A Prosperous Future: Emerging Tech

Opportunities for Australia-US Trade in Digital Economy, Artificial Intelligence, and Quantum Science.

KPMG

AmCham
access to opportunity

Foreword

The comprehensive relationship between Australia and the United States is of great economic and strategic importance for both countries. We share democratic ideals and values, cultural and historic ties and common interests.

But what will this relationship look like in the future? Where will our economic and commercial connections and opportunities lie in a rapidly changing world?

Both countries are emerging from the interrelated health and economic disruptions caused by COVID-19 and looking towards the future – a future characterised by a range of increasingly complex geostrategic, geopolitical and geoeconomic issues, including rapid technological, climate and societal challenges. These pressures are accelerating and testing our nations' resilience while also creating new opportunities. The United States and Australia are committed to working together to face this uncertain future.

Australia and the United States possess many complementary attributes. From a business perspective, the countries are very close partners despite often overlapping and competing interests. With the Australia-US Free Trade Agreement (AUSFTA) operating for the past 16 years, the bilateral trade balance has grown to exceed A$80 billion in 2019-20, making this Australia's second-largest bilateral corridor. Australian exports to the United States were valued at A$27 billion in 2019-20 and 96 per cent of Australian goods and services exports to the United States are now duty free, providing a solid platform for future export growth.

Meanwhile, imports from the United States into Australia were A$53 billion. The United States is also the largest country source of foreign direct investment to Australia, with just over A$1 trillion historically invested by US companies across many sectors, companies and assets.

By building on existing relationships, developing new ones and working collaboratively, the United States and Australia have the potential to achieve more together for a wider benefit than if the status quo was just maintained.

Australia is recognised as a leader in research and development in many sectors including Quantum Computing, renewable energy, Biotechnology, ag-tech and medical research. Yet, despite punching well above its weight in the early stages of research and development within universities and institutes, historically Australia has seen some of its brightest talent move offshore with this research to further develop, commercialise and achieve scale through foreign venture capital investment and superior start-up infrastructure. The United States has been, and will continue to be, the destination of choice as well as the most important source of venture and investment capital for Australian intellectual property and entrepreneurial activity.

The US government, underpinned by its business sectors, is working to rebuild the nation's post-COVID economy with an ambitious US$1.2 trillion infrastructure program. This wide range of reforms aims to reposition the United States for a cleaner, fairer, more modern and competitive future. There are bound to be many opportunities for Australian companies and entrepreneurs to participate.

As a national partner of AmCham in Australia, KPMG is delighted to partner with and co-sponsor this report: *A Prosperous Future: Emerging Tech - Opportunities for Australia-US Trade in Digital Economy, Artificial Intelligence, and Quantum Science*. This follows the initial December 2021 report: A Prosperous Future, and will be followed with future reports in the series on Biotechnology, Energy and Clean Technology and Space.

We thank AmCham's Board of Directors, Council of Governors, executive leadership team, participant companies and other organisations and individuals who have significantly contributed to this report.

Finally, our sincere thanks to Dr. Brendan Nelson AO, April Palmerlee, Sara James and Josh Edwards from AmCham and our KPMG colleagues: Daniel Bahyl, Dr. Merriden Varrall and Julie Bever for their enormous contributions towards this important research series.

Dr. Brendan Rynne
Chief Economist,
KPMG Australia

Doug Ferguson
NSW Chairman and Head of Asia & International Markets
KPMG Australia

From AmCham Australia

The unbreakable alliance between the United States and Australia was born in the trenches of Hamel in 1918, forged in the waters of the Coral Sea in 1942, and codified in the 11 articles of the ANZUS Treaty in 1951.

The US-Australia alliance has been, and remains to this day, the bedrock of our national security. Its foundation has empowered the alliance to flourish underpinned by mutual trust, shared values and thriving commerce.

The United States is also an integral contributor to Australia's economic success, accounting for more than 25 per cent of foreign direct investment and seven per cent of Australia's Gross Domestic Product over the past decade. But Australia must not be tempted to take this economic prosperity for granted. The continued vitality and growth of Australia's economy must include active US economic engagement in the region.

Australia is situated in the world's most dynamic and fast-evolving region: the Indo-Pacific. Technological disruption, accelerated by the COVID-19 pandemic, is rapidly transforming how the country does business and its people conduct their daily lives. Australia is also launching new technologies ahead of international standards and norms into opaque or nonexistent regulatory frameworks.

These geopolitical forces have driven the United States and Australia closer than ever before. The rapidly changing strategic environment means the alliance that has benefited the American and Australian people for more than 100 years must continue to modernise to meet the challenges and opportunities of the next century.

The landmark AUKUS partnership underscores the deep trust that exists among Australia, the United Kingdom and the United States to increase technology transfer and share expertise in quantum technology and Artificial Intelligence among other emerging technologies. It is imperative that the United States and Australia seamlessly collaborate in the emerging industries that will shape our joint economic prosperity and national security.

Artificial intelligence, Quantum Computing and the Digital Economy are three critical areas of untapped potential. Australia has established its credentials in research and must now advance its commercialisation capacity to take full advantage of the economic opportunity.

We have entered the decisive decade. The decisions made during the next 10 years will have profound ramifications on the future of the international order and the role that these technologies will play. The research in this report is vital to ensuring that these decisions are informed, opportunities are identified and action taken.

AmCham Australia is proud to deliver this report *Emerging Tech-Opportunities for Australia-US Trade in Digital Economy, Artificial Intelligence, and Quantum Science* with our national partner KPMG as part of this report series A Prosperous Future. We would like to thank Doug Ferguson, Dr Brendan Rynne, Daniel Bahyl, Dr Merriden Varrall and Julie Bever for their tireless efforts, the AmCham Member Companies for their contributions to this important research, and our AmCham colleagues Sara James and Josh Edwards.

Dr. Brendan Nelson AO
Chairman
AmCham Australia

April Palmerlee
Chief Executive Officer
AmCham Australia

Report foundation

As outlined in KPMG's 2021 introductory report, *A Prosperous Future: Key industries for Australia/US collaboration*, in consultation with the Australian Department of Foreign Affairs and Trade, and the United States Embassy in Australia, AmCham and KPMG identified six emerging industries that will be key to the future of the United States-Australia economic relationship: Biotech, Energy and Clean Technology, Space, Digital Economy, Artificial Intelligence and Quantum Computing. This report focusses on the latter three.

Executive Summary

An unfolding technological renaissance

The disruptions underway in Artificial Intelligence, Quantum Computing and the Digital Economy are a sign of volcanic economic activity and herald the promise of explosive future growth.

Make no mistake about it: a digital renaissance is unfolding across the world.

Emerging technology holds profound potential for both Australia and the United States.

Australian companies could realise billions of dollars in revenue and far greater participation in the value chain if their efforts are focused on enhancing products and services in key Deep Tech sectors.

The stakes are high. Australia is poised to be a key player. But doing 'more of the same' would be to tread water in a highly dynamic market. And treading water is as good as going backwards.

There are several key tech industries where economic and geopolitical considerations overlap and where Australia and the United States share common interests. Artificial Intelligence (AI), Quantum Computing (QC) and the Digital Economy (DE) are three key sectors where it makes strategic sense for the two countries to further explore deep collaboration into the future.

We have already observed that the US and Australian governments recognise this potential and seek opportunities for collaboration. This is demonstrated through partnerships such as AUKUS, the Quad Critical and Emerging Technology Working Group and the bilateral quantum technology cooperation agreement. But more can be done.

Achieving accelerated growth in these Emerging Tech sectors could generate US$24 billion in exports and 80,000 jobs within 10 years.

Australia's AI Advantage

While the United States is home to six of the 'Big Nine' AI companies, Australia is a world-leader in researching the field.

Australia's AI industry is now worth A$370 million and its AI specialisation in mining and defence is globally recognised. But Australian companies have a key commercial opportunity in the US financial services industry which purchases US$2 billion of AI goods and services every year.

The rationale for this assessment relates to the breadth, rather than the depth, of purchases as the financial services sector is utilising AI in the widest possible way. It is this wide spectrum of 'use cases' that suggests there is a high possibility that Australian-developed AI applications are capable of meeting a need in this sector, either in conjunction with a US-developed solution or by themselves.

A Quantum Contender

The fledgling Quantum Computing (QC) industry has taken gigantic leaps forward in recent years and is now poised for significant growth. The QC forecast in the United States predicts the current industry, worth US$288 million, could become a US$3.3 billion behemoth by 2028.

Australia is also a contender. The nation ranks in the top 10 globally for QC research and venture capital investment and 11th in QC patents.

QC opportunities in the defence sector are considered a key strength for Australia.

Quantum technology is already being employed in Australia's defence sector, and there are a variety of dedicated research programs related to defence applications. While the United States indicator for openness in this industry is lower than others, there are still likely to be trade opportunities in the longer term as adoption of the technology increases and globally leading and Australian-developed QC technologies are sold into defence industry organisations.

To succeed, Australian firms will need to already have local industry clients, ideally in government or US subsidiaries that operate here, and they will need to leverage those relationships to access the United States market.

Digital Economy Rounds out the Transformation Trio

The Digital Economy currently accounts for 6.6 per cent of Australia's GDP and creates around A$44 billion in economic value for Australia consumers.

The financial sector is considered a key area of strength and opportunity for Australia. The industry has been an early adopter of innovation and technology, including Digital Economy. The US indicator for openness in this industry is higher than others, indicating trade opportunities are likely in the near term.

The government and education sectors also present opportunities for increased trade between the United States and Australia. US openness in these industries is lower than others, but there may be trade opportunities in the longer term as adoption of the technology increases.

Future Proof

The Deep Tech potential for Australia is incredible. There are risks, too. This ongoing technological transformation is fast, furious and filled with uncertainty.

But this transformation is impossible to ignore or avoid. Companies must engage and compete.

To successfully navigate this new world, the Australian government and businesses must intensify efforts to translate first-rate research into more jobs and greater wealth for the nation.

Intrinsic to this process is a deeper understanding and appreciation of the juggernaut that is Deep Tech in the United States. We offer four strategies for success:

1. *Seek partners and customers* – Trust and credibility can take time to build, as does understanding of a new market. Partnering with US business on a complementary project can benefit both parties.
2. *Assess US opportunities for early adoption of Australian Deep Tech* – US customers may be more open to adopting new technologies, providing options unavailable elsewhere.
3. *Identify where your product or technology fits in the supply chain* – As global supply chains become increasingly complex, a new technology may sit further upstream from the final product.
4. *Research the best market for a new technology* – Many start-ups are attracted to Silicon Valley and New York, but the United States is a large and diverse economy with multiple access points.

The Benefits of Success

Table 1 summarises the estimated value of Australian exports to the US as a share of US domestic industry revenue, under three scenarios analysed by KPMG. Firstly, by using historical average growth rate; secondly, applying the historic rate of trade to the new rapidly growing US industries. The third scenario assumes Australia can increase its share by combining the growth rates derived from scenarios 1+2. This represents growth in Australia/US trade due to increased exports in defence and security-related goods, as a result of arrangements such as AUKUS.

Across all scenarios, Australia maintains a small share of the total US industry size (less than half a per cent), despite a significant increase for Australia's exports.

This highlights that the export potential is more constrained by Australia's capacity to commercialise and deliver new technology, than by a lack of opportunity in the United States. It also highlights that under the 'business as usual scenario,' Australia could lose market share if trade doesn't keep up with the high growth of the United States Deep Tech sectors.

Table 1: Trade scenario estimates as a share of Australia and the United States domestic industry revenue

	QC	AI	DE
Australia exports to US 2019/20 (A$ millions)	0.07	5.69	175.23
Projected Australian exports to US 2027/28 ($A millions 2019/20)			
Scenario 1: business as usual	0.2	13.1	404.2
Scenario 2: fair share	2.3	86.6	4,083.6
Scenario 3: accelerated	13.9	381.3	23,376.7

Source: KPMG analysis.

Getting this right could be a game changer for Australia. Achieving accelerated growth could directly result in more than AUD$23 billion in incremental capital investment and around 80,000 specialised, high-paid jobs by the end of the decade. This doesn't include additional indirect economic benefits. But achieving this depends on both industry and government working cooperatively to maximise the opportunities that will come with even stronger defence and security relationships that will arise under the AUKUS pact, as well as leveraging the successful Australia-US Free Trade Agreement.

This Report

This report provides a state of play for the fast-moving world of Emerging Tech. We offer insight and analysis regarding how Australian businesses can best participate in and profit from this technological renaissance of how we live, work and play.

Glossary of terms

Artificial Intelligence 	Artificial Intelligence (AI) is the integration of various technologies which enable machines to learn and produce information by either thinking and acting like a human, or by exercising original and independent intelligence that is distinct and dissimilar from human thought and behaviour.
Deep tech 	Deep technology, or Deep Tech, describes the bringing together of advanced science, engineering and design by organisations to create new innovations. Deep Tech encompasses Artificial Intelligence, Digital Economy, Quantum Computing and other advanced technologies and typically generates intellectual property that is difficult to reproduce.
Digital Economy 	The Digital Economy is the global network of economic activities, commercial transactions and professional interactions that are enabled by information and communications technologies (ICT). The Digital Economy, also known as the 'new economy', or 'internet economy', is characterised by the creation of safe and secure applications that enable online transactions. Digital Economy incorporates both the economic activity that takes place online and the industry to secure this and other digital services, and it includes cybersecurity, digital communications and e-commerce.
Quantum science 	Quantum science is the search for the minimal amount of physical property involved in fundamental interactions. It includes Quantum Computing, quantum physics and quantum mechanics. We'll focus on the application and use of phenomena to create new and faster ways of computing.

Contents

1 Introduction

Our world is evolving with new technologies, processes and trade patterns that will change the shape of traditional industrial structures. That means emerging sectors will continue to appear and displace traditional ones.

As outlined in KPMG's 2021 introductory report, *A Prosperous Future: Key industries for Australia/US collaboration*, in consultation with the Australian Department of Foreign Affairs and Trade, and the US Embassy in Australia, AmCham and KPMG identified six emerging industries that will both shape the living standards of our citizens and drive the strategic competition between states: Biotech, Energy and Clean Technology, Space, Digital Economy, Artificial Intelligence and Quantum Computing. As likeminded and democratic countries, joined by a security alliance, Australia and the United States are natural partners to collaborate on these future industries.

This report explores three of these industries: Artificial Intelligence (AI), Quantum Computing (QC) and the Digital Economy (DE). The desire to have a better life tomorrow is rapidly driving demand for solutions from these industries today. These three industry sectors are likely to be the powerhouses of the global economy for the next century as the world looks to improve how we live, work and play. As such, they will become fundamentally important in global trade, investment and broader economic development.

This report explores each industry's current state in the United States and Australia. This includes market size estimates, key companies, start-ups, how the technology has been adopted in various sectors and a supply chain analysis. The outlook for these technologies and their potential impacts are also discussed.

To identify potential opportunities for Australia to participate in the US supply chain, Australia's strengths in each industry are assessed against the level of openness to the technology in the US.

To understand the export potential for Australian businesses in these three sectors, AmCham and KPMG consulted with some of the largest public and private companies and leaders of key start-ups that have succeeded in generating new business in both countries.

The report also examines the elements in assessing the future export growth potential for Australia in each of the three sectors. Leveraging Australia's strengths and aligning them to the opportunities in the United States has the potential for a significant uplift in the already strong trade relationship between the two countries.

1.1 Purpose of study

AmCham and KPMG conducted a detailed assessment of the current and future growth potential of the AI, QC and DE industries. The purpose of this study was to gain an understanding of how trade and investment between Australia and the United States in these sectors could enable better outcomes for the two countries as opposed to 'going it alone'.

1.2 Introduction to the American Chamber of Commerce in Australia and KPMG

The American Chamber of Commerce in Australia (AmCham) was founded in 1961 and now has offices in Sydney, Melbourne, Perth, Brisbane, Adelaide and Canberra. AmCham aids US and Australian companies by promoting trade, commerce and investment to and from Australia.

KPMG is a global network of professional services firms providing audit, tax and advisory services. We operate in 146 countries and territories and in FY20 had close to 227,000 people working in member firms around the world. In Australia, KPMG has a long tradition of professionalism and integrity, combined with our dynamic approach to advising clients in a digital-driven world. We have approximately 8,800 people, including more than 600 partners, with offices around the country.

1.3 Report structure

The remainder of this report has been organised into the following sections:

- This section (**Section 1**) has defined the purpose and the structure of this report;
- **Section 2** describes the context on the geopolitical landscape;
- **Section 3** explores the Artificial Intelligence industry in the United States and Australia;
- **Section 4** explores the Quantum Computing industry in the United States and Australia;
- **Section 5** explores the Digital Economy industry in the United States and Australia;
- **Section 6** assesses the future export growth potential for Australia in each industry;
- **Section 7** discusses economic benefits of achieving improved trade between the two countries;
- **Appendix A** describes the methodology for estimating market size;
- **Appendix B** presents supplementary information on each industry;
- **Appendix C** lists the most prominent US businesses in each industry; and
- **Appendix D** provides a bibliography list of references.

2 Geopolitical landscape

2.1 The geopolitical context

The world is experiencing an increase in geopolitical volatility. We expect this to continue as the world shifts from the post-Cold War international economic order to a new geoeconomic order.[1] Rather than viewing international cooperation as a positive, this emerging economic paradigm seems to be characterised by suspicion and concern over the potential security risks of economic interdependence. Economic levers are increasingly being used as a tool for domination in strategic competition.

This shift is driven by a host of interrelated factors. These include uncertainty and insecurity arising from the immense global changes, like structural shifts in the power dynamics of the international system, rapid tech and cyber developments, rising mistrust and the climate crisis.[2] In this geoeconomic global context, international trade and investment are no longer just about the movement of goods and capital according to economic principles of supply and demand or competitive advantage – they're core elements of geopolitical power.[3]

With this context, it's essential to look to the future and start building the capabilities needed to not only maintain a country's current world position but also to enhance it. There is a growing global understanding about the increasing need to strengthen ties with actors who share similar views about how the world order should look and function and about the responsibilities and obligations of a nation-state domestically and internationally. In this geopolitical context, the bilateral security alliance between Australia and the United States is an opportunity to further develop the key industries and sectors that both countries will need for resilience and the ability to thrive in the uncertain times ahead.

2.2 Industries of the future

Profound technological disruption will be a key feature of the changing geopolitical order. Technology capabilities used across the 'hybrid zone' of virtual and physical worlds can and will be instruments of state power, used both domestically and internationally.[4] In fact, technological rivalry may dominate the 21st century world.[5]

There are several key industries in the technology sector where economics and politics overlap and where there are commonalities between Australia and the United States. We can already observe the US and Australian governments recognising this potential and seeking opportunities for collaboration. There is the opportunity for more to be done into the future. As this report explores, Artificial Intelligence, Quantum Computing and the Digital Economy are three key sectors where it makes geopolitical sense for the two countries to explore deep cooperation into the future.

2.2.1 Artificial Intelligence (AI)

AI is an inspirational technology which can be a powerful tool for improving lives. It also has the potential to do harm if used by authoritarian regimes or unscrupulous businesses. AI both drives and is driven by geopolitics and could have a major impact on international and domestic security. AI is already being used in the pursuit of political, economic and social advantage.[6] That will only increase in time. Governments, think tanks and universities are investigating how the development of AI is being shaped by great power competition, while also shaping it; how AI might empower, or undermine, authoritarian or populist regimes; and how it might be used in military conflict.

Two decades ago, the United States was a (if not *the*) world leader in AI research. Since then, other major global actors have invested heavily in AI and made significant progress.[7] In 2017, China declared its ambitious goal of making the country "the world's primary AI innovation centre" by 2030. Recognising the critical importance of Artificial Intelligence to national security, as understood to include economic security, AI is one of the three technology priorities of the AUKUS agreement.

2.2.2 Quantum Computing

Quantum Computing is another priority area of the 2021 AUKUS agreement. Like AI, Quantum Computing has the potential to revolutionise the world. The vast and yet still largely unrealised capabilities of Quantum Computing mean that it has the potential for immense implications for economic growth and national security.

While the fastest existing supercomputer would take more than a billion years to crack the highest level of encryption used by a government to protect its most sensitive information, a quantum computer, once developed, could do it in seconds. Quantum-enabled technologies could also provide a significant strategic advantage to military forces.[9] The potential for strategic advantage that comes from being at the forefront of Quantum Computing is driving a global competition for further development.

2.2.3 Digital Economy

As the Digital Economy grows, it's disrupting conventional ideas of what businesses do and how they do it. It's transforming how consumers get their information, goods and services. The global Digital Economy relies on fast and secure connectivity and instant interoperability. This hyperconnectivity among people, organisations and machines means the Digital Economy's backbone is also a vulnerability. In the context of growing geopolitical volatility and strategic competition for technological primacy, the world faces the real possibility of a 'tech decoupling' or 'tech bifurcation', creating divergent standards and norms. Indeed, concerns about the potential security and defence risks have been growing in the United States, with calls for at least some decoupling of tech from strategic competitors.[10] To remain competitive and take advantage of the opportunities an increasingly digitalised economy offers, Australia, the United States and other like-minded countries are jointly and proactively investing to ensure security and economic opportunity are well-aligned.

2.3 Conclusion

Geopolitical realities should be at the centre of Australia's approach to industries of the future. They guide not only which industries the nation focuses on but with whom it forges partnerships. Working with others based on trust, reliability and a shared vision of how the world should work will be key to building a secure and prosperous future.

Australia and the United States should be clear about how they want the world to look and develop technological priorities accordingly, working with like-minded partners on Deep Tech that will foster prosperity, wellbeing and security.

3 Artificial Intelligence

3.1 Industry introduction and definition

3.1.1 Definition and main activities

Artificial Intelligence integrates various technologies to enable machines, or computers, to learn and produce information. This occurs when the computer can either think or act like a human, or when it can exercise original and independent intelligence that is distinct and dissimilar from human thought and behaviour.

Figure 1 shows popular technologies that are being used by AI adopters around the world.

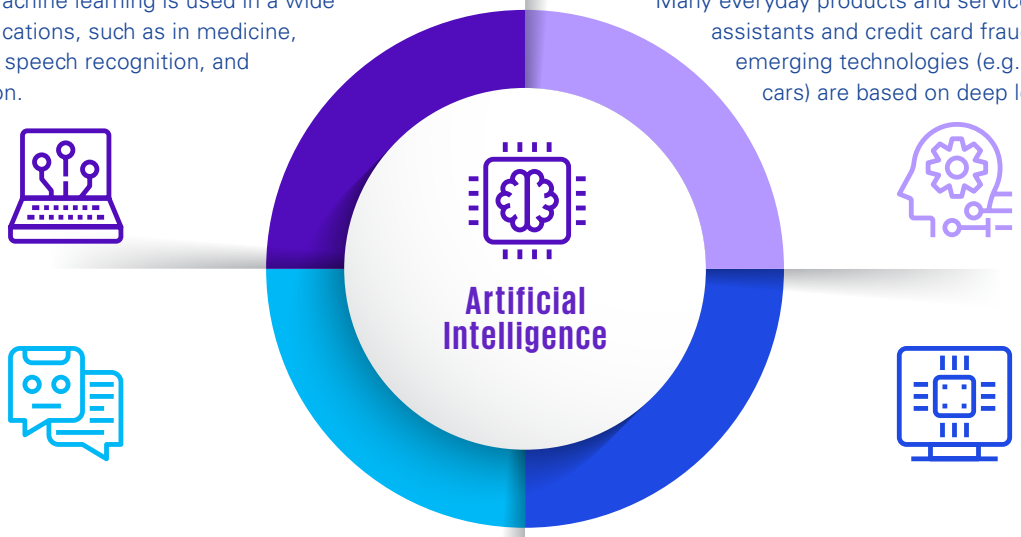
Figure 1: Popular technologies used by global AI adopters

Machine Learning

Machine learning focuses on the use of data and algorithms to imitate the way humans learn and gradually improve its accuracy. Algorithms are trained by the use of statistical methods to make classifications or predictions, drawing key insights within data mining projects. Subsequently, these insights drive decision-making within applications and businesses. Machine learning is used in a wide variety of applications, such as in medicine, email filtering, speech recognition, and computer vision.

Deep Learning

Deep learning is a subset of machine learning that uses a layered structure of artificial neural networks to simulate the human brain's behaviour, enabling it to 'learn' from large amounts of data. Deep learning drives many AI applications and services that improve automation, performing analytical and physical tasks without human intervention. Many everyday products and services (e.g. digital assistants and credit card fraud detection) and emerging technologies (e.g. autonomous cars) are based on deep learning.



Natural Language Processing

Natural Language Processing (NLP) gives computers the ability to understand text and spoken words in a way similar to humans by combining computational linguistics with statistical, machine learning and deep learning models. NLP is behind computer programs that translate text from one language to another, respond to spoken commands, and summarise large volumes of text rapidly (e.g. voice-operated GPS systems, digital assistants, speech-to-text dictation software, customer service chatbots).

Computer Vision

Computer vision allows computers and systems to extract meaningful information from visual inputs (e.g. digital images and videos) and take actions or make recommendations using that information. Machines are trained to perform functions that are the same as those of human vision in much less time with cameras, data and algorithms. A range of industries from energy and utilities to manufacturing and automotive have used computer vision (e.g. autonomous cars, cashier-less stores), and the market continues to grow.

Source: IBM, Grand View Research, KPMG research

AI uses layers of algorithms for data processing, calculation and automated reasoning to perform tasks that typically require human assistance, such as speech recognition, visual perception and language translation. AI algorithms have continuously improved to address the limitations of conventional computing that can struggle with large volumes of data or require extensive human input. These advances have led manufacturers and technology providers to focus on developing standard algorithms.[11]

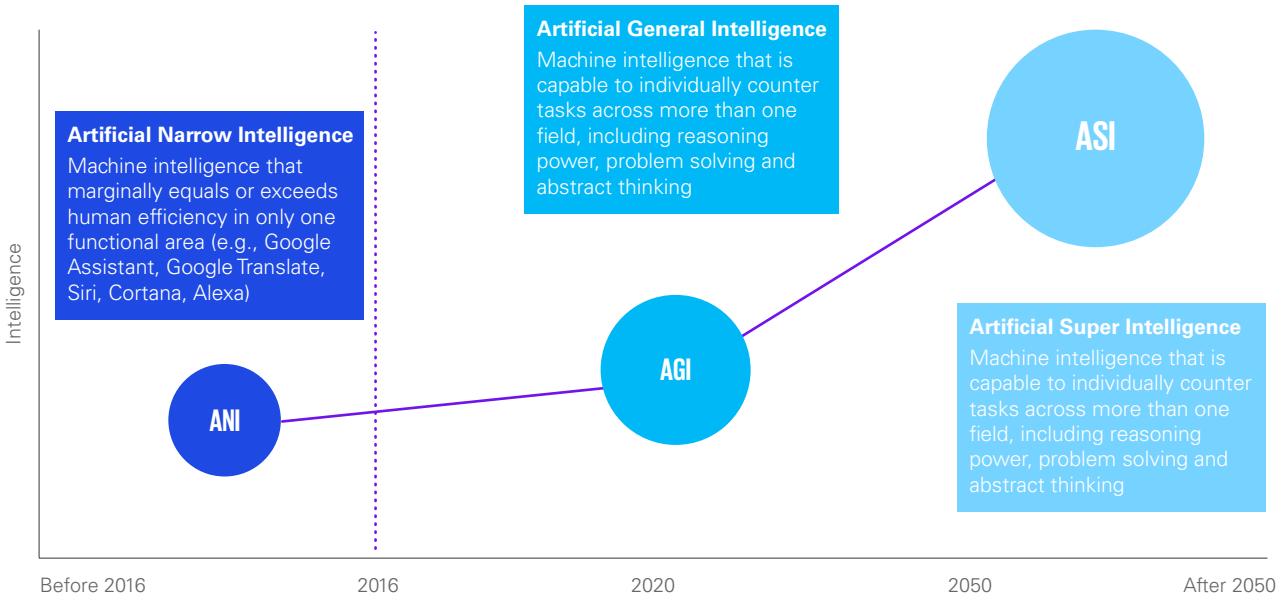
The evolution of AI can be broadly divided into three stages:

1. artificial narrow intelligence, or weak AI (ANI);
2. artificial general intelligence, super AI or human-level AI (AGI) and;
3. artificial super intelligence (ASI).

The transition from ANI to AGI has taken a long time (Figure 2) and it's generally believed that industry is now in the final stages of ANI.

Now, AGI is the emerging stage. ANI represents all existing AI, including the most complex and capable AI that has been invented to date.[12-14] On the other hand, ASI remains a hypothetical concept in which the intelligence of machines surpasses humans across all fields. ASI machines will be able perform tasks that only humans are currently capable of, such as complex decision-making and emotional relationships.

Figure 2: AI evolution



Source: "UBS: The evolution of Artificial Intelligence," KPMG research

3.1.2 Products and services

Applications of AI are realised through software, hardware and services.

3.1.2.1 AI software

AI software learns from patterns in data and insights to mimic human behaviour. There are four types of AI software: platforms for developing applications, chatbots, deep learning software and machine learning software.[15]

3.1.2.2 AI hardware

Graphic processing units (GPUs) and central processing units (CPUs) currently dominate the AI hardware market due to their high computing capabilities.[16] Hardware solutions in AI also consist of Tensor Processing Units (TPU), Intelligence Processing Units (IPU), field-programmable gate arrays (FPGA), application-specific integrated circuits (ASIC), neuromorphic chips, inference chips, training chips, dataflow processors, vector processors, 3D stacking and optical interconnects.

Edge-based AI is where the computation is conducted physically close to the user, that is at the edge of a network, instead of the traditional central or cloud based data centre. The primary applications for edge-based AI include voice and speech, image and video, natural language processing, device controls and high-volume computing. Inference AI chips use considerably less power, generate less heat and have integration compatibility for handheld devices, such as smartphones. Tech giants prefer ASICs to build AI applications. Google, for example, has developed its Edge TPU based on ASIC architecture. Amazon is working on developing an ASIC-based AI chip for its Alexa home assistant.[17]

3.1.2.3 AI services

AI services allow individuals and companies to experiment with AI for various purposes without large initial investments or high risk.[16] This includes installation, integration, maintenance and support for AI software and hardware.[15] AI-as-a-Service (AIaaS) follows the same principle as other cloud services such as Software-as-a-Service (SaaS), Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service (PaaS). Similar to these models, AI service implementations are conducted on a subscription-based technology.

3.2 Relative importance to US economy

3.2.1 Current state and notable players

The United States has been leading in public and private AI research for years[15], recording annual expenditure (equivalent to revenue) in the order of A$21.6 billion in 2020. Investment Monitor's 2021 AI Index, which assessed investor friendliness in the AI Space, shows the United States has remained the leader in AI, ranking first in 8 of 17 indicators (Figure 3).[19] These indicators include intellectual property receipts, investment in emerging technologies and software spending as a percentage of GDP. More than 8,300 AI sales and partnerships were recorded in the United States during the five years up to November 2021, more than triple the amount of China with 2,500 AI deals over the same period.[17]

Figure 3: 2021 Investment Monitor's AI Index

Rank	Country	Index score
1	United States	100
2	Singapore	67.22
3	Switzerland	67.14
4	Netherlands	66.2
5	Japan	64.22
6	South Korea	64.11
7	Sweden	64.05
8	Finland	63.09
9	Germany	62.82
10	Ireland	62.77
…		
19	Australia	50.92

Source: Investment Monitor, GlobalData

The United States AI market consisted of 2,028 AI companies in 2018, and more than two-thirds were start-ups.[21] To compete in this Space, vendors are deploying both organic and inorganic growth strategies and the demand for digital transformation is pushing mergers and acquisitions to record levels among technology and non-technology firms.[17,22]

The United States is also home to some of the world's top technology companies, including six of the 'Big Nine' in the AI industry: Amazon, Apple, Google, IBM, Meta and Microsoft. Table 2 provides a list of top technology giants and start-ups in the United States AI industry by solution segment. A full list of top AI companies in the United States is presented in Appendix C.

Table 2: Top AI companies in the United States by solution segment

	Technology giants	Start-ups
AI software[23]	Apple, Amazon, Microsoft, Google, Meta, IBM, Intel, Salesforce, NVIDIA	Anki, AiBrain, Banjo
AI hardware[24]	IBM, Nvidia, Intel, Google, Advanced Micro Devices (AMD)	SambaNova Systems, Cerebras Systems, Graphcore, Groq, Mythic
AI services[25]	AWS, Microsoft Azure, IBM Developer Cloud, Google	H2O.ai, Prevision.io

Source: KPMG research

By solution segment, AI software comprised the largest share of the US AI market, at almost 40 per cent.[15] AI services were the highest growth segment (from US$1.5 billion in 2018 to US$5.2 billion in 2020), followed by software (from US$3 billion to US$6.3 billion) and hardware (US$3 billion to US$4.8 billion).[15] In 2020, deep learning technology contributed 38 per cent of overall revenue in the industry followed by machine learning (28 per cent).

Figure 4: AI industry revenue between 2018 and 2020, by solution

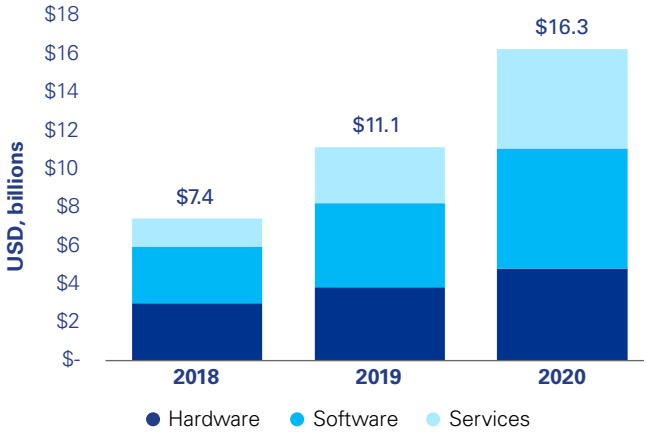
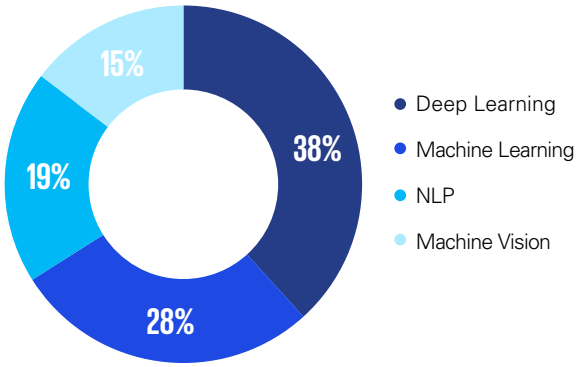


Figure 5: Market value breakdown in 2020, by technology



Source: Grand View Research, 2020

3.2.2 AI adoption by industry

The United States is expected to be the most lucrative market for AI, leading the world in adopting and developing the technology. AI is predicted to significantly transform key industries such as banking, financial services and insurance, healthcare, legal, retail and automation and transportation. Below we provide a breakdown of the industry's revenue (Figure 6 and Figure 7) and examples of how end-user industries are using and benefitting from AI.

Figure 6: AI industry revenue between 2018 and 2020, by end-use industry

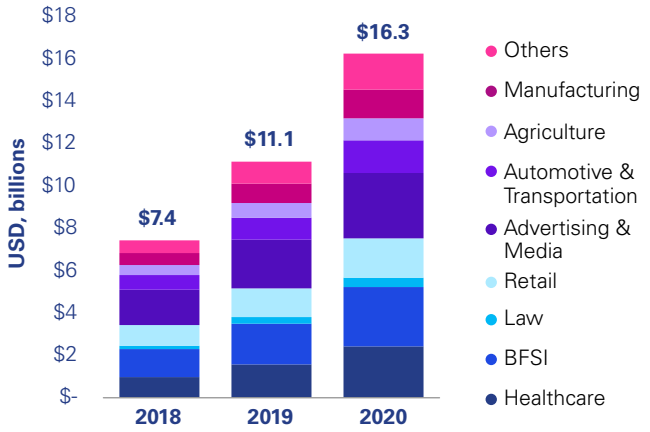
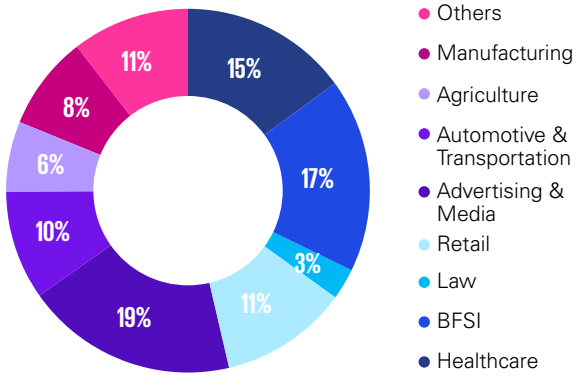


Figure 7: Share of AI industry revenue in 2020, by end-use industry



Source: Grand View Research, 2020

Banking, financial services and insurance

AI is becoming an essential component of the banking, financial services and insurance (BFSI) industry. BFSI businesses are already using the technology to mitigate risks and optimise their operations. For example, the Bank of America launched "CashPro Forecasting", a tool that uses AI to predict future cash positions more accurately across clients' accounts. Similarly, Ocrolus is a machine learning-enabled platform that helps analyse financial data to help BFSI firms make faster and more accurate lending decisions.

AI is expected to continue to play an important role in the future of the industry. A survey from the World Economic Forum in 2020 found that 77 per cent of all respondents anticipated AI would possess high or very high overall importance to their businesses within two years.[18]

Healthcare

Several applications of AI are currently being used by various organisation in the healthcare industry. Key categories of applications involve diagnosis and treatment recommendations, patient engagement and adherence, and administrative activities. Companies such as Google and Enlitic are developing AI-derived image interpretation algorithms that are revolutionising the diagnostics process.[37]

Retail

Businesses in this sector have used AI to conduct market forecasting, direct marketing and in-store visual monitoring. Amazon was an early adaptor of the technology, using it to predict the number of customers willing to buy a given product and offering customised recommendations. Visual searches are another popular tool used in retail. Customers can upload images of products they're interested in buying and find similar items based on patterns, shapes and colours in the image.[15]

Automotive and transportation

AI technology has made a substantial impact on the automotive and transportation industry. While autonomous vehicles are the most well-known use-case of AI, the technology is also being used to streamline freight transportation operations and simulate vehicle test data.[15]

Legal

AI technology is expected to significantly disrupt the legal market. Legal firms are already using the technology to conduct document reviews, analyse contracts, perform legal research and predict case outcomes.[41] For example, the process of documentation review, which involves searching for relevant documents for litigation, is more accurately, quickly and efficiently done by AI.[15]

3.2.3 US AI industry's supply chain

To understand the nature of the AI industry in the United States, the authors investigated which countries and goods were involved in the industry's supply chain. Between 2017 and 2022, there were more than 230,000 recorded shipments of **physical goods** to US businesses operating within standard industry classifications (SIC) most relevant to the AI industry. For more detail on SIC codes, please see Appendix B.

Shipment of origin

China ranks first in terms of imports to US businesses, contributing 38 per cent of total US import shipments. When combined, China and Taiwan ship almost half (47 per cent) of all AI-related imports to the United States. Hong Kong, South Korea and Thailand are also major sources of imports to US businesses, making up approximately 15 per cent of total imports. Australia ranks 27th on this list and currently contributes 0.3 per cent of total imports to US businesses. This data suggests that Australia has limited capability in the manufacturing of AI related goods, but as section 3.3 will discuss, Australia does have other strengths in research and development and producing AI services.

What inputs are used in the industry?

As shown in Table 3, the top inputs imported by US-based businesses are identified by the six-digit Harmonized System (HS) codes 8443.31 and 8504.40, contributing to 12 per cent of the total volume. Physical goods under HS code 8443.31 include "Printing, copying and facsimile machines; machines which perform two or more of the functions of printing, copying or facsimile transmission, capable of connecting to an automatic data processing machine or to a network". Physical goods under HS code 8504.40 include "Electric static converters".

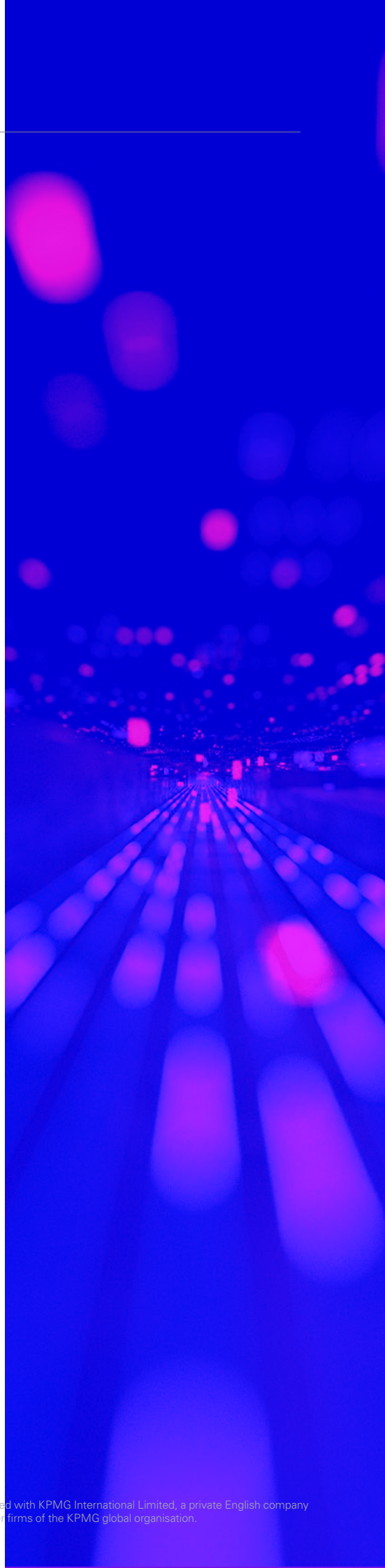


Table 3: Number of shipments to the United States, by imported goods

#	Six-digit HS Code	HS code description	%
1	8443.31	Printing, copying, and facsimile machines; machines which perform two or more of the functions of printing, copying or facsimile transmission, capable of connecting to an automatic data processing machine or to a network	6%
2	8504.40	Electrical static converters	6%
3	8517.62	Communication apparatus (excluding telephone sets or base stations); machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus	5%
4	8473.30	Machinery; parts and accessories (other than covers, carrying cases and the like) of the machines of heading no. 8471	4%
5	8443.99	Printing machinery; parts and accessories, n.e.c. in item no. 8443.91	4%
6	8471.41	Automatic data processing machines; comprising in the same housing at least a central processing unit and an input and output unit, whether or not combined, n.e.c. in item no. 8471.30	4%
7	8538.90	Electrical apparatus; parts suitable for use solely or principally with the apparatus of heading no. 8535, 8536 or 8537	3%
8	8544.42	Insulated electric conductors; for a voltage not exceeding 1000 volts, fitted with connectors	2%
9	8443.32	Printing, copying, and facsimile machines; single-function printing, copying or facsimile machines, capable of connecting to an automatic data processing machine or to a network	2%
10	8536.90	Electrical apparatus; n.e.c. in heading no. 8536, for switching or protecting electrical circuits, for a voltage not exceeding 1000 volts	2%

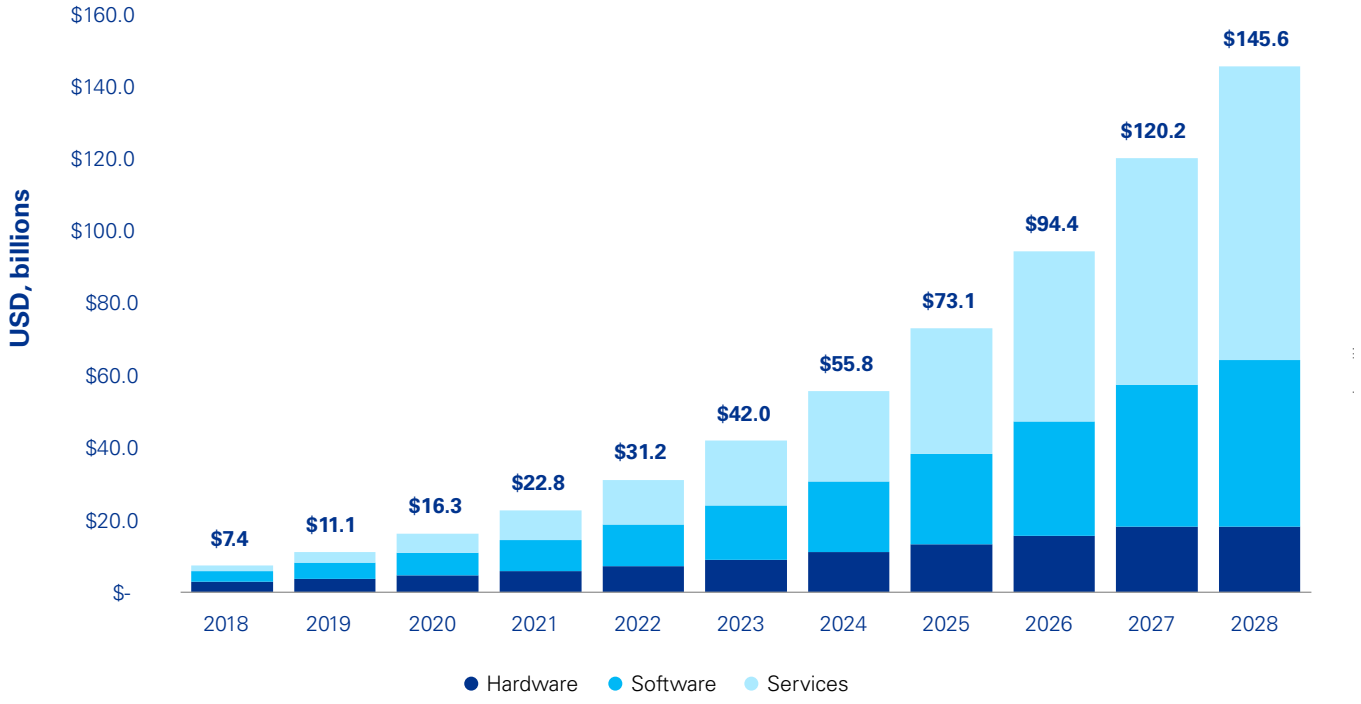
Source: Panjiva, KPMG analysis

3.2.4 Future potential of US' AI industry

The United States' AI market is projected to expand at a compounded annual growth rate (CAGR) of 30.3% between 2018 to 2028, with the services segment leading growth at 38.6% (Figure 8).

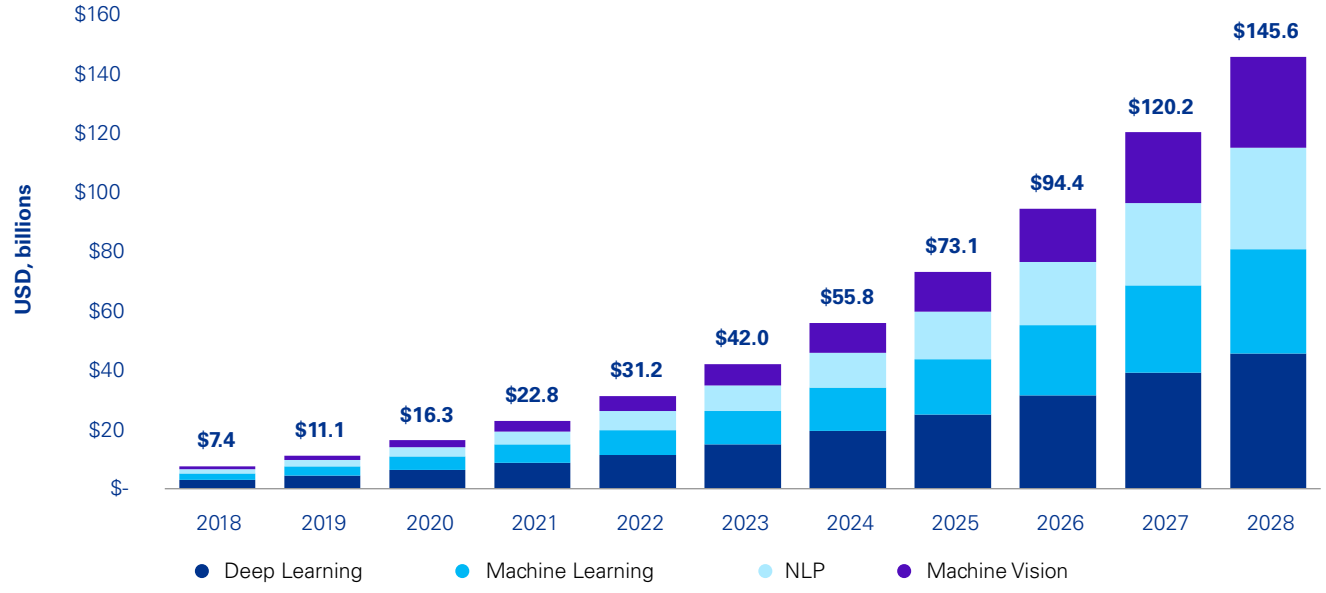
By application, deep learning is estimated to lead the industry in revenue while machine learning is expected to experience the fastest growth over the projected period (Figure 9). By industry, revenue growth is predicted to be bolstered by the implementation of AI in healthcare and legal industries as organisations in these industries continue to automate their business processes and diversify their services (Figure 10).

Figure 8: US AI Market Estimates and Forecast, by solution, 2018-2028 (US$ Billion)



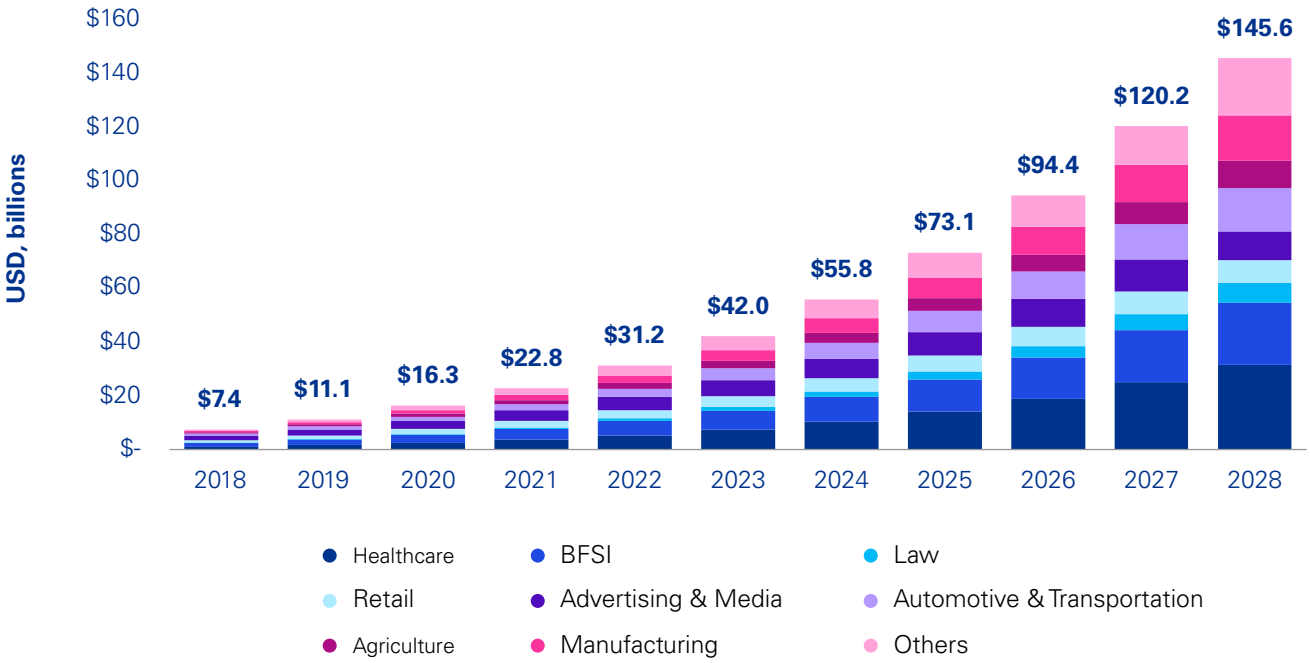
Source: Grand View Research, 2020

Figure 9: US AI Market Estimates and Forecast, by application, 2018-2028 (US$ Billion)



Source: Grand View Research

Figure 10: US AI Market Estimates and Forecast, by application, 2018-2028 (US$ Billion)



Source: Grand View Research

US investment in the AI market

The US government has undertaken substantial initiatives to incentivise and promote the adoption of AI in various industries. In recent years, government agencies have spent approximately US$1.2 billion on research and development and US$1.9 billion on AI enabled services. Organisations such as NASA and the Department of Homeland Security are significant users of AI technology. In 2021, the United States National Security Commission on Artificial Intelligence proposed a US$40 billion increase in government funding for the future. In turn, US government agencies are increasingly using AI, particularly in the research of robotic process automation, trend analyses and surveillance.

The US AI market has experienced increasing research and development investment in recent years, led by IBM and Microsoft. Mass AI deployments in the private sector have catalysed the environment for AI start-ups, where new companies have received significant amounts of investor funding, such as Databricks (US$1,897 million), Tanium Inc. (US$1,170 million), Indigo Ag (US$1,152 million), Tempus (US$1,070 million) and Dataminr (US$1,044 million).

3.3 Australia's capacity to participate in the value chain

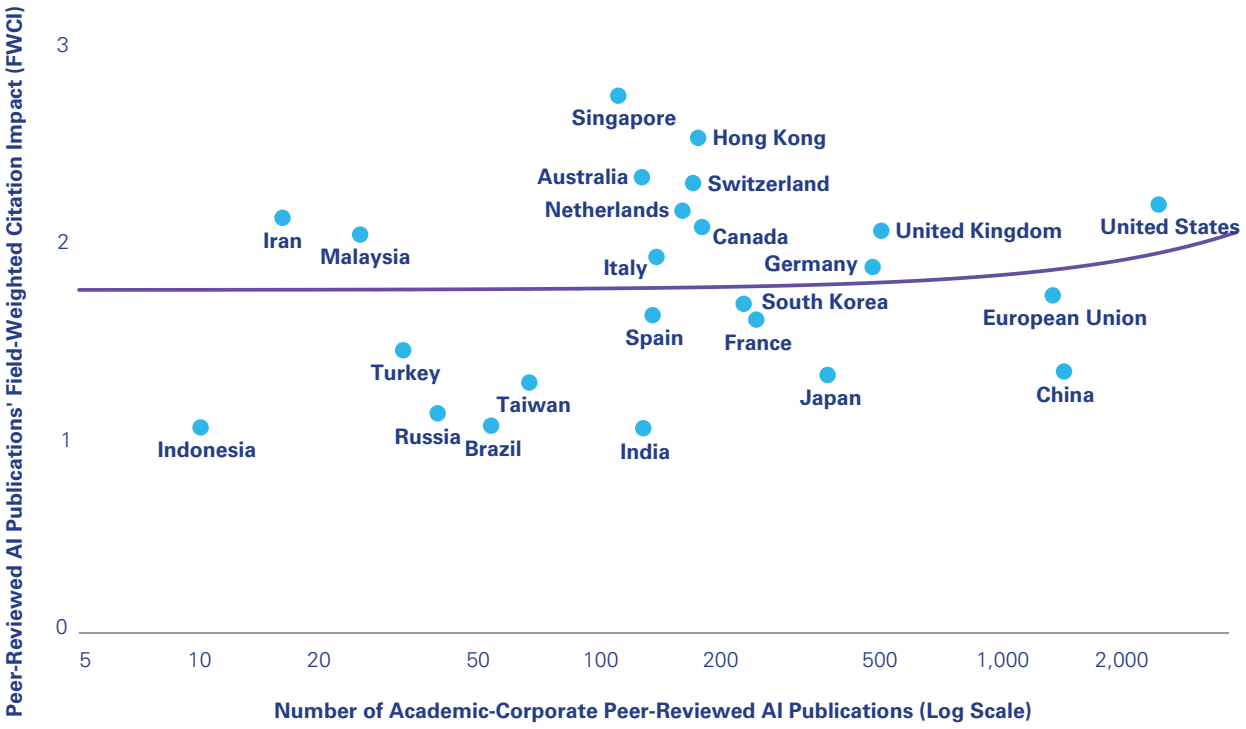
3.3.1 The Australian Artificial Intelligence sector

Australia has world-leading capabilities in a number of core AI-related technology fields.

There are opportunities for Australia to take full advantage of the potential benefits of AI.

The AI industry in Australia is estimated to be worth approximately A$370 million in annual revenue. Universities such as Queensland University of Technology, Australian National University, Monash University and Sydney University have long-established, world leading expertise in AI in areas such as robotics and automation. In terms of the research impact, Australian peer-reviewed publications place well above the world average, ranking third behind Singapore and Hong Kong (Figure 11).[27]

Figure 11: Peer-Reviewed AI Publications Field-Weighted Citation Impact and Number of Academic-Corporate Peer-Reviewed AI Publications, 2019

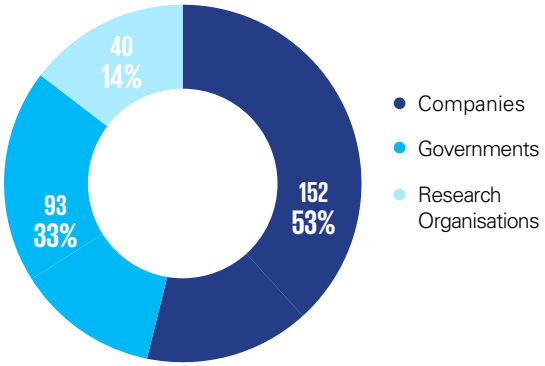


Source: Stanford University Human-Centered Artificial Intelligence (2021)

In 2020, Australia had more than 6,600 AI specialist workers, a substantial increase from 650 in 2014.[27] The growth of the industry is also becoming more widely distributed across the country. Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) estimated that in 2015, nearly 9 in 10 of AI jobs were based in Sydney and Melbourne. By 2018, this share fell to 75 per cent, indicating other cities grew their relative shares of these jobs.[25]

The application of AI technology is evident in Australian companies, governments and research organisations across the country. A report conducted by CSIRO in 2022 identified 285 applications of AI technology being actively used across the Australian economy, with the business sector being the largest active user of AI applications (Figure 12).

Figure 12: Applications of AI technology in Australia

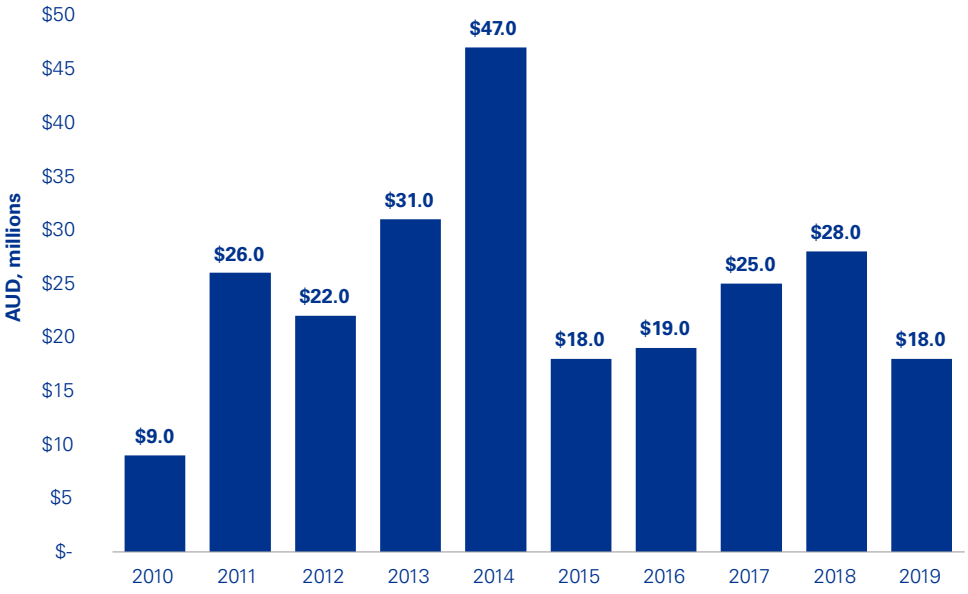


Source: CSIRO

3.3.2 Public Investment in Artificial Intelligence in Australia

As shown in Figure 13, between 2010 and 2019, the Australian Research Council has provided more than A$243 million in funding for projects classified as 'AI and image processing'.[24]

Figure 13: Funding for AI research (millions, AUD)



Source: CSIRO, 2020

In 2021, the Australian government announced its 'AI Action Plan' which set out a vision for the nation to be a global leader in developing and adopting trusted, secure and responsible AI.[24] The plan set out the following budgetary measures that would help strengthen Australia's capability in AI technology:

- A$53.8 million to the National Artificial Intelligence Centre over four years to support AI adoption
- A$33.7 million in a joint public-private partnership pilot project for AI-based solutions to national challenges
- A$24.7 million over six years to the Next Generation AI Graduates Program for increasing AI experts and specialists
- A$12 million over five years to exploring AI solutions for local and regional challenges

3.3.3 AI applications and advantages for Australia

AI is increasingly becoming a part of the everyday lives of Australians, and many sectors of the economy are embracing the technology.[23] Table 4 below reports ways in which AI has enhanced key industries in Australia.

Table 4: Examples of AI applications in Australia

Sector	AI product	Description	Impact
Logistics	Driving monitoring system technology	Uses computer vision to detect fatigue and provides alerts to drivers.	Reduced fatigue-related accidents by over 90%.
Utilities	VAPAR	VAPAR analyses video footage of sewage pipes and detects blockages and cracks.	Identified 15% more errors and defects.
Construction	Voltin	Voltin deploys high-resolution cameras and machine learning to automate building inspections.	Reduced inspection costs by 30%.
Medical products	Coviu PhysioROM	Uses AI-powered tools to capture a patient's range of motion over telehealth systems.	Freed up hospital beds.
Environment	Healthy Country AI Partnership	AI technology is being used to solve complex environmental management problems and care for animal species and habitats.	Used AI to monitor precious habitats.

Source: Department of Industry, Science, Energy and Resources 2021

3.3.4 Identified AI specialisations for Australia

In its 2020 report, CSIRO highlighted three key areas as having high potential for specialisation in Australia.[24] These industries were:

- Natural resources and environment
- Health, ageing and disability
- Cities, towns, and infrastructure

I. Natural resources and environment

Australia's mining engineering technology and services (METS) sector is increasing its use of AI. The industry currently employs more than 400,000 workers, generates approximately A$90 billion in revenue and exports to more than 200 countries. Australian mining companies like BHP, Rio Tinto and Fortescue Metals, for example, are world-leading in applying AI to their operations, including areas such as automated mine site technology. Examples of AI activity in this industry include:

- Queensland University of Technology's world-leading agricultural robots, AgBot II.
- The Australian Centre for Field Robotics (ACFR), one of the world's largest robotics centres and focuses on autonomous research and development, intelligent systems and robots.
- CSIRO's Data61 automation technology that is deployed in most underground coal mines across Australia.

II. Health, ageing and disability

AI has been widely deployed across the Australian healthcare sector. Technologies such as machine learning, data science and predictive analytics are being used to diagnose cancers, infectious diseases and other illnesses with improved accuracy. With predictions that the healthcare market will grow considerably both domestically and internationally, significant opportunities exist for companies that can harness AI technologies in this sector.

III. Cities, towns and infrastructure

Australia has world-leading AI capabilities in infrastructure planning, design, construction, operations and maintenance. Expertise in this area presents vast opportunities for the nation to export these solutions to an increasingly urbanised world. Some examples of AI activity in this industry include:

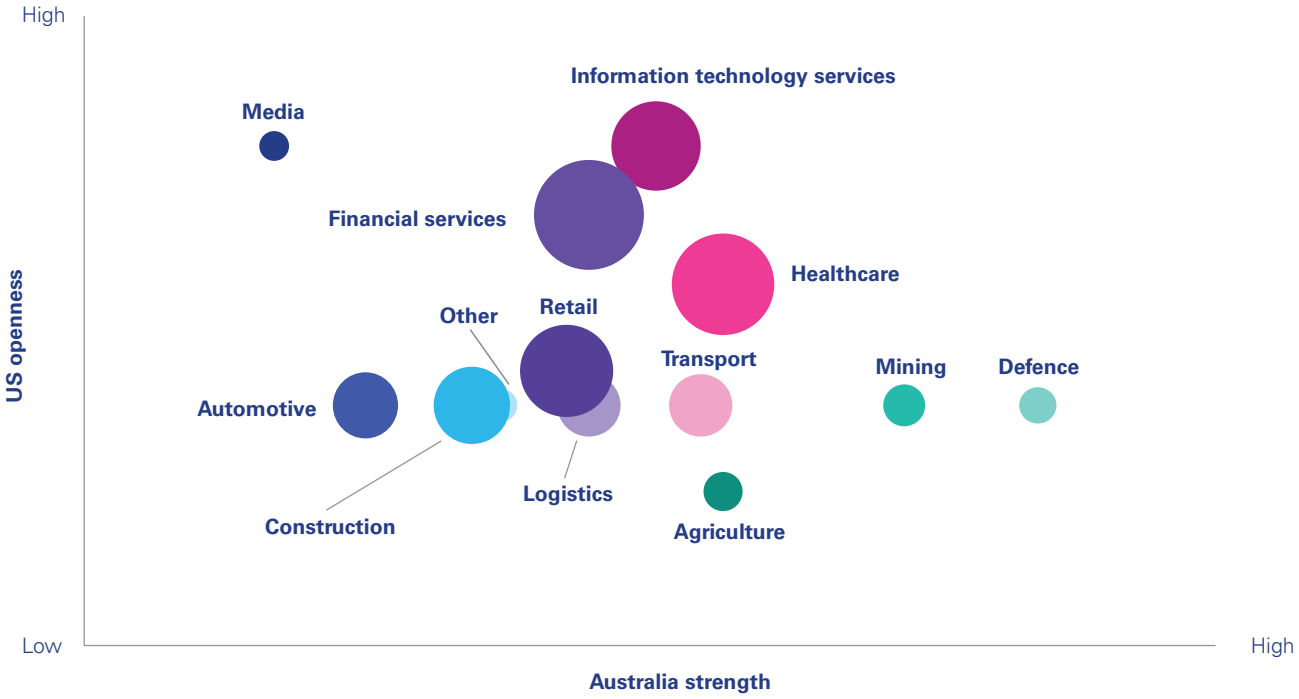
- The Sydney Coordinated Adaptive Traffic System (SCATS) which is used to coordinate road signals and vehicle flows over entire regions, cities and towns.
- The University of Newcastle is developing crowd movement simulations to increase public safety and improve Space design.
- PSMA Australia is deploying AI to construct digital representations of Australia's built environment.
- Esmesent has developed an AI LIDAR system used to provide a three-dimensional map. The system provides more efficient maps for mining, construction and maintenance.

3.4 AI trade opportunities with the United States

In considering the potential for increased trade between Australia and the United States, this report analysed the scale of AI adoption by US industries and then cross-matched these results against CSIRO's assessment of Australian AI technology strength on an industry-by-industry basis. This analysis is presented in Figure 14 below, which suggests while the mining and defence industries are sectors of competitive strength for Australia, they are currently only moderately open to applying AI in their operations.

US industries that have already shown a propensity for early adoption of AI technologies are also likely to be more open to innovations from foreign companies, especially those which are in political, economic and socially aligned jurisdictions.

Figure 14: Australia's strengths in AI by sector and US opportunities



Source: Analysis of GVR and CSIRO research

Note: Bubble size indicates relative US gross value added.

With the United States being the global leader in research, development and commercialisation of AI, the potential for broadscale importation of foreign capabilities and technologies is low. Niche AI products and services that complement US capabilities are more likely to receive market acceptance than technologies that compete against incumbent US capabilities. This is a positive position for Australia given local industry is in the early stages of the development cycle for these products and services.

As noted previously, Australia's areas of AI specialisation currently lie in the mining and defence sectors, although these two sectors in the Unites States are just moderately open to foreign AI solutions. This suggests that instead of dismissing these sectors as being too difficult to penetrate, Australian firms looking to access the US market should focus on other pathways into specific opportunities.

These pathways could include leveraging Australian clients with US connections, including those with subsidiaries operating in Australia.

The US sectors most open to AI imports from foreign companies include Information technology services, financial services, healthcare and media. Australia's current AI capability in these specific sectors is judged to be moderate, except for media which is considered low. Essentially, this means the Australian offerings to the US market in these sectors are 'within the pack', acknowledging this analysis doesn't consider niche suppliers which weren't identified during this study. Experience suggests success in these market segments depends on partnering with a local US business where the combined AI offering is more powerful than the individual products together.

This means Australian businesses in this situation should initially look for joint venture opportunities that allow for combined technology synergies and the potential for new or enhanced AI products to take to the US market, rather than seeking direct sales.

In order of priority it would seem the Financial Services Industry, which purchases around US$2 billion of AI goods and services annually, would be the sector where Australian firms are most likely to be successful. The rationale for this assessment is that it appears the financial services sector is applying AI in the widest possible range of uses. It is this wide spectrum of applications that suggests there is a high possibility of Australian-developed AI applications being capable of meeting a 'need' in this sector. Again, this would be either in conjunction with a US AI-developed technology solution or potentially by itself.

4 Quantum Computing

4.1 Definition and main activities

Quantum science includes Quantum Computing, quantum physics and quantum mechanics. This report focuses on the application and use of quantum technology to create new and faster ways of computing.

Quantum Computing (QC) enables operations to be undertaken at speeds exponentially faster than what's currently possible with conventional computers. QC is based on quantum mechanics, which is a fundamental theory in physics that provides a description of physical properties of nature at the scale of atoms and subatomic particles.

While the use of quantum computers is still in its early stages, the technology is quickly becoming one of the most promising emerging industries and is already adding value to health, defence and automotive sectors in the United States and Australia.

Unlike conventional computers which are binary systems using only values of 0 or 1, quantum computers use qubits (or quantum bits) which can assume superpositions that are combinations of both 0 and 1. This enables new computing algorithms that can significantly reduce computation time. The application of quantum computers can be broken down into machine learning, simulation, optimisation and other segments.

Table 5: Quantum Computing applications

Application	Definition
Machine learning	While machine learning techniques are used to process massive amounts of data, quantum machine learning takes advantage of qubits, quantum operations and specialised quantum systems to boost computational performance and data storage. Quantum machine learning also refers to a field of study examining the methodological and structural parallels between specific learning systems and physical systems, particularly neural networks.
Simulation	Quantum computers can simulate systems of interacting electrons exponentially faster than traditional binary computers. Simulations can be used to control quantum systems to study another less controllable or accessible quantum system.[31]
Optimisation	Quantum optimisation algorithms are used to answer complex problems that improve sub-optimal solutions without suffering the cost and time of the exponentially lengthier compute times.
Other	This includes quantum chemistry and quantum photonic application

Source: Grand View Research, 2020 and Georgescu et al., 2014

Applications of quantum science are realised through quantum enabled systems, including software and hardware, and services.

There are two types of QC software:[32]

1. **Software running quantum algorithms:** Quantum software development kits and computational platforms allow for developing and testing quantum algorithms.
2. **Software enabling quantum computers:** Error-correcting software or firmware to increase the stability of quantum computers.

The necessary hardware components for quantum computers include:[29]

- **Quantum data plane:** which is where the qubits reside
- **Control and measurement plane:** which is responsible for carrying out operations and measurements on the qubits as required
- **Control processor plane:** which determines the sequence of operations and measurements that the algorithm requires, potentially using measurement outcomes to inform subsequent quantum operations
- **Host processor:** which runs a conventional operating system which facilitates user interactions.

Quantum services offer businesses solutions to complex computational problems, simulation and software development. Using quantum-as-a-service (QaaS), companies could use Quantum Computing services remotely, further pushing the uptake of the technology.

For instance, Amazon Braket, a wholly managed Quantum Computing service, accelerates scientific research, tests hardware and helps businesses to explore industry applications for optimisation, complex computational problems, simulation and quantum software development.[30] Similarly, Microsoft has introduced Azure Quantum, a cloud Quantum Computing service that offers a diverse set of quantum solutions and technologies that include optimisation and hardware solutions.[31]

4.2 Relative importance to US economy

4.2.1 Current state and notable players

The QC industry in the United States was worth approximately US$194 million in annual revenue in 2020. The United States continues to lead the world in QC activity, ranking first in the number of QC start-ups, public organisations and academic groups.[32]

As of 2021, there were 213 QC companies in the United States[32], including some of the world's top technology companies, like IBM, Google and Microsoft. Between 2015 and 2021, the number of start-ups in the industry grew from 15 to 59, representing an annual average growth rate of 32 per cent.[32] For a full list of top US-based QC companies, see Appendix C.

QC services dominate the United States QC market, generating about 65 per cent of total market revenue (Figure 15). By application, optimisation and machine learning made up 72 per cent of overall application of QC in 2020, contributing 43 per cent and 29 per cent, respectively (Figure 16).

Figure 15: QC revenue between 2018 and 2020, by offering

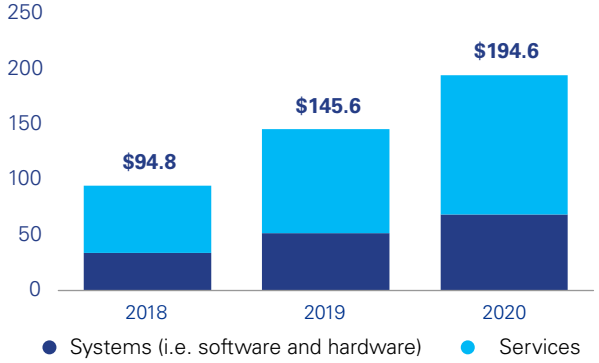
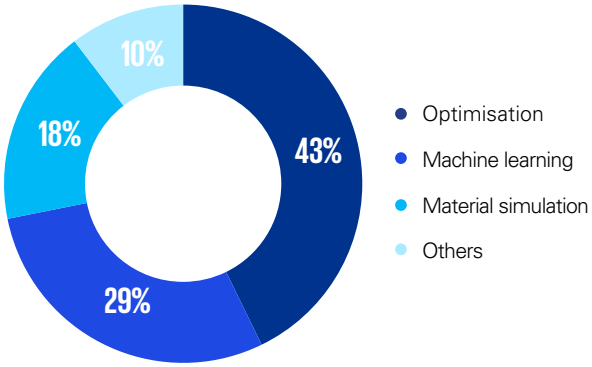


Figure 16: Market value breakdown in 2020, by application



Source: Grand View Research, KPMG analysis

4.2.2 QC adoption by industry

At speed, quantum computers offer the real potential for rapidly advancing industries, such as the healthcare, automotive, chemical and financial sectors. The figures below show a breakdown of the industry's revenue and examples of how end-user industries are using and benefitting from Quantum Computing technology.

Figure 17: Share of QC industry revenue, by end-use sector

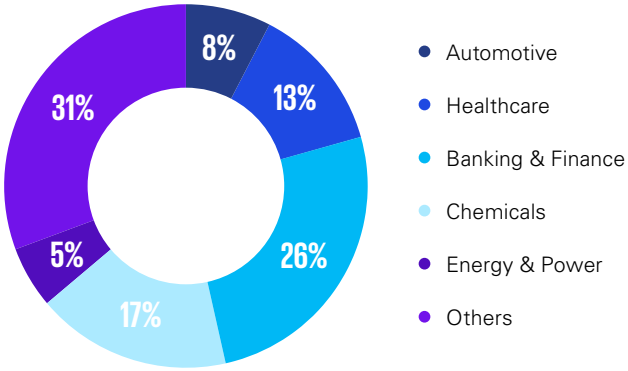
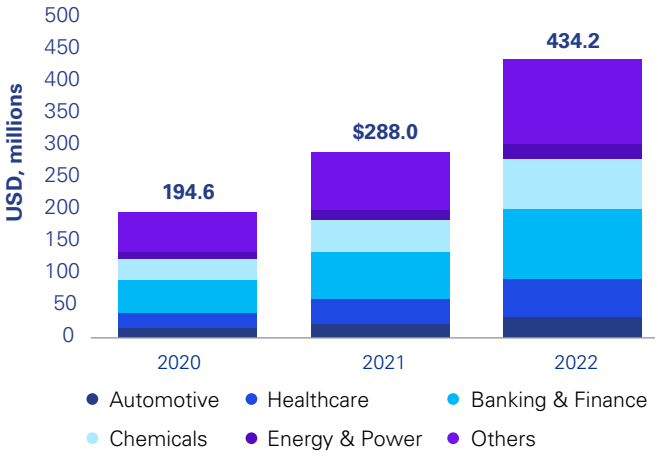


Figure 18: QC industry revenue, by end-use sector



Source: Grand View Research, KPMG analysis

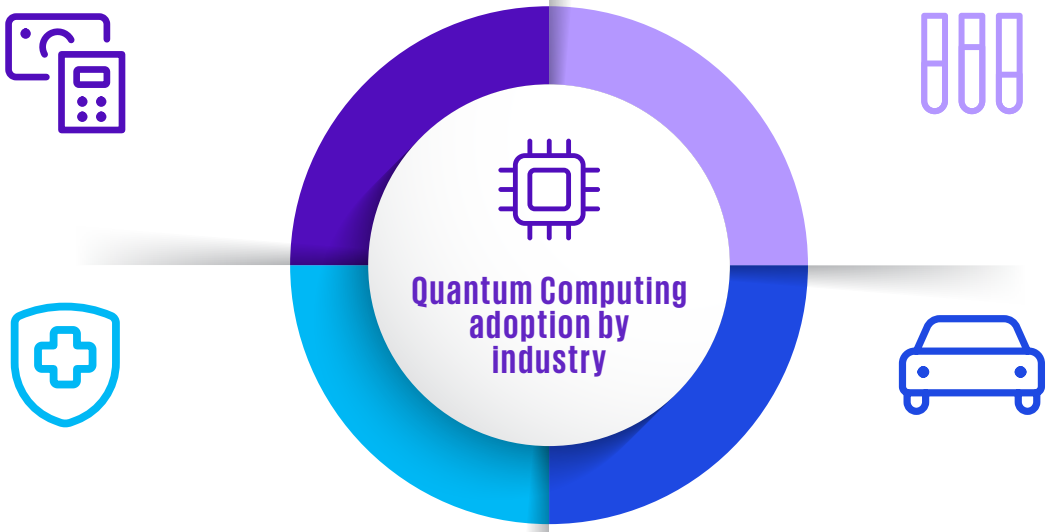
Figure 19: Quantum Computing adoption by industry

Finance

The finance industries have utilised quantum computers to simulate markets and predict how a change in commodity prices will affect the cost of other assets. According to experts, quantum computers can also be used to forecast future markets, predict option prices, and assess risk and uncertainty in financial models. In 2020, the sector contributed USD 50.3 million in revenue which represents 26% of total industry revenue.

Chemical

Quantum Computing also has potential to revolutionise the chemical industry. New Quantum Computing capabilities broaden the horizon of possibility for quantum mechanical modelling systems, such as solids, molecules, and polymers and offer higher levels of precision. In 2020, the sector contributed USD 33.8 million in revenue which represents 17% of total industry revenue.



Healthcare

Quantum Computing in healthcare has enabled various disruptive use cases for providers and health plans, such as accelerating diagnoses, personalising medicine, and optimising pricing. In 2020, the sector contributed USD 25.4 million in revenue which repersents 13% of total industry revenue.

Automotive

The automotive industry will undoubtedly be an essential value pool for Quantum Computing, with a significant influence expected over the forecast period. Quantum Computing can improve a variety of sectors in the industry, including material and process research, vehicle direction and course enhancement, and linked driving security. In 2020, the automotive sector contributed USD 15 million in revenue which represents 8% of total industry revenue.

Source: Grand View Research

Other sectors such as Space, defence, transportation and logistics, academia and government have also adopted QC technology. These sub-sectors, once combined, contributed just USD 59.7 million in revenue or 31 per cent of total industry revenue.

4.2.3 US QC Industry's supply chain

To understand the nature of the QC industry in the United States, we investigated which countries and goods are involved in the industry's supply chain. Between 2017 and 2022, there were more than 186,000 recorded shipments of physical goods to US businesses operating within standard industry classifications (SIC) most relevant to the QC industry. For more detail on SIC codes, please see Appendix B.

Shipment of origin

China ranks first in terms of imports to US businesses, contributing almost 40 per cent of total US import shipments. When combined, China, Taiwan and Hong Kong export almost 60 per cent of imports to the United States. South Korea and Germany are also major importers to US businesses, making up more than 11 per cent of total exports. Australia ranks 27th on this list and currently contributes 0.3 per cent of total imports. This data suggests that Australia doesn't have current strengths in the manufacturing of QC-related goods, but as section 4.3 will discuss, it does have other strengths in research and development and QC services.

Physical goods imported

As shown in Table 6, the top inputs imported by US-based businesses are described by the six-digit HS codes 8541.40 and 8473.30, making up almost 11 per cent of the total. Physical goods under HS code 8541.40 and 8473.30 include "Electrical apparatus; photosensitive, including photovoltaic cells" and "Machinery: parts and accessories", respectively.

Table 6: Number of shipments to the United States, by imported goods

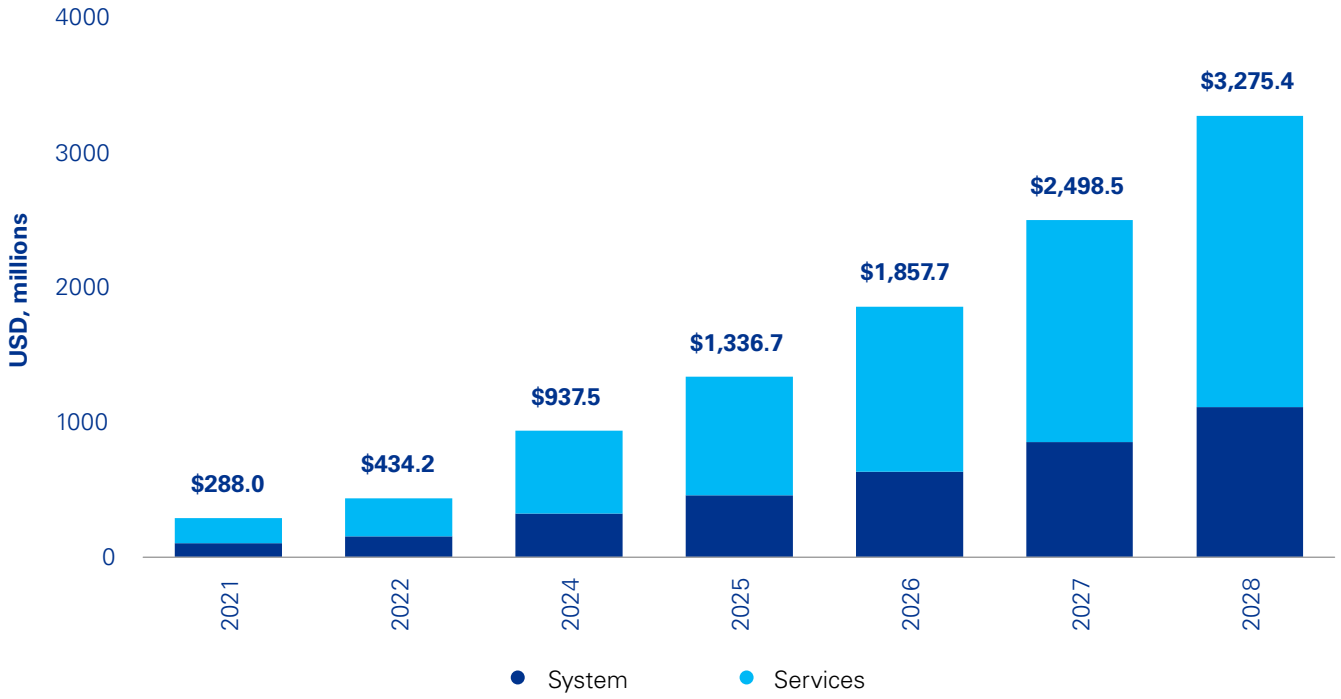
#	Six-digit HS Code	HS code description	%
1	8541.40	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, light-emitting diodes (LED)	6%
2	8473.30	Machinery; parts and accessories (other than covers, carrying cases and the like) of the machines of heading no. 8471	4%
3	8471.41	Automatic data processing machines; comprising in the same housing at least a central processing unit and an input and output unit, whether or not combined, n.e.c. in item no. 8471.30	4%
4	8443.99	Printing machinery; parts and accessories, n.e.c. in item no. 8443.91	4%
5	8443.31	Printing, copying, and facsimile machines; machines which perform two or more of the functions of printing, copying or facsimile transmission, capable of connecting to an automatic data processing machine or to a network	4%
6	8536.90	Electrical apparatus; n.e.c. in heading no. 8536, for switching or protecting electrical circuits, for a voltage not exceeding 1000 volts	3%
7	8517.62	Communication apparatus (excluding telephone sets or base stations); machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus	3%
8	8504.40	Electrical static converters	3%
9	8443.32	Printing, copying, and facsimile machines; single-function printing, copying or facsimile machines, capable of connecting to an automatic data processing machine or to a network	2%
10	8544.42	Insulated electric conductors; for a voltage not exceeding 1000 volts, fitted with connectors	2%

Source: Panjiva, KPMG analysis

4.2.4 Future potential of the US QC Industry

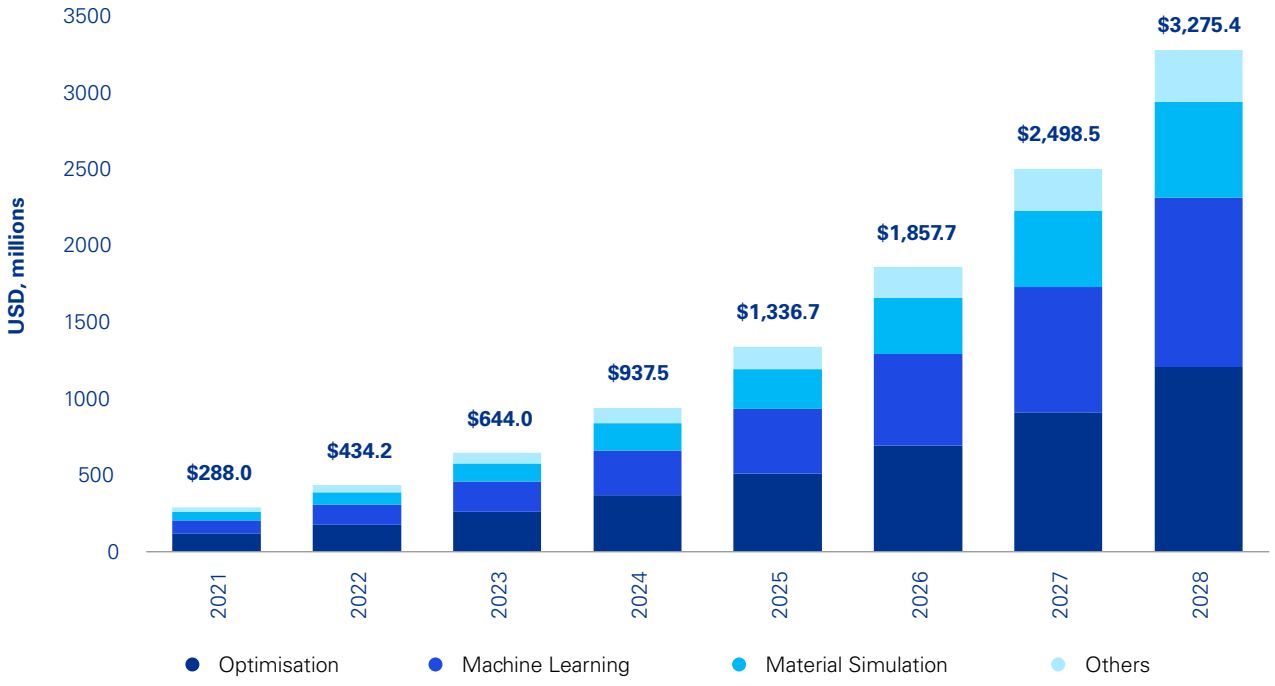
QC industry revenue is forecast to grow from US$288 million in 2021 to US$3.3 billion in 2028, representing an average annual growth rate of 41.5 per cent, suggesting this sector is on the cusp of a significant step-up in market activity and opportunities. The services segment is expected to lead the market in terms of both market share and growth rate. Growth in this segment can be attributed to the rising number of start-ups and funding of QC technology. In terms of the application of QC, machine learning is predicted to contribute significantly to overall growth with an average annual growth rate of 44.1 per cent for the forecast period.

Figure 20: US QC Industry revenue, by offering, 2021-2028 (US$ million)



Source: Grand View Research

Figure 21: US QC Industry revenue, by application, 2021-2028 (US$ million)



Source: Grand View Research

Investments into the US QC Industry

In recent years, the United States has invested considerably into the development of quantum technology. In 2018, the US government passed the National Quantum Initiative Act which provided funds of approximately US$1.2 billion to accelerate quantum research in the country. The current government has actively invested and promoted Quantum Computing research activities. In 2020, it announced a major policy focus on science and technology, committing approximately US$180 billion to research and development and industries of the future such as Quantum Computing.

In 2021, the United States Department of Energy invested around US$73 million into Quantum Information Science research centres to support the National Quantum Initiative. These investments have created significant transformation in various industries and triggered technology companies to increase their investment on quantum computers.

Start-ups in the industry have attracted significant funding, receiving approximately US$3.3 billion as of 2021.[35] Between 2001 and 2021, venture capital contributed almost half (49.8 per cent) of total funding received by start-ups, while public organisations made up 19.1 per cent.

For example, ColdQuanta received US$6.75 million in seed funding from investors and announced sponsorship of research at the University of Wisconsin to increase commercialisation of Quantum Computing technology.

4.3 Australia's capacity to participate in the value chain

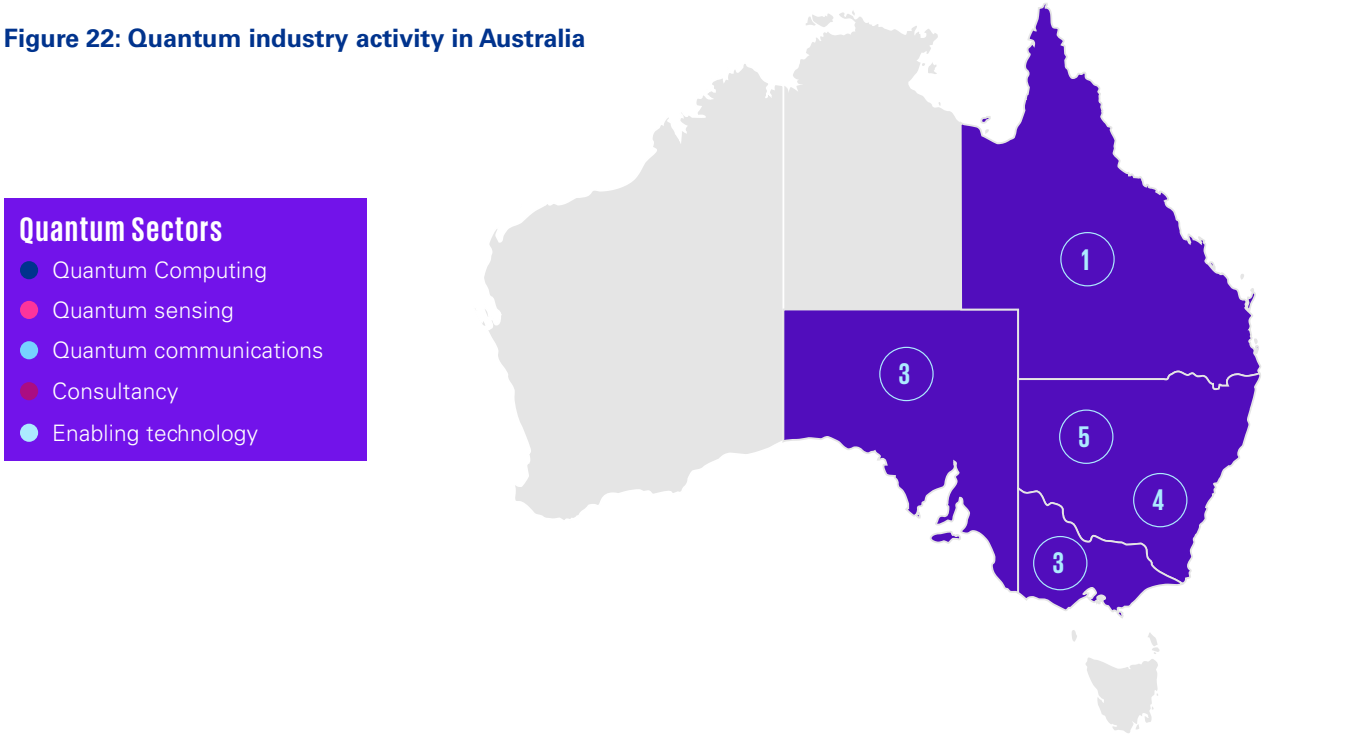
4.3.1 Australian Quantum Industry

Australia has been a world leader in quantum-related research for some time, but it has also struggled with commercialising this capability. The QC industry in Australia is worth approximately A$10 million in annual revenue. The nation's QC industry consists of 16 private organisations, 22 research institutions and two centres of excellence.[37] Globally, Australia ranks 8th in QC research impact, 6th in QC venture capital investment and 11th in QC patents.

Australia's research sector has played a key role in quantum technology and contributed to breakthroughs in the field such as silicon and optical-based Quantum Computing and leading quantum simulation algorithms.[37] While limited, there are also good examples of research-to-commercialisation businesses occurring in Australia, including Q-CTRL and Quantum Brilliance.

Quantum-related research publications from Australia are highly regarded, having an over 60 per cent higher normalised citation impact than global average[37]. This globally recognised expertise in the field is facilitating collaboration between Australia and countries such as the United States. For example, Australian researchers are leading quantum research divisions in both established companies such as IBM (US) and start-ups such as PsiQuantum (US) and Xanadu (Canada)[37].

Figure 22: Quantum industry activity in Australia



Queensland
- Max Kelsen

New South Wales
- Microsoft (US)
- Silicon Quantum Computing
- Redback Systems
- Lucigem
- Q-CTRL

Australian Capital Territory
- Quantum Brilliance
- Nomad Atomics
- QuintessenceLabs
- Liquid Instruments

Victoria
- IBM (US)
- h-bar Consultants
- MOGlabs

South Australia
- Archer
- Rigetti Computing (US)
- Cryoclock

Source: CSIRO

Note: The number indicates how many quantum organisations are within the state or territory.

4.3.2 Public investment into Quantum Computing in Australia

The nation's capabilities and knowledge in Quantum Computing can be attributed to significant research efforts since the emergence of the technology in the 1980s which were funded through government initiatives.

Australian universities continue to significantly invest in education to attract specialists in the field to strengthen the country's quantum capabilities. Top universities such as the University of Queensland and Australian National University offer specialised degrees in quantum technology. The Australian Research Council established the Special Research Centre for Quantum Computer Technology in 2000 which focuses on delivering world-leading quantum research.[37] The council consists of more than 200 researchers across seven Australian universities in 19 co-ordinated programs and nine collaborative work packages[37].

The federal government recently announced an A$111 million investment in a Quantum Commercialisation Hub whose aim is to form strategic international partnerships, commercialise Australia's quantum research and reduce foreign barriers to entry for Australian businesses. The hub will be used for educational and investment activities. It will provide a platform for public and user engagement, and increase innovation by helping Quantum Computing become a more open-source industry.

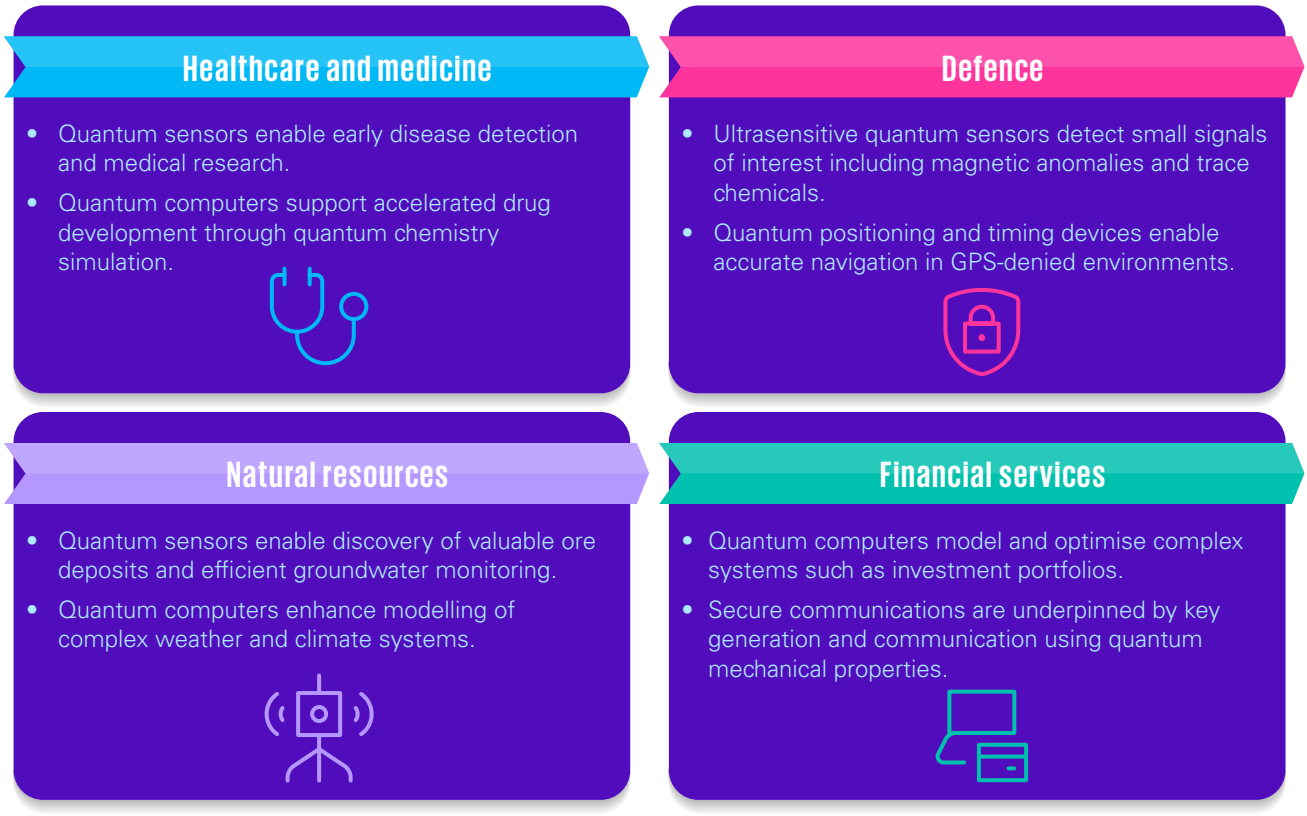
State and federal governments continue to invest in the industry through other initiatives such as the Centre of Excellence for Quantum Computation and Communication Technology and Next Generation Technologies Fund.

Australia's leading researchers also continue to attract funding internationally from the US government[38] and companies such as Google, IBM, Microsoft.[39] In the private sector, Australian QC companies received more A$125 million in funding and investment between 2017 and 2019.[36]

4.3.3 QC applications and advantages for Australia

Quantum technologies offer new capabilities and higher productivity to the Australian economy due to their applications across various industries such as healthcare, financial services, natural resources and defence, as shown in Figure 23 below.

Figure 23: QC industry applications in Australia



Source: CSIRO

4.3.4 QC Specialisations in Australia

CSIRO believes the commercialisation of Australia's quantum capabilities could lead to decades of higher economic growth, with increased productivity throughout various industries. This could generate more than A$4 billion per year and create 16,000 new jobs by 2040.[41] The following quantum technology fields present Australian companies the opportunity to participate in the trade and value chain.

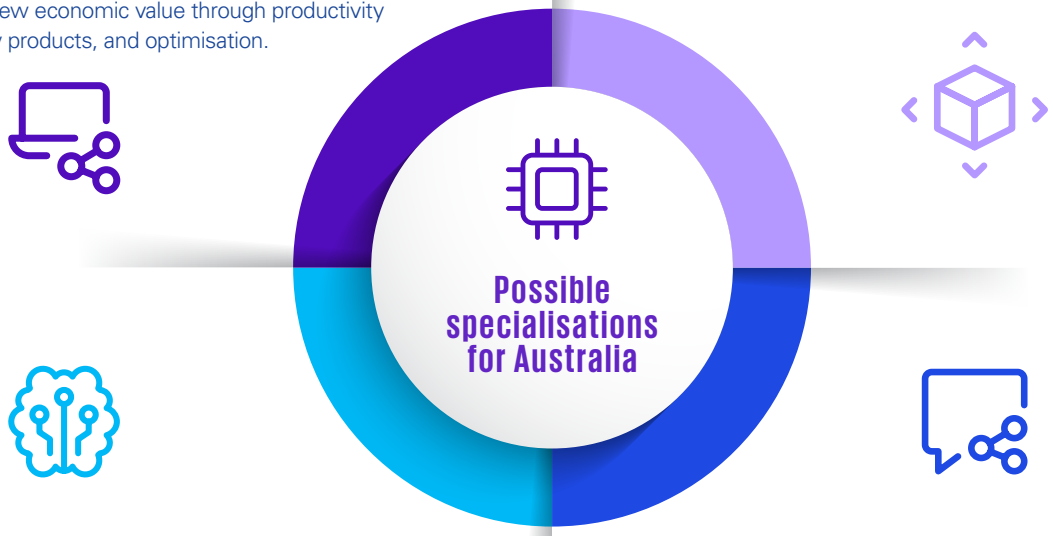
Figure 24: Potential specialisations for Australia, by quantum application

Quantum Computing

Given Australia's Quantum Computing capabilities, there is potential to engage in cross-border trade with countries, particularly the United States. Australia has targeted to capture 5 per cent of Quantum Computing global market by 2040. Commercialisation of these technologies will enable Australia to create 10,000 jobs, generate A$2.5 billion revenue by 2040 and create new economic value through productivity growth, new products, and optimisation.

Enabling technologies and services

While Australia does not currently possess capabilities in this area, the nation's research capabilities and expertise in QC present opportunities for businesses to enter global supply chains such as the United States.



Quantum sensing

Australia holds strong capabilities in quantum sensing technology research and aims to capture 5 per cent of global market, creating 2,900 new jobs and generating A$940 million revenue. The deployment of quantum sensing technologies enables Australia to strengthen its national security, contribute to global knowledge capital, protect the environment and safeguard health.

Quantum communications

Australia has developed significant capabilities in quantum-safe cryptography and wired optical networks for secure communications. Australian can generate A$820 million in revenue and 3,300 new jobs by 2040 if it captures 5 per cent of the estimated global market share for quantum communication. Commercialisation of such technology will also strengthen Australia's national and industrial security and significantly contribute to productivity growth.

Source: CSIRO

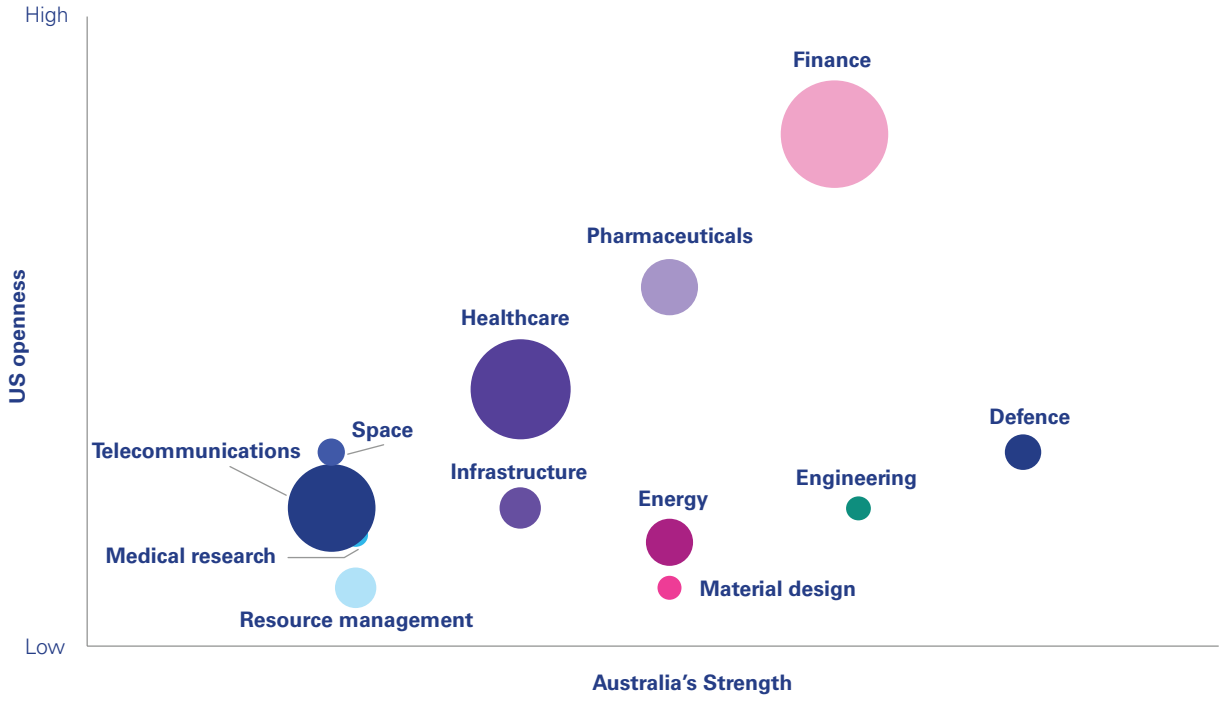
4.4 QC Trade opportunities with the United States

In considering the potential for increased trade between Australia and the United States, we analysed the scale of QC adoption by US industries and then cross-matched these results against CSIRO's assessment of Australian QC technology strength on an industry-by-industry basis. This analysis is shown below. It suggests that while the finance and defence industries are sectors of competitive strength for Australia, they're currently only moderately open to applying QC in their operations.

US industries that have already shown a propensity for early adoption of QC technologies are also likely to be more open to innovations from foreign companies, especially those which are in politically, economically and socially aligned jurisdictions.

QC associated with the defence sector are considered a key area of strength for Australia. Quantum technology is already being employed in Australia's defence sector and there are a variety of dedicated research programs related to defence applications. The US indicator for openness in this industry is lower than others, but there are still likely to be trade opportunities in the longer term as adoption of the technology increases and globally leading, Australian-developed QC technologies are sold into defence industry organisations. To succeed, Australian businesses will need to already have clients in the local industry, ideally government or subsidiaries of US companies, and they will need to leverage those relationships to access the United States market.

Figure 25: Australia's strength in QC by sector and US opportunities



Source: Analysis of GVR and CSIRO research

Note: Bubble size indicates relative US gross value added.

5 Digital Economy

5.1 Definition and main activities

The Digital Economy (DE) is the global network of economic activities, commercial transactions and professional interactions that are enabled by Information and Communications Technologies (ICT). The Digital Economy, also known as the 'new economy' or 'internet economy', is characterised by the creation of safe and secure technologies that enable transactions via the internet. The Digital Economy primarily serves five types of businesses as shown in Table 7.

Table 7: Digital Economy Breakdown

Type of Business	Definition
Cloud computing	Cloud computing refers to the process of storage, maintenance, management, analytics and processing of data by exploiting a network of internet-based services.
E-commerce	E-commerce is an activity that takes place online through the internet. It includes networking strategies via social media and other internet platforms used to build an online business.
High speed trading	High-speed trading involves using complex algorithms to analyse the markets and execute the orders based on market needs and conditions.
Online advertising	Online advertising uses the internet to target and deliver marketing messages to customers.
Online payment services	Online payment service providers enable the parties involved to conduct payments without sharing their financial information.
Others	This segment includes participative networked platforms and app stores. A participative networked platform enables users to extend, develop, comment and distribute user-created content. Types of distribution platforms include blogs, social bookmarking sites, social networking sites, and podcasting, among others.

Source: Grand View Research

5.1.1 Products and services

Applications of the Digital Economy are realised through software, technology and hardware.

5.1.1.1 Digital Economy technologies

There are four types of software and technology powered by the Digital Economy[43]:

1. **Artificial Intelligence and data analytics**: The ability of software to continually improve on the efficiency of human tasks based on information collected through big data. It is the optimisation of existing processes through software that autonomously learns and self-improves.
2. **Automation and robotics:** The ability of software and other technologies to carry out tasks that have traditionally been performed by humans. Basic types of automation include industrial automation and software automation. Software automation includes business process automation (BPA), robotic process automation (RPA) and intelligent process automation (IPA), whilst industrial automation refers to the automation of different mechanical processes and machineries in lieu of a human worker.
3. **Blockchain**: Blockchain is a highly secure system of storing transactions or records which are carried out across several computers linked in a peer-to-peer network. The best-known application of blockchain is in cryptocurrencies. Other applications include money transfers, to financial exchange, lending, real estate, insurance, logistics, supply chain tracking and data storage.
4. **Internet of Things (IoT)**: IoT is defined as a network powered by software which embeds objects with sensors, receivers and other technologies to exchange data over the internet. IoT finds wide uses in smart manufacturing, smart power grids, smart cities, telehealth, traffic management, and water and waste management. It is the digitalisation of objects by embedding them with a data collection and transmission capability.

5.1.1.2 DE hardware

ICT infrastructure is vital in ensuring that Digital Economy software can be smoothly executed and maintained. There are two types of ICT hardware that are needed to power various parts of the Digital Economy:

- **Traditional ICT infrastructure**: This consists of physical hardware, such as desktop computers, smartphones, smart devices, etc, which are connected to a network via a remote server. These servers are hosted by data centre facilities on-site, and are physical in nature.[44]
- **Cloud infrastructure**: Similar to traditional ICT infrastructure, cloud infrastructure requires networking equipment, servers and data storage. However, cloud infrastructure also includes a hardware abstraction layer that powers the virtualisation of resources and reduces cost through economies of scale. This allows for the construction of off-site data centres, enabling users to store and manage data via the internet.[45]

5.2 Relative importance to US economy

5.2.1 Current state and notable players

The United States plays a significant role in innovating and powering the Digital Economy. As seen in the executive summary, the country's Digital Economy market was estimated to be approximately A$665.9 billion in 2020. Growth in the industry has been driven largely by the use of smartphones and the internet in day-to-day life. With a large number of Artificial Intelligence and blockchain technology services, the United States has created a favourable environment for the Digital Economy to grow.[43]

Cloud computing, e-commerce, high speed trading, online advertising and online payment services are the primary types of businesses in the United States that rely on the Digital Economy. E-commerce contributes to 24 per cent of the sector followed by online advertising at 20 per cent, cloud computing at 18 per cent and online payment services at 15 per cent. Other types of businesses (which includes participative networked platforms and application stores) contributes 12 per cent of the sector, followed by high-speed trading at 11 per cent.

Figure 26: DE industry revenue 2018 to 2020, by type of business

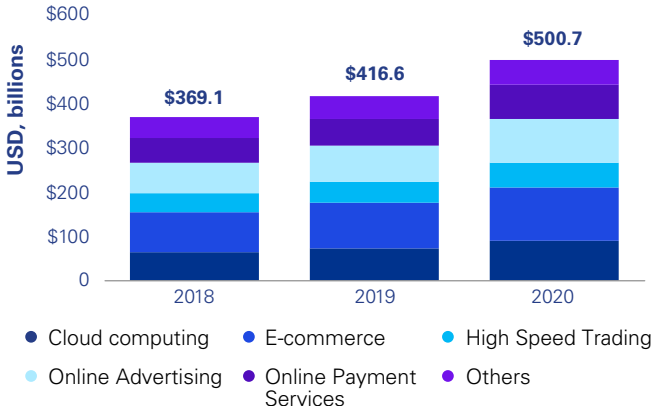
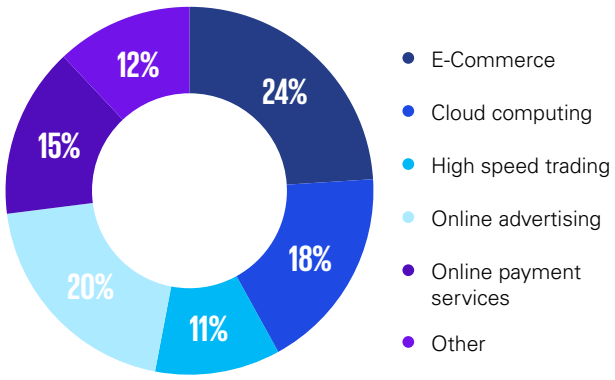


Figure 27: US Digital Economy market share 2020, by type of business



Source: Grand View Research, KPMG analysis

Table 8: Notable players

	Technology giants	Start-ups
AI	Blue River Technology, Google, IBM, Advanced Micro Devices	Aeye, AIBrain, AlphaSense, Anki,
Automation and Robotics	ABB Ltd., RD Global Inc, HelpSystems	UiPath, Skydio, Anduril Industries
Blockchain	SoluLab, IBM, The Linux Foundation, Microsoft, Ripple	Coinme, Mintable, Zerion, Chainalysis
Internet of Things (IoT)	Microsoft, General Electric, Senet, Helium	Hypervolt, Jiobit, SmartRent

Source: Grand View Research, KPMG analysis, Exploding Topics

Seen in Table 8, the providers of Artificial Intelligence services in the United States include businesses such as Aeye, AIBrain, AlphaSense and Blue River Technology. These companies offer AI capabilities to industries including automotive, consumer electronics, aerospace, healthcare, and wireless communication. AI solutions enable these sectors to track and improve their performance and revenue in real time.[43]

The major blockchain technology providers in the United States include companies such as Coinme, Unicsoft and Cubix. These solutions enable clients to create a smarter and more efficient supply chain, verify transactions faster, create disruptive and industry-leading business models and reduce fraud, among other benefits.

Improvements in the adoption of smart manufacturing and the creation of new growth opportunities has been the driver of key decisions made by the United States Department of Energy (DOE). In August 2021, in collaboration with the Clean Energy Smart Manufacturing Innovative Institute, the DOE announced the selection of four new Smart Manufacturing Innovation Centres (SMICs), increasing the total to eight SMICs nationwide. These centres have helped US manufacturers implement intelligent manufacturing technologies to optimise their processes as well as their use of materials and energy.[43]

The United States is leading the deployment of full-scale IoT operations, with more than 44 per cent of companies adopting the technology one way or another. The incubatory start-up climate in the country has contributed to the large number of IoT startups, further increasing their presence in the Digital Economy.[43]

Further information on notable players within the US Digital Economy can be found in Appendix C.

5.2.2 DE adoption by industry

As the Digital Economy grows, it's disrupting conventional ideas of what businesses do and how they do it. Below is a breakdown of revenue by industry and examples of how end-user industries are utilising and benefitting from the technology.[43]

Figure 28: US Digital Economy market share, by end use, 2020

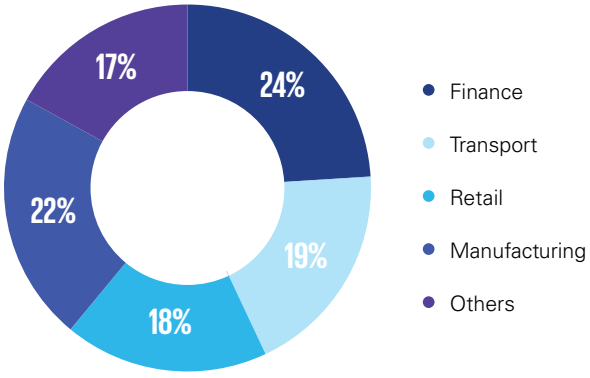
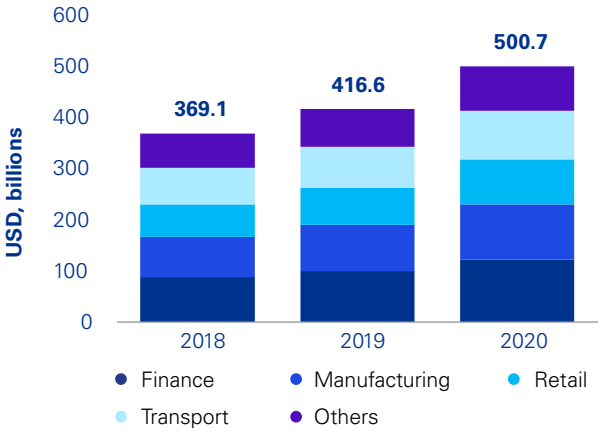


Figure 29: US Digital Economy revenue, by end use, 2020



Source: Grand View Research, KPMG analysis

Finance: The Digital Economy is quickly becoming a vital part of everyday operations for banks, insurance providers and other financial institutions. This is the largest segment in the US Digital Economy industry with US$122.6 billion of associated economic activity in 2020, up from US$100.6 billion in 2019 and US$87.9 billion in 2018. These service-based businesses are digitalising processes and enabling customers to manage their finances, access new products, conduct transactions and carry out other activities online. These new forms of digital activities include branchless banking, mobile financial services, electronic money and digital payment solutions.

Manufacturing: With estimated revenue of US$107.8 billion in 2020, manufacturing has experienced vast growth in the Digital Economy Space. It accounts for 22 per cent of all Digital Economy activity in 2020. Using digital technologies such as additive manufacturing, IoT, robotics and cloud computing to automate their processes, companies can improve their operational efficiency, reduce production costs, enhance the quality of their products and respond faster to shifting market demands. The large segment of the Digital Economy occupied by manufacturing is the result of data-driven decisions and self-improving, automated processes which the DE enables.

Retail: Retailers are using Digital Economy technologies such as facial recognition, virtual store assistants, self-service checkouts, augmented reality experiences and movement analytics to track consumer buying patterns, allowing them to improve supply chains and reduce delivery times. This industry has generated 18 per cent of the revenue associated with the Digital Economy in the United States, and the increasing use of digital devices by shoppers and retailers alike is further bolstering the retail sales of product categories such as electronics, apparel, books, food and beverage and furniture.

Transport: This industry accounts for 19 per cent of the Digital Economy in the United States, or US$95 billion. Digital technology in the form of movement and tracking analytics for vehicles, optimising mobility in the logistics industry to track freight and cargo across continents are becoming a fundamental operating tool within the transport sector. Digital business models across the transport sector include app-based private hire, ride-share, micro-mobility, mobility as a service, connected cars and drones.

5.2.3 US DE Industry's supply chain

To understand the nature of the Digital Economy Industry in the United States, we investigated which countries and goods are involved in the industry's supply chain. Between 2017 and 2022, there were more than 182,000 recorded shipments of physical goods to US businesses operating within Standard Industry Classifications (SIC) most relevant to the DE industry. For more detail on SIC codes, please see Appendix B.

Shipment of origin

China ranks first in terms of imports to US businesses, contributing 53 per cent of total US import shipments. When combined, China, Taiwan and Hong Kong make up almost 70 per cent of imports to the United States. South Korea, and Germany are also major source of imports to US businesses, making up more than nine per cent of total imports.

Australia ranks 27th on this list and currently contributes 0.2 per cent of total US imports. This data suggests that Australia does not have current strengths in the manufacturing of DE-related goods, but as section 5.3 will discuss does have other strengths in research and development and DE services.

What inputs are used in the industry?

As shown in Table 9, the top inputs imported by US-based businesses are described by the 6-digit HS codes 8528.52 and 8528.51, contributing to over 15 per cent of total shipments. Physical goods under HS code 8528.52 and 8528.51 include monitors, or display devices that are capable of connecting to and primarily used with automatic data processing machines.

Table 9: Number of shipments to the United States, by imported goods

#	Six-digit HS Code	HS code description	%
1	8528.52	Monitors other than cathode-ray tube; capable of directly connecting to and designed for use with an automatic data processing machine of heading 84.71	10%
2	8528.51	Monitors other than cathode-ray tube; of a kind solely or principally used in an automatic data processing system of heading 84.71	5%
3	8471.41	Automatic data processing machines; comprising in the same housing at least a central processing unit and an input and output unit, whether or not combined, n.e.c. in item no. 8471.30	4%
4	8473.30	Machinery; parts and accessories (other than covers, carrying cases and the like) of the machines of heading no. 8471	4%
5	8443.31	Printing, copying, and facsimile machines; machines which perform two or more of the functions of printing, copying or facsimile transmission, capable of connecting to an automatic data processing machine or to a network	3%
6	8471.30	Automatic data processing machines; portable, weighing not more than 10kg, consisting of at least a central processing unit, a keyboard and a display	3%
7	8517.62	Communication apparatus (excluding telephone sets or base stations); machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus	3%
8	8504.40	Electrical static converters	3%
9	8544.42	Insulated electric conductors; for a voltage not exceeding 1000 volts, fitted with connectors	2%
10	8518.30	Headphones and earphones, whether or not combined with a microphone, and sets consisting of a microphone and one or more loudspeakers	2%

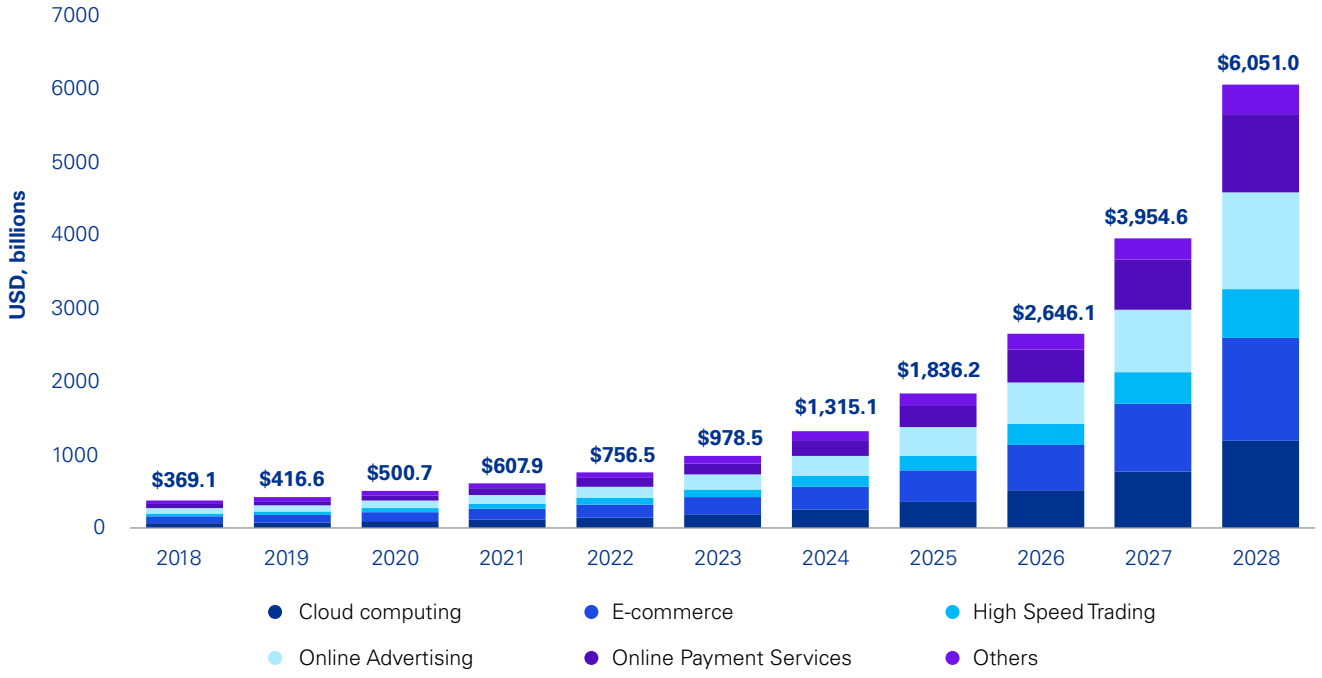
Source: Panjiva, KPMG analysis

5.2.4 Future potential of US DE Industry

The US Digital Economy is forecast to reach US$6.051 trillion by 2028 from US$607.9 billion in 2021, at an average annual growth rate of 38.9 per cent. The US economy is experiencing an ongoing mass digitalisation. Digital technology is replacing old systems and processes to improve productivity, especially those associated with healthcare, finance, education, retail and transport and manufacturing industries.

E-commerce is expected to be the most significant business segment within the Digital Economy by 2028, with a predicted value of US$1.4 billion. Although e-commerce is expected to be the largest proportion by volume, online advertising is expected have the largest growth with an annual growth rate of 40.6 per cent and an expected value of US$1.3 billion by 2028.

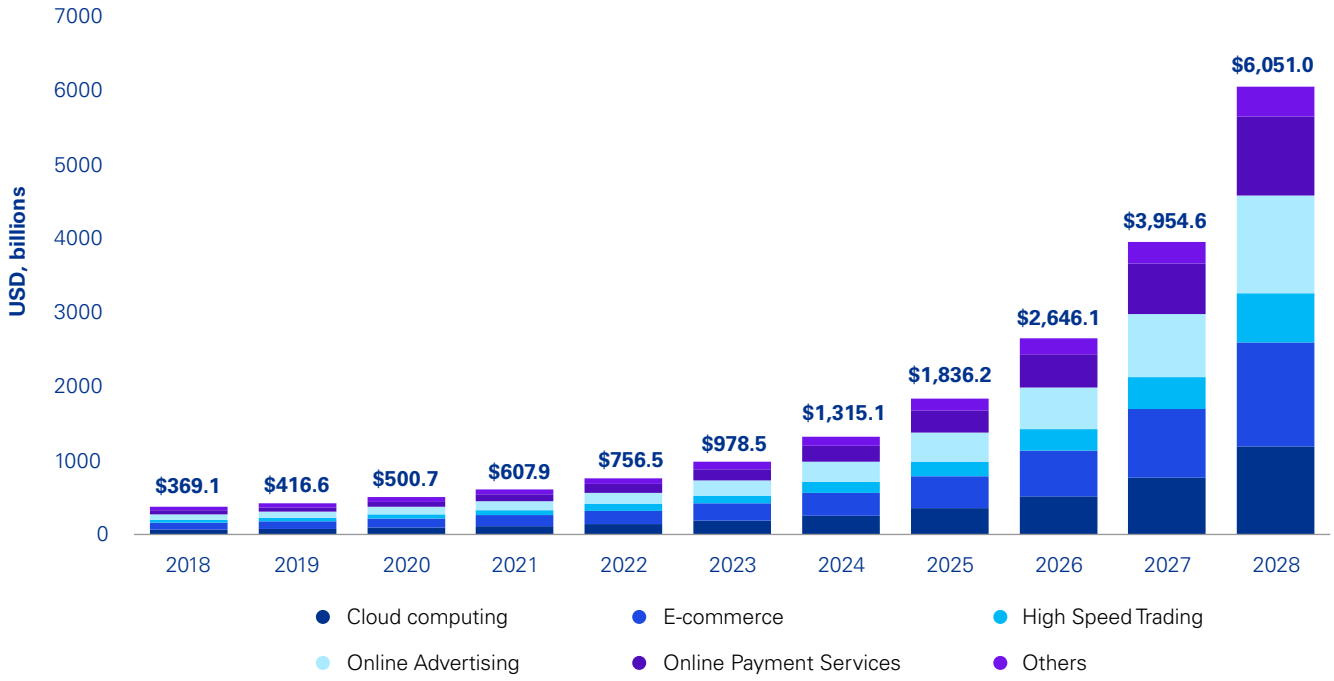
Figure 30: US DE Industry revenue, by type of business, 2018-2028 ($US Billion)



Source: Grand View Research, KPMG analysis

Shifting the lens to the type of DE technology and how it is forecast to grow (Figure 31), blockchain is expected to see the highest growth. That's predicted to be at 41.9 per cent annually until 2028 due to the emergence of the decentralised financial systems that it supports.

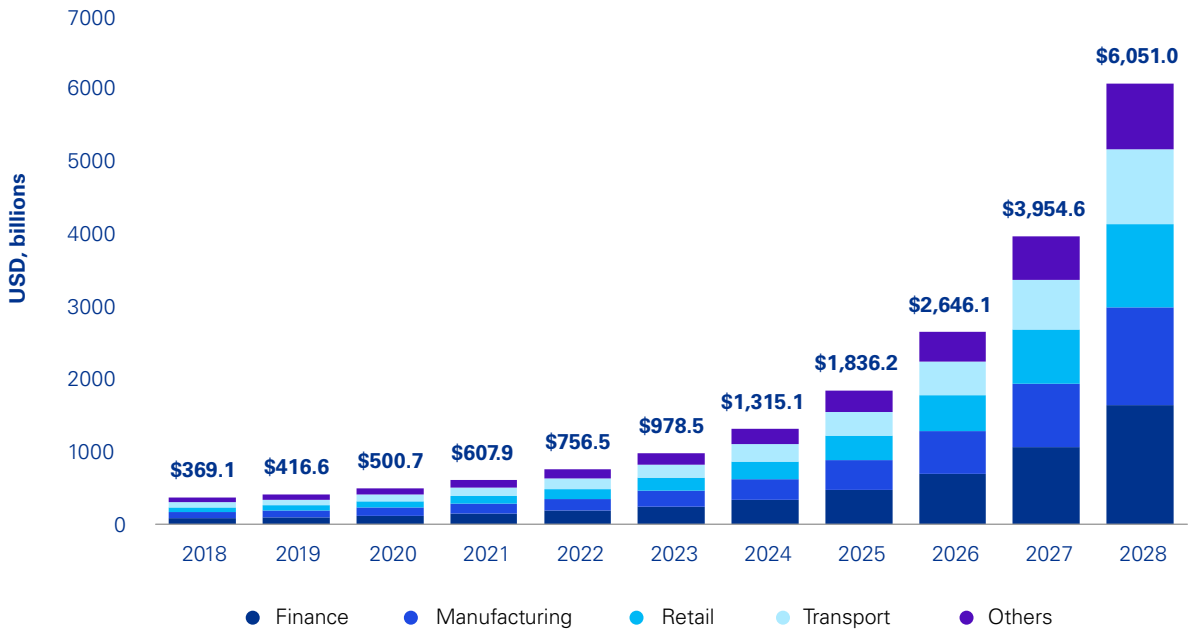
Figure 31: US DE Industry revenue, by type of technology, 2018-2028 ($US Billion)



Source: Grand View Research, KPMG analysis

The finance sector within the Digital Economy is expected to experience the highest rate of annual growth by 2028 at 40.6 per cent (Figure 32). Finance is predicted to have an annual turnover of about US$1.6 billion in 2028. This growth can be attributed to the emergence of FinTech companies that are disrupting the industry by offering platforms and services that traditional institutions can't yet offer, such as cryptocurrency trading and buy-now-pay-later schemes.[46]

Figure 32: US DE Industry revenue, by end use, 2018-2028 ($US Billion)



Source: Grand View Research, KPMG analysis

Investments into the United States DE industry

Significant growth of the Digital Economy in the United States can be attributed to the high volume of investment from both the private and public sector.

Many US-based financial service providers are increasing their technology spend to meet changing consumer demands. Over the next decade, US financial institutions are expected to be investing in operational improvement, increasing technology spending by 25 per cent. In other countries, that spend is expected to be a moderate increase of nine per cent.[4] Furthermore, US banks are entering into strategic partnerships with technology providers to digitalise and improve their services. In February 2022, KeyBank, Google and Deloitte Touche Tohmatsu Limited announced a joint partnership to accelerate KeyBank's vision of taking a cloud-first approach to banking. Through this joint venture, KeyBank will become one of the largest regional banks in the United States to operate its primary applications and platforms on Google's cloud infrastructure.

Strong investment has also been made by US-based manufacturing companies to make key processes less labour-intensive. For instance, in April 2021, Rockwell Automation, an industrial automation and digital transformation company, announced a joint partnership with Comau, a robotics manufacturer, to provide automation solutions to businesses worldwide through unified robotic control solutions.

Many retailers in the United States are increasingly relying on digital technologies to enhance their consumer experiences. In 2021, Microsoft announced a collaboration with NMI and Global Payment to launch the 'Cloud Tap on Phone' solution, allowing for smartphones and tablets to effectively be used as a point-of-sale (POS) terminal. This innovation is a part of Microsoft's investment into developing POS-acceptance products hosted on its Azure cloud platform.

Transportation companies in the United States are also increasing investment into cloud-based Transportation Management Systems (TMS), optimising and automating daily processes and reducing operational costs. TMS integrates detailed order-related information on cloud-based platforms, allowing for data-driven decisions to be made in real-time. This allows transportation companies to seamlessly facilitate human processes and overcome issues with the delivery of their services.

5.3 Australia's capacity to participate in the value chain

5.3.1 The Australian Digital Economy Industry

Australia is well-placed to be a leading Digital Economy and opportunities exist for the nation to take full advantage of the potential benefits of digital technologies.

The Digital Economy accounts for 6.6 per cent of Australia's GDP.[47] Annually, it creates around A$44 billion in economic value for Australian consumers through the creation of more than 500,000 jobs, which is equivalent to five per cent of the total working population.

In 2019-20, the digital activity share of aggregate value of 5.9 per cent was higher than 13 other industries, but still remained below the traditional drivers of economic activity like Mining (10.9 per cent), Finance (8.1 per cent), Construction (7.6 per cent) and Health (7.8 per cent). Support services, telecommunications and wholesale e-commerce industries accounted for almost 85 per cent of digital activity in 2019-20.[48]

Figure 33: Industry share in aggregate value added (%)

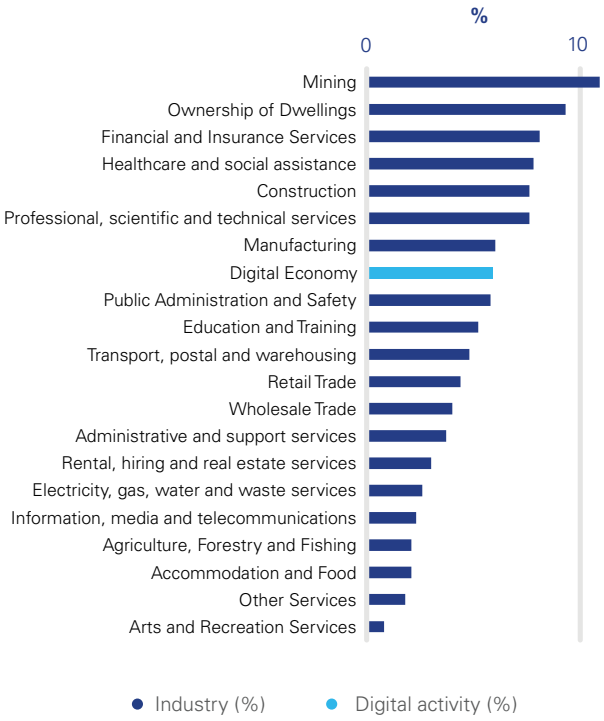
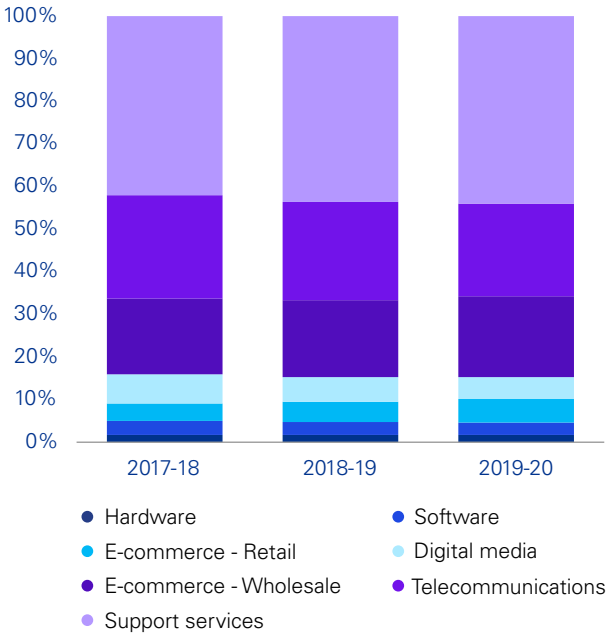


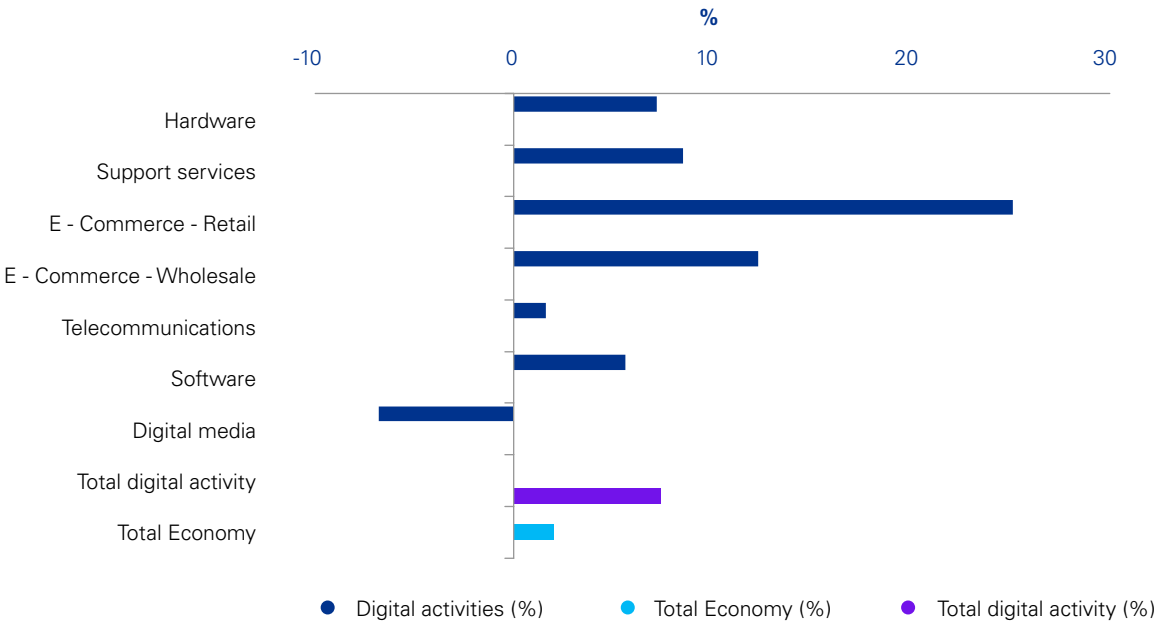
Figure 34: Share in total digital activity value added (%)



Source: Australian Bureau of Statistics

Growth within the Digital Economy has outpaced the overall economy in both current price and volume terms, indicating an acceleration in the sector's expansion. Compared to the total economy's two per cent growth in value, the value added by the Digital Economy increased by 7.4 per cent in 2019.[48]

Figure 35: Annual value added (%), digital activity vs. total economy, 2019-2020



Source: Australian Bureau of Statistics

5.3.2 Public Investment into the Digital Economy in Australia

Digitalisation within the economy significantly encourages competition, innovation, productivity and variety. The Australian Data Strategy in the federal budget of 2021-22 announced the government's vision for the nation to become a "modern data and digital-driven society" by 2030. The government acknowledges the importance of data in building a modern Digital Economy and has allocated:

- A$164.1 million to the ongoing implementation of Consumer Data Right, an initiative by the Australian Competition and Consumer Commission (ACCC) to give consumers greater visibility and control of their data, and the ability to compare and switch products and services more conveniently.
- A$40.2 million to deliver the Digital Atlas of Australia, an online platform that aggregates powerful insights harnessing real-time, location-based data allowing for more data-driven decisions.
- A$16.5 million to deliver a pilot program that democratises the Australian Government's non-sensitive data assets, giving powerful insights to the wider economy to optimise decision making and understanding.[49]

Compared to global peers, Australia spends relatively less on ICT research and development. Supportive tax incentives, subsidies and policy reform can significantly improve this investment and the commercialisation of such pursuits. Similar policies have proven effective in the UK, Ireland and France in enabling companies to increase patent inventions and research and development investment through enforcing lower tax rates for such activities.[47]

5.3.3 Applications and advantages of the Digital Economy

The Digital Economy will bring myriad changes that have the potential to fundamentally alter the way the Australian economy operates, as seen in Table 10 below.

Table 10: Outcome and benefits of the Digital Economy for Australia

Outcome	Benefit
More online interactions	As businesses and consumers interact through online platforms for marketing, promotions and collaborations, the digital presence and interaction between consumers, businesses and systems allows for greater symmetry and understanding.
Increased data collection and analysis	This gives businesses and entities the capabilities to monitor, understand and personalise their goods or services, enabling them to pivot where necessary.
Disruptive business models	Digital platforms allow for new, innovative solutions to existing problems or market gaps. This enables sharing economy participants to utilise previously absent capabilities such as crowdfunding, rental, ridesharing, coworking, reselling, knowledge sharing, etc.
Flexible supply chains	Digitising processes allows businesses to compete in more marketplaces with fewer and cheaper barriers to entry.
Evolving tasks and capabilities	The way we live, play, find and perform work are all revolutionised by a digital world.
Seamless international trade	As marketplaces become digital, country borders, language and other barriers to entry become less binding, improving the interoperability of trade.

Source: Digital Economy Strategy 2030

5.3.4 Identified Digital Economy specialisations for Australia

Mining: The mining sector can significantly benefit from the digitalisation of manual processes and back-end logistics. Rio Tinto's "Mine of the Future" program is widely used across Australia, the United States, New Zealand and Mongolia. Rio Tinto has confirmed the insights gleaned from this program have enabled the company to mitigate major hazards, giving way to safer assets, higher yields and improved operations.[50]

Health: The digital health ecosystem has been identified as a clear prospect for vast operational improvement through increasing its applications associated with the Digital Economy.[51] With a range of smarter, more connected devices, digital technologies can facilitate innovative health solutions surrounding accessibility, cost, quality, safety and sustainability of healthcare.

Financial services: Rapid evolution of the Digital Economy has driven disruptions to both the demand and supply side of financial services. With the advent of the smartphone, mobile usage has become indispensable to the consumer, and with it, an entirely new platform for third-party developers to capitalise.

This shift in consumer sentiment means the financial services sector is adopting a more efficient, innovative, diverse and competitive approach to digitalisation.[46]

Education and training: Catalysed by restrictions and lockdowns, online learning has become an essential part of the way schools, universities and institutions now deliver student curricula. The adoption of 'paperless' classrooms and 'classroom-less learning' has redefined how we think about education. For those with a computer, an internet connection, and ICT skills, there are a host of new academic opportunities. The convenience and increased accessibility of digital education means more learning for more people, resulting in stronger productivity and a stronger future workforce.[41]

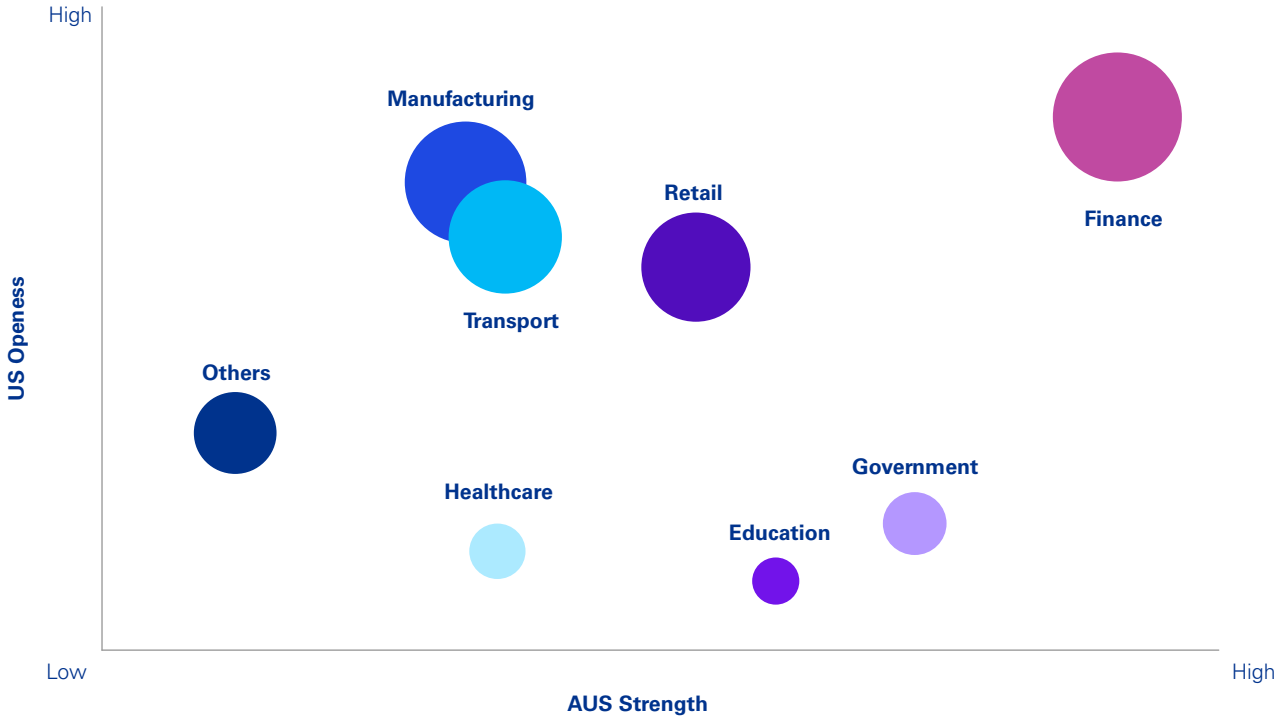
5.4 Digital Economy trade opportunities with the United States

In considering the potential for increased trade between Australia and the United States, we have analysed the scale of DE technology adoption by US industries and then cross-matched these results against Australia's strengths. The number of individuals with tertiary qualifications at the bachelor level or above is used as an indicator for the level of highly skilled labour and strength in a given industry. This analysis is presented in Figure 36 below, which suggests the financial, government and education sectors are areas of competitive strength for Australia.

US industries that have already shown a propensity for early adoption of DE technologies are likely to be more open to innovations from foreign companies, especially those companies which are in political, economic and socially aligned jurisdictions.

The financial sector is considered a key area of strength and opportunity for Australia. The nation has been an early adopter of financial services innovation and technology. The United States indicator for openness in this industry is higher than others, indicating trade opportunities are likely in the near term. The government and education sectors also present opportunities for increased trade between the United States and Australia. Although US openness in these industries is lower than others, there may be trade opportunities in the longer term as adoption of the technology increases.

Figure 36: Australia's strength in QC by sector and US opportunities



Source: Analysis of GVR and ABS data

Note: Bubble size indicates relative US gross value added.

6 Australia's export potential to the United States

Australia has proven capability in the fields of AI, Quantum Computing and Digital Economy. As shown these sectors are expected to experience substantial growth in the near term. This section outlines advice for Australian businesses that will help identify export opportunities in the United States for new and emerging products and technologies. It then quantifies the potential trade uplift for Australia if these opportunities are realised.

6.1 Advice for businesses expanding to the United States

To understand the export potential for Australian-based businesses in AI, Quantum Computing and the Digital Economy sectors, AmCham and KPMG consulted companies who have been successful in generating new business in the United States and Australian markets. Key learnings gleaned from these consultations include:

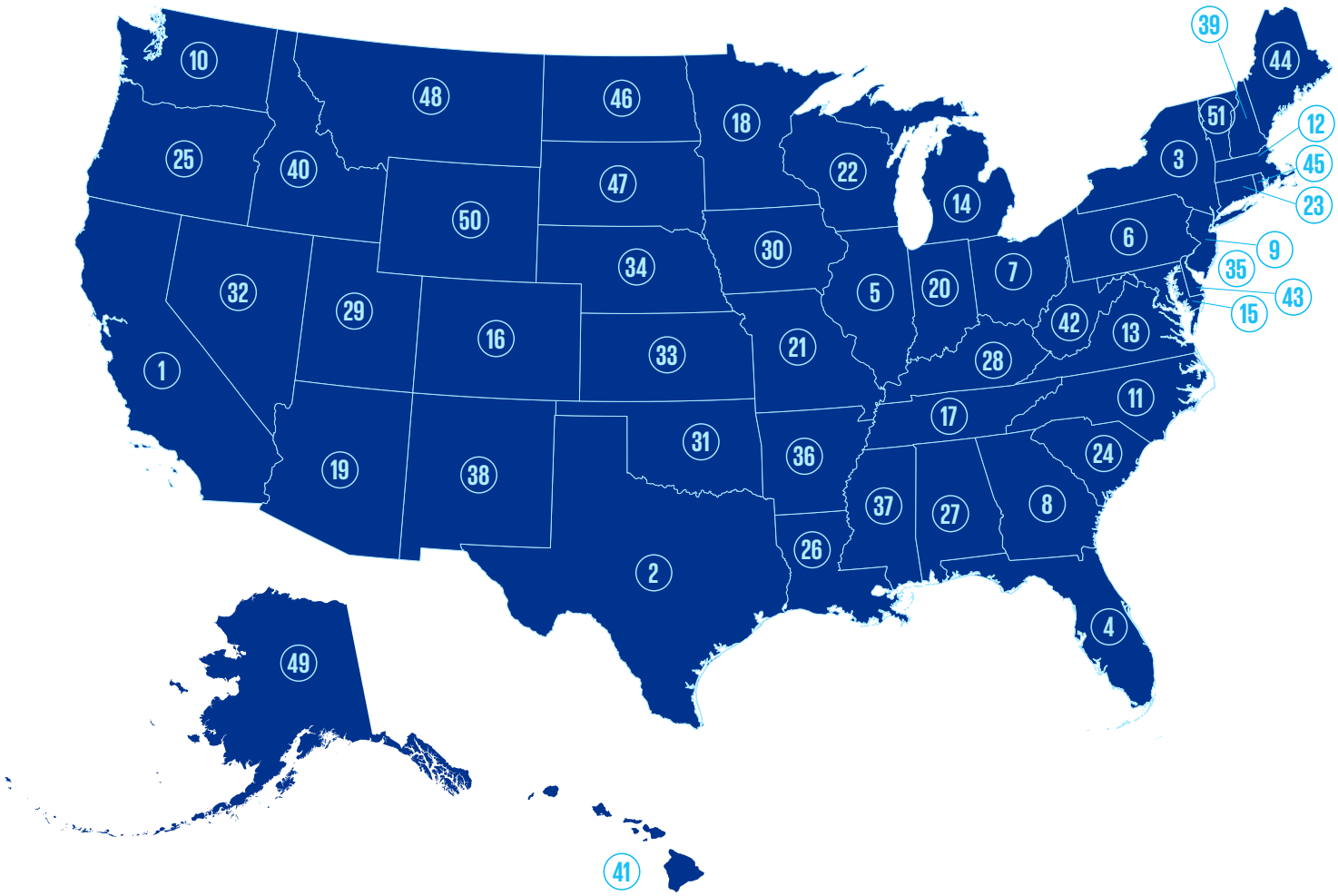
Look for partnerships, not just customers. Industry stakeholders identified that simply meeting with potential customers and pitching a new product may not be enough to find new business. Trust and credibility can take time to build, as does a deep understanding of the US market and supply chains. An alternative approach is to identify a complementary service already provided by a US business in the local market that aligns with an Australian product or technology and form a joint offering. This has the dual benefit of the market understanding the US partner and the innovative offering of the Australian partner, providing more trust to potential customers.

The United States can provide unique opportunities for early adoption of technology. Industry stakeholders identified that US customers can be more open to adoption of new technologies, providing options that might be difficult in other markets. This is in part due to an apparent openness of regulatory authorities in the United States to new technologies. It is also in part due to competitive, diverse markets that can be more eager to find a competitive edge in productivity. The size of the United States market also means that trials for new technologies and products can be tested on a larger pool of users. Once a technology is tested and proved in the United States, adoption in other markets, including Australia, appears to be easier.

Understand where a product or technology fits in the supply chain. As the complexity of technology increases, so do the supply chains. Where a new technology might improve an existing good or service, the entry point could be further up the supply chain in 'sub-systems' or even 'sub-sub-systems'. For example, a piece of Artificial Intelligence software that has applications for connected and automated vehicles may not be sold directly to a car manufacturer, or even the primary software provider, but possibly to a specialist firm providing software for a specific function.

Research the most suitable market for a new technology. The US economy is large and diverse and at the technological frontier for many sectors. It can be appealing for many businesses in Artificial Intelligence, Quantum Computing, and the Digital Economy sectors to aim for deals in Silicon Valley or New York, but there are many opportunities in other cities and states. Australia's largest state economy, New South Wales, would rank 15th in economic size amongst the United States state economies. Furthermore, US state economies are unique, with their own industrial specialisations (Table 11). Australian businesses should identify which markets might best need their products. For example, a Digital Economy technology for the mining sector might be applied in Oklahoma or Montana.

Table 11: US states ranked by GDP (US$ billions) and their top 3 industry specialisations



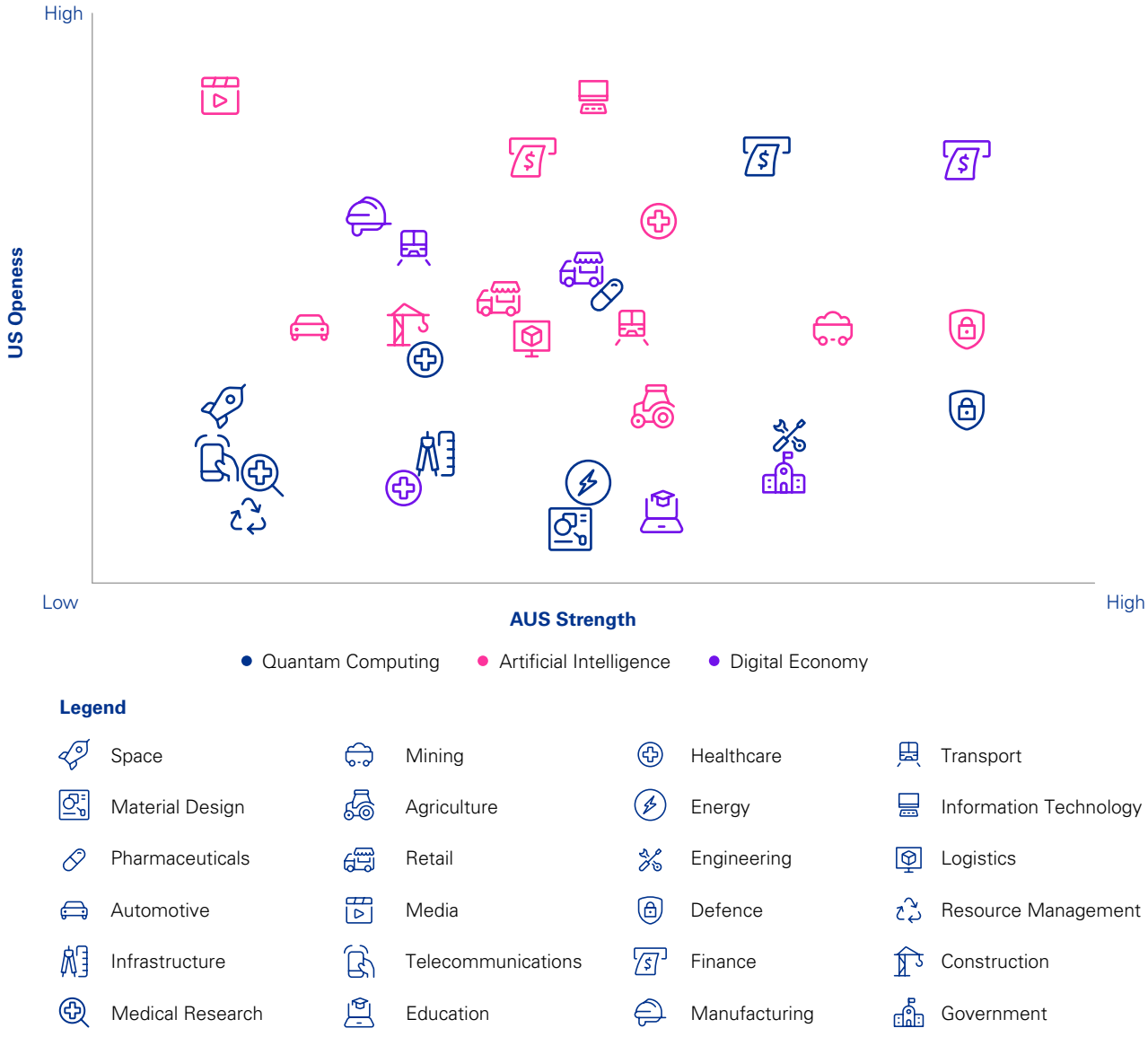
Rank	State (GDP, US$ billions)	Top 3 industry specialisations	Rank	State (GDP, US$ billions)	Top 3 industry specialisations
1	California (3,357)	Information services; Manufacturing; Professional services	27	Alabama (247)	Manufacturing; State and local government; Federal government
2	Texas (1,985)	Mining; Wholesale trade; Manufacturing	28	Kentucky (234)	Manufacturing; Transportation; Wholesale trade
3	New York (1,854)	Finance; Information services; Health and education	29	Utah (220)	Construction; Manufacturing; Mining
4	Florida (1,226)	Finance; Arts, Hotels and food services; Retail trade	30	Iowa (220)	Agriculture; Manufacturing; Finance
d5	Illinois (938)	Manufacturing; Wholesale trade; Finance	31	Oklahoma (207)	Mining; State and local government; Transportation
6	Pennsylvania (839)	Health and education; Manufacturing; Transportation	32	Nevada (193)	Arts, hotels and food services; Construction; Mining
7	Ohio (736)	Manufacturing; Health and education; Transportation	33	Kansas (192)	Manufacturing; Agriculture; Transportation
8	Georgia (683)	Information services; Wholesale trade; Finance	34	Nebraska (150)	Agriculture; Transportation; Manufacturing
9	New Jersey (672)	Professional services; Wholesale trade; Finance	35	District of Columbia (152)	Federal government; Professional services; Other services
10	Washington (668)	Information services; Retail trade; Agriculture	36	Arkansas (145)	Manufacturing; Wholesale trade; State and local government
11	North Carolina (655)	Manufacturing; Military; State and local government	37	Mississippi (125)	Manufacturing; State and local government; Retail trade
12	Massachusetts (637)	Professional services; Health and education; Finance	38	New Mexico (109)	Mining; Federal government; State and local government
13	Virginia (592)	Professional services; Federal government; Military	39	New Hampshire (98)	Health and education; Professional services; Wholesale trade
14	Michigan (568)	Manufacturing; Wholesale trade; Utilities	40	Idaho (94)	Agriculture; Retail trade; Construction
15	Maryland (438)	Federal government; Construction; Professional services	41	Hawaii (90)	Arts, hotels and food services; Military; Federal government
16	Colorado (422)	Professional services; Construction; Mining	42	West Virginia (87)	Mining; Federal government; State and local government
17	Tennessee (418)	Manufacturing; Transportation; Health and education	43	Delaware (81)	Finance; Agriculture; Utilities
18	Minnesota (412)	Manufacturing; Health and education; Wholesale trade	44	Maine (76)	Health and education; Retail trade; Finance
19	Arizona (411)	Retail trade; Finance; Construction	45	Rhode Island (66)	Health and education; Finance; Arts, hotels and food services
20	Indiana (420)	Manufacturing; Transportation; Health and education	46	North Dakota (63)	Mining; Agriculture; Transportation
21	Missouri (360)	Manufacturing; Health and education; Agriculture	47	South Dakota (61)	Agriculture; Finance; Health and education
22	Wisconsin (366)	Manufacturing; Health and education; State and local government	48	Montana (59)	Mining; Agriculture; State and local government
23	Connecticut (296)	Finance; Health and education; Manufacturing	49	Alaska (55)	Transportation; Mining; State and local government
24	South Carolina (270)	Manufacturing; State and local government; Retail trade	50	Wyoming (42)	Mining; Transportation; State and local government
25	Oregon (267)	Manufacturing; State and local government; Agriculture	51	Vermont (36)	Health and education; State and local government; Arts, hotels and food services
26	Louisiana (255)	Manufacturing; Construction; Mining			

Source: KPMG analysis of United States Bureau of Economic Analysis GDP by state data. Note: specialisation is calculated using the location quotient approach, where a state has a highest share of a given industry above the national average.

6.2 Summary of Australia's strengths

Figure 37 shows a distinct difference between AI and QC in terms of US openness. On average, the United States is more receptive to AI-specialised imports than it is to QC-specialised imports. The infancy of the QC industry means less demand for these imports, and in turn a lower openness. Despite this, it's clear that the defence sector is an area of strength for potential exports from Australia to the United States in the fields of QC and AI, while the finance sector stands out as a key industry for Australian DE companies to target.

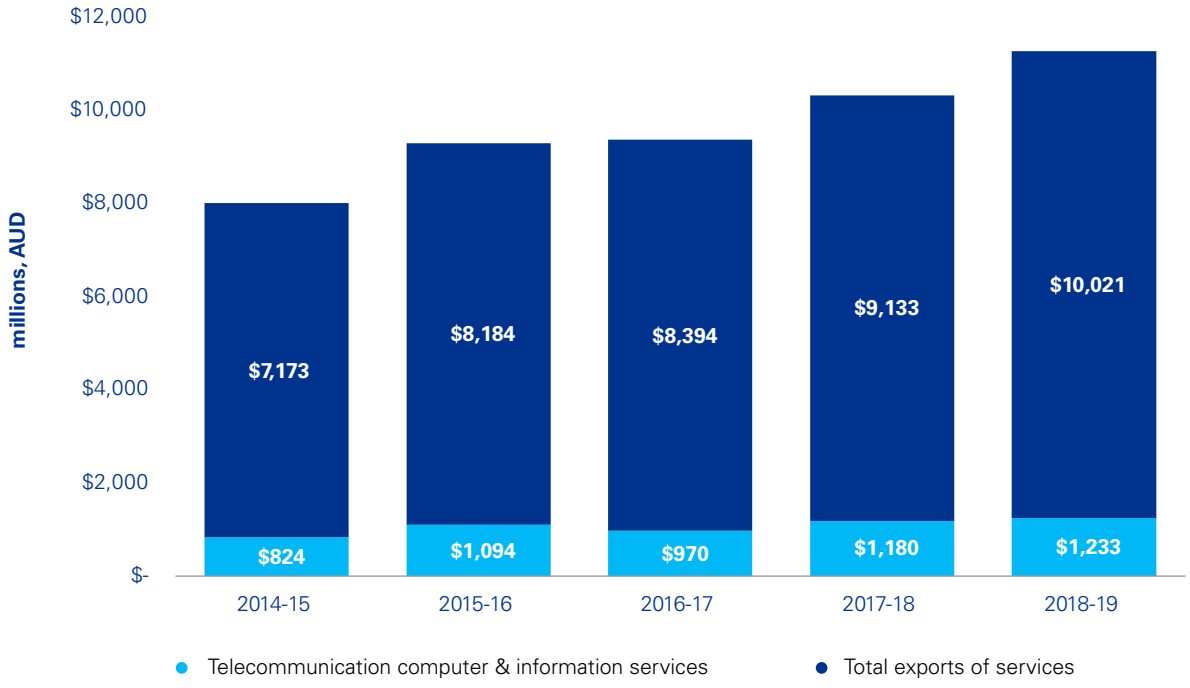
Figure 37: Australian imports to US possibility frontier



6.3 Estimated trade uplift for increasing US engagement

The United States was Australia's largest two-way services trading partner in 2018-19, accounting for 13.9 per cent of total services trade.[42] As shown in Figure 38, between 2014-15 and 2018-19, total exports to the United States grew at an average annual rate of 8.4 per cent. In the same period, exports of ICT services, which includes AI, QC and DE, grew at a faster rate, at 10.6 per cent. In 2018-19, total exports to the United States were approximately A$10 billion, of which the telecommunications and computer and information services contributed A$1.2 billion (12.3 per cent).

Figure 38: Australia service exports to US between 2014-15 to 2018-19 (A$ millions)

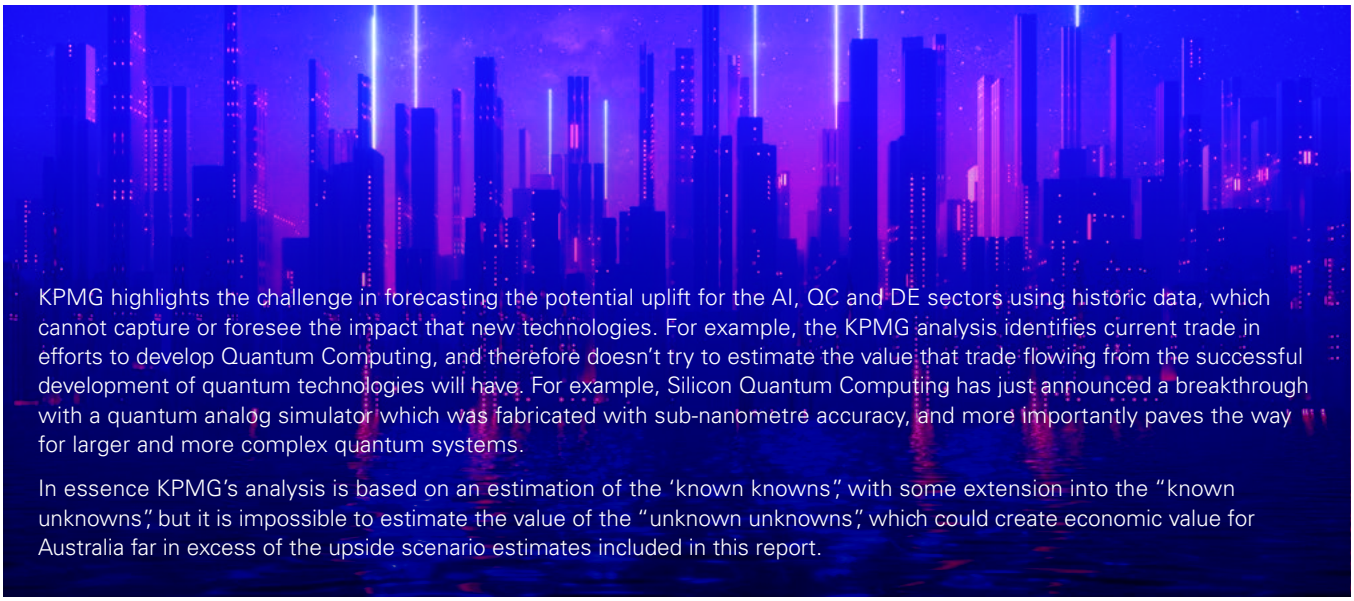


Source: DFAT Trade in services[41]

Note: Other services includes construction, maintenance, finance, insurance, personal and recreation services.

We have extrapolated three scenarios to estimate the benefit of an uplift in trade between the United States and Australia in the three industries. In all scenarios, the value of service exports are estimated from Australia to the United States between 2020 and 2030.

In the first scenario, we used data from 2014-15 to 2018-19 from Australia's Department of Foreign Affairs and Trade to calculate the historical growth in trade between the two countries. Using this annual average growth rate, the report extrapolates the value of exports from Australia from 2020 to 2030. In the second scenario, an average annual growth rate is calculated by assuming Australia maintains its historical share of trade to these rapidly growing US industries. Scenario three assumes Australia can increase its share of trade to the United States by combining growth rates derived from scenarios one and two. This scenario represents growth in trade between the two nations due to increased exports in the defence and security related goods, as a result of arrangements such as AUKUS.



KPMG highlights the challenge in forecasting the potential uplift for the AI, QC and DE sectors using historic data, which cannot capture or foresee the impact that new technologies. For example, the KPMG analysis identifies current trade in efforts to develop Quantum Computing, and therefore doesn't try to estimate the value that trade flowing from the successful development of quantum technologies will have. For example, Silicon Quantum Computing has just announced a breakthrough with a quantum analog simulator which was fabricated with sub-nanometre accuracy, and more importantly paves the way for larger and more complex quantum systems.

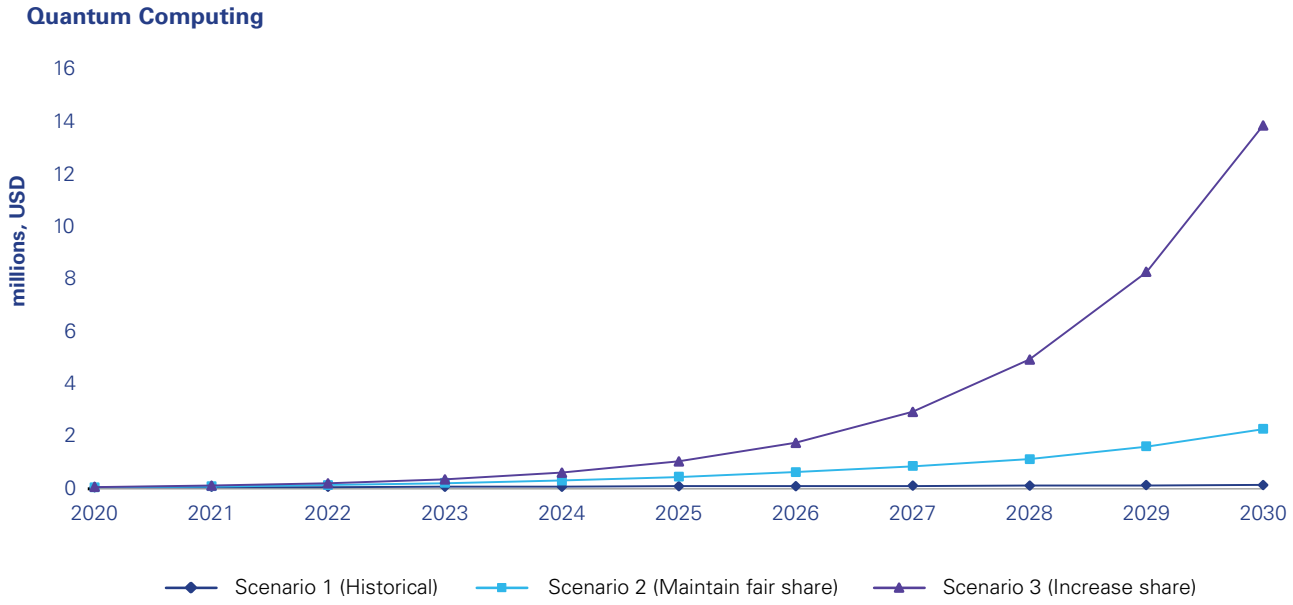
In essence KPMG's analysis is based on an estimation of the 'known knowns", with some extension into the "known unknowns", but it is impossible to estimate the value of the "unknown unknowns", which could create economic value for Australia far in excess of the upside scenario estimates included in this report.

As seen in the below figure, scenario one, the baseline for the Quantum Computing sector estimates the value of service exports to the United States in 2030 to be approximately A$0.2 million. Scenario two indicates that if Australia can maintain its share of the rapidly growing US QC market, the value of service exports to the United States will grow to A$2.3 million. Scenario three indicates that if Australia can increase its share of trade through arrangements such as the AUKUS agreement, the value of service exports could be as high as A$13.9 million.

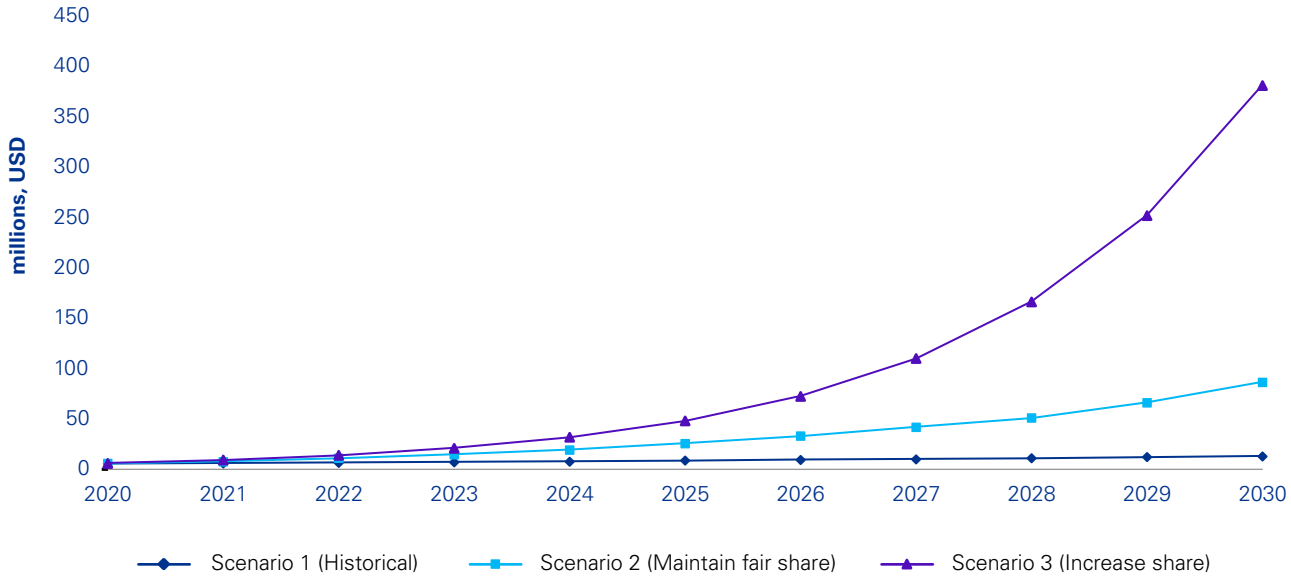
In the baseline scenario for the Artificial Intelligence sector, this report estimates the value of service exports to the United States in 2030 to be approximately A$13.1 million. Scenario two indicates that if Australia can maintain its share of the rapidly growing US AI market, the value of service exports to the United States will grow to A$86.6 million. Scenario three indicates the value of service exports is estimated to be A$381.3 million if Australia can leverage defence and security related arrangements.

Lastly, in the baseline scenario for the Digital Economy sector, the authors of this report estimate the value of service exports to the United States in 2030 to be approximately A$404.2 million. Scenario two indicates that if Australia can maintain its share of the rapidly growing US DE market, the value of service exports to the United States will grow to A$4.1 billion. Scenario three indicates that if Australia can increase its share of trade, the value of service exports is estimated to be A$23.4 billion.

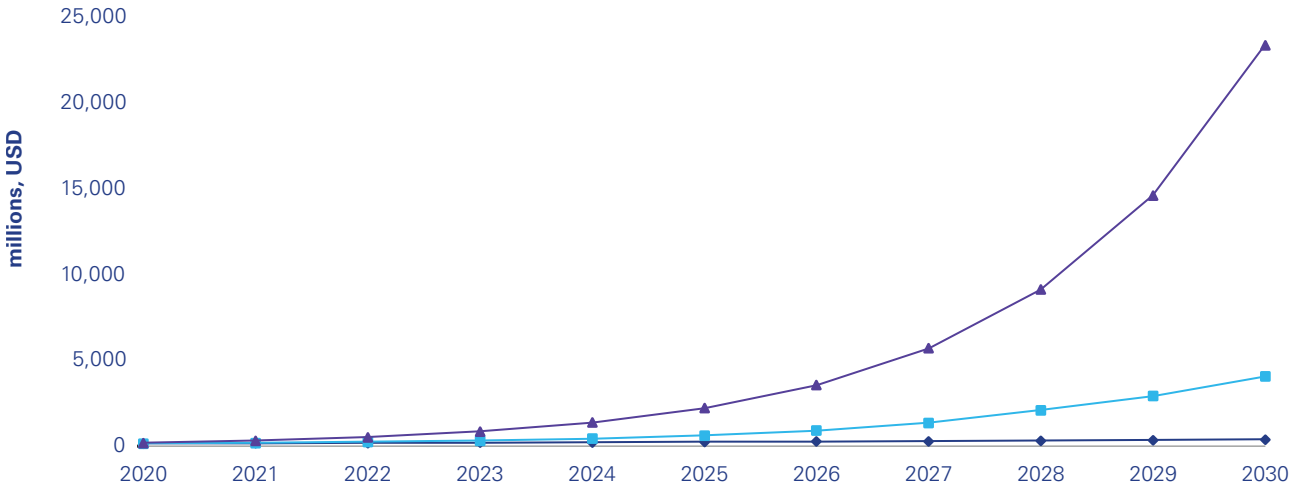
Figure 39: Scenarios for increasing trade between the United States and Australia



Artificial Intelligence



Digital Economy



Source: KPMG analysis, Department of Foreign Affairs and Trade, Bureau of Economic Analysis

Table 12 summarises the estimated value of exports from Australia to the US as a share of the United States domestic industry revenue across the three scenarios. Across all scenarios, Australia maintains a small share of the total US industry size (less than half a per cent), despite the significant increase for Australia's exports. This highlights that the export potential is more constrained by Australia's capacity to commercialise and deliver new technology, rather than by a lack of opportunity in the United States. It also highlights that under the business as usual scenario, Australia could lose market share if trade doesn't keep up with the high growth of the United States Deep Tech sectors.

Table 12: Trade scenario estimates as a share of US domestic industry revenue

	QC	AI	DE
Australia exports to US 2019/20 (A$ millions)	0.07	5.69	175.23
% of US domestic industry revenue	0.026%	0.026%	0.026%
US imports from Australia as a share of 2027/28 US industry revenue			
Scenario 1: business as usual	0.003%	0.006%	0.005%
Scenario 2: fair share	0.037%	0.034%	0.037%
Scenario 3: accelerated	0.190%	0.130%	0.182%

Source: KPMG analysis,

6.4 Investment and employment implications

If Australian businesses are to step-up and participate more actively in bilateral trade with the United States in the fields of AI, QC and DE, they will require a corresponding step-up in investment in physical capital and labour.

Using information from various ABS datasets, including the national accounts and those associated with estimating multifactor productivity, KPMG has estimated the incremental capex spend and employment that would be necessary in order for the trade uplift forecasts to be achieved. We note these are broad estimates using industry-wide averages and apply today's capital-labour ratios. Table 13 presents estimates of necessary investment in new capital stock and incremental FTE workers by industry segment required to achieve the potential trade-uplift forecast in section 6.3.

Table 13: Incremental capital stock and labour force required to meet trade-uplift scenarios, 2030

	Capital Stock (A$B 2022)	FTE ('000)
Scenario 1: business as usual	0.4	1.4
Scenario 2: fair share	4.1	13.9
Scenario 3: accelerated	23.2	79.2

Source: KPMG analysis

The above analysis shows the economic benefits to Australia are significantly higher under the accelerated market share scenario. The achievability of this outcome depends on both industry and government working cooperatively to maximise the opportunities that will come with even stronger defence and security relationships that will arise under the AUKUS pact, and leveraging the already well functioning Australia-US Free Trade Agreement.

Appendix A: Market size estimates

This appendix outlines the methodologies used to estimate the market size and trade opportunity for the Digital Economy, Artificial Intelligence and Quantum Computing sectors.

Market size

It's important to note that the sectors analysed don't follow specific industry classification codes and so a degree of subjectivity and classification is required to determine market sizes. The market size for each of the target sectors in the US captures the direct revenues for Digital Economy, Artificial Intelligence and Quantum Computing products by businesses selling these products. These estimates are provided by Grand View Research, which uses a combination of data mining of its proprietary database, consolidation of company reports and other financial statements, and interviews with key opinion leaders in the industry.

Market size estimates in Australia have been taken from multiple sources. The DE sector has been estimated based on the direct value reported by Digi[1]. The Australian AI market has been estimated based on the amount of private investment in AI reported in the 2021 AI Index report[2] and relative size to the US AI sector and private investment. The QC market has been estimated based on the value of public funding for quantum technology in Australia[3] and relative size to the US QC sector and public funding.

US openness

Estimates of trade openness for each of the target sectors are based on the uptake of the technology within industry verticals across the US economy provided by Grand View Research. For example, AI products are heavily used in the information communication technology industry, which is therefore considered to be relatively open to new products with this technology. It should be noted that this openness is considered a good indication of short- to medium-term opportunities, but as technologies develop they are expected to have wider application across more industries.

Australia's strength

Australia's strength in each target sector has been estimated based on data available. Strength in DE is measured using a similar approach to the indicators reported in the Digital Economy Strategy 2030,[4] by calculating the relative share of high-skill information communication technology workers (those with a bachelor degree or greater) employed by Australian industry. Australia's strength in AI has been estimated based on the top-selling industries reported in the 2021 AI export survey.[5] Australia's strength in QC by industry is calculated based on the forecasted values reported by CSIRO for computing, sensing and communication applications for Australia's quantum technologies.[6] For example, defence industries are expected to employ all three of these applications and so have a relatively large strength in this industry.

1 https://digi.org.au/digitalopportunity/

2 https://aiindex.stanford.edu/wp-content/uploads/2021/03/2021-AI-Index-Report-_Chapter-3.pdf

3 https://www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/CSIRO-futures/Future-Industries/Quantum

4 https://digitaleconomy.pmc.gov.au/sites/default/files/2022-02/digital-economy-strategy.pdf

5 https://www.austrade.gov.au/news/publications/the-2021-australian-artificial-intelligence-export-survey

6 https://www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/CSIRO-futures/Future-Industries/Quantum

Appendix B: Supplementary industry information

Using the Panjiva database,we extracted import data on the Artificial Intelligence, Digital Economy and Quantum Computing industries in the United States. We restricted our search to:

- goods imported to the United States between 2017 and 2022
- consignees with a Standard Industrial Classification (SIC) code relevant to the AI, DE and QC industries
- inputs with a Harmonised System (HS) code relevant to the AI, DE, QC industries.

While there is no unique Standard Industrial Classification (SIC) code for the AI, DE and QC industries, Grand View Research has classified the industry within the SIC code 737 (Computer Programming, Data Processing, and other Computer Related Services). There are several sub-categories within this code and the following table outlines the most relevant to each industry:

Artificial Intelligence	
SIC Code	**Description**
7371	Computer programming services
7372	Pre-packaged software
7373	Computer integrated systems design
7374	Computer processing and data preparation and processing services
7379	Computer related services, not elsewhere classified
Digital Economy	
4791	Retail Sale Via Mail Order Houses or Via Internet
4812	Radiotelephone Communications
7374	Computer processing and data preparation and processing services
7375	Information Retrieval Services
7379	Computer related services, not elsewhere classified
Quantum Computing	
7371	Computer programming services
7374	Computer processing and data preparation and processing services
3674	Semiconductors and Related Devices

Source: https://www.naics.com/

Our search also focussed on inputs most relevant in the production of goods in the AI, DE and QC industries. Conducting a search for products most relevant to the above SIC codes yielded the following HS codes:

1. HS Code 84: Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof.
2. HS Code 85: Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles

Source: https://www.seair.co.in/computer-services-hs-code.aspx

Limitations:

There are several key limitations to this approach. First, the SIC code system was last revised in 1987 and therefore may not capture emerging industries such as QC, AI and DE accurately. SIC code definitions are also broad and no unique codes for AI, DE or QC have been defined. This means that restricting our search by SIC code is likely to include data relevant to industries that may not be relevant. Second, SIC codes most relevant to the AI, DE and QC industries are similar and may overlap. Therefore, when extracting data, it is difficult to identify which industry trade data is associated with.

To overcome these limitations, the authors used Grand View Research reports which identify prominent companies from AI, QC and DE industries to supplement our data extract. A search in Panjiva was then conducted for these companies and trade data was collated. By doing so, the authors could get an understanding of trade data for industries most relevant to AI, QC and DE and key companies within each industry.

Appendix C: Prominent US businesses by industry

Digital Economy

Company	Company size	Location
Global Arena Holding, Inc.	Small	New York
Netki	Small	California
AEye	Small	California
Jiobit	Small	Illinois
Casetext Inc.	Small	California
Crate.io	Small	California
Sensely, Inc.	Small	California
Enlitic, Inc.	Small	California
AiCure	Small	New York
Clarifai, Inc.	Small	New York
Atomwise Inc.	Small	San Francisco
LeewayHertz	Small	California
Blue River Technology	Small	California
H2O.ai.	Small	California
Circle Internet Financial Ltd	Midsize	Massachusetts
ScienceSoft	Midsize	Texas
DataRobot	Midsize	Massachusetts
Linux Foundation	Midsize	California
Ooma Inc	Midsize	California
Watchguard Technologies	Midsize	Washington
SimpliSafe, Inc.	Midsize	Massachusetts
Promethean Inc.	Midsize	Washington
Digi International	Midsize	Minnesota
PTC	Large	Massachusetts
Arm Limited	Large	California
Advanced Micro Devices, Inc	Large	California
NVIDIA Corporation	Large	California
Oracle Corporation	Large	California
Cisco Systems, Inc.	Large	California
Intel Corporation	Large	California
T-Mobile USA, Inc.	Large	Washington
Meta	Large	California
AT&T	Large	Texas
Microsoft	Large	Washington
Google	Large	California

Source: KPMG research

Notes: Small, medium and large businesses refer to those with less than US$50m revenue, between US$50m and US$1b and over US$1b respectively.

Artificial Intelligence

Company	Company size	Location
Cyrcadia Health	Small	Nevada
HyperVerge, Inc.	Small	California
AiBrain Inc.	Small	California
Sensely Inc.	Small	California
Ayasdi AI LLC.	Small	California
Enlitic, Inc.	Small	California
AiCure.	Small	New York
Clarifai, Inc.	Small	New York
Atomwise Inc.	Small	New York
H2O.ai.	Small	California
NMB Technologies	Midsize	Michigan
Scale AI	Midsize	California
Premio	Midsize	California
Feedzai	Midsize	California
SentinelOne Group	Midsize	California
Anduril Industries	Midsize	California
Fundbox	Midsize	San Francisco
Bright Machines	Midsize	California
Dataminr	Midsize	New York
DataRobot	Midsize	Massachusetts
Verkada	Midsize	California
Nuro	Midsize	California
Samsara Inc	Midsize	California
Advanced Micro Devices	Large	California
NVIDIA Corporation	Large	California
International Machines Corp.	Large	New York
Amazon Web Services Inc.	Large	Washington
Intel Corporation	Large	California
Meta	Large	California
Apple Inc.	Large	California
Microsoft	Large	Washington
Google	Large	California

Source: KPMG research

Notes: Small, medium and large businesses refer to those with less than US$50m revenue, between US$50m and US$1b and over US$1b respectively.

Quantum Computing

Company	Company size	Location
IonQ, Inc.	Small	Maryland
Strangeworks Inc.	Small	Texas
Quantum Circuits	Small	Connecticut
Aliro Technologies	Small	Massachusetts
Rigetti & Co, Inc.	Small	California
QuEra Computing	Small	Massachusetts
QC Ware	Small	California
Zapata Computing	Small	Massachusetts
Adam Computing, Inc.	Small	California
ColdQuanta	Small	Colorado
PsiQuantum	Small	California
MagiQ Technologies	Midsize	Massachusetts
NMB Technologies	Midsize	Michigan
HRL Laboratories	Midsize	California
Hewlett Packard Enterprise	Large	Texas
Honeywell International Incorporation	Large	North Carolina
International Business Machines Corp.	Large	New York
Amazon Web Services, Inc.	Large	Washington
Intel Corporation	Large	California
Microsoft	Large	Washington
Google	Large	California

Source: KPMG research

Notes: Small, medium and large businesses refer to those with less than US$50m revenue, between US$50m and US$1b and over US$1b respectively.

Appendix D: References

1. Roberts, A., Choer Moraes, H., and Ferguson, V., "Towards a geoeconomic order", Journal of International Economic Law (2019): 655-676.
2. KPMG. 2021. Geopolitical megatrends and business resilience. [online] Available at: <https://home.kpmg/au/en/home/insights/2021/06/geopolitical-megatrends-business-resilience.html> [Accessed 12 May 2022].
3. Klein, E., 2022. Can the West Stop Russia by Strangling Its Economy?. [podcast] The Ezra Klein Show. Available at: <https://www.nytimes.com/2022/03/01/podcasts/transcript-ezra-klein-interviews-adam-tooze.html> [Accessed 12 May 2022].
4. Hanson, F. and Cave, D., 2022. The real potential of AUKUS is about far more than submarines | The Strategist. [online] The Strategist. Available at: <https://www.aspistrategist.org.au/the-real-potential-of-aukus-is-about-far-more-than-submarines/> [Accessed 13 May 2022].
5. Allen-Ebrahimian, B., 2020. Report: How democracies can push back on China's growing tech dominance. [online] Axios. Available at: <https://www.axios.com/2020/09/15/china-tech-dominance-democracies> [Accessed 13 May 2022].
6. National Security Commission on Artificial Intelligence. 2021. [ebook] NSCAI. Available at: <https://www.nscai.gov/wp-content/uploads/2021/03/Full-Report-Digital-1.pdf> [Accessed 13 May 2022].
7. Li, D., Tong, t. and Xiao, Y., 2021. Is China Emerging as the Global Leader in AI?. [online] Harvard Business Review. [Accessed 13 May 2022].
8. Curtis, H., 2021. How Australian AI will benefit from AUKUS | The Strategist. [online] The Strategist. Available at: <https://www.aspistrategist.org.au/how-australian-ai-will-benefit-from-aukus/> [Accessed 13 May 2022]. Quantum-Computing.-A-National-Security-Primer.pdf (aei.org)
9. Allen-Ebrahimian, B., 2021. Former Google CEO and others call for US-China tech "bifurcation". [online] Axios. Available at: <https://www.axios.com/2021/01/26/scoop-former-google-ceo-and-others-call-for-us-china-tech-bifurcation> [Accessed 13 May 2022].
10. Finance.yahoo.com. 2020. Yahoo is part of the Yahoo family of brands. [online] Available at: <https://finance.yahoo.com/news/artificial-intelligence-market-size-share-114000180.html> [Accessed 13 May 2022].
11. 2022. The Evolution of Artificial Intelligence. [online] Available at: <https://www.ubs.com/microsites/artificial-intelligence/en/new-dawn.html> [Accessed 13 May 2022].
12. Joshi, N., 2019. 7 Types Of Artificial Intelligence. [online] Forbes. Available at: <https://www.forbes.com/sites/cognitiveworld/2019/06/19/7-types-of-artificial-intelligence/> [Accessed 13 May 2022]. The Three Types of Artificial Intelligence: Understanding AI (interestingengineering.com)
13. Software Testing Help. 2022. 10 Best Artificial Intelligence Software (AI Software Reviews In 2022). [online] Available at: <https://www.softwaretestinghelp.com/artificial-intelligence-software/> [Accessed 13 May 2022].
14. Dilmegani, C., 2022. AI chips: A guide to cost-efficient AI training & inference in 2022. [online] AIMultiple. Available at: <https://research.aimultiple.com/ai-chip/> [Accessed 13 May 2022].
15. Grand View Research, 2022. Artificial Intelligence Market Size, Share & Trends Analysis Report. Grand View Research.
16. Dilmegani, C., 2022. What it is AI as a Service? Complete guide for executives in 2022. [online] AIMultiple. Available at: <https://research.aimultiple.com/aiaas/> [Accessed 13 May 2022].
17. Davies, N., 2021. Index shows US is winning the AI race – but for how long?. [online] Investment Monitor. Available at: <https://www.investmentmonitor.ai/ai/ai-index-us-china-artificial-intelligence> [Accessed 13 May 2022].
18. World Economic Forum, 2020. Transforming Paradigms. A Global AI in Financial Services Survey.
19. Statista. 2018. Global AI startups by country 2018. [online] Available at: <https://www.statista.com/statistics/942657/global-ai-startups-by-country/> [Accessed 13 May 2022].

20. Prnewswire.com. 2022. Artificial Intelligence (AI) Market: 19.84% Y-O-Y Growth Rate in 2021 | By End-user (retail, banking, manufacturing, healthcare, and others) and Geography | Market Size, Share, Trends Analysis, and Segments Forecasts, 2021-2025. [online] [Accessed 13 May 2022].

21. Thomasnet.com. 2022. Top Artificial Intelligence (AI) Software Companies in the United StatesA and Internationally. [online] Available at: <https://www.thomasnet.com/articles/top-suppliers/ai-software-companies/> [Accessed 13 May 2022].

22. Gençer, G., 2022. Top 10 AI Chip-makers of 2022: In-depth Guide. [online] AIMultiple. Available at: <https://research.aimultiple.com/ai-chip-makers/> [Accessed 13 May 2022].

23. KPMG, 2020. Trust In Artificial Intelligence. Australian Insights.

24. Data61 – CSIRO. 2022. Data61 – Home – Data61. [online] Available at: <https://data61.csiro.au/> [Accessed 16 May 2022].

25. Deloitte Access Economics, 2021. ACS Australia's Digital Pulse. Future directions for Australia's Technology workforce.

26. Stanford University: Human Centered Artificial Intelligence, 2021. Artificial Intelligence Index Report.

27. Department of Industry, Science, Energy and Resources. 2021. Australia's Artificial Intelligence Action Plan. [online] Available at: <https://www.industry.gov.au/data-and-publications/australias-artificial-intelligence-action-plan> [Accessed 16 May 2022].

28. Georgescu, I. M., Ashhab, S., & Nori, F. (2014). Quantum simulation. Reviews of Modern Physics, 86(1), 153.

29. National Academies of Sciences, Engineering, and Medicine. 2019. Quantum Computing: Progress and Prospects. Washington, DC: The National Academies Press. https://doi.org/10.17226/25196.

30. Amazon Web Services, Inc. 2022. Quantum Computing Service—Amazon Braket. [online] Available at: <https://aws.amazon.com/braket/> [Accessed 16 May 2022].

31. Microsoft. 2022. What is Azure Quantum? – Azure Quantum. [online] Available at: <https://docs.microsoft.com/en-us/azure/quantum/overview-azure-quantum> [Accessed 16 May 2022].

32. McKinsey & Company, 2021. The Quantum Technology Monitor. Facts and Figures.

33. Bick, M., 2022. Growing Australia's Quantum Technology Industry – CSIRO. [online] CSIRO.au. Available at: <https://www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/CSIRO-futures/Future-Industries/Quantum> [Accessed 16 May 2022].

34. CQC2T. 2022. Centre of Excellence for Quantum Computation Technology. [online] Available at: <https://www.cqc2t.org/about-us/> [Accessed 16 May 2022].

35. Department of Defence. 2018. Australian and US universities to collaborate on defence research. [online] Available at: <https://www.dst.defence.gov.au/news/2018/05/28/australian-and-us-universities-collaborate-defence-research> [Accessed 16 May 2022].

36. The University of Sydney. 2022. Microsoft and University of Sydney forge quantum partnership. [online] Available at: <https://www.sydney.edu.au/news-opinion/news/2017/07/25/microsoft-and-university-of-sydney-forge-quantum-partnership.html> [Accessed 16 May 2022].

37. Davenport, T. and Kalakota, R., 2019. The potential for Artificial Intelligence in healthcare. Future healthcare journal, 6(2), p.94.

38. Donahue, L., 2018. A primer on using artificial intelligence in the legal profession. JOLT Digest.

39. KPMG, 2021. Responsible Quantum: Starting the Conversation. KPMG Australia & Sydney Quantum Academy Discussion Paper.

40. Exploding Topics. 2022. 20 Thriving Robotics Startups (2022). [online] Available at: <https://explodingtopics.com/blog/robotics-startups> [Accessed 11 May 2022].

41. Department of Foreign Affairs and Trade. 2022. Trade in services Australia. [online] Available at: <https://www.dfat.gov.au/about-us/publications/Pages/trade-in-services-australia> [Accessed 16 May 2022].

42. Gartner. 2016. Digital Business Requires a New Lens on How Economic Value Is Created. [online] Available at: <https://www.gartner.com/smarterwithgartner/unlock-digital-business-value-with-digital-economics> [Accessed 10 May 2022].

43. Grand View Research, 2022. US Digital Economy. Market Analysis From 2018 to 2028.

44. IBM. 2022. What is IT Infrastructure?. Available at: <https://www.ibm.com/topics/infrastructure> [Accessed 10 May 2022].

45. Brown, H., 2022. Key Elements in Cloud Infrastructure | Cyclr. [online] Cyclr.com. Available at: <https://cyclr.com/blog/key-elements-in-cloud-infrastructure> [Accessed 10 May 2022].

46. OECD. 2020. [online] Available at: <https://www.oecd.org/competition/digital-disruption-in-banking-and-its-impact-on-competition-2020.pdf> [Accessed 10 May 2022].

47. AlphaBeta, 2019. Australia's Digital Opportunity. Growing a $122 Billion A Year Tech Industry.

48. Australia Bureau of Statistics: Digital activity in the Australian economy, 2021.

49. Australian Government: Digital Economy Strategy – A top 10 Digital Economy and society by 2030, 2022.

50. Digital Transformation. 2020. Rio Tinto. [online] Available at: <https://reports.weforum.org/digital-transformation/rio-tinto/> [Accessed 10 May 2022].

51. World Health Organisation: Global strategy on digital health 2020-2025, 2021.

52. Gleason, N., 2022. The Digital Economy and Learning | OpenMind. [online] OpenMind. Available at: <https://www.bbvaopenmind.com/en/articles/the-digital-economy-and-learning/> [Accessed 10 May 2022].

53. Exploding Topics. 2022. 20 Thriving Robotics Startups (2022). [online] Available at: <https://explodingtopics.com/blog/robotics-startups> [Accessed 11 May 2022].

54. Department of Foreign Affairs and Trade. 2022. Trade in services Australia. [online] Available at: <https://www.dfat.gov.au/about-us/publications/Pages/trade-in-services-australia> [Accessed 16 May 2022].

Contact us

Dr Brendan Rynne
Partner, Chief Economist
KPMG Australia
T: +61 3 9288 5780
E: bjrynne@kpmg.com.au

Doug Ferguson
Head of Asia & International Markets
NSW Chairman
KPMG Australia
E: dougferguson@kpmg.com.au

Dr Merriden Varrall
Director, Geopolitics Hub
KPMG Australia
E: mvarrall@kpmg.com.au

Daniel Bahyl
Senior Manager, Economics
KPMG Australia
E: dbahyl1@kpmg.com.au

April Palmerlee
Chief Executive Officer
AmCham Australia
E: aprilpalmerlee@amcham.com.au

Sara James
National Strategy Director
AmCham Australia
E: sarajames@amcham.com.au

Josh Edwards
Special Projects Officer
AmCham Australia
E: joshedwards@amcham.com.au

KPMG.com.au

July 2022. 876593801PTN.