, with their substantial effects currently limited to industries with already high robot deployment. They characterise robots as having a capital-augmenting effect that contributes to total factor productivity and thereby increases labour productivity. The paper does not explicitly calculate or quantify the costs of achieving the estimated productivity uplift through increased robot density.
	Manufacturing overall (9 industries, 12 countries)	0.088%	
Acemoglu, D. and Restrepo, P. (2020)[46]	Manufacturing (USA)	– One additional robot per thousand workers reduces employment by 0.2 percentage points and wages by 0.42%. – Robot adoption reduces costs by about 30% in the tasks where robots replace workers. – Robots are approximately 3 times as productive as the workers they replace in automated tasks.	This paper examines the economic effects of industrial robots on employment and wages in the United States between 1990 and 2007. Their key findings include: – One additional robot per thousand workers reduces employment by about 0.2 percentage points and wages by 0.42% in aggregate (equivalent to one robot replacing about 3.3 workers). – Effects are stronger in manufacturing and especially in industries that have heavily adopted robots (automotive, plastics, chemicals, metal products). – Job losses are concentrated among routine manual, blue-collar occupations with negative spillovers to construction, retail, and service sectors. – Robot adoption is distinct from and uncorrelated with other economic trends like Chinese import competition, offshoring, IT capital, or general capital deepening. The paper does not directly measure the financial costs of robot adoption but mentions that about two-thirds of robot costs come from services provided by local, specialised robot integrators who install, program, and maintain the equipment.

[44] Oxford Economics 2019, H*ow robots change the world - what automation really means for jobs and productivity*, June.
[45] Jungmittag, A., Pesole, A. 2019, *The impact of robots on labour productivity: A panel data approach covering 9 industries and 12 countries*, Seville: European Commission, JRC118044.
[46] Acemoglu, D. and Restrepo, P. 2020, *Robots and Jobs: Evidence from US Labor Markets*, Journal of Political Economy, 2020, vol. 128, no. 6, April.

Study	Industry	Relevant estimates	Summary and notes
Acemoglu, LeLarge and Restrepo (2020)[47]	Manufacturing (France)	N/A	This paper by examines the firm-level effects of robot adoption in French manufacturing from 2010-2015 using data on robot purchases across 55,390 firms (598 of which adopted robots), they find that, at the firm level, robot adoption leads to: – significant decreases in labour share and share of production workers – increases in value added and productivity – expansion of the adopting firm's overall employment. However, this employment expansion comes at the expense of competitors, as automation reduces relative costs for adopting firms. When measuring industry-wide effects, the overall impact of robot adoption on employment is negative. The paper estimates that a 20 percentage point increase in robot adoption (the average in their sample) is associated with a 3.2% decline in industry employment. The paper does not explicitly measure the economic costs of robot adoption in terms of investment required.
Ahmed and Hossain (2019)[48]	Manufacturing (global)	Robot adoption raised annual GDP growth by 0.37% across 17 countries	This paper examines the economic impacts of adoption of robotics globally. The authors analyse the robotics market's growth and impact on economic development, with a focus on major robotics-adopting countries like China, Japan, the US, South Korea, and Germany. The paper highlights several economic benefits of robotics adoption: – increased productivity and manufacturing efficiency – new job creation in robot-related industries (estimated 500,000-750,000 new jobs between 2008-2011) – higher GDP growth (citing research that robot adoption raised annual GDP growth by 0.37% across 17 countries) – cost-effectiveness compared to rising labour wages – improved product quality and reduction in defective products. While acknowledging job displacement concerns (noting Oxford Economics' projection of 20 million manufacturing jobs potentially replaced by 2030), the authors argue that robotics creates more jobs than it eliminates through increased productivity and new opportunities in programming, maintenance, and support services. The paper does not comprehensively measure the costs of increased robot adoption beyond mentioning the initial investment required. It primarily focuses on the positive economic impacts while acknowledging some challenges, particularly for labour markets and developing economies seeking to catch up with robotics leaders.

[47] Acemoglu, D., LeLarge, C. and Restrepo, P. 2020, *Competing with robots: firm-level evidence from France*, National Bureau Of Economic Research (NBER) Working Paper Series, Working Paper 26738, February.

[48] Ahmed, S. and Hossain, F 2019, *The impact of robotics in the growth and economic development*, The Business and Management Review, Volume 10 Number 5, December.

Study	Industry	Relevant estimates	Summary and notes
Cette, G., Devillard, A. and Spiezia, V. (2021) [49]			This paper examines the contribution of robots to productivity growth across 30 OECD countries from 1975-2019. The authors use a growth accounting approach to measure robot impact through two channels: capital deepening and total factor productivity (TFP). Key findings include: – Robot contribution to productivity growth was modest in most countries, including the US (not exceeding 0.2 percentage points per year). – The largest impacts were observed in Germany (0.7 percentage points in 1996-2005) and Japan (0.87 percentage points in 1976-1995). – Eastern European countries saw significant robot contributions in the 2005-2019 period due to manufacturing outsourcing from Western Europe. – Robot diffusion was concentrated in specific manufacturing sectors, particularly transport equipment (45% of world robot stock) and electronics (30%). – The authors conclude that robotisation does not appear to be the source of a significant revival in productivity. The paper does not directly measure the cost of increased robot adoption. Instead, it focuses on measuring productivity benefits, noting that their approach assumes stable robot prices relative to output prices over the evaluation period, potentially making their productivity impact estimates conservative.

Graetz, G. and Michaels, G. (2018)[50]	Manufacturing	Increases in the use of robots per hour boosts total factor productivity (contributing approximately 0.36 percentage points to annual labour productivity growth)	This paper examines the economic impact of industrial robots across 17 countries from 1993-2007 using data from the IFR in an industry-country panel specification. Key findings include:
			– An increase in the use of robots per hour boosts total factor productivity (contributing approximately 0.36 percentage points to annual labour productivity growth, while also raising TFP and lowering output prices)
			– Robot adoption varied significantly across countries (led by Germany, Denmark, and Italy) and industries (especially transport equipment, chemicals, and metals)
			– Increased robot use had a positive impact on productivity that persisted after controlling for other factors like ICT adoption.
			– Robots did not significantly reduce overall employment but did reduce the employment share of low-skilled workers.
			– The productivity gains from robotization primarily benefited consumers through lower prices, with only small wage increases for workers.
			The paper includes some details about the cost of adoption, though cost analysis is not the primary focus of the research:
			– From 1990-2005, the nominal price of industrial robots in six major economies (US, France, Germany, Italy, Sweden, UK) approximately halved. When quality improvements are accounted for, the decline was even more dramatic - quality-adjusted prices fell by about 80% (to roughly one-fifth of their 1990 level).
			– Investment Returns: the authors analyse 24 case studies from Danish robot manufacturer. These case studies reveal payback periods ranging from 2-18 months. The authors calculate this translates to annual returns of approximately (assuming a 10% depreciation rate, infinite service life, and 5% interest rate):
			  – 202% for investments with 2-month payback periods
			  – 25% for investments with 18-month payback periods.
			The authors note these high returns raise questions about why robots haven't been adopted even more widely.

[49] Gilbert Cette, Aurélien Devillard, Vincenzo Spiezia 2021, *The contribution of robots to productivity growth in 30 OECD countries over 1975–2019, Economics Letters*, Volume 200, 109762, ISSN 0165-1765, https://doi.org/10.1016/j.econlet.2021.109762.

[50] Georg Graetz & Guy Michaels 2018, *Robots at Work*, The Review of Economics and Statistics, MIT Press, vol. 100(5), pages 753-768, December.

Study	Industry	Relevant estimates	Summary and notes
IFR (2017)[51]	N/A	N/A	This 2017 positioning paper by the IFR examines the impact of robots on productivity, employment, and jobs. The paper is primarily a synthesis of multiple studies that argues that robots positively impact economies by increasing productivity and creating more jobs than they replace. The paper refers to the following estimates of robotics impacts in the literature: – Robot densification contributed to approximately 0.37 percentage points of annual GDP growth (about 10% of total GDP growth) across 17 countries between 1993 and 2007 (from Graetz and Michaels 2018). – Investment in robots contributed 10% of growth in GDP per capita in OECD countries from 1993 to 2016 and a one-unit increase in robotics density is associated with a 0.04% increase in labour productivity (referring to the Centre for Economics and Business Research 2017). – Future forecasts suggest automation could drive up to half of productivity growth needed for 2.8% GDP growth over the next 50 years (estimate from McKinsey Global Institute). The paper challenges the "robots as job killers" narrative, arguing that: – robots complement and augment human labour rather than fully substituting jobs – less than 10% of jobs are fully automatable – countries with highest robot density (Germany, South Korea) have among the lowest unemployment rates – robots enable companies in high-cost countries to reshore manufacturing operations. The paper does not measure the costs of increased robot adoption.
Kromann, L. et al (2020)[52]	Manufacturing	An increase of one standard deviation in robot intensity is associated with more than 6% higher TFP.	This paper examines the relationship between industrial robots and productivity across countries and industries. The authors analyse industry-level panel data for 9 countries and 10 manufacturing industries from 2004-2007 to investigate three questions: – whether industrial robots increase productivity in manufacturing – if competition from developing countries drives robot adoption – how automation affects wages and employment. Key findings: – Higher robot intensity has a positive effect on TFP. An increase of one standard deviation in robot intensity is associated with more than 6% higher TFP. – Increased automation is associated with higher average wages and unchanged or higher employment. – The paper suggests that industrial robots help developed countries respond to competition from low-wage countries by improving productivity, and that this productivity growth does not come at the expense of labour (the authors find no evidence that robots reduce employment or wages at the industry level). The paper does not specifically measure the costs of increased robot adoption.

Source: ACIL Allen based on the sources above.

[51] International Federation of Robotics 2017, *The Impact of Robots on Productivity, Employment and Jobs*, April.

[52] Lene Kromann, Nikolaj Malchow-Møller, Jan Rose Skaksen, Anders Sørensen 2020, *Automation and productivity—a cross-country, cross-industry comparison*, Industrial and Corporate Change, Volume 29, Issue 2, April 2020, Pages 265–287, https://doi.org/10.1093/icc/dtz039

Service robots' target

As discussed in Chapter 2, while Australia lags behind other countries in its use and manufacturing of industrial robots, it has developed a special expertise in field robotics in many sectors not traditionally served by robotics companies in other markets. Despite this, there is limited information about adoption of service robots in Australia and the world. The IFR's report on service robots (2024)[53] is based on a sample of 298 companies (which varies each year) and does not include data projected to the whole industry.

Given the gaps in data, a different approach was used to model the impact of increase adoption of service robots.

In 2019 McKinsey produced a report assessing Australia's automation opportunities.[54] The report estimated the potential impact of increased adoption of automation technologies (advanced robotics, machine learning and Artificial Intelligence - AI) on the Australian economy.

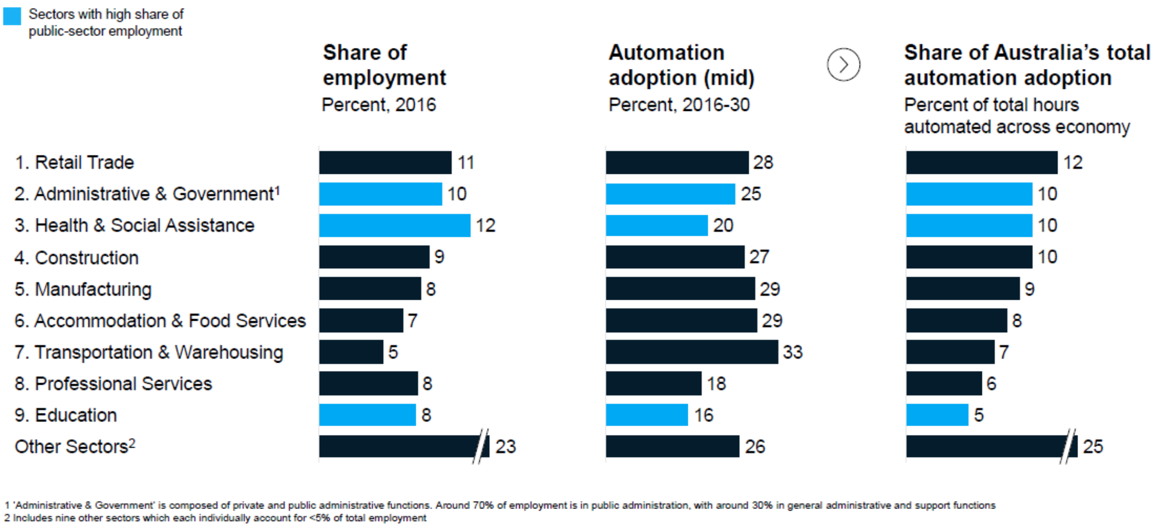
Based on previous research by the McKinsey Global Institute which estimated the time spent on different work activities and the feasibility of automating them using existing technologies, McKinsey Australia estimated that:

— 44% of existing workforce activities in Australia could already be automated using existing technologies

— by 2030 between 63% and 81% of work activities in Australia could be automated.

While a potential rate of automation of 81% was considered technically feasible, the study notes that in practice an average of between 25% and 46% workplace activities could be automated by 2030. McKinsey suggests that three-quarters of this automation opportunity is found in the 6 sectors that are among the largest employers in the economy and are highly susceptible to automated activities: retail, administration and government, construction, manufacturing, accommodation and food services, and logistics (see Figure A.9). Three more sectors are identified as likely to experience significant automation simply due to their size and diversity of activities: healthcare, professional services and education.

Figure A.9 Industry sectors with the highest automation opportunity



Source: McKinsey & Company 2019, Australia's automation opportunity, March.

53 IFR 2024, *World Robotics: Service Robots, September.*

54 McKinsey & Company 2019, *Australia's automation opportunity*, March.

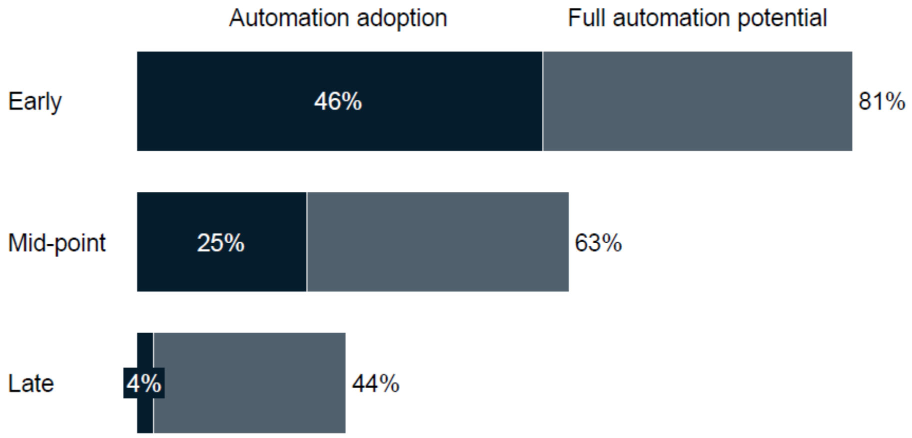
Based on the above potential rates of automation, McKinsey modelled 3 scenarios for automation potential and adoption in Australia (see Figure A.10):

— a late (or slow) scenario

— an early (or fast) scenario – for early adoption to happen, technologies and solutions would need to be developed at an accelerated speed, requiring both the public and private sectors to invest significantly in R&D, technology development and technology deployment

— a mid-point scenario (which is the average of the late and early scenarios) – this scenario estimates that less than half of the total automation potential will be realised by 2030. Activities that together account for 25% of the hours put in by Australia's workforce would be handled by machines.

Figure A.10 McKinsey's scenarios for automation potential and adoption for Australia by 2030, percent of time spent on work activities



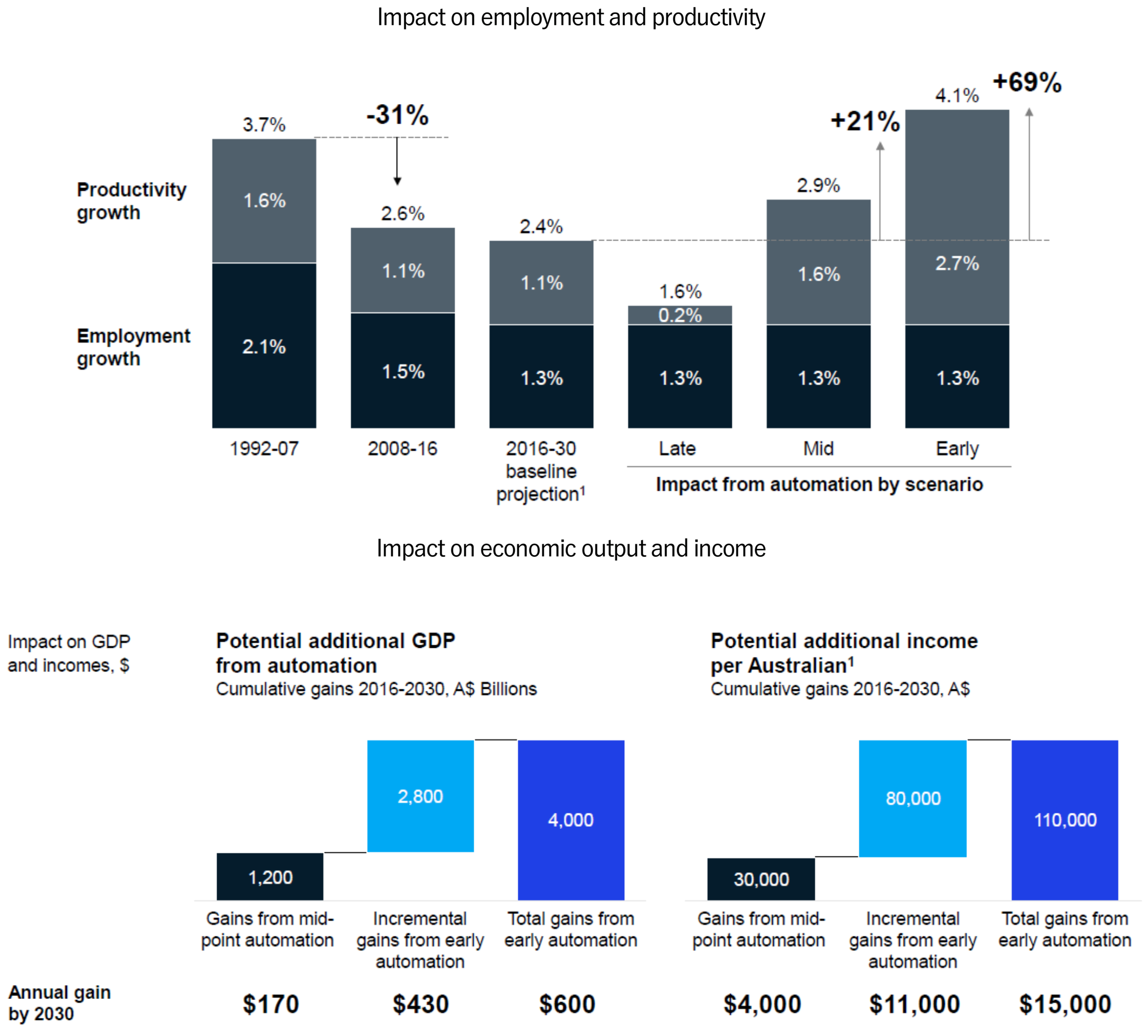
Source: McKinsey & Company 2019, Australia's automation opportunity, March.

McKinsey's findings on the impacts of the above automation scenarios (compared to baseline projections) on the Australian economy are outlined below.

— Under the **mid-point scenario** automation could:
  – drive up productivity growth in Australia from 1.1% to 1.6% between 2016 and 2030 (see Figure A.11)
  – could lift Australia's GDP by around $170 billion by 2030. Over 15 years (from 2016 to 2030), this translates into a cumulative increase of $1.2 trillion in economic output
  – increase incomes of Australians by $4,000 per year per person (or $30,000 over 15 years – see Figure A.11).

— **Rapid automation** adoption could:
  – boost productivity growth to as much as 2.7% (more than double the baseline rate)
  – increase GDP by around $600 billion by 2030 or $4 trillion cumulative over the same period
  – increase incomes of Australians by $15,000 per year per person (or $110,000 over 15 years).

Figure A.11 Impact of McKinsey's automation scenarios on the Australian economy



Source: McKinsey & Company 2019, Australia's automation opportunity, March.

As illustrated in Figure A.9, McKinsey's analysis indicates that the majority of automation opportunities exist outside the manufacturing sector and are therefore associated with activities likely to involve service robots. Based on this, the aspirational target for service robots assumes that one-third of the productivity improvements estimated in McKinsey's mid-scenario stem from increased adoption of service robots. The remaining two-thirds are attributed to other automation technologies (such as machine learning and AI) and the use of industrial robots within the manufacturing sector.

For Scenario 2 it has been assumed that industry sectors that benefit from the additional productivity growth delivered by service robots are those with high and medium-high automation potential as classified in Table A.5 (excluding manufacturing). All these sectors are assumed to benefit equally. The assigned potential for automation in this table is based on a number of sources, including the Strategy, the 2025

Roadmap, DIIS Mechanical boon's report[55], Synergies and QUT's Queensland automation advantage report[56] and McKinsey's Australia's automation opportunity report.

Table A.5 Industries potential for automation

ANZSIC Industry	Potential for automation	Explanation
Agriculture, Forestry and Fishing	Medium-High	– Widespread incidence of AI and Robotics for agricultural use (precision agriculture systems optimising resource use, autonomous harvesting solutions addressing seasonal labour shortages, drone monitoring of crops and livestock reducing management costs). – Robotics increasingly being used in aquaculture and fisheries industries (automation improving yield and sustainability).
Mining	High	– Global leader in autonomous mining operations. – Robotics playing an increasing role in the resources supply chain, from exploration through to shipping and rehabilitation of mined land.
Manufacturing	High	– High potential for use of industrial robots.
Electricity, Gas, Water and Waste Services	Medium-High	– Many functions open to automation (e.g. smart grid management systems optimising energy distribution, autonomous inspection of infrastructure using drones and robots, automated waste sorting systems, predictive maintenance).
Construction	High	– Construction remains labour intensive, but technology is increasingly being integrated in construction processes (e.g. modular construction techniques with robotic assembly, autonomous equipment for earthworks and site preparation, 3D printing of building components/entire structures, drones for site surveys and progress monitoring). – Cutting edge robotic technology becoming a key driver in accelerating building capabilities, enhancing production and improving safety on construction sites.
Wholesale Trade	Medium-High	– Rise of e-commerce and demand for fully automated logistics facilities. – Automation in warehousing and distribution. Increased use of self–delivery robots for shipping, staffing and cargo tracking intelligent systems.
Retail Trade	Medium-High	– Large employer in the economy with highly automatable activities. – Use of robotics in in-store services (e.g. cashier-less checkout systems), inventory management and customer service.

[55] Synergies Economic Consulting and Queensland University of Technology (QUT) 2018, *The robotics and automation advantage for Queensland*, June.

[56] Edmonds, E. and Bradley, T. 2015, *Mechanical boon: will automation advance Australia?*, Research Paper 7/2015, Department of Industry, Innovation and Science

ANZSIC Industry	Potential for automation	Explanation
Accommodation and Food Services	Medium-High	– Large employer in the economy with highly automatable activities (e.g. food preparation, automated ordering and payment systems). – Already impacted by "helper robots" that carry bags, give directions, clean rooms and perform other low-level tasks.
Transport, Postal and Warehousing	High	– Autonomous vehicles can revolutionise transport across Australia's vast distances. – Warehouse automation addressing labour shortages in logistics hubs. – Drone delivery systems for regional and remote areas. – Port automation.
Information Media and Telecommunications	Medium	– Significant amount of non-routine cognitive work. – Content creation assistance tools and automated content moderation handling improving productivity. – Personalisation engines improving user engagement and retention.
Financial and Insurance Services	Medium	– Potential varies across different segments of the industry: – AI-powered underwriting reducing assessment time – Robo-advisory platforms for wealth management services – Process automation for handling claims without human intervention – Chatbots and virtual assistants managing customer service interactions – Blockchain and smart contracts automating contract execution and compliance – Fraud detection systems using machine learning – Regulatory compliance automation (RegTech)
Rental, Hiring and Real Estate Services	Medium	– Automation and robotics used in maintenance, security, appraisals/inspections and customer research.
Professional, Scientific and Technical Services	Medium	– Professionals cover a wide variety of tasks. The automation of their work depends on the routineness of the tasks. Some tasks of most professionals can be automated including healthcare and insurance workers, architect's, journalists, teachers and legal workers and paralegal professionals.
Administrative and Support Services	High	– Large employer in the economy with highly automatable activities (e.g. travel agency and tour arrangement services, building cleaning, pest control, gardening services, packaging services).
Public Administration and Safety (e.g. defence, public order and safety services, regulatory services)	Medium-High	– Similar to Administrative and Support Services with the exception that the work tasks are more discretionary and therefore less likely to be automated to the same degree. – High potential of robotics use in Defence.

ANZSIC Industry	Potential for automation	Explanation
Education and training	Medium	– Automation potential due to its size and diversity of work activities (automation, including big data systems, have the potential to replace some areas of teaching and training). – Robotics as a tool to assist and enhance learning.
Health Care and Social Assistance	High	– Hospitals are using robots for advanced surgical procedures, cleaning and disinfection, handling samples, patient care and support in rehabilitation and independent living. They are also used to transport medicine, medical supplies, equipment, meals and bed linen. – Aged Care services are using robots to move various trollies around the facility delivering meals, moving dirty and clean linen and resident clothing, window cleaning, floor vacuum and wet polishing, social and comfort robots. – Process work in the social assistance segment likely to be replaced by automation.
Arts and Recreation Services	Low	– Some processes in the recreation segment can be automated (e.g. ticketing and booking automation) – The arts segment involves high discretion so likely less impacted. However, robotics can enhance performance, and audience engagement in innovative ways. Robotics can bring dynamic elements to live performances as well as digital and film, building immersive, interactive environments.
Other Services (repair and maintenance, personal care services, funeral services, religious services, etc.)	Low	– Some services can be automated (e.g. automated diagnostic systems for repair services, self-service kiosks for simple personal care services, digital platforms connecting service providers with customers).

Source: ACIL Allen

A.3.2 Scenario 2: increased adoption and production of robots in Australia

As noted above, this scenario refers to a case where additional efforts are made to:

— increase use of both industrial and service robots, and

— increase production (manufacturing) of robots in Australia.

To simulate this scenario the following shocks were applied to

— the 3 shocks from Scenario 1, plus

— an aspirational target for the growth of Australia's robotics industry.

Estimating the direct benefits of increased production of robots requires the following:

— defining the manufacturing subsectors that comprise the Australian robotics industry (for the purposes of this report)

— establishing the current size of the Australian robotics industry and its projected growth under the BAU

— setting a target for increased manufacturing of robots under Scenario 2.

More details about these inputs are provided in following sections.

Defining the Australian robotics industry

Robotics is not recognised as an industry in the ABS ANZSIC. As robotics is not recognised as an industry in its own right, it is difficult to obtain measurements of the size of the industry (e.g. employment, revenue, value added and export values). Furthermore, a clear definition of the industry is required to ensure that economic shocks can be accurately applied to the relevant sectors within the *Tasman Global* model.

HowToRobot and Robotics Australia Group published the first overview of Australian robotics industry in 2023.[57] Key findings include:

— Robotics industry in Australia includes 466 suppliers (57% integrators, 19% robot manufacturers, 15% component suppliers, 7% distributors, and 3% advisors).

— Top industries served by most robotics suppliers (besides the robotics industry itself) include metal and machinery (47% of suppliers), logistics (42% of suppliers), and food & beverage (30% of suppliers).

— Non-manufacturing industries with a particularly strong focus in Australia include mining (29% of robotics suppliers), energy (24% of suppliers), construction (20% of suppliers), agriculture and forestry (19% of suppliers), and recycling (17% of suppliers).

For the purposes of this report we adopted HowToRobot's definition of the Australian robotics industry, which includes robot manufacturers, integrators, component suppliers, distributors, and advisors. Using this framework, we identified and mapped the most relevant ANZSIC classes to each of these sectors. The assumed categorisation is presented in Table A.6.

Table A.6 Assumed ANZSIC classes corresponding to the Australian robotics industry

	ANZSIC Class	Notes
Robot manufacturers	Core robot manufacturing: 1. 2491 Lifting and Material Handling Equipment Manufacturing Specialised industrial robots: 2. 2462 Mining and Construction Machinery Manufacturing 3. 2463 Agricultural Machinery and Equipment Manufacturing 4. 2464 Machine Tools and Parts Manufacturing	1. Robotic material handling equipment manufacturing (Primary classification for manufacturers of complete robotic systems and automation equipment) 2. For robots designed specifically for mining and construction applications 3. For agricultural robots and automated farming equipment 4. For precision automation machinery
Robotics Systems Integrators (specialise in designing, programming and implementing customised robotic solutions for businesses)	1. 6923 Engineering Design and Engineering Consulting Services 2. 7000 Computer System Design and Related Services	1. Assumes this includes designing and implementing customised robotic solutions 2. For robotics solutions with significant focus on software development

[57] HowToRobot 2023, *First overview of Australian robotics industry published,* November, https://howtorobot.com/expert-insight/first-overview-australian-robotics-industry-published, Accessed 7 May 2025.

	ANZSIC Class	Notes
Advisors	Not mapped – excluded from Scenario 2	Advisors include robot engineers, procurement specialists, and legal experts (amongst others) with experience in planning and sourcing complex technology projects. Could include various classes under the overall Professional, Scientific and Technical Services division so it cannot be appropriately mapped.
Component suppliers	1. 2429 Other Electronic Equipment Manufacturing 2. 2439 Other Electrical Equipment Manufacturing 3. 2461 Machine Tool and Parts Manufacturing 4. 2469 Other Specialised Machinery and Equipment Manufacturing 5. 2391 Computer and Electronic Office Equipment Manufacturing 6. 3491 Professional and Scientific Goods Wholesaling	1. Manufacturers of electronic components, circuit boards, sensors, and control systems 2. Covers electric motors, generators, and related components 3. Includes mechanical components, gears, bearings, and precision parts 4. Covers specialised robotic hardware components and subsystems 5. For suppliers of computing components used in robotics control systems 6. Includes wholesalers of specialised electrical and electronic components
Distributors	1. 3494 Other Machinery and Equipment Wholesaling 2. 3491 Professional and Scientific Goods Wholesaling 3. 3493 Computer and Computer Peripheral Wholesaling 4. 3499 Other Goods Wholesaling n.e.c.	1. For businesses primarily engaged in distributing (rather than manufacturing) robotic and automation equipment (includes businesses that import, distribute and sell robotic systems and automation solutions) 2. For distributors focusing on specialised scientific and precision robotic equipment (may include laboratory automation and specialised measurement/sensing robots) 3. For distributors focusing on the computing and digital control aspects of robotics and automation 4. Could apply to distributors of highly specialised robotic equipment not classified elsewhere

Source: ACIL Allen

Current size of the Australian robotics industry and projected growth under the BAU

According to the 2022 Roadmap, Australian robotics companies were worth about $18 billion in annual revenue in 2021 (up from $12 billion in 2018).[58] In addition, the 2025 Roadmap set the following targets for industry growth:

— expand Australia's robotics industry to $50 billion by 2030 (a short-term target of $25 billion by 2026 was set in the 2023 Roadmap[59])

— increase the export value of robotics and AI by 30% by 2030.

Various market research companies estimate the value of different Australian robotics markets and forecast market growth. A summary of selected publicly available market estimates is provided in Table A.7. These estimates have been used to inform the assumed overall industry growth under the BAU over the next 15 years - which is assumed to be 7.1% per annum as per Statista CAGR for industrial robots (see Figure A.12).

Table A.7 Australia robotics markets – estimates of size and outlook

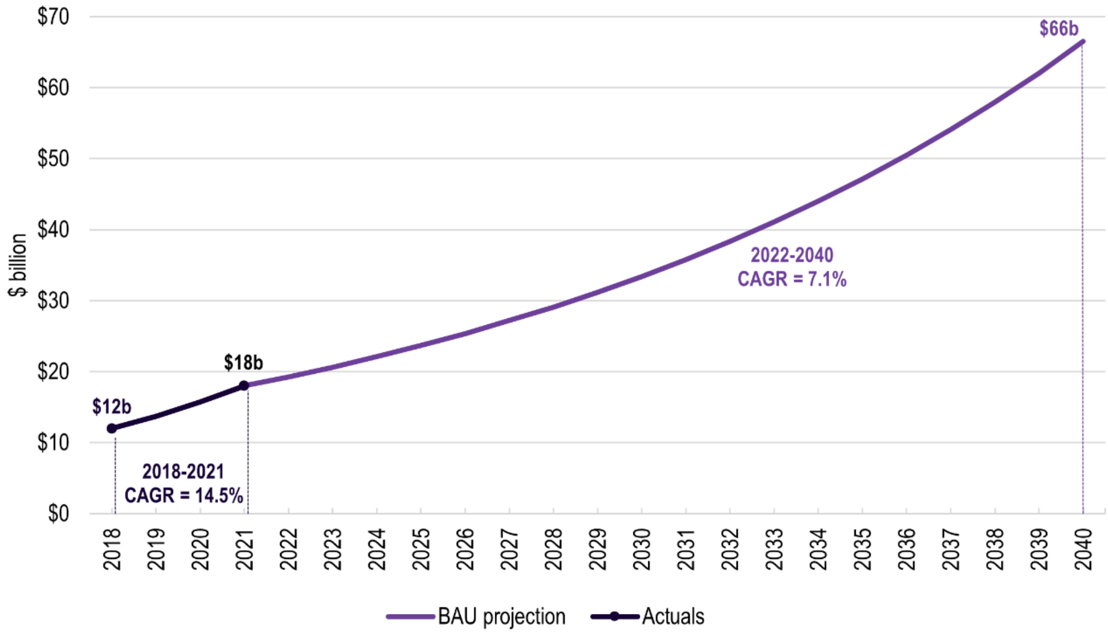
	Annual Revenue, (US$M 2022-2024)	CAGR	CAGR period
Overall industrial robotics market [a] (Statista)	38.09	7.1%	2025-2029
Estimates from Horizon Grand View Research:			
Healthcare/medical			
Medical Robotic Systems Market	177.8	22.7%	2023-2030
Laboratory Robotics Market	54.2	7.3%	2024-2030
Healthcare Companion Robots Market	46.4	18.3%	2025-2030
Rehabilitation Robots Market	7.7	19.2%	2025-2030
Other			
Humanoid Robot Market	29.6	18.3%	2024-2030
Disinfection Robots Market	71.8	21.4%	2024-2030
Logistics Robot Market	402.4	15.5%	2025-2030
Professional Services Robotics Market	946.8	12.5%	2025-2030
Consumer Robotics Market	247.1	28.1%	2025-2030
Warehouse Robotics Market	155.0	21.2%	2024-2030
Data Center Robotics Market	372.3	24.9%	2024-2030
	2,511.1	18.0%	Weighted average

[58] Robotics Australia Group 2022, *A Robotics Roadmap for Australia 2022.*
[59] Robotics Australia Group 2023, *A Robotics Roadmap for Australia 2023.*

[a] Statista defines the industrial robotics market as covering 'use cases that focus on the design, manufacturing, and deployment of robotic systems for industrial applications'. The following sectors are in-scope: Automotive Industry Robotics, Chemical Industry Robotics, Electric/Electronic Industry Robotics, Food Industry Robotics, Metal Industry Robotics, and Other Industry Robotics.

Source: Statista Market Insights 2024, Industrial Robotics – Australia, https://www.statista.com/outlook/tmo/robotics/industrial-robotics/australia; Horizon Grand View Research 2025, https://www.grandviewresearch.com/horizon.

Figure A.12 Assumed size of Australia's robotics industry under BAU (industry revenue)

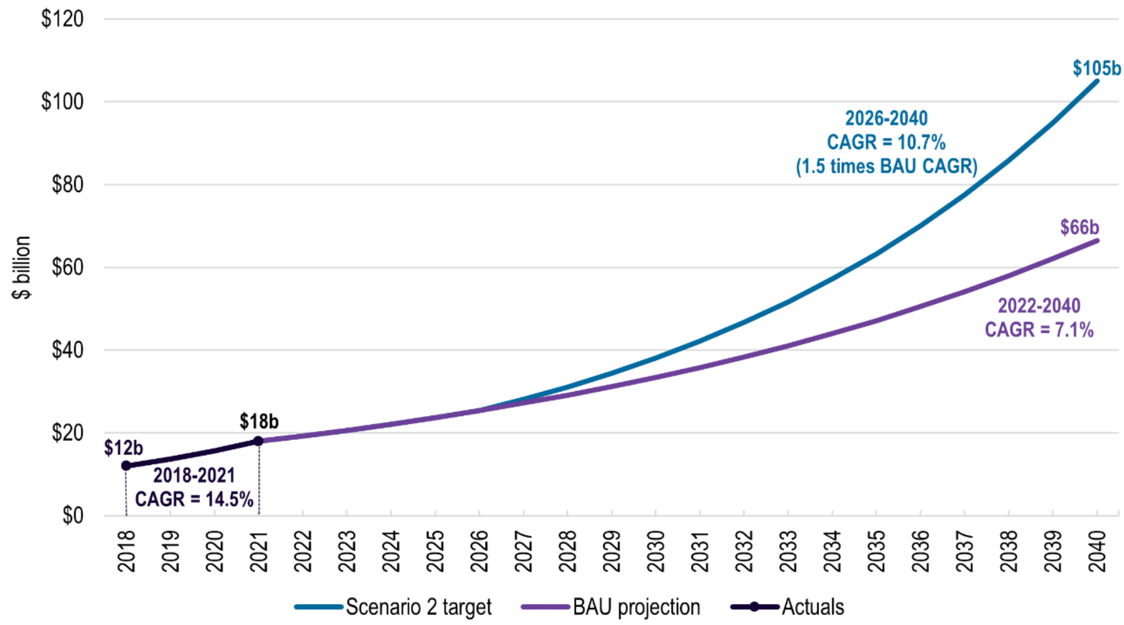


Source: ACIL Allen

Increased robot production target

Under Scenario 2, we assume that Australia's robotics industry revenue achieves an aspirational target of 1.5 times the annual growth under the BAU (a CAGR of 10.7% from 2026 to 2040). This implies reaching $105 billion in revenue by 2040, which equates to approximately $39 billion relative to the BAU scenario (see Figure A.13).

Figure A.13 Aspirational target for Australia's robotics industry revenue under Scenario 2



Source: ACIL Allen

A.4 Discount rate used in the presentation of results

There is extensive debate around the basis and selection of the appropriate rate to discount the stream of costs and benefits of policy and industry changes and public sector reform projects, as the discount rate used in economic impact analyses has a very significant impact on the value placed on benefits accumulated in the future over a long period of time.

Various government documents provide different advice regarding the selection of a discount rate, for instance:

— Recently released guidance on cost benefit analyses by the NSW Treasury recommends a 5% central point estimate for the discount rate, with sensitivity testing at 3% and 7%[60].

— The Victorian Department of Treasury and Finance[61] recommends using the following real discount rates:
  – a 4% discount rate for the provision of goods and services in traditional core public service delivery areas where the benefits are not easily quantifiable in monetary terms (e.g., education, public health and justice)
  – a 7% discount rate for when benefits are more easily monetised (e.g., public transport, roads and housing)
  – a 4% discount rate for regulatory and legislative proposals.

— In Western Australia:
  – the Department of Treasury recommends the use of a 6% discount rate for public sector comparators (PSCs)[62]

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[60] NSW Treasury 2023, *NSW Government Guide to Cost-Benefit Analysis*, TPG 23-08.

[61] Victorian Department of Treasury and Finance 2014, *Victorian Guide to Regulation, Toolkit 2: Cost-benefit analysis*, July.

[62] Western Australia Department of Treasury (2013). Public Sector Comparator Policy: Additional Policy Guidance. Government of Western Australia.
https://www.treasury.wa.gov.au/uploadedFiles/_Treasury/Infrastructure_Strategy/ppps_public_sector_comparators.pdf?n=9348.

  - several Regulatory Impact Statements (RISs) have used a central rate of 7%, with sensitivity analysis at 3% and 10%[63]
  - a recent analysis of a policy proposal with long term social and environmental benefits undertaken by the Department of Water and Environmental Regulation used a discount rate of the weighted average cost of capital of 3%[64].
- The Commonwealth's Office of Impact Analysis (OIA)[65] generally requires the calculation of net present values at an annual central real discount rate of 7%, with sensitivity analysis conducted using a lower bound discount rate of 3% and an upper bound discount rate of 10%. In addition, the OIA's guidance for incorporating environmental impacts and uncertainty into regulatory impact analysis suggests that for analyses involving very long timeframes it is appropriate to use a time declining discount rate. In particular, it is recommended that for analyses involving a period of analysis of between 31 and 75 years, the central discount rate declines from 7% to 5.4% after 30 years.

A range of discount rates have been suggested by different parties to use in the Australian context, for instance:

- the House of Representatives Standing Committee on Infrastructure in 2018 recommended the use of a 4% discount rate in the context of built infrastructure[66]
- the Grattan Institute[67] has suggested the use of a:
  - 3.5% discount rate for transport infrastructure projects with very low systematic risk
  - 5% discount rate for transport infrastructure projects with somewhat low systematic risk.

To ensure comparison with other economic analysis, the analysis uses a central discount rate of 7% real and provides sensitivity analysis of the results using a 3%, 5% and 10% real discount rate.

[63] See, for instance: Department of Mines, Industry Regulation and Safety WA 2019*, Decision Regulatory Impact Statement Reforms to Plumbing Regulation in Western Australia*, https://www.wa.gov.au/system/files/2021-01/dris-reforms-to-plumbing-regulation-in-western-australia.pdf; Department of Water and Environmental Regulation WA 2019, *Decision Regulation Impact Statement Western Australian Container Deposit Scheme*, https://www.wa.gov.au/system/files/2021-01/dris-western-australian-container-deposit-scheme.pdf.

[64] Department of Water and Environmental Regulation WA 2022, *WA Plan for Plastics Stage 2 consultation paper,* https://consult.dwer.wa.gov.au/programs/plan-for-plastics-stage-2-business-survey/supporting_documents/WA%20Plan%20for%20Plastics%20Stage%202%20consultation%20paper.pdf.

[65] Commonwealth of Australia, Department of the Prime Minister and Cabinet 2021, *Regulatory Impact Analysis Guide for Ministers' Meetings and National Standard Setting Bodies*, May; Commonwealth of Australia, Department of the Prime Minister and Cabinet 2020, *Environmental Valuation Guidance Note*.

[66] Parliament of Australia 2018, *Building up and moving out*, Canberra: Parliament of Australia, House of Representatives Standing Committee on Infrastructure, Transport and Cities.

[67] Terrill, M. and Batrouney, H. 2018, *Unfreezing discount rates: transport infrastructure for tomorrow*. Grattan Institute.

B Sensitivity analysis of labour market assumptions

As mentioned in Section 3.2.3, a key issue when estimating the impact of a policy or industry change using a CGE framework is the assumption made regarding the availability of labour and consequent crowding out of other industries (i.e. how the labour market will clear).

This section analyses the sensitivity of the projected economic impacts of the robotics scenarios to two 'extreme' labour market environments, namely:

1. a fully constrained labour market where no additional jobs or hours worked across Australia in total are allowed relative to the Reference Case (but people are allowed to move between regions)
2. an unconstrained labour market, where the supply of labour (at the Reference Case wage rates) is fully responsive to demand.

This sensitivity analysis has been included because the relationship between robotics and employment remains a significant and widely debated policy issue. While there is ongoing debate in academic and policy circles about whether automation may displace workers and reduce overall employment, others argue that robotics will drive job creation and new opportunities through productivity gains. To reflect this uncertainty, we have modelled two extreme labour market scenarios to capture the full range of possible economic outcomes.

This approach acknowledges valid concerns about potential job displacement while also recognising historical evidence that technological progress often gives rise to new forms of employment. By presenting results under both constrained and unconstrained labour market assumptions, we aim to provide policymakers and stakeholders with a clearer understanding of how different labour market conditions could shape the economic impact of robotics adoption in Australia.

The analysis demonstrates that even under conservative assumptions about labour market constraints, robotics adoption and production still generate meaningful economic benefits, though the magnitude varies significantly depending on how employment patterns evolve.

In the fully constrained labour market scenario it is assumed that, at the national level, there will not be any additional people employed as a result of the additional labour demand generated by the increased robot utilisation or manufacturing, nor will any workers choose to work longer hours in response to increasing wages relative to the Reference Case. This is deemed to be an extreme and unrealistic assumption, but one that the authors believe generates a floor to the projected economic impacts of the scenarios (all else equal).

The opposite extreme is modelled in the unconstrained scenario where it is assumed that there is an 'unlimited' pool of labour available to meet any additional labour demand generated by the increased utilisation of robotics or manufacturing, relative to the Reference Case. Note, that this does **not** mean that there is an infinite supply of labour, rather that all *additional* labour demands generated by the scenarios (at the Reference Case wage rates) can be met without needing to crowd out employment from other industries. Except for the availability of other factors of production, this assumption is the same as those obtained from using the upper-level estimates from input-output employment multipliers.[68]

The results are presented in **Table B.1** and **Table B.2**.

A key constraint to achieving the projected impacts under the unconstrained labour market will be the ability for employers to successfully train up unemployed or underemployed locals or to attract the workers and

[68] More specifically, the Type 2A employment multipliers which include the direct, production induced and consumption induced effects.

their families overseas. As per past advances in labour productivity since the industrial revolution, it is likely that people will trade at least some of the additional income generated by the productivity improvements into greater leisure/personal time.

Table B.1 Labour market sensitivity analysis – Macroeconomic impacts (2026-2040)

	Scenario 1		Scenario 2	
	Real economic output (GDP)	Real income	Real economic output (GDP)	Real income
	2024 $trillion	2024 $trillion	2024 $trillion	2024 $trillion
Fully constrained (Lower bound)	1.02	1.05	1.08	1.18
Standard Tasman Global labour market (Policy case)	1.32	1.34	1.44	1.52
Unconstrained (Upper bound)	2.97	2.95	3.40	3.42

Source: ACIL Allen

Table B.2 Labour market sensitivity analysis – Employment impacts (2026-2040)

	Scenario 1	Scenario 2
	Million employee years	Million employee years
Fully constrained (Lower bound)	0	0
Standard Tasman Global labour market (Policy case)	1.62	1.93
Unconstrained (Upper bound)	10.72	12.75

Source: ACIL Allen

C Australian Robotics Hubs and Clusters

Table C.1 Australian robotics research centres, collaboration centres, testing facilities and incubators

State	Facility	Research Centre	Collab Centre	Testing Facility	Incubator
ACT	Collaborative Robotics Laboratory - University of Canberra	✓	✓		
ACT	Indoor Robotics Flight Test Facility – University of New South Wales, Canberra			✓	
NSW	Australian Centre for Field Robotics - University of Sydney	✓			
NSW	Charles Sturt AgriPark Co-operative Research Centre	✓			
NSW	Cicada National Space Industry Hub				✓
NSW	Facility for Intelligent Fabrication - University of Wollongong	✓			
NSW	Factory of the Future - Western Sydney University	✓			
NSW	Lindfield Collaboration Hub – Commonwealth Scientific and Industrial Research Organisation (CSIRO)				✓
NSW	MQ Incubator – Macquarie University				✓
NSW	Nandin Innovation Centre – Australian Nuclear Science and Technology Organisation (ANSTO)		✓		✓
NSW	Robotics Laboratory - University of Newcastle	✓			
NSW	Robotics Institute – University of Technology Sydney	✓			
NSW	Australian Composites Manufacturing CRC	✓			
NSW	Tech Lab – University of Technology Sydney	✓	✓	✓	
NT	North Australia Centre for Autonomous Systems (NACAS)	✓			
QLD	Advanced Design and Prototyping Technologies Institute (ADaPT)		✓		
QLD	Advanced Robotics for Manufacturing Hub (ARM Hub)	✓	✓		
QLD	Advanced Technology and Innovation Centre (ATIC)		✓		
QLD	Australian Cobotics Centre	✓			

State	Facility	Research Centre	Collab Centre	Testing Facility	Incubator
QLD	Australian Institute of Marine Science (AIMS): ReefWorks			✓	
QLD	Central Queensland Smart Cropping Centre	✓			
QLD	EPE Military Training, Evaluation Certification and Systems Assurance (MILTECS)			✓	
QLD	Queensland Flight Test Range (QFTR)			✓	
QLD	Robotics Innovation Centre - Queensland Centre for Advanced Technologies (QCAT)	✓	✓		
QLD	Resources Centre of Excellence	✓		✓	
QLD	University of Queensland School of Electrical Engineering and Computer Science	✓			
SA	Adelaide Biomed City		✓		
SA	Centre for Advanced Defence Research in Robotics and Autonomous Systems	✓			
SA	Australian Research Centre Interactive and Virtual Environments - University of South Australia	✓			
SA	Edinburgh Defence Precinct	✓			
SA	Lot Fourteen: Entrepreneur & Innovation Centre and Innovation Hub		✓		
SA	Tonsley Innovation District		✓		
TAS	Australian Maritime College Autonomous Underwater Vehicle Facility - University of Tasmania	✓		✓	
VIC	Australian Manufacturing and Materials Precinct (AMMP)		✓		
VIC	Centre for Sustainable Infrastructure and Digital Construction - Swinburne University	✓			
VIC	Centre for Technology Infusion - La Trobe University	✓		✓	
VIC	Fishermans Bend National Employment and Innovation Cluster		✓		
VIC	Institute for Intelligent Systems Research and Innovation - Deakin University	✓	✓		
VIC	ManuFutures - Deakin University	✓	✓		
VIC	Melbourne School of Design Robotics Lab	✓	✓		
VIC	Robotics Research Facility - Monash	✓	✓	✓	
VIC	Digital Manufacturing Facility – Royal Melbourne Institute of Technology (RMIT)		✓		
VIC	Robotics and Internet of Things (RIoT) Lab at Deakin University	✓			
VIC	National Industry 4.0 Testlab – Swinburne and CSIRO			✓	

State	Facility	Research Centre	Collab Centre	Testing Facility	Incubator
WA	Australian Automation and Robotics Precinct (AARP)	✓	✓	✓	
WA	Australian Marine Complex		✓		
WA	Australian Space Automation AI and Robotics Control Complex (SpAARC)			✓	

Source: Australian Department of Industry, Science and Resources.

D Tasman Global

Tasman Global is a dynamic, global CGE model that has been developed by ACIL Allen for the purpose of undertaking economic impact analysis at the regional, state, national and global level.

A CGE model captures the interlinkages between the markets of all commodities and factors, taking into account resource constraints, to find a simultaneous equilibrium in all markets. A global CGE model extends this interdependence of the markets across world regions and finds simultaneous equilibrium globally. A dynamic model adds onto this the interconnection of equilibrium economies across time periods. For example, investments made today are going to determine the capital stocks of tomorrow and hence future equilibrium outcomes depend on today's equilibrium outcome, and so on.

A dynamic global CGE model, such as *Tasman Global*, has the capability of addressing total, sectoral, spatial and temporal efficiency of resource allocation as it connects markets globally and over time. Being a recursively dynamic model, however, its ability to address temporal issues is limited. In particular, *Tasman Global* cannot typically address issues requiring partial or perfect foresight. However, as documented in Jakeman et al (2001), it is possible to introduce partial or perfect foresight in certain markets using algorithmic approaches.[69] Notwithstanding this, the model does have the capability to project the economic impacts over time of given changes in policies, tastes and technologies in any region of the world economy on all sectors and agents of all regions of the world economy.

Tasman Global was developed from the 2001 version of the Global Trade and Environment Model (GTEM) developed by ABARE (Pant 2007)[70] and has been evolving ever since. In turn, GTEM was developed out of the MEGABARE model,[71] which contained significant advancements over the Global Trade Analysis Project (GTAP) model of that time.[72]

D.1 A dynamic model

Tasman Global is a model that estimates relationships between variables at different points in time. This is in contrast to comparative static models, which compare 2 equilibriums (one before an economic disturbance and one following). A dynamic model such as *Tasman Global* is beneficial when analysing issues for which both the timing of and the adjustment path that economies follow are relevant in the analysis.

D.2 The database

A key advantage of *Tasman Global* is the level of detail in the database underpinning the model. The database is derived from the GTAP database.[73] This database is a fully documented, publicly available global data base which contains complete bilateral trade information, transport and protection linkages among regions for all GTAP commodities. It is the most detailed database of its type in the world.

Tasman Global builds on the GTAP database by adding the following important features:

[69] Jakeman, G., Heyhoe, E., Pant, H., Woffenden, K. and Fisher, B.S. (2001). *The Kyoto Protocol: economic impacts under the terms of the Bonn agreement*. ABARE paper presented to the International Petroleum Industry Environmental Conservation Association conference, 'Long Term Carbon and Energy Management - Issues and Approaches', Cambridge, Massachusetts, 15-16 October.

[70] Pant, H.M. (2007), *GTEM: Global Trade and Environment Model*, ABARE Technical Report, Canberra.

[71] Hanslow, K. & Hinchy, M. (1996). *The MEGABARE model: interim documentation*. Canberra: ABARE.

[72] Hertel, T. (1997). *Global Trade Analysis: modelling and applications*. Cambridge University Press, Cambridge.

[73] Aguiar, A., Chepeliev, M., Corong, E., McDougall, R., & van der Mensbrugghe, D. (2019). *The GTAP Data Base: Version 10*. Journal of Global Economic Analysis, 4(1), 1-27.

- a detailed population and labour market database
- detailed technology representation within key industries (such as electricity generation and iron and steel production)
- disaggregation of a range of major commodities including iron ore, bauxite, alumina, primary aluminium, brown coal, black coal and LNG
- the ability to repatriate labour and capital income
- explicit representation of the states and territories of Australia
- the capacity to represent multiple regions within states and territories of Australia explicitly.

Nominally, version 10.1 of the *Tasman Global* database divides the world economy into 153 regions (145 international regions plus the 8 states and territories of Australia) although in reality the regions are frequently disaggregated further. ACIL Allen regularly models Australian or international projects or policies at the regional level including at the or at the state/territory/provincial level for various countries.

The *Tasman Global* database also contains a wealth of sectoral detail currently identifying up to 76 industries (Table D.1). The foundation of this information is the input-output tables that underpin the database. The input-output tables account for the distribution of industry production to satisfy industry and final demands.

Industry demands, so-called intermediate usage, are the demands from each industry for inputs. For example, electricity is an input into the production of communications. In other words, the communications industry uses electricity as an intermediate input.

Final demands are those made by households, governments, investors and foreigners (export demand). These final demands, as the name suggests, represent the demand for finished goods and services. To continue the example, electricity is used by households – their consumption of electricity is a final demand.

Each sector in the economy is typically assumed to produce one commodity, although in *Tasman Global*, the electricity, transport and iron and steel sectors are modelled using a 'technology bundle' approach. With this approach, different known production methods are used to generate a homogeneous output for the 'technology bundle' industry. For example, electricity can be generated using brown coal, black coal, petroleum, base load gas, peak load gas, nuclear, hydro, geothermal, biomass, wind, solar or other renewable based technologies – each of which has its own cost structure.

The other key feature of the database is that the cost structure of each industry is also represented in detail. Each industry purchases intermediate inputs (from domestic and imported sources) primary factors (labour, capital, land and natural resources) as well as paying taxes or receiving subsidies.

Table D.1 Standard sectors in the Tasman Global CGE model

no	Name	no	Name
1	Paddy rice	39	Diesel (incl. nonconventional diesel)
2	Wheat	40	Other petroleum, coal products
3	Cereal grains nec	41	Chemical, rubber, plastic products
4	Vegetables, fruit, nuts	42	Iron ore
5	Oil seeds	43	Bauxite
6	Sugar cane, sugar beet	44	Mineral products nec
7	Plant- based fibres	45	Ferrous metals
8	Crops nec	46	Alumina
9	Bovine cattle, sheep, goats, horses	47	Primary aluminium

no	Name	no	Name
10	Pigs	48	Metals nec
11	Animal products nec	49	Metal products
12	Raw milk	50	Motor vehicle and parts
13	Wool, silkworm cocoons	51	Transport equipment nec
14	Forestry	52	Electronic equipment
15	Fishing	53	Machinery and equipment nec
16	Brown coal	54	Manufactures nec
17	Black coal	55	Electricity generation
18	Oil	56	Electricity transmission and distribution
19	LNG	57	Gas manufacture, distribution
20	Other natural gas	58	Water
21	Minerals nec	59	Construction
22	Bovine meat products	60	Trade
23	Pig meat products	61	Road transport
24	Meat products nec	62	Rail and pipeline transport
25	Vegetables oils and fats	63	Water transport
26	Dairy products	64	Air transport
27	Processed rice	65	Transport nec
28	Sugar	66	Warehousing and support activities
29	Food products nec	67	
30	Wine	68	Communication
31	Beer	69	Financial services nec
32	Spirits and RTDs	70	Insurance
33	Other beverages and tobacco products	71	Business services nec
34	Textiles	72	Recreational and other services
35	Wearing apparel	73	Public Administration and Defence
36	Leather products	74	Education
37	Wood products	75	Human health and social work activities
38	Paper products, publishing	76	Dwellings

Source: ACIL Allen.

Note: nec = not elsewhere classified.

D.3 Model structure

Given its heritage, the structure of the *Tasman Global* model closely follows that of the GTAP and GTEM models and interested readers are encouraged to refer to the documentation of these models for more detail.[74] In summary:

— The model divides the world into a variety of regions and international waters.
  – Each region is fully represented with its own 'bottom-up' social accounting matrix and could be a local community, an LGA, state, country or a group of countries. The number of regions in a given simulation depends on the database aggregation. Each region consists of households, a government with a tax system, production sectors, investors, traders and finance brokers.

[74] Namely Hertel, T. (1997). Op. cit. and Pant, H.M. (2007). Op. cit., respectively.

  - 'International waters' are a hypothetical region in which global traders operate and use international shipping services to ship goods from one region to the other. It also houses an international finance 'clearing house' that pools global savings and allocates the fund to investors located in every region.
  - Each region has a 'regional household'[75] that collects all factor payments, taxes, net foreign borrowings, net repatriation of factor incomes due to foreign ownership and any net income from trading of emission permits.
- The income of the regional household is allocated across private consumption, government consumption and savings according to a Cobb-Douglas utility function, which, in practice, means that the share of income going to each component is assumed to remain constant in nominal terms.
- Private consumption of each commodity is determined by maximising utility subject to a Constant Difference of Elasticities (CDE) function which includes both price and income elasticities.
- Government consumption of each commodity is determined by maximising utility subject to a Cobb-Douglas utility function.
- Each region has *n* production sectors, each producing single products using various production functions where they aim to maximise profits (or minimise costs) and take all prices as given. The nature of the production functions chosen in the model means that producers exhibit constant returns to scale.
  - In general, each producer supplies consumption goods by combining an aggregate energy-primary factor bundle with other intermediate inputs and according to a Leontief production function (which in practice means that the quantity shares remain in fixed proportions). Within the aggregate energy-primary factor bundle, the individual energy commodities and primary factors are combined using a nested Constant Elasticity of Substitution (CES) production function, in which energy and primary factor aggregates substitute according to a CES function with the individual energy commodities and individual primary factors substituting with their respective aggregates according to further CES production functions.
  - Exceptions to the above include the electricity generation, iron and steel and road transport sectors. These sectors employ the 'technology bundle' approach developed by ABARE[76] in which non-homogenous technologies are employed to produce a homogenous output with the choice of technology governed by minimising costs according to a modified Constant Ratios of Elasticities of Substitution, Homothetic (CRESH) production function. For example, electricity may be generated from a variety of technologies (including brown coal, black coal, gas, nuclear, hydro, solar etc.), iron and steel may be produced from blast furnace or electric arc technologies while road transport services may be supplied using a range of different vehicle technologies. The 'modified-CRESH' function differs from the traditional CRESH function by also imposing the condition that the quantity units are homogenous.
- There are 4 primary factors (land, labour, mobile capital and fixed capital). While labour and mobile capital are used by all production sectors, land is only used by agricultural sectors while fixed capital is typically employed in industries with natural resources (such as fishing, forestry and mining) or in selected industries built by ACIL Allen.
  - Land supply in each region is typically assumed to remain fixed through time with the allocation of land between sectors occurring to maximise returns subject to a Constant Elasticity of Transformation (CET) utility function.
  - Mobile capital accumulates as a result of net investment. It is implicitly assumed in *Tasman Global* that it takes one year for capital to be installed. Hence, supply of capital in the current period depends on the last year's capital stock and investments made during the previous year.
  - Labour supply in each year is determined by endogenous changes in population, given participation rates and a given unemployment rate. In policy scenarios, the supply of labour is

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[75] The term "regional household" was devised for the GTAP model. In essence it is an agent that aggregates all incomes attributable to the residents of a given region before distributing the funds to the various types of regional consumption (including savings).

[76] Hanslow, K. & Hinchy, M. (1996). Op. cit.

positively influenced by movements in the real wage rate governed by the elasticity of supply. For countries where sub-regions have been specified (such as Australia), migration between regions is induced by changes in relative real wages with the constraint that net interregional migration equals zero. For regions where the labour market has been disaggregated to include occupations, there is limited substitution allowed between occupations by individuals supplying labour (according to a CET utility function) and by firms demanding labour (according to a CES production function) based on movements in relative real wages.

  – The supply of fixed capital is given for each sector in each region.

  The model has the option for these assumptions to be changed at the time of model application if alternative factor supply behaviours are considered more relevant.

— It is assumed that labour (by occupation) and mobile capital are fully mobile across production sectors implying that, in equilibrium, wage rates (by occupation) and rental rates on capital are equalised across all sectors within each region. To a lesser extent, labour and capital are mobile between regions through international financial investment and migration, but this sort of mobility is sluggish and does not equalise rates of return across regions.

— For most international regions, for each consumer (private, government, industries and the local investment sector), consumption goods can be sourced either from domestic or imported sources. In any country that has disaggregated regions (such as Australia), consumption goods can also be sourced from other intrastate or interstate regions. In all cases, the source of non-domestically produced consumption goods is determined by minimising costs subject to a CRESH utility function. Like most other CGE models, a CES demand function is used to model the relative demand for domestically produced commodities versus non-domestically produced commodities. The elasticities chosen for the CES and CRESH demand functions mean that consumers in each region have a higher preference for domestically produced commodities than non-domestic commodities and a higher preference for intrastate- or interstate-produced commodities than foreign commodities.

— The capital account in *Tasman Global* is open. Domestic savers in each region purchase 'bonds' in the global financial market through local 'brokers' while investors in each region sell bonds to the global financial market to raise investible funds. A flexible global interest rate clears the global financial market.

— It is assumed that regions may differ in their risk characteristics and policy configurations. As a result, rates of return on money invested in physical capital may differ between regions and therefore may be different from the global cost of funds. Any difference between the local rates of return on capital and the global cost of borrowing is treated as the result of the existence of a risk premium and policy imperfections in the international capital market. It is maintained that the equilibrium allocation of investment requires the equalisation of changes in (as opposed to the absolute levels of) rates of return over the base year rates of return.

— Any excess of investment over domestic savings in a given region causes an increase in the net debt of that region. It is assumed that debtors service the debt at the interest rate that clears the global financial market. Similarly, regions that are net savers gives rise to interest receipts from the global financial market at the same interest rate.

— Investment in each region is used by the regional investor to purchase a suite of intermediate goods according to a Leontief production function to construct capital stock with the regional investor cost minimising by choosing between domestic, interstate and imported sources of each intermediate good via the CRESH production function. The regional cost of creating new capital stock versus the local rates of return on mobile capital is what determines the regional rate of return on new investment.

— In equilibrium, exports of a good from one region to the rest of world are equal to the import demand for that good in the remaining regions. Together with the merchandise trade balance, the net payments on foreign debt add up to the current account balance. *Tasman Global* does not require that the current account be in balance every year. It allows the capital account to move in a compensatory direction to maintain the balance of payments. The exchange rate provides the flexibility to keep the balance of payments in balance.

— Detailed bilateral transport margins for every commodity are specified in the starting database. By default, the bilateral transport mode shares are assumed to be constant, with the supply of international transportation services by each region solved by a cost-minimising international trader according to a Cobb-Douglas demand function.

— Emissions of 6 anthropogenic greenhouse gases (namely, carbon dioxide, methane, nitrous oxide, HFCs, PFCs and SF_6) associated with economic activity are tracked in the model. Almost all sources and sectors are represented; emissions from agricultural residues and land-use change and forestry activities are not explicitly modelled but can be accounted for externally. Prices can be applied to emissions which are converted to industry-specific production taxes or commodity-specific sales taxes that impact on demand. Abatement technologies similar to those adopted in a report released by the Commonwealth Government (2008) are available and emission quotas can be set globally or by region along with allocation schemes that enable emissions to be traded between regions.[77]

More detail regarding specific elements of the model structure is discussed in the following sections.

D.4 Population growth and labour supply

Population growth is an important determinant of economic growth through the supply of labour and the demand for final goods and services. Population growth for each region represented in the *Tasman Global* database is projected using ACIL Allen's in-house demographic model. The demographic model projects how the population in each region grows and how age and gender composition changes over time and is an important tool for determining the changes in regional labour supply and total population over the projected period.

For each of region, the model projects the changes in age-specific birth, mortality and net migration rates by gender for 101 age cohorts (0-99 and 100+). The demographic model also projects changes in participation rates by gender by age for each region, and, when combined with the age and gender composition of the population, endogenously projects the future supply of labour in each region. Changes in life expectancy are a function of income per person as well as assumed technical progress on lowering mortality rates for a given income (for example, reducing malaria-related mortality through better medicines, education, governance etc.). Participation rates are a function of life expectancy as well as expected changes in higher education rates, fertility rates and changes in the work force as a share of the total population.

Labour supply is derived from the combination of the projected regional population by age by gender and regional participation rates by age by gender. Over the projected period labour supply in most developed economies is projected to grow slower than total population because of ageing population effects.

For the Australian states and territories, the projected aggregate labour supply from ACIL Allen's demographic module is used as the base level potential workforce for the detailed Australian labour market module, which is described in the next section.

D.5 The Australian labour market

Tasman Global has a detailed representation of the Australian labour market which has been designed to capture:

— different occupations

[77] Australian Government (2008), *Australia's Low Pollution Future: the economics of climate change mitigation*, Australian Government, Canberra.

— changes to participation rates (or average hours worked) due to changes in real wages
— changes to unemployment rates due to changes in labour demand
— limited substitution between occupations by the firms demanding labour and by the individuals supplying labour, and
— limited labour mobility between states and regions within each state.

Tasman Global recognises 97 different occupations within Australia – although the exact number of occupations depends on the aggregation. The firms that hire labour are provided with some limited scope to change between these 97 labour types as the relative real wage between them changes. Similarly, the individuals supplying labour have a limited ability to change occupations in response to the changing relative real wage between occupations. Finally, as the real wage for a given occupation rises in one state relative to other states, workers are given some ability to respond by shifting their location. The model produces results at the 97 3-digit Australian New Zealand Standard Classification of Occupations (ANZSCO) level which are presented in Table D.2.

The labour market structure of *Tasman Global* is thus designed to capture the reality of labour markets in Australia, where supply and demand at the occupational level do adjust, but within limits.

Labour supply in *Tasman Global* is presented as a 3-stage process:

3. labour makes itself available to the workforce based on movements in the real wage and the unemployment rate
4. labour chooses between occupations in a state based on relative real wages within the state
5. labour of a given occupation chooses in which state to locate based on movements in the relative real wage for that occupation between states.

By default, *Tasman Global*, like all CGE models, assumes that markets clear. Therefore, overall, supply and demand for different occupations will equate (as is the case in other markets in the model).

Table D.2 Occupations in the Tasman Global database, ANZSCO 3-digit level (minor groups)

ANZSCO code, Description
1. MANAGERS
111 Chief Executives, General Managers and Legislators
121 Farmers and Farm Managers
131 Advertising and Sales Managers
132 Business Administration Managers
133 Construction, Distribution and Production Managers
134 Education, Health and Welfare Services Managers
135 ICT Managers
139 Miscellaneous Specialist Managers
141 Accommodation and Hospitality Managers
142 Retail Managers
149 Miscellaneous Hospitality, Retail and Service Managers
2. PROFESSIONALS
211 Arts Professionals
212 Media Professionals
221 Accountants, Auditors and Company Secretaries
222 Financial Brokers and Dealers, and Investment Advisers
223 Human Resource and Training Professionals
224 Information and Organisation Professionals
225 Sales, Marketing and Public Relations Professionals
231 Air and Marine Transport Professionals
232 Architects, Designers, Planners and Surveyors
233 Engineering Professionals
234 Natural and Physical Science Professionals
241 School Teachers
242 Tertiary Education Teachers
249 Miscellaneous Education Professionals
251 Health Diagnostic and Promotion Professionals
252 Health Therapy Professionals
253 Medical Practitioners
254 Midwifery and Nursing Professionals
261 Business and Systems Analysts, and Programmers
262 Database and Systems Administrators, and ICT Security Specialists
263 ICT Network and Support Professionals
271 Legal Professionals
272 Social and Welfare Professionals
3. TECHNICIANS & TRADES WORKERS
311 Agricultural, Medical and Science Technicians
312 Building and Engineering Technicians
313 ICT and Telecommunications Technicians
321 Automotive Electricians and Mechanics
322 Fabrication Engineering Trades Workers
323 Mechanical Engineering Trades Workers
324 Panel beaters, and Vehicle Body Builders, Trimmers and Painters
331 Bricklayers, and Carpenters and Joiners
332 Floor Finishers and Painting Trades Workers
333 Glaziers, Plasterers and Tilers
334 Plumbers
341 Electricians
342 Electronics and Telecommunications Trades Workers
351 Food Trades Workers
361 Animal Attendants and Trainers, and Shearers
362 Horticultural Trades Workers
391 Hairdressers
392 Printing Trades Workers
393 Textile, Clothing and Footwear Trades Workers
394 Wood Trades Workers
399 Miscellaneous Technicians and Trades Workers
4. COMMUNITY & PERSONAL SERVICE
411 Health and Welfare Support Workers
421 Child Carers
422 Education Aides
423 Personal Carers and Assistants
431 Hospitality Workers
441 Defence Force Members, Fire Fighters and Police
442 Prison and Security Officers
451 Personal Service and Travel Workers
452 Sports and Fitness Workers
5. CLERICAL & ADMINISTRATIVE
511 Contract, Program and Project Administrators
512 Office and Practice Managers
521 Personal Assistants and Secretaries
531 General Clerks
532 Keyboard Operators
541 Call or Contact Centre Information Clerks
542 Receptionists
551 Accounting Clerks and Bookkeepers
552 Financial and Insurance Clerks
561 Clerical and Office Support Workers
591 Logistics Clerks
599 Miscellaneous Clerical and Administrative Workers
6. SALES WORKERS
611 Insurance Agents and Sales Representatives
612 Real Estate Sales Agents
621 Sales Assistants and Salespersons
631 Checkout Operators and Office Cashiers
639 Miscellaneous Sales Support Workers
7. MACHINERY OPERATORS & DRIVERS
711 Machine Operators
712 Stationary Plant Operators
721 Mobile Plant Operators
731 Automobile, Bus and Rail Drivers
732 Delivery Drivers
733 Truck Drivers
741 Store persons
8. LABOURERS
811 Cleaners and Laundry Workers
821 Construction and Mining Labourers
831 Food Process Workers
832 Packers and Product Assemblers
839 Miscellaneous Factory Process Workers
841 Farm, Forestry and Garden Workers
851 Food Preparation Assistants
891 Freight Handlers and Shelf Fillers
899 Miscellaneous Labourers

Source: ABS (2009), ANZSCO – Australian and New Zealand Standard Classifications Of Occupations, First edition, Revision 1, ABS catalogue no. 1220.0.

The *Tasman Global* database includes a detailed representation of the Australian labour market that has been designed to capture the supply and demand for different skills and occupations by industry. To achieve this, the Australian workforce is characterised by detailed supply and demand matrices.

On the supply side, the Australian population is characterised by a 5-dimensional matrix consisting of:

— 7 post-school qualification levels

— 12 main qualification fields of highest educational attainment

— 97 occupations

— 101 age groups (namely 0 to 99 and 100+)

— 2 genders.

The data for this matrix is measured in persons and was sourced from the ABS 2011 Census. As the skills elements of the database and model structure have not been used for this project, it will be ignored in this discussion.

The 97 occupations are those specified at the 3-digit level (or Minor Groups) under the ANZSCO (see Table D.2).

On the demand side, each industry demands a particular mix of occupations. This matrix is specified in units of FTE jobs where an FTE employee works an average of 37.5 hours per week. Consistent with the labour supply matrix, the data for FTE jobs by occupation by industry was also sourced from the ABS 2011 Census and updated using the latest labour force statistics.

Matching the demand and supply side matrices means that there is the implicit assumption that the average hours per worker are constant, but it is noted that mathematically changes in participation rates have the same effect as changes in average hours worked.

A.1 Labour market model structure

In the model, the underlying growth of each industry in the Australian economy results in a growth in demand for a particular set of skills and occupations. In contrast, the supply of each set of skills and occupations in a given year is primarily driven by the underlying demographics of the resident population. This creates a market for each skill by occupation that (unless specified otherwise) needs to clear at the start and end of each time period.[78] The labour markets clear by a combination of different prices (i.e., wages) for each labour type and by allowing a range of demand and supply substitution possibilities, including:

- changes in firms' demand for labour driven by changes in the underlying production technology
  - for technology bundle industries (electricity, iron and steel and road transportation) this occurs due to changes between explicitly identified alternative technologies
  - for non-technology bundle industries this includes substitution between factors (such as labour for capital) or energy for factors
- changes to participation rates (or average hours worked) due to changes in real wages
- changes in the occupations of a person due to changes in relative real wages
- substitution between occupations by the firms demanding labour due to changes in the relative costs
- changes to unemployment rates due to changes in labour demand, and
- limited labour mobility between states due to changes in relative real wages.

All of the labour supply substitution functions are modified-CET functions in which people supply their skills, occupation and rates of participation as a positive function of relative wages. However, unlike a standard CET (or CES) function, the functions are 'modified' to enforce an additional constraint that the number of people is maintained before and after substitution.[79]

Although technically solved simultaneously, the labour market in *Tasman Global* can be thought of as a 5-stage process:

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[78] For example, at the start and end of each week for this analysis. *Tasman Global* can be run with different steps in time, such as quarterly or bi-annually in which case the markets would clear at the start and end of these time points.

[79] As discussed in Dixon et al (1997), a standard CES/CET function is defined in terms of *effective units*. Quantitatively this means that, when substituting between, say, X_1 and X_2 to form a total quantity X using a CET function a simple summation generally does not actually equal X. Use of these functions is common practice in CGE models when substituting between substantially different units (such as labour versus capital or imported versus domestic services) but was not deemed appropriate when tracking the physical number of people. Such 'modified' functions have long been employed in the technology bundles of *Tasman Global* and GTEM. The Productivity Commission have proposed alternatives to the standard CES to overcome similar and other weaknesses when applied to internationally traded commodities. See Dixon, P.B., Parmenter, B., Sutton, J., & Vincent, D. (1997), *ORANI: A Multisectoral Model of the Australian Economy*, Amsterdam: North Holland.

- labour makes itself available to the workforce based on movements in the real wage (that is, it actively participates with a certain number of average hours worked per week)
- the age, gender and occupations of the underlying population combined with the participation rate by gender by age implies a given supply of labour (the potentially available workforce)
- a portion of the potentially available workforce is unemployed, implying a given available labour force
- labour chooses to move between occupations based on relative real wages
- industries alter their demands for labour as a whole and for specific occupations based on the relative cost of labour to other inputs and the relative cost of each occupation.

By default, *Tasman Global*, like all CGE models, assumes that markets clear at the start and end of each period. Therefore, overall, supply and demand for different occupations will equate (as is the case in other markets in the model). In principle, (subject to zero starting values) people of any age and gender can move between any of the 97 occupations while industries can produce their output with any mix of occupations. However, in practice the combination of the initial database, the functional forms, low elasticities and moderate changes in relative prices for skills, occupations etc. means that there is only low to moderate change induced by these functions. The changes are sufficient to clear the markets, but not enough to radically change the structure of the workforce in the timeframe of this analysis.

Factor-factor substitution elasticities in non-technology bundle industries are industry specific and are the same as those specified in the GTAP database, while the fuel-factor and technology bundle elasticities are the same as those specified in GTEM.[80] The detailed labour market elasticities are ACIL Allen assumptions, previously calibrated in the context of the model framework to replicate the historical change in the observed Australian labour market over a 5 year period[81]. The unemployment rate function in the policy scenarios is a non-linear function of the change in the labour demand relative to the base case with the elasticity being a function of the unemployment rate (that is, the lower the unemployment rate the lower the elasticity and the higher the unemployment rate the higher the elasticity).

[80] Pant, H.M. (2007). Op cit.

[81] This method is a common way of calibrating the economic relationships assumed in CGE models to those observed in the economy. See for example Dixon, P.B. and Rimmer, M.T. (2002), *Dynamic General Equilibrium Modelling for Forecasting and Policy*. Contributions to Economic Analysis 256, Amsterdam: North Holland.

E International clusters analysis

This section provides a more detailed analysis of our international clusters review.

E.1 MassRobotics (Boston, USA)

MassRobotics is a non-profit robotics hub based in Boston's Innovation District. It is positioned near over 400 robotics companies and world-class universities. In the early 2000s, the Massachusetts Robotics Cluster, and existing group of companies, institutions and individuals, discussed their shared motivation to develop an innovation hub and co-working space focused on robotics. Crucial to getting the innovation hub off the ground was a series of "champions", dedicated individuals who could see the potential of a robotics facility in Boston. The result of the cluster's discussion and the efforts of its founding champions produced MassRobotics in 2015, with its mission to accelerate innovation and adoption in robotics by providing infrastructure, funding opportunities, and networking support for startups and industry stakeholders.

"It starts with a champion or champions that have the right mindset for growth."

Tye Brady – MassRobotics co-founder and Amazon Chief Technologist

The centre offers a complete ecosystem, including shared prototyping facilities, industrial automation labs, and an accelerator program that provides US$100,000 in non-dilutive funding.

MassRobotics has been instrumental in supporting over 200 startups, which collectively have raised over US$1 billion and hired more than 600 people. Through initiatives such as the International Immersion Program and custom industry challenges, MassRobotics collaborates globally and ensures that new robotics ventures have access to the resources and guidance that are necessary to succeed in both U.S. and international markets.

While MassRobotics is run by an independent board, it had a strong collaborative culture from the outset, with the role of academia being significant. Located near world-renowned universities like Harvard and Massachusetts Institute of Technology (MIT) meant a steady supply of enthusiastic and talented graduates and academics keen to apply their theoretical skills to real-world robotics problems. MassRobotics also worked with the Government of Massachusetts in securing initial grants and funding, though the bulk of funding now comes through sponsorships and resident fees.

MassRobotics currently has 26 Annual Sponsors. These are mainly larger private sector firms, such as ABB, Mitsubishi Electric and Amazon Robotics (generally those with annual revenues in excess of US$100 million). MassRobotics notes that the most successful sponsorships have been high-touch engagements where the sponsors embed themselves into the community.

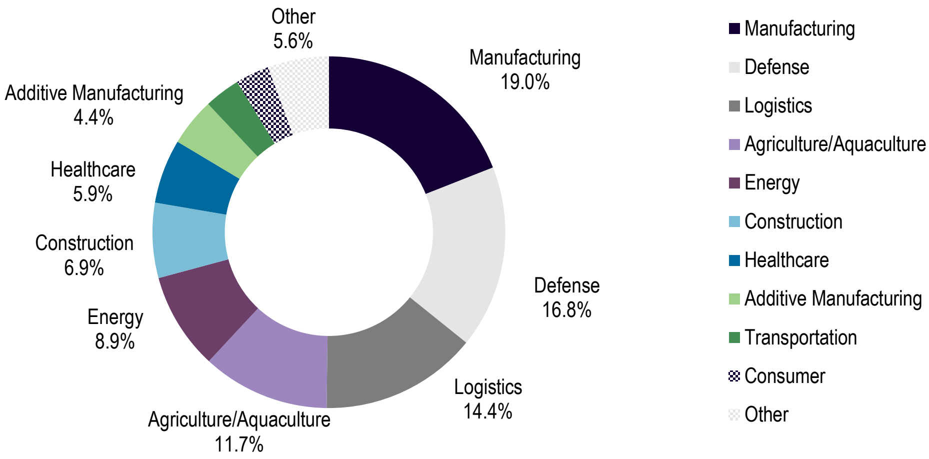
There are three tiers of sponsorship: Basic, Enhanced and Strategic. Sponsors must provide some cash support but can partially offset this amount by providing in-kind support (such as equipment). In addition, MassRobotics developed a program called the Associated Network that allows affiliation with MassRobotics (and a yearly in-person event). It is aimed at smaller/midsize suppliers, manufacturers and service providers. The Associated Network is limited to companies with revenue no greater than $50M.

Monthly participant fees vary and depend on the options chosen and the number of employees on site. The resident agreement is flexible and can be changed monthly to accommodate company circumstances as they grow or contract.

In 2023 the Centre published an Impact Report[82] covering their first 5 years of operations (2017-2022). The report speaks to their success in outreach, encouraging the uptake of STEM education, and supporting startups – from one in 2017 to over 60 in 2022 (an average annual growth of 23%).

MassRobotics takes an agnostic approach to the sector in which robotics are developed, as highlighted by an industry breakdown of the $1 billion invested in MassRobotics startups (shown in **Figure E.1**)

Figure E.1 Investment in MassRobotics startups by industry



Source: MassRobotics

Table E.1 MassRobotics – Boston, USA

Feature	Summary
Objectives or Goals	Accelerating innovation and adoption in the field of robotics; to support the growing robotics ecosystem by creating and scaling the next generation of successful global robotics and connected device companies.
Participants and sectoral focus	Across all of Industry, Governments and Academia. MassRobotics is not sector specific and supports all sectors that can use robotics.
Funding	Funded by sponsorships, resident fees, custom programming and federal and state grants. There are 26 Annual Sponsors (larger firms) and an Associated Network of smaller firms.
Activities and services	Offers participants offices and shared facilities, including testing labs, lab equipment (such 3D printers, oscilloscopes, soldering stations and laser cutters), specialised robotics resources (such as multiple robotic arms, grippers, conveyors, AMRs, sensors and humanoids), and CAD and other useful software. Operates a range of programs to support startups and STEM education.

[82] 5 Year Impact Report 2017-2022, MassRobotics. https://www.massrobotics.org/wp-content/uploads/2022/05/MassRobotics-5-Year-Impact-Report-2022-.pdf

Feature	Summary
Commercialisation role	Their *Resident Startup Program* offers a variety of supports, including facilitated meetings with investors, partners, delegations, and manufacturers. MassRobotics help withs fundraising through investor events and venture capital introductions. The *Accelerator* Program supports robotics startups through funding (US$100,000), custom tailored training, and mentorship. The *International Immersion Program* is for international startups who are ready to launch in the US.
Project selection	Competitive application process.
Collaboration	The Centre collaborates extensively through its programs with its industry sponsors, academia and government, including with overseas organisations and researchers. Custom Challenges are designed to help industry, startups, and academia gain knowledge by connecting them to solve challenges and highlight achievements in the field of robotics (these are open to overseas participants).
Evaluation or impact	The Centre has produced an impact report covering the first five years of operation (2017-2022). The report speaks to their success in outreach, encouraging the uptake of STEM education, and supporting startups. By 2022 startups had raised over US$350 million and employed over 450 persons. By mid-2024 startups had collectively hired over 600 people and raised over US$1 billion.
Lessons to learn	Stakeholders consulted about MassRobotics suggested that there exists an "Minimum Viable Product" for a robotics cluster to work. These suggestions include: – At least 50,000 square feet (approximately 4,600 square metres) of building space – Ideally located between universities, making it walkable for students and graduates – An advocate at state and national level to see the cluster through the initial years – An agreement with academic institutions – One or two founding companies – The hiring of good people to make it run This blueprint would be useful to keep in mind when assessing the long-term viability potential of a robotics cluster in Australia.

E.2 Advanced Robotics for Manufacturing (ARM) Institute (Pittsburgh, USA)

The ARM Institute was created in January 2017 when Carnegie Mellon University won the bid to create a robotics-focused Manufacturing USA Institute. The ARM Institute is a non-profit organisation focussing on strengthening U.S. manufacturing by advancing robotics, automation, and AI solutions. It does this by acting as an advisor for manufacturers evaluating robotics and connecting them with those offering solutions within the Institute's consortium of members.

The ARM Institute is located in Pittsburgh's Hazelwood neighbourhood at Mill 19. It is co-located with Carnegie Mellon University's Manufacturing Futures Institute, and has a second location in St Petersburg, Florida. The main facility at Mill 19 has 265,000 square feet (approximately 25,000 square metres) of additive manufacturing laboratory, workshop, low bay and high bay project areas, collaborative workspaces, and conference and meeting facilities.

ARM has a 12-person Board of Directors and is run by a 6-person Leadership Team, supported by additional 27 staff. There is also a 6-person Government Team.

Pittsburgh is reportedly a large epicentre for robotics development. ARM partners with the Pittsburgh Robotics Network[83], according to which, the greater Pittsburgh area has:

— Over 125 robotics industry organisations
— More than 20 academic and research organisations
— US$7.5B of investments in robotics companies
— Some 7,300 workers employed by the robotics industry

ARM views collaboration as key to robotics adoption, and the Institute has over 400 organisations as members. They include manufacturers, robotics, AI and automation suppliers, government stakeholders, universities, community colleges, non-profits and workforce training organisations. There are three categories of members: for profit; non-profit and government. The first two categories have a range of membership levels that require varying levels of annual fees (from US$50k to zero). These members are all required to provide in-kind support each year (usually around US$5k).

The Institute facilitates the commercialisation of robotics solutions through competitive Project Calls, targeting technology readiness levels (TRL) 4-7. The institute also plays a role in workforce development, maintaining the RoboticsCareer.org database to connect workers with training opportunities. ARM supports small and medium-sized manufacturers through the Robotics Manufacturing Hub, providing no-cost prototyping and proof-of-concept demonstrations.

ARM has a focus on industrial sectors such as aerospace, automotive, electronics, textiles, and others as defined by their members. They target growing sectors that are ready for rapid adoption of robotics in manufacturing. Member needs are identified through discussions with members, industry research, and road mapping. Funded with a grant from the Department of Commerce, the Institute and Robotics Hub provide free services to small or medium-sized manufacturers in local Pennsylvania counties.

While no formal evaluation of its impact has been conducted, ARM continues to drive industrial automation and national security innovations through government and industry collaboration.

Table E.2 ARM Institute – Pittsburgh, USA

Feature	Summary
Objectives or Goals	The ARM Institute's *Mission* is to accelerate the development and adoption of innovative robotics technologies for advanced manufacturing activity.
Participants and sectoral focus	The Institute has over 400 organisations as members, ranging from companies in manufacturing and government stakeholders to startups and academic organisations. The Institute is focused on manufacturing, particularly solutions for industry that have a dual use in Defence (e.g., aerospace, automotive, electronics, and textiles).
Funding	Funding is provided by a mix of government support or grants and member fees

[83] Pittsburgh Robotics Network. Accessed May 2025. https://www.robopgh.org/

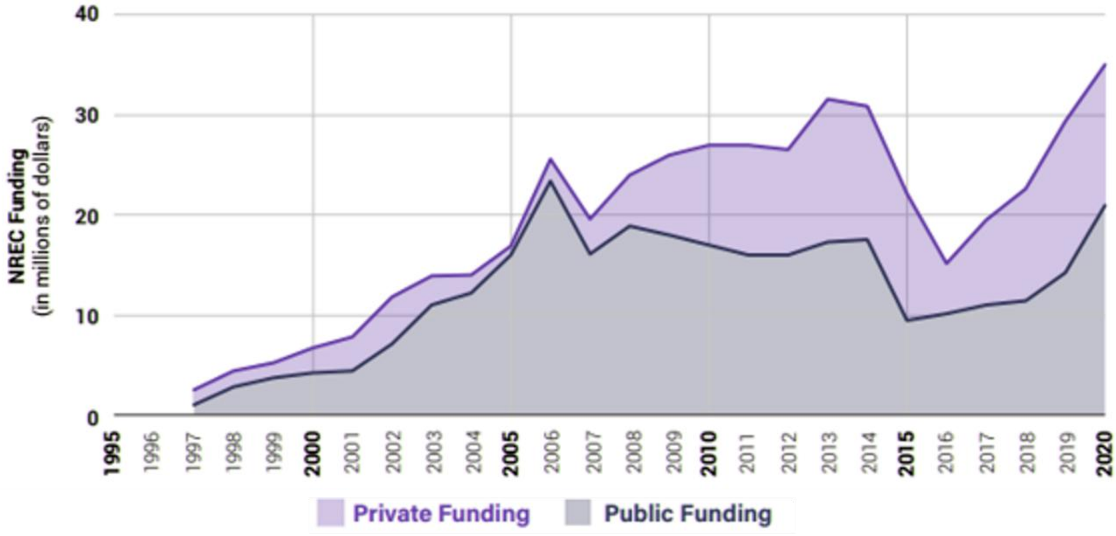
Feature	Summary
Activities and services	Services include automation assessment and business case assessments, proof of concepts and demonstrations, robotics education, and connection with the Institute's manufacturing and automation members.
Commercialisation role	ARM invites small and medium-sized manufacturers into the Institute's facilities to prototype solutions and demonstrate proofs-of-concept at no-cost. Primarily their role is facilitator with their large membership base to connect problem with solution.
Project selection	ARM uses experts and government stakeholders to identify areas of need, for which Project Calls are developed to address these needs. The most impactful solutions proposed by project teams are selected.
Collaboration	Collaboration within the Institute's consortium of members is one of its primary functions, linking manufacturers, robotics, AI and automation suppliers, government stakeholders, universities, community colleges, non-profits and workforce training organisations.
Evaluation or impact	No formal evaluation identified.
Lessons to learn	The success of ARM lies in its network of members and its ability to facilitate connections between these members. To the extent that a robotics cluster in Australia could emulate such a network, this would dramatically improve the rate of commercialisation of robotics projects.

E.3 National Robotics Engineering Center (NREC) (Pittsburgh, USA)

Operating as part of Carnegie Mellon University's Robotics Institute since 1996, NREC specialises in developing robotics solutions from concept to commercialisation. The Centre was founded by a partnership between Carnagie Mellon University, NASA, the Commonwealth of Pennsylvania, the city of Pittsburgh and others. The initial NREC investment was between $8-$10 million, and has since raised $545 million in direct funding.

The figure below outlines the relationship between public and private funding of NREC over time. While competitive public funding made up the bulk of NREC's early budget, the public-private funding ratio now sits between 1:1 and 3:2.

Figure E.2 NREC annual budget allocation 1997-2020



Source: Robots in the Backyard: How the National Robotics Engineering Center changed a neighborhood, a region and an industry; Fourth Economy, Carnegie Mellon University, NREC.

A 2021 evaluation report, Robotics in the Backyard[84], highlighted NREC's role in workforce development—64% of its alumni remain in the Pittsburgh robotics sector, and over 20 firms with a combined valuation exceeding US$25 billion were founded by former NREC personnel. Additionally, NREC's 450 technology licenses across 31 countries demonstrate its global influence. The centre has also played a significant role in the economic transformation of the Lawrenceville neighbourhood in Pittsburgh, driving job creation and regional development.

Table E.3 National Robotics Engineering Centre – Pittsburgh, USA

Feature	Summary
Objectives or Goals	The Center seeks to develop custom robotics solutions for their clients, from the concept stage through to commercialisation.
Participants and sectoral focus	The Centre takes a project-oriented approach. NREC staff include robotics, electrical, mechanical, system and software engineers, as well as program managers and technicians skilled in technology development and program execution. Their sectors of focus include agriculture, defence, mining, energy, manufacturing, and supply chain and logistics.
Funding	NREC's funding is provided by a mixture of government support or grants and client fees and royalties. The public-private funding ratio is between 1:1 and 3:2. Private firms invest around $10 million annually.
Activities and services	NREC has a standard 8 step process that it follows when a client comes to them with a problem, from proof-of-concept demonstrations to more focused development and testing, to commercialisation. NREC has a range of large warehouses for industrial testing and labs, as well as a number of external sites.

[84] Robots in the Backyard: How the National Robotics Engineering Center changed a neighborhood, a region and an industry; Fourth Economy, Carnegie Mellon University, NREC. https://www.cmu.edu/regional-impact/assets/docs/nrec-report.pdf

Feature	Summary
Commercialisation role	NREC aids with business development of a project, including the management of new client relationships, marketing and licensing for intellectual property. Commercialisation is a core focus for the Centre, and they employ business development staff to help with robotics projects.
Project selection	Projects are nominated by commercial clients. The Centre then works with the client to develop a business case before progressing.
Collaboration	As well as its private-sector partnerships, the Centre also collaborates with government, particularly in areas of defence. NREC's Carnagie Mellon Robotics Academy also provides services for educators and students.
Evaluation or impact	The Robotics in the Backyard report[85] examined NREC's impact over its first 25 years of operation. It found that NREC alumni worked in 60% of firms in the robotics/AI/tech sector in Pittsburgh region. NREC alumni had founded over 20 firms with a total valuation over $25 billion.
Lessons to learn	The Robotics in the Backyard[86] report noted the importance and interplay of four key elements in the catalyst for an Innovation hub: 1. Robust research and development networks generating new ideas 2. Commercialisation capacity to take ideas to market 3. Investment capital that is patient and risk tolerance 4. Specialised talent that has the expertise, creativity and drive to succeed. These lessons would be key to the success of a robotics cluster in Australia.

[85] Robots in the Backyard: How the National Robotics Engineering Center changed a neighborhood, a region and an industry; Fourth Economy, Carnegie Mellon University, NREC. https://www.cmu.edu/regional-impact/assets/docs/nrec-report.pdf
[86] Ibid.

E.4 High Value Manufacturing Catapult

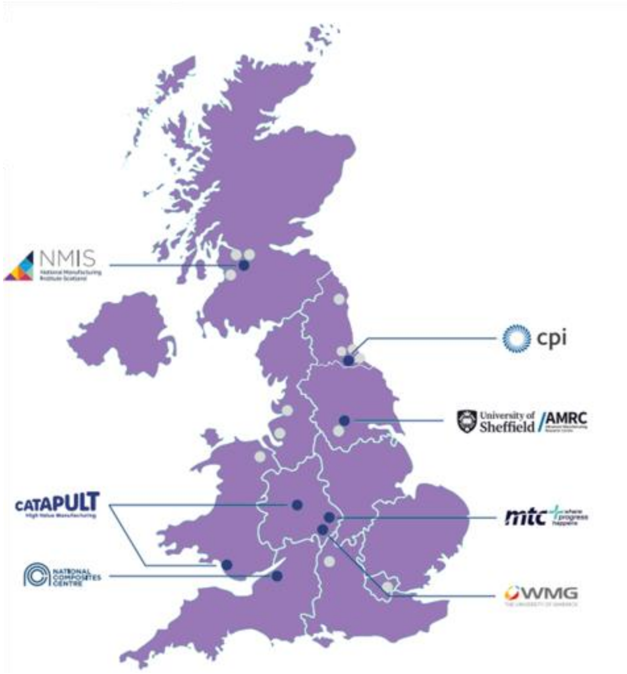
Part of the UK's Catapult Network, and established and supported by Innovate UK, HVMC focuses on enhancing manufacturing productivity by providing R&D expertise and technological infrastructure to businesses. Unlike other robotics-specific hubs, HVMC supports a broad range of manufacturing innovations, including robotics.

Catapults are physical centres across the UK and are run as independent not-for-profits. The centres' infrastructure includes testbeds, factories and offices. Their services also include skills training and access to a network of partners, including supply chains, government and universities. It offers support for startups, SMEs, and large enterprises, helping businesses scale their operations and integrate new technologies.

HVMC engages in collaborative R&D, connecting manufacturers with academia and government to accelerate commercialisation. In 2023-24, it worked with 6,050 companies, of which 3,611 were commercial projects.[87] In 2022-23, the centres generated £275 million in R&D and commercial income.[88]

While run by independent boards, the UK government plays a central role in HVMC's funding, making up 36% of the centres' income. The remainder is made up of competitively won R&D funding (29%), commercial income (34%) and other income (1%).

Figure E.3 HVMC locations - UK



Source: HVMC

Table E.4 High Value Manufacturing Catapult – United Kingdom

Feature	Summary
Objectives or Goals	HVMC looks to create the conditions for economic growth by enabling UK manufacturers to achieve improvements in their performance and productivity.
Participants and sectoral focus	HVMC includes industry, academia and government members. HVMC focuses on manufacturing.
Funding	Funding is provided by the government. Firms pay nothing for an exploratory conversation or meeting to discuss their needs. HVMC can scale and shape a project to match the firm's level of ambition and the funds they have available.
Activities and services	HVAC offers support for startups and entrepreneurs, SMEs, large and multinational companies in the form of expertise, equipment, connections and workforce development. HVAC also assists with finding funding.

[87] High Value Manufacturing Catapult. *Annual Report 2025.* https://hvm.catapult.org.uk/wp-content/uploads/2025/04/LUN2616_Annual-Report_FINAL-1.pdf

[88] High Value Manufacturing Catapult. *Annual Review 2022/23.* https://hvm.catapult.org.uk/wp-content/uploads/2023/12/HVMCatapult_Annual_Review_22_23-1.pdf

Feature	Summary
Commercialisation role	HVMC helps startups to develop new products and manufacturing processes, helps to access new markets and connect startups with partners in industry, government and academia.
Project selection	By application
Collaboration	HVMC works with government, business and academia. Many of the Catapults are based at or near universities, and HVMC has access to more than 3,700 engineers, scientists and technicians.
Evaluation or impact	No formal evaluation found, but since 2011, the Catapults have worked on 16,193 projects, 36,655 companies and 20,878 SMEs.
Lessons to learn	HVMC is an example of a whole-of-country approach to fostering innovation, led primarily with government funding. This style of funding lends itself to the networking approach of the centres, where resources and personnel can be readily shared (though it also speaks to the size of the UK and therefore may not be the most applicable model for Australia).

E.5 Odense Robotics (Denmark)

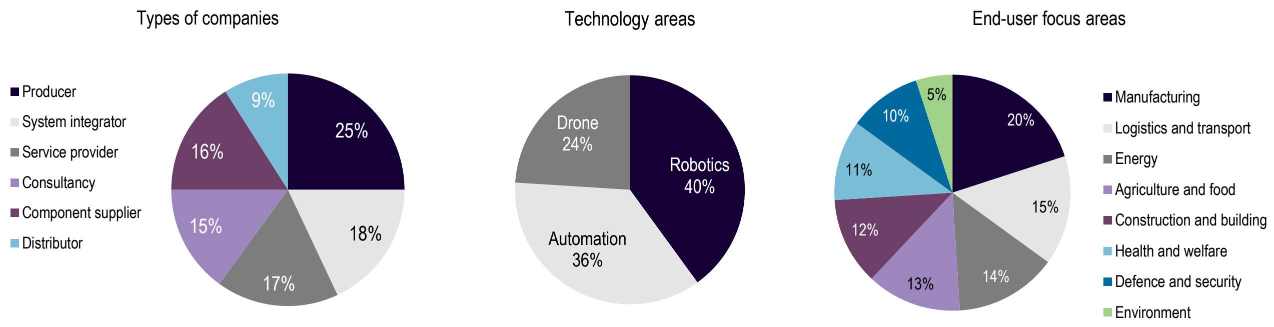
Odense Robotics is Denmark's national robotics, automation, and drone cluster, with regional hubs across the country. Its mission is to drive innovation and sustainable development in the robotics sector by fostering collaboration between private companies, research institutions, and government agencies.

The cluster grew relatively organically. Odense was a small shipping town which had a culture of private and academic robotics collaboration, notably between the shipping giant Maesk and the University of Southern Denmark (SDU). While the shipyard closed down in 2009, Maersk had invested substantially in robotics research at SDU. Since the early 2000s, there has been a more concerted effort to stimulate Denmark's robotics, led by both private business angels and foundations, as well as an array of public-sector partners—including Odense Municipality, RoboCluster, Developing Funen, Odense Robotics, the Danish Growth Fund, and various EU funding programmes.[89]

Odense Robotics has more than 350 members. These include private robotics companies, research and education organisations, industry organisations, and public sector organisations. Member services include startup support, such as expert advice, access to soft funding and investors, incubator and accelerator programs, testing facilities and innovation workshops, and direct access to the Odense Robotics StartUp Fund. In addition, the cluster facilitates connections to talent through their network at events and exhibitions.

[89] Invest in Odense. *How Odense became a powerful robotics hub with excellent access to venture capital.* Accessed April 2025. https://investinodense.dk/how-odense-became-a-powerful-robotics-hub-with-excellent-access-to-venture-capital/

Figure E.4 Odense Robotics members and focus



Source: Odense Robotics, Insight Report 2022

The cluster has regional hubs in Aalborg, Aarhus, Copenhagen, Odense and Sonderborg. The cluster is founded on partnerships with leading knowledge institutions: Aalborg University, Aarhus University, Kolding Design School, Danmark's Technical University, FORCE Technology, the University of Southern Denmark and the Danish Technological Institute.

Odense Robotics is co-funded by the Danish Board of Business Development, the Danish Agency for Higher Education and Science and the European Union, and through a range of projects and partnerships.

Table E.5 Odense Robotics - Denmark

Feature	Summary
Objectives or Goals	Odense Robotics aims to make Denmark a bigger, better robot nation. Its mission is to drive innovation and accelerate sustainable development throughout the Danish robotics and drone industry.
Participants and sectoral focus	Odense Robotics has 384 members. These are private companies, research and education organisations, industry organisations, and public sector organisations. Its focus is robotics and drone startups from across the economy, including manufacturing, logistics and transport, energy, defence and security. Their technological focus areas are autonomous systems, drones as tools, multi-robot-systems, robots and AI, and safe human-robot interaction.
Funding	Odense Robotics is co-funded by the Danish Board of Business Development, the Danish Agency for Higher Education and Science and the European Union, as well as a broad range of projects and partnerships. Odense Robotics Startup Fund has a total capital of DKK 18.4 million ($4.29 million) consisting of donations from three private investors.
Activities and services	The startup hub helps companies at every stage of the development process, from early explorative innovation to late-stage innovation / next generation development. Companies can collaborate with some of Denmark's leading researchers to both accelerate and improve their innovation level. Companies can also access financial support through projects and business development expertise.
Commercialisation role	Access to expert advice, soft funding and investors, incubator and accelerator programs, testing facilities and innovation workshops. Startups also have direct access to the Odense Robotics StartUp Fund.
Project selection	By application.

Feature	Summary
Collaboration	The cluster works with private companies, research and education organisations, industry organisations, and public sector organisations. Overseas groups can also apply for support.
Evaluation or impact	Odense Robotics Startup Hub was one of Europe's leading incubators with a success rate of 80%. More than 30 startups were part of the hub and today they employ more than 170 employees. During their time in the hub, the startups received more than EUR 30 million in external investments and more than EUR 7.5 million in soft money, without renouncing ownership rights.
Lessons to learn	Odense Robotics has become the primary driver of robotics innovation across Denmark, its growth largely a result of an existing culture of collaboration between industry and academia. Over time, it has evolved into a network of members that connect across the country, again highlighting the need for buy-in across research, industry and government.

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