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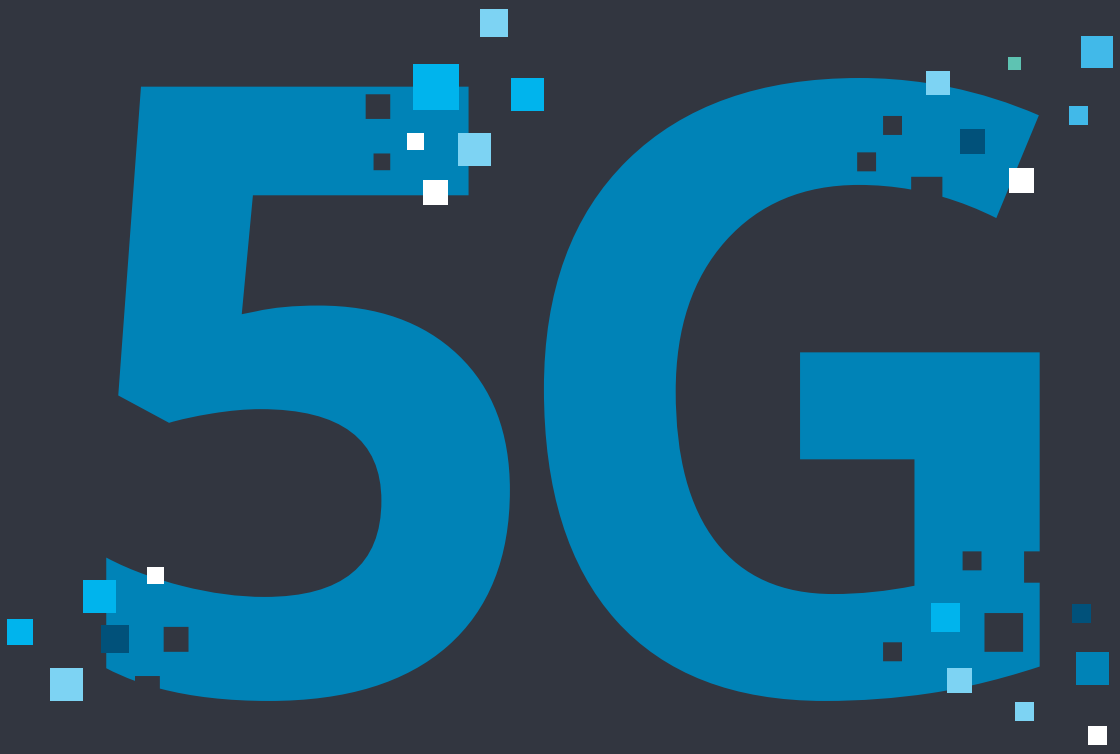
5G Unleashed: Realising the potential of the next generation of mobile technology

Australian Mobile Telecommunications Association

2022

Deloitte Access Economics


5G

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Glossary

Acronym	Full name
ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
ACMA	Australian Communications and Media Authority
AMTA	Australian Mobile Telecommunications Association
ETNO	European Telecommunications Network Operators' Association
GSMA	Global System for Mobile Communications Association
ICT	Information and Communications Technology
IoT	Internet of Things
ITU	International Telecommunications Union
MNO	Mobile Network Operator
M2M	Machine to Machine
NPV	Net Present Value
OBPR	Office of Best Practice Regulation
OTT	Over the Top
WTP	Willingness to Pay

Terminology	Description
Edge computing	Edge computing is a distributed computing paradigm that brings computation and data storage closer to the sources of data. This is expected to improve response times and save bandwidth.
Internet of Things	The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, all collecting and sharing data. The term "IoT device" is often used to refer to physical objects that are connected to the internet to either be controlled or communicate information.
Net Present Value	Net Present Value is the worth of a series of cash flows occurring at different times. NPV accounts for the time value of money.
Over The Top service provider	Over-The-Top (OTT) is a term used to describe when a provider delivers audio, video and other media. Some prominent global examples include Netflix and Facebook.
Smart cities	Smart cities use advanced technologies to help in planning and developing solutions for cities specifically. These initiatives are usually targeted at helping cities cope with increasing density, while optimising the use of resources.
Willingness to Pay	Willingness to Pay is the maximum price at or below which a consumer or business will buy one unit of a product. This corresponds to the standard economic view of a reservation price.

5G is the latest generation of mobile technology and represents a leap forward in fundamental telecommunications and will enable the use of technologies such as AI, IoT, AR/VR, drones, Edge Computing and autonomous vehicles by mainstream businesses.

AUSTRALIA'S 5G CHALLENGE

Australia is currently ranked
3rd in 5G connected devices
per capita, but is at risk of not keeping up and forecast to fall to 9th

Top countries for 5G connected devices per capita

Rank	2022	2025
1	South Korea	Singapore
2	Japan	Japan
3	Australia	.
.		.
.		.
.		.
9		Australia

If Australia is able to maintain its current global leadership, the productivity benefit from 5G would be 40% higher or

$27 billion

added to the Australian economy over the next nine years to 2030, highlighting the importance of leading the 5G technology race

BUSINESS READINESS FOR 5G

Businesses recognise the importance of 5G

71% agree 5G will make Australia **more internationally competitive**

62% agree 5G will **accelerate the growth of their business**

Yet, businesses struggle to take tangible actions to implement 5G

59% have no strategy to realise 5G

30% have no plans to implement 5G

Businesses with a strategy referencing 5G have:

2x the number of advanced use cases such as AI, AR/VR and IoT devices.

Barriers to adopting advanced mobile use cases

28% **not a current priority**

27% **costs are too high**

22% **not relevant for my business**

Lifting business readiness will require more upskilling because many applications are industry-specific such as greenhouse automation for agriculture, remote stock monitoring for manufacturing, monitoring patient outcomes in health care and traffic monitoring in smart cities.

POLICY PRIORITIES TO RECHARGE 5G

To accelerate the rollout and take-up of 5G, the report identifies 11 policy initiatives across three key areas.

Executive summary

Mobile connectivity is fundamental to the Australian economy and society. Australians spend on average three hours every day on devices – connecting with family and friends, accessing services, and working. Connectivity is also important for Australian businesses – for communication, commerce, and digital innovations that power farms, factories, supply chains, offices, clinics, and classrooms across the country.

5G is the latest generation in mobile technology transforming Australia's business landscape. 5G networks deliver faster speeds, better reliability and improved capacity. It enables a range of technologies – such as drones, Internet of Things (IoT), Edge Computing, autonomous vehicles, and virtual reality. At the core of this technology sits a network and devices sector that is continually investing and innovating to enable mobile connectivity.

Australia has been a world leader in mobile telecommunications for decades, with an innovative and competitive sector, an accommodating policy regime and a strong uptake of mobile innovations by Australian households. However, this report finds that Australia's global leadership is at risk in the 5G era of the coming decade. The key risks are modest levels of business readiness for change and a policy regime that needs to be recharged. If Australia can maintain its world-leading position and capitalise on 5G, it will deliver billions in economic and social benefits.

Australia's 5G opportunity

Australia is a world leader in terms of its 5G rollout with three live networks. By the end of 2021, Australia's Mobile Network Operators (MNOs) had already deployed around 4,000 operational 5G base stations and more were added in 2022. Trials of 5G technology are being undertaken by industry and supported by the Australian Government's *5G Innovation Initiative*. Currently, Australia is ranked 3rd in the world in terms of 5G connected devices per capita according to data collected by the Global System for Mobile Communications Association (GSMA) Intelligence.

Yet despite an early lead in rollout terms, Australia's 5G advantage could slip in other areas. GSMA Intelligence forecast suggest that Australia could fall from ranking 3rd to 9th in terms of 5G connected devices per capita by 2025 when compared to 30 other advanced economies. Other countries exploiting the benefits of 5G faster than Australia means that Australian businesses could miss out on potential productivity gains. This report estimates the size of the potential opportunity.

Overall, productivity benefits from 5G are expected to be large. Economic modelling undertaken for this report estimates that 5G will increase Australia's Gross Domestic Product (GDP) by $67 billion in 2022 dollars by 2030. This is similar to previous estimates that have found significant benefits overall and to key industries such as health care, financial services, advanced manufacturing, and consumer entertainment.[i]

The significance of this research is that *accelerating* 5G adoption would also bring a huge economic dividend. Modelling for this report finds that if Australia is able to maintain its current level of global leadership in terms of the adoption rate of 5G devices (compared with the current forecast trajectory) the uplift is worth $27 billion by 2030 (in 2022 dollars).

Technology adoption is an intense race, and the earlier businesses can develop and uncover potential 5G applications, the larger the productivity benefits. Australia can unlock this dividend by lifting business readiness and recharging the policy regime for 5G.

Business readiness for 5G

A critical part of global leadership in 5G is business development and adoption of innovations which depend on the speed, capacity and low latency of 5G networks. Innovations such as drones, edge computing, autonomous vehicles, and augmented reality/virtual reality already exist but will more fully come to life with 5G. These opportunities beg the question: How ready is the Australian business community for the next wave of change that will come from 5G?

Overall, analysis of a range of data and a fresh survey of 400 business leaders finds it's a mixed picture at best. Businesses recognise the importance of 5G for accelerating business growth (62%) but that leaves many who may need more information about what 5G offers. 30% of businesses are not planning to take up 5G-enabled technologies or don't know.

Many businesses (over 40%) have a strategy for using 5G – and those with a strategy were twice as likely to be adopting advanced mobile use cases than those without one. However, a whopping 59% of businesses surveyed had no strategy for exploiting 5G. Australia cannot be a world leader in 5G unless this changes.

Nearly 90% of businesses faced a barrier to adopting advanced mobile use cases. The most commonly cited barriers to using 5G amongst surveyed businesses are a lack of prioritisation (28%), high costs (27%) and a lack of relevance (22%).

The survey reached business leaders in four key industries: agriculture, manufacturing, health care and smart cities; on the basis that 5G will be important for powering the future farm, the future factory, the future clinic and the future city.

Many 5G use cases of interest to business leaders are **industry-specific**, such as greenhouse automation in agriculture, remote monitoring of stock levels in manufacturing, data analytics for patient outcomes in health care and traffic monitoring for smart cities. This is quite different from previous generations of mobile technology where uses were more **economy-wide** (such as mobile connectivity, data, apps etc). This difference helps explain why business leaders will need to do more to educate themselves about 5G and how it can transform their business.

On the same theme, the survey found that some of the highest mobile use cases businesses acknowledged were ones that could already be possibly delivered with 4G technology such as mobile payments (42% of respondents), cyber security (36%) and storing large data sets (31%).

One way to accelerate business use of 5G is to focus on those businesses least ready to adopt 5G and the technology it enables. Based on creating a single index on 5G readiness informed by a range of indicators, we find that businesses in professional services and information, media and telecommunications have the highest levels of industry readiness to 5G.

Many traditional industries including mining, manufacturing, and utilities have similarly high levels of readiness. For instance, manufacturing businesses are using the low latency of 5G to conduct machine repairs through high-quality video streaming. This is compared to other service-based industries (such as retail trade), as well as businesses in agriculture (potentially due to their concentration in regional and remote locations), and construction (which has a high number of small businesses).

Promoting opportunities for businesses in these industries less ready for 5G will be necessary for Australia to remain a global leader in 5G and unlock its potential for the Australian economy.

A recharged policy for 5G in Australia

Australia has a 5G policy framework covering innovation, spectrum and infrastructure. Australia's *5G – Enabling the future economy* strategy, released in late 2017 was one of the world's first. More broadly, the Australian Government's *Digital Economy Strategy 2030* outlines the objective of making Australia a leading digital economy and society by 2030 and recognises that this requires building capabilities in emerging technologies enabled by 5G.[ii]

However, there is also a strong case for recharging the 5G policy framework. Some aspects of the strategies above have not been implemented. There have also been other inquiries recommending change. A 2020 House of Representatives Standing Committee on Communications and the Arts report had 13 recommendations, the *2021 Australian Infrastructure Plan* from Infrastructure Australia included three telecommunications-specific recommendations and the *2021 Regional Telecommunications Review* had a series of recommendations across 12 areas, many of which included regional mobile telecommunications. The task now is to get on with the highest priorities.

The analysis in this report is based on industry data, the business survey and high-level consultations including with MNOs, other industry participants, as well as general industry bodies and key stakeholders.[1] Two things stand out. First is the general need to boost business awareness and take-up of 5G. Second is to address, where appropriate, barriers to investment.

The telecommunications industry has the highest investment rate of all industries in the Australian economy (equivalent to two-thirds of industry value added in 2019-20), higher than 95 other industries. However, returns on continued investment in telecommunications have fallen in recent years. While there are many industry developments behind these changes, fostering sustainable competition to drive investment must be an objective of policy.

Broadly, policies can be considered in two areas:

- **Driving national adoption of 5G:** policies that will support industry, business and government to adopt 5G by increasing awareness and skills and through direct uptake; and
- **Facilitating continued investment in 5G:** policies that support the telecommunications sector to invest in 5G networks through, firstly, spectrum and secondly, infrastructure deployment.

[1] Those consulted included Telstra, Optus, Vodafone, Nokia, Ericsson, the Australian Communications Consumer Action Network (ACCAN), Property Council of Australia, Roads Australia, Australian Local Government Association (ALGA), and NBN Co.

Figure i: Policy initiatives to drive greater adoption of 5G and an unimpeded rollout

Driving national adoption of 5G

- Encourage greater awareness of 5G benefits to Australian businesses and the economy
- All levels of government should assess opportunities for the early adoption of 5G for Government Service Delivery
- Ensure procurement policies for new infrastructure funding require considering the use of 5G applications
- Support 5G education and skills development for both technology workforce and business leaders

Spectrum allocation

- Ensure spectrum allocation is a transparent process harmonised with international standards and at a pace to meet changing demands
- Ensure spectrum is allocated to its Highest Value Use, using clearly identified factors in the determination of the value
- Encouraging refarming and reallocation of existing spectrum to ensure the optimal use

Infrastructure deployment

- Coordinate clear and consistent policy across all communications-related issues at Federal, State and Territory level
- Facilitate reform opportunities outlined in *AMTA's 5G Infrastructure Readiness Assessment* report at the state & territory level, and progressing reforms to Carrier powers and immunities framework
- Government to consider incentives to encourage private investment in 5G services such as new funding arrangements or tax incentives to support greater 5G coverage into regional and remote areas
- Government should consult with industry on the need for further de-regulation with a view to removing out of date and inefficient regulatory requirements across the sector and seek to enable greater co-regulation

Source: GSMA Intelligence (2021), Deloitte Access Economics (2021)

Key points for government

- Australia is a global leader in 5G mobile, but needs to accelerate uptake and investment to maintain its lead on other countries
- If Australia can maintain its current position amongst global leaders, this creates an extra $27 billion in economic benefits to GDP by 2030 by lifting business productivity
- Key 5G policy priorities include driving adoption and facilitating private sector investment through spectrum and infrastructure policy, especially for regional areas

Key points for business

- Most Australian businesses (59%) have no strategy for 5G and 30% have no plans to adopt the technology. According to survey findings, 5G is not a priority, not relevant or costs too much
- Businesses without a 5G strategy risk missing out on benefits from technologies such as drones, Internet of Things (IoT), Edge Computing, autonomous vehicles, and virtual reality
- All business can gain from 5G-enabled technologies and many are industry-specific such as greenhouse automation for agriculture, remote stock monitoring for manufacturing, monitoring patient outcomes in health care and traffic monitoring in smart cities

1. Australia's 5G opportunity

Mobile connectivity is essential to modern life, underpinning communication with friends and family, access to news and entertainment, and an ever-growing list of services and applications. Mobile connectivity is increasingly important for businesses, central to lifting productivity and driving the economy. During the COVID-19 pandemic, 5G and 4G connectivity played a crucial role in Australia's response and enabled flexible working and remote education. As Australia emerges from the COVID-19 pandemic mobile connectivity is sure to be central to the economic and social recovery.

Importance during COVID-19 recovery

As households and businesses shift to being increasingly on the move again, they will rely on mobile connectivity for social purposes, services, and work. Businesses seeking a competitive advantage in the marketplace will invest in mobile technologies to become more efficient, reach more customers, or offer wholly new services.

5G can increase automation and collaboration in supply chains, improving efficiency beyond pre-pandemic levels and building resilience to future disruptions.[iii] This can be done through increasing the use of autonomous vehicles, more transparent inventory tracking and a greater ability to track vehicles. 71% of businesses have stated that they have accelerated digital transformation plans due to the pandemic, and 5G can play a critical role in that transformation.[iv]

To help realise the potential of mobile in Australia's economy and society, the Australian Mobile and Telecommunications Association (AMTA) has worked with Deloitte Access Economics for over 14 years on a series of economic and social impact studies. Since the last edition of *Mobile Nation* in 2019, the rollout of 5G infrastructure is well underway and 5G use cases are being trialled by Australian businesses. In this context, this report estimates the benefits from a faster rollout and uptake of 5G, assesses industry readiness for 5G and identifies the policy and regulatory principles to support and facilitate this.

5G is the latest generation of innovation in the sector, building on the foundation of 4G technology to deliver faster download and upload speeds, better reliability, reduced latency and improved capacity. At the core of this technology sits a network and user devices sector that is continually investing and innovating to enable mobile connectivity.

5G will also facilitate the increasing use of emerging technologies and applications that rely on mobile networks to transmit large volumes of data quickly, reliably and with low latency. This includes technologies such as drones, Internet of Things (IoT), Edge Computing, autonomous vehicles, virtual reality and other technologies that were previously only available in a trial or pilot setting. A mature 5G network offers the possibility of large-scale use of these technologies by mainstream businesses.

Importance of connectivity during natural disasters

Telecommunications plays a vital role during natural disasters as it enables information to be shared between emergency agencies and with the community. The *Royal Commission into National Natural Disaster Arrangements* highlighted the import ance of mobile connectivity during these events and the need for critical infrastructure to support Australia's resilience,[v] where 1,390 facilities were impacted during the 2019-20 bushfire season.[vi] In response, the Australian Government has committed $37.1 million through the Strengthening Telecommunications Against Natural Disasters (STAND) to improve resilience of telecommunications in bushfire and disaster prone areas.[vii] This initiative includes improving connectivity for fire service and evacuation centres, improving regional telecommunications resilience, boosting portable telecommunications capabilities and improving community awareness. In the future, 5G applications have the potential to improve our resilience and recovery from natural disasters as well. For instance, the lower latency, greater connection density and higher transmission speeds enabled by 5G could help improve disaster monitoring and warning systems.

1.1. 5G transforming the Australian economy

The positive impact of 5G technology is already being felt across the Australian economy. With businesses experimenting with 5G use cases and adoption forecast to grow rapidly, the size of this impact will increase significantly over the coming decade. By delivering higher speeds, lower latency and greater coverage, 5G will drive major change in supply chains and logistics, enable new production techniques that will help create jobs, and improve the quality of health care and other services.

Early estimates of the benefits of 5G forecast its adoption could add between $1,300 and $2,000 in additional Gross Domestic Product (GDP) per capita by 2030.[viii] More recent work suggests the adoption of 5G technology in Australia could increase the size of the economy by $70 billion by 2030 in 2022 dollars.[ix]

The benefits for key Australian industries are significant. Over the next nine years, the productivity benefits of 5G are forecast to be $31 billion for health care, $14 billion for smart cities and $7 billion for manufacturing in 2022 dollars.[x] In a separate study, the introduction of digital technologies to agriculture in Australia, many of which are enabled by 5G, would result in an increase of $15 billion to the industry.[xi]

The estimated benefits are based on known applications of 5G and its impact on the economy has been recognised and quantified. However, the full potential of 5G and its value is still largely unknown and its true benefits are unquantifiable as technology continues to evolve and use cases are applied in more complex and advanced ways. For instance, it would have been difficult to forecast the true value of the internet in the 1980s when email communication was first introduced, when now currently more than 60% of the world's population are internet users and more than two thirds use a mobile phone.[xii]

1.2. Australia as a global 5G leader

Australia is among the leading nations in terms of its current adoption of 5G technology (as measured through connections to 5G devices per capita) and 5G rollout (measured through spectrum and infrastructure deployment).

Using data from GSMA Intelligence on 30 countries, we estimate that Australia's adoption of 5G technology currently – as measured by 5G connections per capita – is behind only South Korea and Japan. The current gap is relatively small – Australia would reach the same levels of 5G connections per capita currently in South Korea within just over a year.[2]

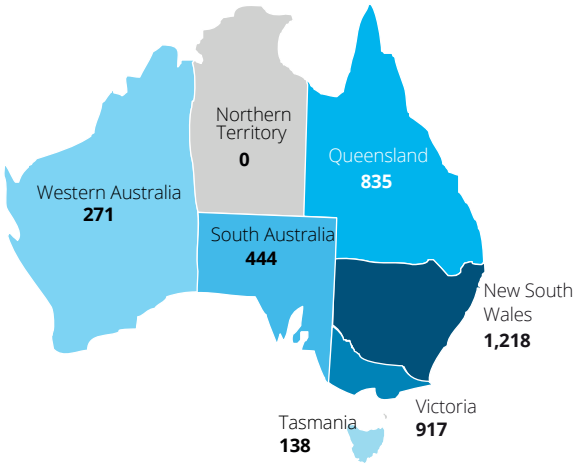
Australia has been described as 'world leading' in terms of the current spectrum allocation for 5G.[xiii] Australia has completed the auction of low, mid and high band spectrum for 5G, including of the 26 GHz mm Wave spectrum band, in 2021 which is key to enabling more advanced 5G technologies.[3] In addition to allocating new bands of spectrum, Australia has also engaged in reallocating existing spectrum, such as the 3.6 GHz spectrum in 2018.

The three Mobile Network Operators (MNOs) had already deployed and activated around 4,000 5G sites by the end of 2021 and more were added in 2022. Australia currently ranks 12th out of the 30 countries considered for telecommunications capital expenditure per capita. Figure 1.1 shows the distribution of 5G network site deployments across the states and territories (in late 2021).

[2] Countries included in the GSMA data used in the analysis for this report: Australia, Austria, Belgium, Canada, Chile, Colombia, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Singapore, Spain, South Korea, Sweden, Switzerland, Turkey, United Kingdom, United States of America.

[3] Spectrum enables many forms of modern telecommunications such as radio, broadcast television and mobile devices – including 5G.

Figure 1.1: Geographical distribution of 5G network site deployments



Source: ACCC (2021)

MNOs have sought to extend coverage of previous mobile generations into regional areas of Australia. However, declining profitability and returns on investment could impact the timing of this rollout and access to 5G in regional areas. The costs of deployment could also increase as the rollout moves from metro areas to regional areas where base stations will be deployed further apart leading to an increase in backhaul costs. The ACCC's *Mobile Infrastructure* Report *2021* recognised that low commercial returns for MNOs discourage building network infrastructure in areas with lower population densities, exacerbating the issue.[xiv] Government assistance to support deployment in regional areas requires careful consideration to ensure equitable outcomes for communities.

More broadly, the telecommunications industry already has the highest investment rate of all industries in the Australian economy. It allocates significant resources to improve existing infrastructure, conduct new research and deploy new technology to the market. In 2019-20, the telecommunications industry invested 65.8% of total industry value added (approximately $19.5 billion).[xv] This investment rate is higher than all of the 95 other industries in the economy – including water supply, sewerage and drainage services (50.9%), electricity supply (47.3%), and agriculture (40.6%).[xvi]

Returns on continued investment in telecommunications have fallen in recent years. The extent and speed of the 5G rollout has had financial impacts for Australia's three major MNOs - Telstra, Optus and TPG. Comms Day analysis has revealed that operating profit for the MNOs over the past four years has decreased 24% while the capital expenditure per year remained constant at $5.4 billion per annum over the same period. This has meant that returns on invested capital have decreased from over 10% to under 5% across the three MNOs. Importantly, this declining rate of return on invested capital is not a COVID-19 related dip, but rather a longer-term trend which could have implications for the sustainability of the continued 5G infrastructure rollout in Australia. The declining profitability and return on investment during the 5G rollout may be the result of multiple factors – including competition amongst MNOs and other telecommunications providers, returns from using the networks going to users such as Over-the-Top (OTT) service providers and the general regulatory environment that the telecommunications sector operates within. Declining profitability and returns on investment will become a bigger issue due to the increasing density of physical infrastructure and the additional spectrum that will be required as the 5G network matures and mainstream businesses adopt more advanced 5G use cases. In this environment, sustainable competition will be key to ensuring future investment.

The industry environment for 5G is also expected to continue to evolve. Some developments are Open RAN, Network Slicing and private networks. Open RAN (Radio Access Network) allows for the separation between hardware and software for MNOs and other telecommunications providers. This could enable greater competition for services in an area with a given amount of physical infrastructure.[xvii] Network slicing enables an MNO to deliver many different capabilities by creating slices that can be tailored for the intended usage. Private 5G networks, similarly to network slicing arrangements, can offer businesses exclusive control over the mobile network so they can customise networks according to their needs and applications.

1.3. Opportunity from maintaining 5G leadership

Despite having early success in the rollout of 5G, Australia is expected to fall behind international peers as other countries accelerate their 5G investment. Forecasts from the GSMA Intelligence suggest that the gap between Australia and the global 5G leader is expected to widen if current trends continue.

By the end of 2025, the gap between the global 5G leader (forecast to be Singapore) and Australia is expected to grow to more than 5 years, from a current gap of 1.2 years behind current leader South Korea. In addition, the number of countries with a greater number of 5G connected devices per capita than Australia will increase from 2 to 8 by the end of 2025 (Table 1.1).

Table 1.1: Top 10 countries for 5G connected devices per capita

	2022	2025
1	South Korea	Singapore
2	Japan	Japan
3	**Australia**	Finland
4	United States of America	South Korea
5	Finland	Germany
6	Singapore	Switzerland
7	Norway	Denmark
8	Switzerland	United States of America
9	Israel	**Australia**
10	Germany	New Zealand

Source: GSMA Intelligence (2021), Deloitte Access Economics (2021)

A similar trend of relative decline in Australia's international leadership of 5G is also evident when examining other metrics of 5G investment and adoption. For instance, while Australia currently ranks 12th out of the 30 countries in terms of telecommunications capital expenditure per capita, by 2025 the GSMA Intelligence forecasts that Australia will be ranked 18th, with capital expenditure per capita declining in real terms. Partly, this could reflect investment cycles, but also must be monitored to ensure sustainable competition to drive investment.

Australia has historically been a global leader for rolling out infrastructure in previous mobile generations. This trend towards the middle of the pack in terms of adoption of 5G technology and declining expenditure threatens this leadership and represents a missed opportunity. While there are geographic and demographic factors, such as population density, which may limit the acceleration of Australia's 5G deployment, improving business awareness and preparation for 5G and the policy and regulatory regime remain key determinants of whether Australia will be able to retain its position as an international leader in 5G. If Australia is able to maintain or improve on its current position, it will receive a significant economic dividend as the benefits to the Australian economy from 5G are brought forward.

1.4. The dividend from continued investment and greater use of 5G

Leaders in the adoption of transformative new technologies receive significant benefits. They can gain a competitive advantage over others with the adoption of productivity enhancing tools and unlock new markets by being among the first to utilise industry transforming technology. Importantly, leaders also bring forward any benefits new technology delivers, which significantly increases their current value.

With the rollout and adoption of 5G expected to bring significant economic benefits, how much could be gained if Australia's rollout is accelerated so that it remains among the 5G leaders?

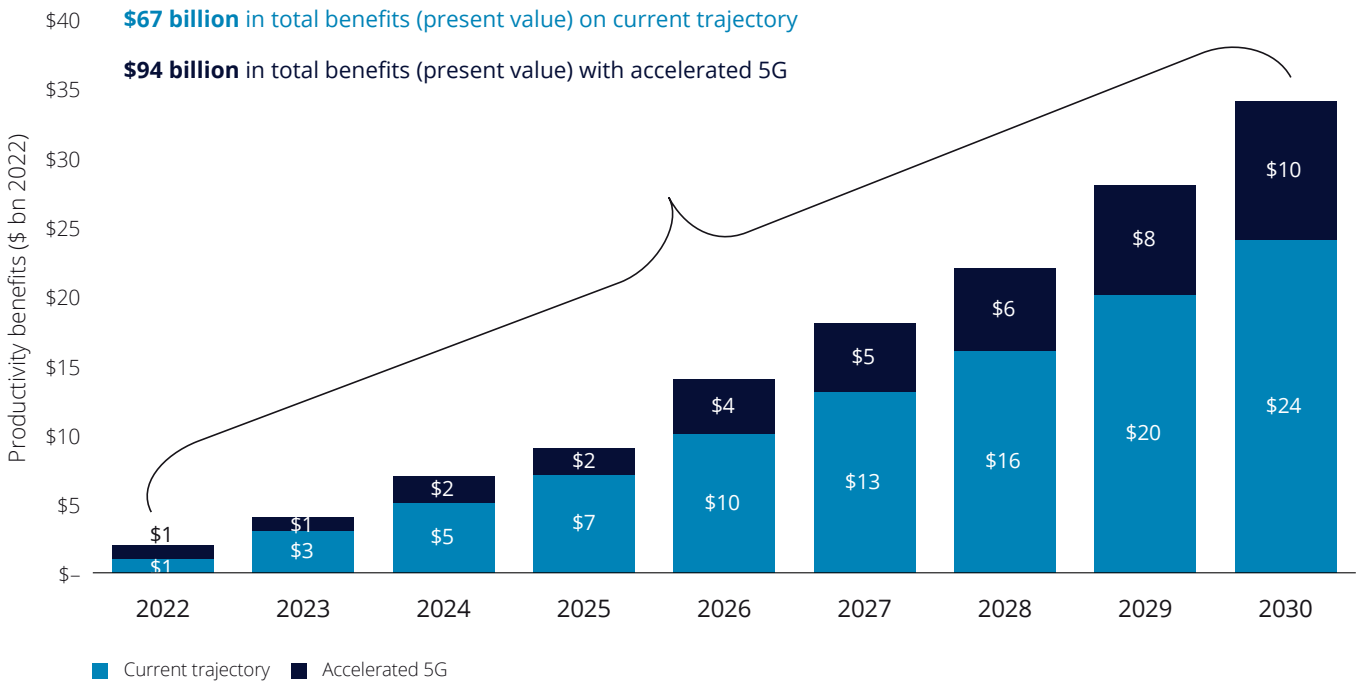
This report estimates the size of the benefits delivered by 5G over the next nine years to 2030, both what we can expect on Australia's cur rent trajectory and the dividend from an accelerated rollout and adoption due to continued investment and greater use of 5G.

We find that on Australia's current 5G trajectory, the adoption of 5G will increase Australia's steady state GDP by $24.1 billion (real GDP, in 2022 dollars) by 2030 and deliver a total economic benefit worth over $66.6 billion (present value terms, in 2022 dollars) over the next nine years.

If Australia were to increase the speed of its 5G adoption to maintain its current position as a global 5G leader, we estimate that the economic impact would be worth $27.2 billion (in 2022 dollars) to the Australian economy over the next nine years. This is relative to the current forecast scenario where Australia's adoption is expected to slow compared with other 5G global leaders. The costs of a slower 5G adoption could also grow even larger over time. If Australia is behind in 2030, it will be harder to catch up and the foregone benefits will continue to accumulate.

Technology adoption is an intense race, and the earlier businesses can develop and see the potential 5G applications, the larger the productivity benefits. Australia can unlock this dividend by lifting business readiness and re-energising the policy regime for 5G.

Chart 1.1: The dividend from continued investment and greater use of 5G



Note: The figures in Chart 1.1 are in real 2022 dollars. They do not add to the total present value benefits because they are first discounted at a rate of 7% per year.
Source: Deloitte Access Economics (2021).

Of course, GDP is only one measure of economic welfare. It does not capture all the benefits that 5G will deliver. For example, it may not capture the social welfare benefits to consumers associated with the convenience and multi-purpose functionality of a 5G connected mobile or 5G enabled IoT devices.

However, even though these estimates only capture the benefits of 5G to the economy, they still highlight the significant dividend that accelerating Australia's 5G rollout and adoption could deliver. For comparison, the previous *Mobile Nation* report forecast that the benefits of all mobile technology (not only 5G) would, between 2005 and 2023, increase Australia's GDP by $65 billion ($70 billion in 2022 dollars).

Other modelling of the benefits of 5G to the Australian economy has estimated that 5G will be worth $70 billion (in 2022 dollars) to the Australian economy over the next 8 years.[xviii]

Achieving the higher economic dividend from continued investment and greater use of 5G relies on both greater business uptake and an improved policy setting to facilitate the development of the network. The next two chapters of this report examine these two considerations, considering first industry readiness for 5G and then policy priorities to support 5G.

When interpreting the modelling results presented in this chapter, it is important to note the assumptions and methodology, that underpins them. To forecast the productivity impacts of 5G, we combined updates of previous DAE econometric modelling with digital industry forecasts to estimate the effect of the take-up of digital technology on GDP. This, combined with GSMA Intelligence mobile and 5G device forecasts, IDC ICT expenditure forecasts, IBISWorld industry revenue data and Cisco's VNI index forecasts, is used to predict the current and future contribution of 5G technology to GDP per capita.

The contribution of 5G technology is computed indirectly as a share of the forecast total digital contribution, based on 5G's share of mobile devices and mobile's share of industry revenue. A more in-depth discussion of model specification, choice of variables and forecast methodology is available in Appendix A.

It is also important to note the limitations of this modelling when interpreting these results. Chiefly, the approach relies on proxies for the entire contribution of digital technologies to GDP per capita, namely mobile cellular penetration, ICT industry revenue, fixed broadband penetration and percentage of the population with internet access. It also relies on proxies for the contribution of mobile technology and 5G to the digital economy.

Environmental benefits of a 5G network and technology

There is recognition that enabling the 5G technology will overtime require a higher density of 5G sites than previous generations of mobile technology. While this may suggest that the energy requirements of mobile telecommunications sector under a 5G mobile network will be higher than previous generations of mobile networks, it will be a more efficient use of energy.

Yet the applications of technology enabled by 5G can more than offset the energy requirements for the mobile network. For example, modelling in the United States of America suggest that 5G could lead to a reduction of 374 metric tonnes of Greenhouse Gas emissions in 2025.[xix] In the United Kingdom, the applications of 5G have been forecast to lead to a reduction of 269 megatons CO_2 emissions by 2035.[xx]

In Queensland, there are currently trials of 5G technology that could have significant environmental benefits. Telstra has deployed 55 IoT enabled weather stations to provide local weather data to farmers in the region which will enable greater crop yields and a less intensive use of natural resources.[xxi]

The mobile telecommunications sector is also exploring ways to develop 5G networks with greater environmental sustainability. The Global Enabling Sustainability Initiative (GeSI) has led to the development of a sector-specific decarbonisation pathway that would be compatible with the *United Nations Framework Convention on Climate Crisis (UNFCCC) Paris Agreement'* and aligned with the IPCC *Special Report*, of which Australia is a signatory.[xxii]

2. Business readiness for 5G

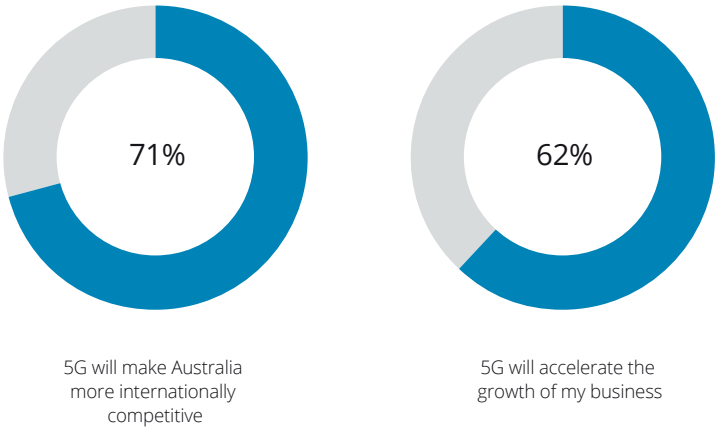
A critical part of global leadership in 5G is business development and adoption of innovations that depend on the speed, capacity and low latency of 5G networks. Innovations such as drones, edge computing, autonomous vehicles, and augmented reality/virtual reality. Which begs the question: How ready is the Australian business community for the next wave of change that will come from 5G?

Overall, analysis of a range of data and a fresh survey of 400 business leaders in four key industries finds it's a mixed picture at best.[4] In general, businesses recognise the importance of 5G for the future of business and many have some level of 5G connectivity. Many businesses can see the potential from a range of 5G use cases. On the other hand, most businesses don't have a strategy to exploit 5G, and some industries that have a lot to gain are the least ready to absorb the new technology. A key conclusion from this chapter is that there is a sizeable job ahead for business leaders across Australia to educate and inform themselves about 5G so they can keep up with or edge out their competitors.

2.1. The race for 5G readiness

In general, business leaders recognise the importance of 5G, with 71% of business respondents agreeing that 5G will make Australia more internationally competitive and 62% agreeing that 5G will accelerate the growth of their business (Chart 2.1). The remaining third may have a very different view on the evolution of the Australian economy or need more information about precisely what 5G means for them.

Chart 2.1: Business perceptions on the impact of 5G

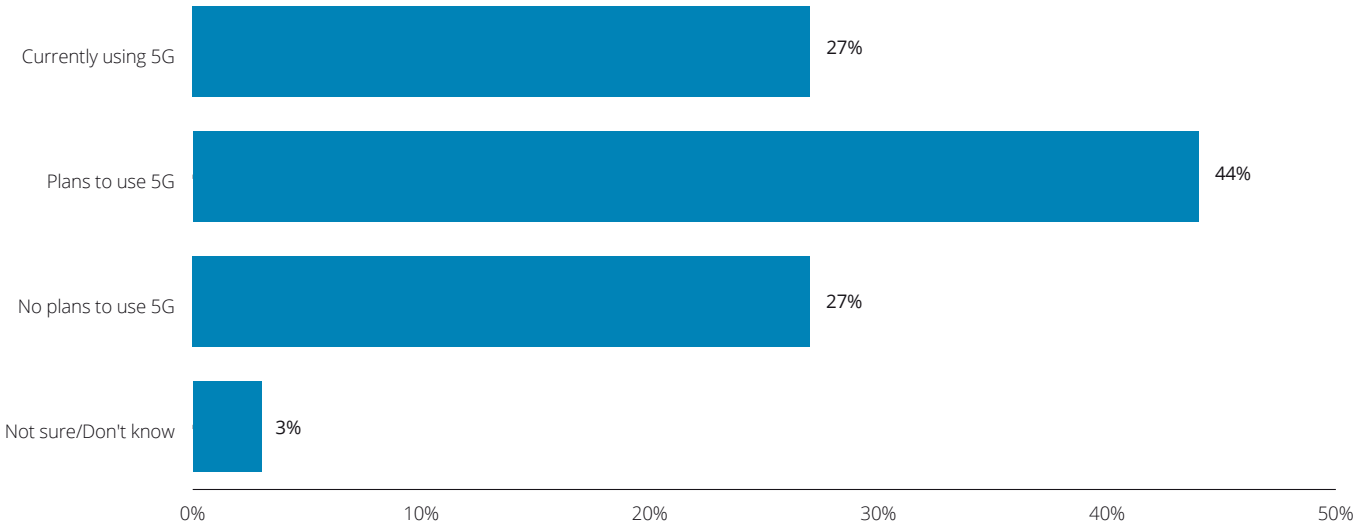


Source: Deloitte Access Economics (2021)

[4] Further detail of the methodology and respondent characteristics can be found in Appendix B.

Ericsson has predicted that 5G will be the fastest deployed mobile communication technology in history.[xxiii] Early evidence supports this, with 5G adoption reaching over a quarter (27%) of surveyed businesses in late 2021 (see Chart 2.2) compared with just 11% in 2019-20 (noting some differences in industries covered). As MNOs have rolled out networks, many businesses have jumped at the opportunity for 5G connectivity.

Chart 2.2: Share of businesses with current and planned 5G connections*



Source: Deloitte Access Economics (2021)
*Note: The responses from surveyed businesses have been weighted by the average size of businesses in the Australian economy.

On the other hand, as was seen in the perspective on the importance of 5G, 30% of businesses are not planning to take up 5G-enabled technologies or don't know. These businesses could face being left behind as businesses that use 5G are able to increase adoption of 5G-enabled technology.

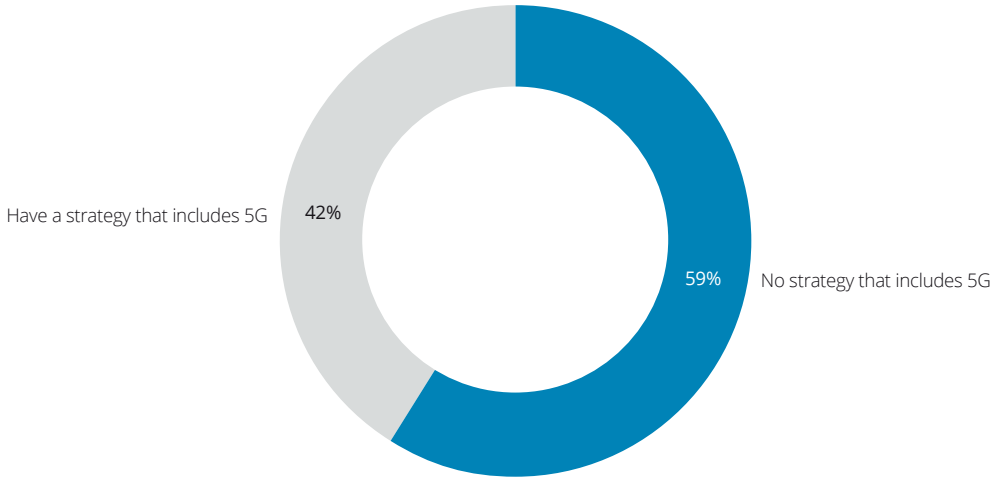
In fact, a divide already exists between 5G connected businesses and those without 5G connections. Surveyed businesses with a 5G connection are currently using twice as many advanced mobile use cases compared to those without one (4 use cases compared to 2).

Understanding the opportunity of 5G in agricultural and small businesses

Our survey results show that businesses in regional or remote locations and small businesses are at risk of being left behind as 5G technology becomes more commonly used by mainstream businesses. Businesses in regional or remote areas are 3 times more likely than businesses in metropolitan areas to have no desire to adopt 5G, with 31% of regional businesses having no plans to use 5G compared to 9% in metropolitan businesses. There are also differences across business sizes, with 27% of businesses with less than 20 employees having no plans to use 5G in the future, while less than 2% of businesses with more than 20 employees have no plans.

Many businesses (42%) have a strategy for using 5G – and those with a strategy were twice as likely to be adopting advanced mobile use cases as those that didn't. However, a whopping 59% of businesses surveyed had no strategy for exploiting 5G. Australia cannot be a world leader in 5G unless this changes.

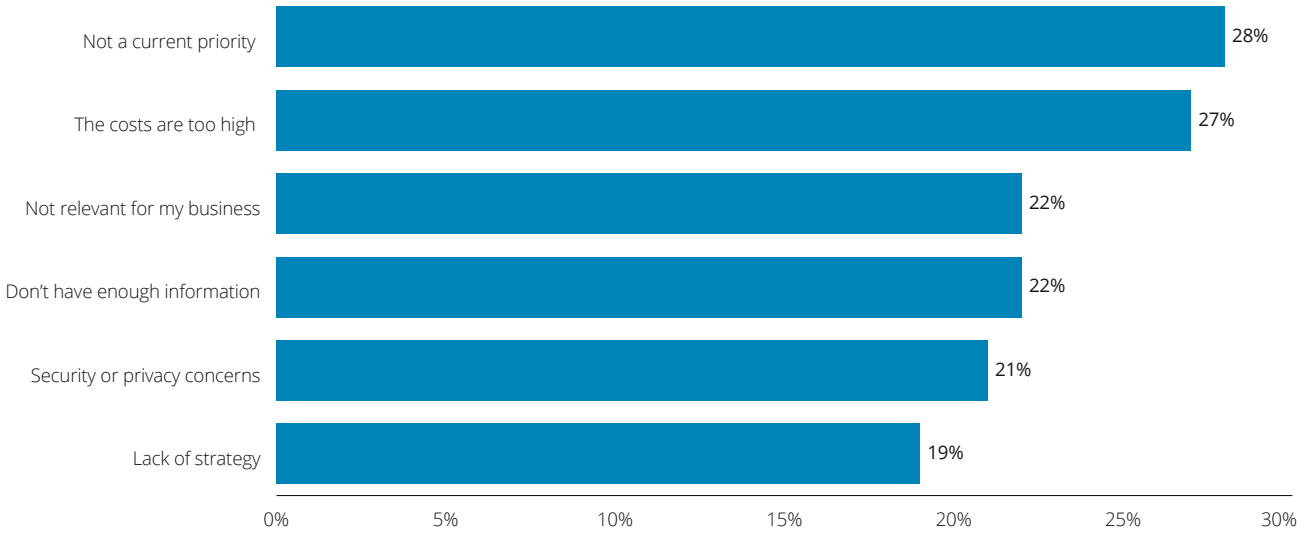
Chart 2.3: Share of businesses with a strategy that includes 5G



Source: Deloitte Access Economics (2021)
Note: Figure may not add up to 100% due to rounding.

Nearly 90% of businesses faced a barrier to adopting advanced mobile use cases. Chart 2.4 shows the most commonly cited barriers to using 5G amongst surveyed businesses are a lack of prioritisation (28%), high costs (27%) and a lack of relevance (22%). **These shared barriers suggests that a greater understanding around the potential of 5G versus the cost of adoption is needed across all priority industries.**

Chart 2.4: Barriers to using advanced mobile use cases



Source: Deloitte Access Economics (2021)

Another potential barrier is workforce skills. A federal Parliament inquiry into the deployment, adoption and application of 5G in Australia noted the need for continuous and adequate training to ensure that businesses have access to the skills to use new technologies and a workforce that is ready and able to transition into new roles will be an important part of Australia's 5G implementation.[xxiv]

The survey reached business leaders in four key industries: agriculture, manufacturing, health care and smart cities; on the basis that 5G will be important for powering the future farm, the future factory, the future clinic and the future city. More detail on each of these industries is presented in this chapter.

Many 5G use cases of interest to business leaders are **industry-specific**, such as greenhouse automation in agriculture, remote monitoring of stock levels in manufacturing, data analytics for patient outcomes in health care and traffic monitoring for smart cities. This is quite different from previous generations of mobile technology where uses were more **economy-wide** (such as mobile connectivity, data, apps etc). This difference helps explain why business leaders will need to do more to educate themselves about 5G and how it can transform their business.

On the same theme, the survey found that some of the highest mobile use cases businesses acknowledged were ones that could already be possibly delivered with 4G technology such as mobile payments (42% of respondents), cyber security (36%) and storing large data sets (31%).

Table 2.1: Most common use cases of 5G technology being prepared or planned for use in the next 12 months

The Future Farm	The Future Factory	The Future Clinic	The Future City
Artificial intelligence/ Machine learning	Sensors and data analytics	Data analytics for predicting patient outcomes	Cyber security
Greenhouse automation	Tracking individual products/ machines	High quality real-time video for emergency services	Remote monitoring of pedestrian traffic, road, congestion, air quality
Remote control of tools and machines	Remote monitoring of stock levels and production assets	High quality real-time video and streaming for health consultations	Smart devices or applications for security purposes
Cyber security	Mass customisation	Virtual and augmented reality for training	Automation (e.g., streetlights)
Automated machine/tools	Factory automation	Sensors and wearables for monitoring patient health	Artificial intelligence/ Machine learning

Source: Deloitte Access Economics (2021)

Spotlight on agriculture

Businesses with 5G connections: 15%

Potential uplift from 5G: $15 billion

Top 5 use cases planned in the next 12 months	• Artificial intelligence/Machine learning • Greenhouse automation • Remote control of tools and machines • Cyber security • Automated machine/tools
Top 3 barriers to adopting advanced mobile use cases	• Not a current priority • Security of privacy concerns • Lack of strategy

Agriculture has the lowest share of businesses currently connected to 5G (15%) compared to other key industries. Geographic location is a key factor influencing this low share with many agricultural businesses located in regional or remote areas of Australia. As a result, many agricultural businesses do not have complete or reliable 3G or 4G mobile coverage, and the ACCC noted the lack of economic feasibility for MNOs in expanding coverage in these areas.

The National Farmers Federation (NFF) has also noted this disparity, and while some farmers are excited about the possibilities of 5G, many are seeking the benefits from basic levels of coverage – such as the ability to make emergency calls in remote locations on a paddock. This perhaps explains why the most common barrier to adopting more advanced mobile use cases was that it was not a current priority.

5G provides significant opportunities for the agriculture industry through its ability to connect with multiple devices or sensors at a larger scale. These technologies will enable automation of routine, manual tasks and increase efficient use of resources. For example, the use of sensor technology to monitor soil moisture is designed to help improve yields while using less water. It is estimated 5G will be able to connect 10 times the number of devices as 4G within a set area (like a farm), significantly increasing the data available to the farmer.[xxv]

Case study: Counting sheep with 5G

Counting livestock is a manual and time-consuming task. Meat and Livestock Australia recognised that manually counting livestock not only represents a labour cost but can reduce revenue due to human errors. Combined, these factors account for an annual loss of $1.9 million for sheep farmers.[xxvi]

Using 5G-enabled technologies to automate the process can mitigate human error as well as save many hours of manual labour per year for Australian farmers and minimise these types of costs.

TPG Telecom, with funding support from the Australian Government's *5G Innovation Initiative*, is currently trialling the use of a 5G network to automatically count sheep at Bendigo Regional Livestock Exchange in Victoria.

5G will enable artificial intelligence-enabled image processing, computer vision and edge computing technologies. These technologies will count the sheep and relay real-time data back to farmers on their tablet or mobile device.

TPG Telecom General Manager Wireless and Transmission Networks, Yago Lopez recognises that this trial is only the start of the journey. Lopez noted that "We look forward to seeing what benefits from this trial can be rolled out across the livestock industry nationally and are looking at other innovation opportunities to ensure 5G supports key industries."

Source: TPG (2021)[xxvii] and Department of Infrastructure, Transport, Regional Development and Communications (2021)[xxviii]

Spotlight on manufacturing

Businesses with 5G connections: 32%

Potential uplift from 5G: $7 billion over the next nine years

Top 5 use cases planned in the next 12 months	• Sensors and data analytics • Location tracking machines and products • Remote monitoring of stock and production assets • Mass customisation • Factory automation
Top 3 barriers to adopting advanced mobile use cases	• Concerns related to compatibility with existing systems and processes • Lack of funding for initiatives • The costs are too high/Lack of strategy

Manufacturing has the second highest share of 5G business connections (32%) out of the four key industries. The focus on promoting advanced manufacturing and the technological capabilities of the industry within Australia has likely contributed to this comparatively higher share.

The Australian Government's *Modern Manufacturing Strategy* noted global supply chain expectations of customisation is becoming the new norm, and Australian manufacturers will develop greater reliance of digital connectivity to remain competitive.[xxix]

To promote advanced mobile use cases in manufacturing, increasing awareness of 5G mobile networks as a critical enabler for future technologies is key. The Ai Group highlighted that, to most Australian manufacturers, 5G remains an abstract concept.

Global manufacturers – such as Ford, Volkswagen, Audi, Konecranes, and Bosch are trialling 5G use cases. Ford is testing the use of 5G through virtual reality, to allow Autonomous Guided Vehicles (AGV) to move component parts across the factory.[xxx]

Developing a greater understanding of how 5G enables current technologies and emerging technologies will be necessary to fast track 5G adoption in Australian manufacturers.

Case study: South Australia's National 5G Industrial Incubation Lab

Nokia, in partnership with the South Australian Government, is developing a National 5G Industrial Incubation Lab with the purpose of delivering three key industry use cases made possible by the network speeds, reduced latency and increased capacity of 5G.

5G networks and connections will utilise camera and scene analytics to detect abnormal data patterns to **improve rail passenger safety**. Real-time data is communicated to drivers so that they can make decisions based in real time. This is the first instance of a 5G application in rail safety in Australia.

The second use case is to leverage 5G-enabled technologies in **airports** to improve repair efficiencies for aircraft. With the 5G-enabled low latency, technicians will be able to perform equipment fixes and maintenance using HoloLens and video cameras to broadcast live video to remote specialised technicians.

The third use case is the use of semi-autonomous drones in **energy management** within a power network. The drones can access assets safely and efficiently with 5G-enabled low latency allowing technicians to observe and control the operation remotely and mitigate safety risks.

These innovations and industry applications are only possible with a 5G network which provides faster network speeds, reduced latency and increased capacity.

Source: Nokia (2021) and South Australian Government (2021)[xxxi]

2.2. Which industries are ready for 5G?

What about more broadly – beyond the key industries of agriculture, manufacturing, health care and smart cities, how ready are Australian industries for 5G?

To answer this question, we constructed a 5G Industry Readiness Index for this report, based on 12 indicators across four pillars – 5G connectivity, workforce skills, technology use and innovation. Details on sources, methodology and detailed results by pillar are provided in Appendix C of the report.

Perhaps not surprisingly, 'white collar' industries were amongst the most prepared. Professional services, IT & media and finance were all in the top five most ready industries, with index scores of 65%, 63% and 59% respectively. Other services industries such as hospitality, retail and real estate were far less prepared with scores of 39%, 41% and 44% respectively. For businesses in the professional services industry, the relatively higher share (15%) of businesses with 5G connections (see Chart 2.6),[xxxii] alongside the high level of workforce skills, are key factors for the overall higher level of readiness compared to other industries.

The most interesting finding is the divide between different non-service industries that are traditionally capital intensive. Some, which have more larger players, like mining, manufacturing and utilities were towards the top of the Readiness Index rankings, with 60%, 59% and 57%.

Mining had relatively high results for the innovation indicators, with 12% of mining businesses spending more than $1 million on innovation expenditure, more than 2.5 times the share of the next highest industry (utilities).[xxxiii]

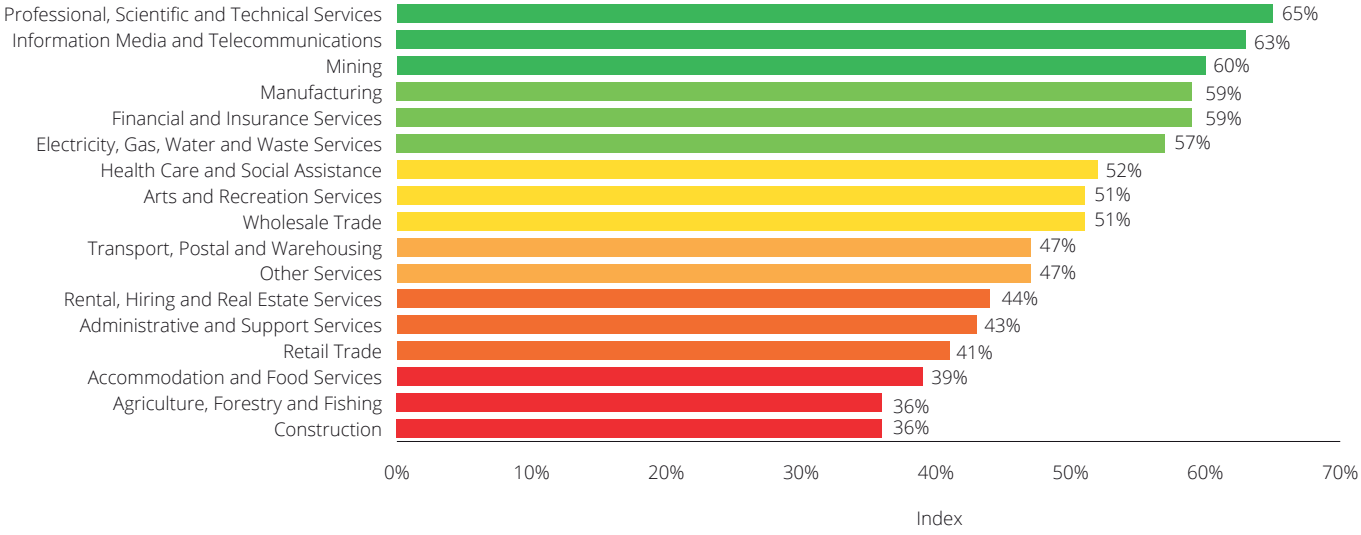
Other traditional sectors – construction and agriculture – recorded the lowest of any readiness scores, both 36%. The relatively lower levels of readiness is partly because they have more small businesses. Mining and utilities businesses have 24 and 15 employees on average respectively while businesses in agriculture have 3 on average.[xxxiv] Another factor may be lower levels of workforce skills and innovation compared to other Australian industries. While construction has relatively higher levels of 5G connections and use of 5G-enabled technology, the comparatively lower levels of innovation and workforce skills indicate that the industry may find unlocking the potential of 5G difficult compared to other industries. For agricultural businesses, the low levels of 5G connections – with only 4% of businesses having a connection – point to difficulty in the mobile network design in regional areas to enable these businesses to benefit from 5G.

While both agriculture and construction have relatively lower levels of 5G readiness, there are substantial opportunities provided by 5G:

- In the construction industry, 5G presents an opportunity to enable operations on a construction site to be conducted remotely and allow teams to survey the foundations of a structure without physically drilling.[xxxv]
- For agricultural businesses, greater use of drone technology provides a non-invasive and time efficient way to monitor and fertilise crops. Use of this technology has been estimated to lead to between $245 to $508 million in terms of reduced farm injuries and fatalities and to increased efficiency and yield for NSW agriculture.[xxxvi]

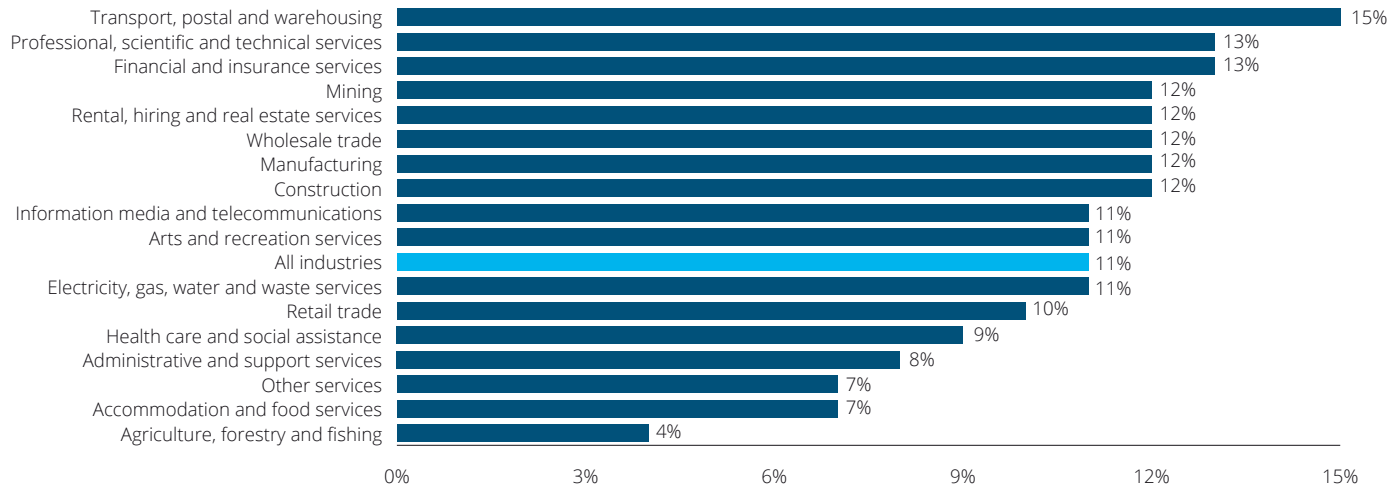
Concerted effort will be required by businesses in these industries to ensure they are able to access the benefits from 5G technology. Chart 2.5 presents the Industry 5G Readiness Index score results by industry.

Chart 2.5: Industry 5G Readiness Index score across all pillars, by industry



Source: Deloitte Access Economics (2021)

Chart 2.6 Share of businesses with 5G connections, by industry, 2019-20



Source: ABS (2021)

Spotlight on health care

Businesses with 5G connections: 30%

Potential uplift from 5G: $31 billion over the next nine years

Top 5 use cases planned in the next 12 months	• Advanced collaboration between medical experts • Data analytics for predicting patient outcomes • High quality video streaming for emergency services/health consultations • Augmented Reality/Virtual Reality for training purposes • Sensors and wearables for monitoring patients
Top 3 barriers to adopting advanced mobile use cases	• It's not relevant for my business • Not a current priority • The costs are too high

Digitisation in health care has been significantly accelerated due to the COVID-19 pandemic, with over half of GP visits being conducted virtually in between March and April 2020.[xxxvii] The Medical Technology Association of Australia (MTAA) has noted this increase in interest in digital connectivity for health care service is part of a long-term trend towards 'connected health care' that has sparked growth in wearable devices and using data analytics and artificial intelligence to predict patient outcomes.

This connected health care will be enhanced through 5G, as the low latency of 5G will, for the first time, provide the real-time access needed for telemedicine and telesurgery, making it possible to treat and operate remotely on patients.[xxxviii] Other health care uses of 5G include smart bandages that track healing and wearables that transmit real-time data to medical professionals.[xxxix]

Yet the MTAA recognises the need to encourage new ways of working to many small health care providers who have established methods of practice. Developing greater awareness of the possibilities of medical technology enabled by 5G – including improved patient comfort and outcomes – will be required to entice greater adoption of 5G-enabled technology in health care.

Use of 5G to eHealth start-ups

Optus' 5G Future Innovations team has been working with international e-Health start-ups to leverage 5G technologies in delivering innovative e-Health solutions.

For example, Spanish start-up, Psious, with the assistance of psychologists is developing mobile based technology to provide a proactive approach to mental health management. 5G allows psychologists to use hyper-realistic virtual environments to treat anxiety disorders through virtual exposure therapy. The mobile platform has expanded their range of applications to effectively treat targeted disorders and phobias.

TrackActive is a platform providing remote physiotherapy to patients. Through the platform, physiotherapy practitioners can stay connected with their patients' progress and provide personalised exercise and rehabilitation programs. Patients can also log program completion and feedback between consultations. With the faster speeds of 5G connection, TrackActive can more easily achieve the priority of staying engaged with clients and can provide fast and effective exercise prescription.

Use of 5G in COVID-19 response

InDro Robotics, Cradlepoint and Ericsson collaborated to test drone delivery as an alternative route for transporting vital medical supplies in Montreal, Canada.

Drone missions have reduced delivery time of vital medical supplies by 90% and allowed for more effective emergency response into remote locations. Extensive trials against paramedic vehicles indicated that delivery via drones saved an average of 7 minutes, which is critical in lifesaving emergency situations.

Source: Optus (2020)[xl] (Ericsson, 2022)

Spotlight on smart cities

Businesses with 5G connections: 33%

Potential uplift from 5G: $14 billion over the next nine years

Top 5 use cases planned in the next 12 months	• Cyber security • Remote monitoring of pedestrian traffic, road congestion, air quality • Smart devices or applications for security purposes • Automation (e.g. street lights) • Artificial intelligence/Machine learning
Top 3 barriers to adopting advanced mobile use cases	• Not a current priority • The costs are too high • It's not relevant for my business

Many businesses are involved in the development of smart cities – including transport, utilities, engineering, and telecommunication services. These businesses have the highest share of 5G connections (33%) of any of the four key industries. This is no surprise as businesses in this industry are increasingly being asked to provide greater digital connectivity, with many using smart devices to improve public safety, the efficient use of resources and on-demand service provision. Examples include smart street lighting, smart irrigation and data insights to monitor public asset use to inform maintenance.

Strategies for smart cities enabled through 5G are being used in fast-growing areas such as the Western Parkland City in Sydney's outer west. The government has released its 5G strategy for the area and allocated $2 million out of the next round of *5G Innovation Initiative* for projects in this area.[xli]

In 2019, Melbourne City developed an Emerging Technology Testbed to explore potential uses for 5G and IoT devices to identify best practice methodologies to unlock the value from this technology. One trial in Argyle Square, a public park, uses sensors and smart devices to measure micro-climate, and motion sensors and pedestrian counters to develop an understanding of where residents spend the most time in the park and their behavioural response to changes in climate.[xlii]

One obstacle facing smart cities is the impact of 5G infrastructure on the amenity of urban street scapes. The Smart Cities Council Australia and New Zealand believe this will be the biggest challenge for the 5G rollout in urban areas and only with proper consideration of potential amenity impacts as well as the possibilities of the technology will cities realise the potential value from 5G.

Improving cyclist safety through 5G

As the number of cyclists on the roads increase, road safety is becoming paramount. Each year, 40 cyclists lose their lives on Australian roads. To help address this issue, Telstra, in partnership with Arenberg, has developed a 5G-connected bike helmet prototype.

Through an in-built speaker, the helmet provides warnings and safety alerts to cyclists. The helmet collects and processes data from the cyclist's surrounding infrastructure and connected cars to provide real-time alerts. These alerts give the rider visibility around corners and on the back of their head. For example, the real-time video from the bike helmet is analysed on a cloud platform, to identify opening door hazards which provides an audio alert to give the rider adequate time to safely react. This technology and other innovations made possible by 5G will play a vital role in improving the safety of Australian roads.

Source: Telstra (2021)[xliii]

3. Policy priorities for 5G

Accelerating 5G in Australia can unlock a huge economic and social dividend. But to get there, Australia will need continued investment by MNOs, greater engagement and readiness from industry, and increased awareness from consumers. Improving policy and regulatory settings alone cannot make Australia a world leader in 5G, but they can help facilitate faster investment and take-up.

Australia's 5G policy framework already exists. The Australian Government released: *5G – Enabling the future economy* – its national 5G strategy in late 2017,[xliv] making Australia one of the first countries to develop a strategy compared to the US and many other European nations.[xlv] The strategy identified the need for timely spectrum allocation and a review of existing telecommunications regulatory arrangements to ensure they are fit-for-purpose. Over time, its limitations have emerged – a lack of allocated government funding for the identified actions and stated objectives in terms of 5G coverage. A 5G working group aimed to look at other sectors and identify impediments to the take-up of 5G. The group identified few impediments and, as highlighted throughout this report, there are clear barriers to the use of 5G and more work is needed.

More broadly, the Australian Government's *Digital Economy Strategy 2030* outlines the objective of making Australia a leading digital economy and society by 2030 and recognises that this requires building capabilities in emerging technologies enabled by 5G.[xlvi] Specifically, the *Digital Economy Strategy 2030* noted the need to support 5G rollout in the next 2 years through the allocation of spectrum in the 26GHz and 850/900 MHz bands via competitive auction, which was completed in April and December 2021 respectively. The *Digital Economy Strategy 2030* also recommends showcasing successful trials for 5G use cases to promote business uptake while noting the need over a 5-year horizon to invest in underlying infrastructure to support the next generation telecommunications technologies, such as future generation technologies.

However, the need to recharge 5G policy is well-recognised. In March 2020, a House of Representatives Standing Committee on Communications and the Arts report, *The Next Gen Future*, Inquiry into the deployment, adoption and application of 5G in Australia, made 13 recommendations, covering spectrum, infrastructure, safety and security, trials, education and awareness. The *2021 Australian Infrastructure Plan* from Infrastructure Australia included 29 recommendations, three of which related to mobile telecommunications. The 2021 Regional Telecommunications Review, *A step change in demand*, had a series of recommendations across 12 areas, many of which included regional mobile telecommunications.

The recommendations are there for government action, the focus should now be on implementation.

This chapter of the report draws out some of the common themes of these reviews and ways in which general objectives can be achieved with specific actions. This analysis is informed by high-level consultations including with MNOs, other industry participants, as well as general industry bodies and key stakeholders.[6] Broadly, the policies can be considered in two areas:

- **Driving national adoption of 5G:** policies that will support industry, business and government to adopt 5G by increasing awareness and skills and through direct uptake; and
- **Facilitating continued investment in 5G:** policies that support the telecommunications sector to invest in 5G networks through, firstly, spectrum and secondly, infrastructure deployment.

[6] Those consulted included Telstra, Optus, Vodafone, Nokia, Ericsson, the Australian Communications Consumer Action Network (ACCAN), Property Council of Australia, Roads Australia, Australian Local Government Association (ALGA), and NBN Co.

3.1. Driving national adoption of 5G

Key actions

- Encourage greater awareness of 5G benefits to Australian businesses and the economy
- All levels of government should assess opportunities for the early adoption of 5G for Government Service Delivery
- Ensure procurement policies for new infrastructure funding requiring considering the use of 5G applications
- Support 5G education and skills development for both technology workforce and business leaders

The government is trying to raise awareness of the benefits of 5G in several ways. The objectives of the *Digital Economy Strategy 2030* were supported by funding in the 2020–21 Budget that included:

- $29.2 million to trial 5G use across industry and improve the management of radiofrequency spectrum.[xlvii] More recently, $1.8 million over two years to invest in systems that allow for a more efficient allocation of spectrum and $5.3 million over two years to update and simplify the digital spectrum licence system.[xlviii]
- $22.1 million to fund the *Australian 5G Innovation Initiative*, which supports the take-up of 5G technologies through a competitive grants process that will help businesses test and develop 5G use cases. In the first of three rounds of funding, 19 projects in key industry sectors received funding.[xlix] In fact, there was significant interest in the program which led to an oversubscription of projects in the first round and the full allocation of the three round program was allocated in the first round, requiring an additional $20 million to be allocated for the second round.[l]

Consultations with industry associations revealed that for many businesses, 5G is an abstract concept that does not translate into tangible investment opportunities or potential business offerings. The *Australian 5G Innovation Initiative* could be expanded, with greater publicity of its impacts. An example of this was the Small Business Digital Champions Project, which involved successful businesses having their experience filmed and showcased to Australia's small business community through online case studies.[li]

Another way to boost 5G use would be for government to assess opportunities for the early adoption of 5G for Government Service Delivery. There are no definitive statistics about 5G use in education and general government contexts, but the Health Care and Social Assistance sector is only about average in terms of use and readiness. If government was a leader in 5G use it would likely have a positive demonstration effect on other industries.

Federal, State and Territory governments – are also in a position to fast-track deployment of 5G through their purchasing and procurement. The Australian Government spent nearly $5 billion on computer services and components for information technology, broadcasting or telecommunications in 2020-21.[lii] This does not include the ICT procurement budgets of state and territory governments. This significant purchasing power represents an important opportunity. The federal, state and territory governments should incentivise, where applicable, the use of 5G-enabled technology to increase the demand for these types of technologies in Australia.

More generally, all levels of government within Australia spend a significant amount on major infrastructure each year,[7] approximately $200 billion in 2021.[liii] A significant share of this spending is for major infrastructure projects. Federal, State and Territory governments should investigate whether procurement could mandate the inclusion of 5G infrastructure or be capable for supporting 5G infrastructure inclusion, to support the rollout in new infrastructure projects.

There is an opportunity to boost education and skills across the economy to support the use of 5G. This is a broad opportunity that extends from business leaders educating themselves about the potential applications of 5G, to reviewing courses in educational institutions so that students come out with relevant knowledge. By 2026, Australia is forecast to need some 1.1 million information and communications technology (ICT) workers, up from 806,000 in 2020. Currently, telecommunications providers report a shortage of professionals with core engineering skills to support 5G.

[7] Defined as gross fixed capital expenditure projects worth $50 million or more.

One of the major challenges with addressing ICT skills shortages is the time lag to training more professionals. By the time actions to encourage more people to study ICT take effect in the labour market, three to four years may have passed. Some telecommunications and digital businesses are partnering with universities to develop micro-credentials in key topic areas like data analytics and product management. There are also an increasing range of short courses that existing professionals can undertake to upskill or reskill in key areas.

The Parliamentary Inquiry[liv] into 5G identified several education and skills actions to promote more widespread adoption by businesses, including:[lv]

- Reviewing current ICT curricula for roles related to 5G in TAFE, training providers and tertiary education to be modified
- Lifting apprenticeships in the ICT sector
- Developing a campaign to boost industry awareness on benefits to business.

Finally, we note that there are some regulatory barriers to 5G use in Australia and that national action to set clear rules for use would be beneficial.[8] Regulations around privacy and cybersecurity could become major issues for technologies that can leverage 5G such as IoT devices and drones. For example, research has found that simplifying the regulations for drone use in an agricultural setting could save the average farmer up to $11,000 in upfront regulatory and training fees as well as other time and cost savings. Overall, this could lead to $500 million in net benefits for the NSW economy by 2041.[lvi] Testbeds for emerging technology, such as Melbourne City's Emerging Technology Testbed, to explore potential uses for 5G and IoT devices offers a good example of government providing the space for businesses and industry to explore the new possibilities created by 5G.

3.2. Spectrum allocation

Key actions

- Ensure spectrum allocation is a transparent and certain process that is harmonised with international standards and at a pace to meet changing demands.
- Ensure spectrum is allocated to its Highest Value Use, using clearly identified factors in the determination of the value
- Encouraging refarming and reallocation of existing spectrum to ensure the optimal use of spectrum.

Spectrum is a valuable economic resource that enables many forms of modern telecommunications such as radio, broadcast television and mobile devices – including 5G. Spectrum must be allocated between these different uses for these technologies to work effectively. The efficiency of allocating spectrum and cost of acquiring it by telecommunication providers is critical for the telecommunications industry to rollout 5G in Australia.

In terms of the current spectrum allocation for 5G enabled by the ACMA, Australia performs relatively well by international standards. Australia – along with the South Korea, Japan and the US – was one of the first countries to auction the 26GHz mm Wave spectrum band in 2021.[lvii] This 26GHz mm Wave spectrum band is important to achieving more advanced 5G use cases. Table 3.1 shows spectrum allocations assigned in Australia and other countries.

[8] The regulatory landscape for the telecommunications industry is discussed below.

Table 3.1: 5G Target bands assigned across countries

	Australia	China	South Korea	Japan	USA	EU
						
5G target bands assigned	850/900 MHz 3.4 GHz** 3.6 GHz 26 GHz 28 GHz	700 MHz 2.6 GHz 3.6 GHz	3.6 GHz 28 GHz	3.6 GHz 3.6 – 4.1 GHz 4.5 GHz 28 GHz	600 MHz 2.5 GHz 3.45–3.55 GHz 3.5–3.7 GHz 3.7–3.98 GHz 24 GHz 28 GHz 39 GHz 47 GHz	900 MHz 3.6 GHz 26 GHz

Source: Department of Infrastructure, Transport, Regional Development and Communications (2021)[lviii] and European 5G Observatory (2021)[lix]

*The 3.4 GHz is an upcoming spectrum allocation that the ACMA have started

*Australia's list does not include previous auctions for spectrum initially used for 5G

**In February 2022, the Minister for Communications, Urban Infrastructure, Cities and the Arts, the Hon Paul Fletcher MP, issued a Ministerial Policy Statement (MPS) for the 3.4-4.0 GHz band, providing guidance to ACMA in its planning and allocation of the band, some of which will be for 5G. The ACMA has commenced its consultations on the re-allocation of that band.

GSMA's *5G Spectrum*: *GSMA Public Policy Position* report highlights that keeping Australia's spectrum allocation aligned with international standards will be important for harmonisation with global networks.[lx] There are benefits to aligning spectrum at an international level, including making it easier to use 5G enabled equipment and compatibility of devices, minimising interference with other countries, leveraging economies of scale and reducing costs of spectrum, and supporting a more competitive economy.

An efficient allocation of spectrum should also seek to maximise its Highest Value Use rather than just commercial returns from auctions. There are clear economic and social benefits from 5G and other uses of spectrum that should be considered when making decisions around spectrum allocation. ACMA provides a clearly identified list of factors in its assessment for spectrum allocation.

Compared with other countries, telecommunications businesses in Australia generally pay similar or higher prices. A 2017 report by GSMA found that across a range of capacity and coverage, reserve and actual prices, the results were median or high.[lxi] It is important that this is consistently monitored because higher prices tends to reduce a country's overall mobile performance.

AMTA's *Policy Position Paper: Spectrum for 5G and Beyond* recommends allocation decisions should provide clarity around how decisions are made through an assessment criteria which is available for all stakeholders. This transparency will provide organisations with greater insight and understanding into the decision-making process.[lxii]

Improving spectrum allocation will be important as the demand increases for spectrum capable of providing 5G services and technology. Analysis undertaken by Coleago, a specialist telecommunications consulting firm, found that in three major Australian cities – Sydney, Melbourne and Brisbane – there is expected demand for mid band spectrum out to 2025-2030 that exceeds what is currently available for telecommunication providers.[lxiii] If additional spectrum is not made available, delivering 5G capabilities will require such high levels of cell site density that it may be too challenging.[lxiv]

This increasing demand for spectrum points to a need to develop a clear long-term strategy for spectrum allocation to facilitate the growing need for 5G capabilities in Australia. The *AMTA Policy Position Paper: Spectrum for 5G and Beyond* identified the need to set a target for an additional 8 GHz in total spectrum for mobile telecommunications use by 2030.[lxv] Where possible, this AMTA policy states that additional spectrum should be contiguous to avoid any fragmentation risk of spectrum that will undermine the usefulness and cost effectiveness of investments by MNOs. AMTA concludes that a statement from the Minister would provide the required direction to establish a consistent policy approach to guide the ACMA's decision making.

Refarming and reallocation of existing spectrum should be encouraged to ensure the optimal use of spectrum. The Australian National Audit Office (ANAO) conducted a review of the spectrum reallocation to support 5G deployment and found the process was largely effective and was informed by international best practice.[lxvi]

There has been some progress in state and territory reforms to enable refarming and reallocation of spectrum. One example is removal of stamp duty on spectrum trades as the majority of states and territories have made transactions for non-real estate business assets, such as spectrum licences, no longer subject to stamp duty. However, Queensland and the Northern Territory continue to tax spectrum trades at rates of 5.45% or more. Continuation of stamp duty in these jurisdictions is a disincentive to spectrum trading, which is important for enabling larger bands of contiguous spectrum to be used by licensees to enhance the performance of 5G services.[lxvii]

3.3. Infrastructure deployment

Key actions

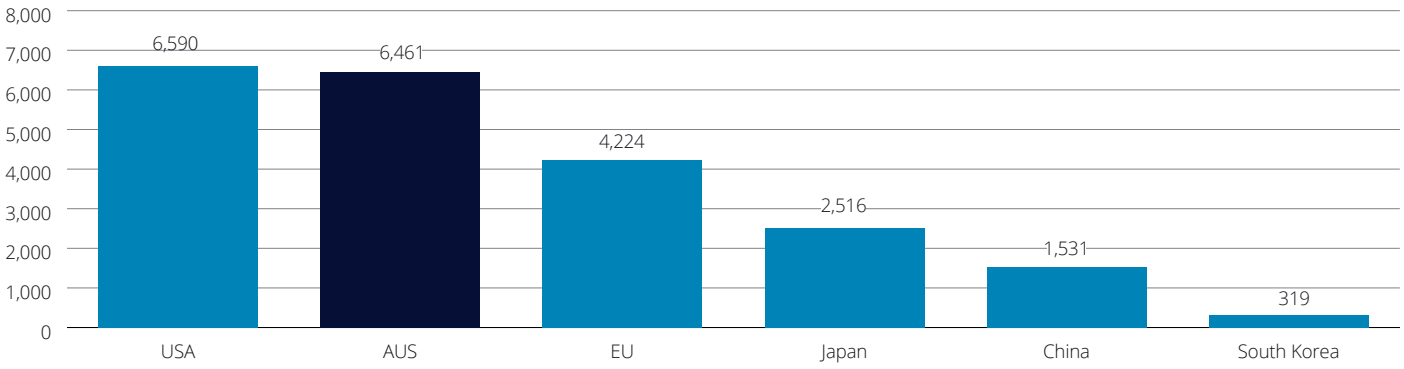
- Coordinate clear and consistent policy across all communications-related issues at Federal, State and Territory level
- Facilitate reform opportunities outlined in *AMTA's 5G Infrastructure Readiness Assessment* report at the State and Territory level, and progressing reforms to Carrier powers and immunities framework
- Government to consider incentives to encourage private investment in 5G services such as new funding arrangements or tax incentives to support greater 5G coverage into regional and remote areas
- Government should consult with industry on the need for further de-regulation with a view to remove out of date and inefficient regulatory requirements across the sector and seek to enable greater co-regulation

The Australian Government could play a more active **coordinating role** in promoting clear and consistent policy for 5G deployment across Federal, State and Territory levels. The Department of Infrastructure, Transport, Regional Development and Communications could bring together the perspectives of federal agencies such as the ACCC and the ACMA, state and territory government, industry associations, property and digital sector interests, and Non-Government Organisations (NGOs) to help achieve greater coherence to infrastructure deployment.

Avoiding unnecessary delays in planning approvals will be critical to realising the benefits from a faster rollout of 5G infrastructure. For instance, inconsistent requirements across LGAs can make it challenging to develop national networks. At the same time, these planning approvals exist to ensure that developments – including infrastructure required by utilities – meet community expectations about the impact of development on local amenity.

Australia has already deployed significant 5G infrastructure, with around 4,000 5G base stations operational in 2021 and more were added in 2022. Australia is among leading economies in this regard. One measure is the number of people per 5G base station. The fewer people covered by a single base station indicates a higher level of 5G capabilities for those covered. In Australia, there are approximately 6,461 people per 5G base station which is similar to 6,590 in the US, but higher than 5G world leaders such as Japan, China and South Korea. As we move towards 5G network maturity, we can expect movement towards fewer people being covered per site to ensure full 5G capabilities.

Chart 3.2: People per 5G base station, by country



Source: ACCC (2021), and the European 5G Observatory (2021)[lxviii]

Some of the new sites will fall under regulation by the *Telecommunications (Low-Impact Facilities) Determination 2018*. The Determination means that telecommunication providers are exempt from seeking local government approval when their planned facilities and activities are unlikely to cause community disruption or significant environmental disturbances. Yet, there will be a significant proportion of 5G sites that will require MNOs to navigate planning arrangements at the state and local government level. The planning requirements for the state and local government level can be categorised into the following scenarios:

01. When facilities meet performance requirements of state/territory code, regulations and planning regulations. This means MNOs do not face a full assessment of the proposed site under planning legislation. An example is in Victoria where a code of practice was developed for telecommunications facilities in Victoria.
02. Development approval required, which includes a detailed assessment against planning policy and criteria. This is generally in accordance with state/territory planning legislation, and any council requirements.

AMTA's 5G Infrastructure Readiness Assessment report identified reform opportunities for 5G infrastructure deployment in every state and territory in Australia.[lxix] For example, one reform opportunity for Queensland was the need for state-wide consistency in the form of a Telecommunications Code (like in New South Wales & Victoria). Similarly, several States and Territories could significantly benefit from the development of a Master Agreement including terms for the leasing of Crown Land to carriers to establish infrastructure.

Delivering quality and reliable connection to **regional and rural Australians** continues to be a challenge. The ACCC's *Mobile Infrastructure Report 2021* recognised that low commercial returns for MNOs discourage building network infrastructure in areas with lower population densities.[lxx] In fact, the report revealed that 12% of 5G sites are located in regional or remote areas of Australia which make up 28% of Australia's population. This compares to 88% of 5G sites being located in major cities.[lxxi] Because of the economics of the infrastructure rollout major cities benefit earlier than regional areas.

Co-contribution programs – such as the Regional Connectivity Program (RCP) – offer incentives for MNOs and others to invest in regional and remote areas where there is either inadequate or no mobile coverage (or other digital issues).[lxxii] The RCP has been used to offer incentives for 5G rollout as well. If the level of support or incentives for 5G was expanded through the RCP, the roll out of 5G infrastructure in regional and remote areas could be fast-tracked. A previous program with similar objectives to the RCP was the Mobile Blackspot Program. The ACCC has suggested that setting clear objectives for improving coverage, and promoting competition, for such programs will help maximise benefits for consumers and communities.[lxxiii]

To support greater 5G coverage in regional and rural areas beyond the existing footprint, government can provide incentives to encourage private investment services such as through new funding arrangements and tax breaks. Other countries have set clear goals and funding for 5G deployment in their national strategies. For example, the UK strategy launched in 2017 included £200 million to fund local projects to test ways to accelerate market delivery of 5G and £400 million allocated to establish a new *Digital Infrastructure Investment Fund* alongside matched Industry co-investment.[lxxiv]

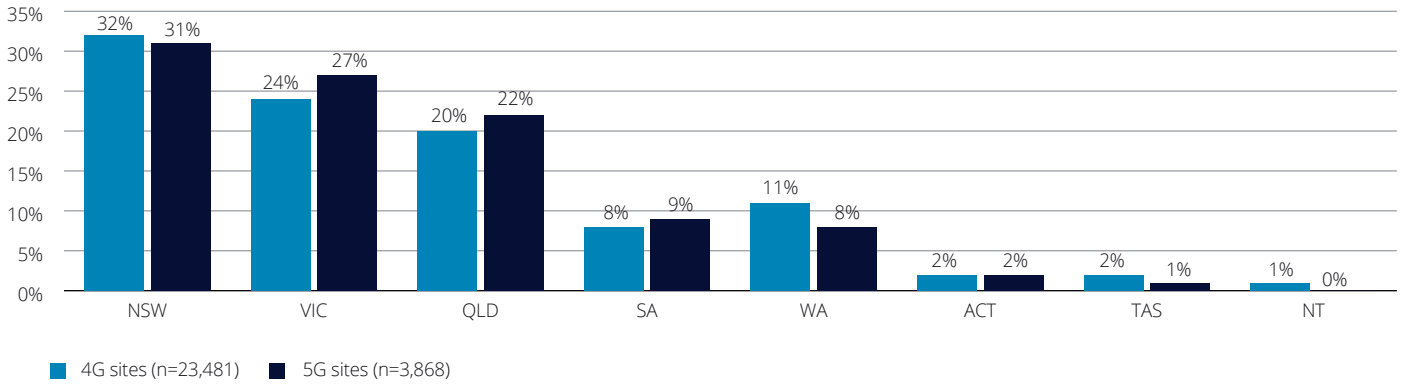
Table 3.2: Policy initiatives of benchmark countries

Country	Key policy initiatives
Singapore	• Aims for 100% 5G coverage by 2025 • $57 million AUD set aside for strategic 5G trials • Created 5G training programs at two major universities
Japan	• To apply for spectrum license, applicants must plan for 50% national coverage in all prefectures • Aims to have 98% of 5G coverage by 2024 • 15% tax break to companies investing in 5G technology
Finland	• Combined deployment and construction permits to streamline application process • 150% tax deduction for joint R&D projects • Multibillion-dollar 5G initiative to encourage the export of 5G technologies, run by the publicly funded Business Finland. Projects include: the development of a test network and business innovation competitions
South Korea	• Target to cover 70% of the country by 2025 • Tax credits for MNOs to rollout 5G
Germany	• Aims to have at least 98% of households with 100Mbit/s downloads and 1,000 5G base stations by the end of 2022 • Goal to cover all major transport routes by 2024 • Encouraged diversity of the supply chain through open-interface technologies
United Kingdom	• Goal to provide the majority of the population with 5G by 2027 • Established a national telecoms lab for joint research between suppliers • $57 million AUD competition to develop open interface 5G technologies

Source: CMS (2021) and Deloitte Access Economics (2022)

While regional and rural coverage is an ongoing challenge, we note the geographic distribution of 5G sites across states and territories closely follows population share and is relatively equal across jurisdictions (except for Northern Territory, which has none). Chart 3.3 shows that Victoria has a slightly higher share of 5G sites compared to its share of the 4G infrastructure, and some other states like Western Australia have a slightly lower share of 5G sites relative to their share of 4G sites.

Chart 3.3: Share of 4G and 5G sites by state and territory, 2021



Source: ACCC (2021)

Regulation is a key feature in all industries in Australia and the telecommunications industry is no different. Well-designed and critically considered policies can safeguard consumers and provide security for providers and businesses to encourage a take-up of 5G. The Office of Best Practice Regulation (OBPR) has recognised that the Australian Government's approach seeks to ensure that "Where regulation is demonstrated to be necessary, policy makers must seek practical solutions and ensure that they are well-designed, well-targeted and fit-for-purpose."[lxxv]

The key challenge is to deliver regulation that is effective in addressing an identified problem and efficient in terms of maximising the benefits to the community. An analysis by an AMTA member estimates that telecommunications carriers are subject to more than 300 regulations and need to engage with more than 20 regulators nationwide. Nationally inconsistent regulations can impede the rollout of 5G technology in Australia. While the mobile telecommunications sector is subject to a variety of forms of regulation, the specific regulatory environment for 5G begins with spectrum allocation and extends to physical infrastructure all the way through to mobile technology and services enabled by 5G. In addition, there are benefits to strong competition in the telecommunications sector without a need of unnecessary interventions.

There are several opportunities to improve regulatory approach. One is to expand the use of co-regulation with industry. Another is to constantly review the need for regulation in the sector, with a focus on removing out of date, inefficient and costly regulatory requirements across the sector. Consultation with the telecommunications industry should take place to prioritise which legislation is most in need of reform. This could include areas such as powers and immunities from state and territory laws in Schedule 3 of the *Telecommunications Act*. Another area is Universal Service Obligation regulations. A finding of the 2021 Regional Telecommunications Independent Review Committee (RTIRC) was that there is an urgent need to consider the future of the USO and recommended reform arrangements.

Appendix

Appendix A: Productivity modelling

A.1. Theoretical modelling framework

This report follows previous Deloitte Access Economics and OECD research in taking a panel approach to identify the growth effects of digital technology, mobile and 5G, controlling for policy and institutional influences. The econometric methods employed largely follow the approach of Qu, Simes and O'Mahony (2016), and Bassanini, Scarpetta and Hemmings (2001).[lxxvi]

The modelling approach adheres to previous research with some changes to the main variable of interest. The underlying framework is based on a human-capital augmented Solow-Swan model where output at time t is given by:

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} \big(A(t)L(t)\big)^{1-\alpha-\beta}$$

Y,K,H and *L* are respectively output, physical capital, human capital and labour, α and β are the partial elasticities of output with respect to physical capital and human capital, and *A(t)* is a composite measure of technical progress *Ω(t)* and economic efficiency *I(t)*:

$$A(t) = I(t)\Omega(t)$$

Economic efficiency includes a range of 'enabling services', $V_j(t)$, such as advertising, trade, transport and logistics, professional and support services, and innovation. These enabling services provide support to firms at all stages of production. In addition to measures of digital technology, controls are included for each market's urbanisation rate, research and development expenditure and trade exposure, all three of which are widely recognised as key determinants of economic efficiency. Other technological progress, *Ω(t)*, is assumed to be exogenous and to grow at a rate *g(t)*.

The following equations can be used to describe the time paths of the various factors of production over time.

$$\dot{k}(t) = s_k(t)A(t)^{1-\alpha-\beta}k(t)^{\alpha}h(t)^{\beta} - \big(n(t) + d + g(t)\big)k(t)$$

$$\dot{h}(t) = s_h(t)A(t)^{1-\alpha-\beta}k(t)^{\alpha}h(t)^{\beta} - \big(n(t) + d + g(t)\big)k(t)$$

$$\dot{A}(t) = g(t)A(t) = g(t)I(t)\Omega(t)$$

$$\ln I(t) = p_0 + \sum_j p_j \ln V_j(t)$$

$$\dot{\Omega}(t) = g(t)\Omega(t)$$

$$\dot{L}(t) = n(t)L(t)$$

Where *y=Y/L* and *k=K/L* are output and physical capital in intensive terms, *h=H/L* stands for average human capital, s_k and s_h are the investment rate in physical and human capital respectively, n*(t)* is the growth rate of labour, *g(t)* is the rate of technological change and *d* is the common (time-invariant) depreciation rate.

Under the assumption that α+ β< 1 (decreasing returns to scale in human and physical capital), this system of equations can be solved to obtain steady-state values of *k** and *h** defined by:

$$\ln k^*(t) = \ln A(t) + \frac{1-\beta}{1-\alpha-\beta}\ln s_k(t) + \frac{\beta}{1-\alpha-\beta}\ln s_h(t) - \frac{1}{1-\alpha} ln\big(n(t) + d + g(t)\big)$$

$$\ln h^*(t) = \ln A(t) + \frac{\alpha}{1-\alpha-\beta}\ln s_k(t) + \frac{1-\alpha}{1-\alpha-\beta}\ln s_h(t) - \frac{1}{1-\alpha} ln\big(n(t) + d + g(t)\big)$$

These steady-state values of physical and human capital can used to express the steady state output per capita as:

$$\ln y^*(t) = \ln A(t) + \frac{\alpha}{1-\alpha}\ln s_k(t) + \frac{\beta}{1-\alpha}\ln h^*(t) - \frac{\alpha}{1-\alpha}\ln\big(g(t) + d + n(t)\big)$$

Steady state human capital, *h**, is unobservable, but it can be expressed as a function of the actual level of human capital, *h(t)*.

$$\ln h^*(t) = \ln h(t) + \frac{1-\psi}{\psi}\Delta \ln\left(\frac{h(t)}{A(t)}\right)$$

Substituting this into the previous expression for steady state output per capita yields:

$$\ln y^*(t) = \ln A(t) + \frac{\alpha}{1-\alpha}\ln s_k(t) + \frac{\beta}{1-\alpha}\left(\ln h(t) + \frac{1-\psi}{\psi}\Delta \ln\left(\frac{h(t)}{A(t)}\right)\right) - \frac{\alpha}{1-\alpha}\ln\big(g(t) + d + n(t)\big)$$

Adding convergence dynamics and expanding the productivity term A(t) yields the transitional equation for output per capita.

$$\Delta \ln y(t) = -\phi\left(\ln y(t-1) - \frac{\alpha}{1-\alpha}\ln s_k(t) - \frac{\beta}{1-\alpha}\ln h(t) + \frac{\alpha}{1-\alpha}\ln(g(t) + n(t) + d) - g(t)t - \ln A(0)\right) + \frac{1-\psi}{\psi}\frac{\beta}{1-\alpha}\Delta \ln h(t) + \left(1 - \frac{\phi}{\psi}\right)g(t)$$

This last equation represents the functional form that was empirically estimated in this report. The coefficient estimate Φ represents the convergence parameter, which reflects the speed at which countries converge to their new steady-state output.

A.1.1. Theoretical limitations

It is important to recognise that under the conditional convergence model used in this paper, various forms of capital as well as policies and institutions are assumed to have a permanent impact on cross-market differences in GDP per capita levels but only temporary effects on growth rates. This means the observed growth in output in any given period, abstracting from cyclical fluctuations, is a combination of three different forces:

- Exogenous growth in other technological progress.
- A convergence process towards the steady-state path of output per capita.
- Shifts in steady state output per capita that arise from changes in policies and institutions, productivity enhancing services, as well as capital investment rates and changes in population growth rates.

It should also be noted that the framework is derived under the assumption of equilibrium employment and hence that variations in the intensity of labour utilisation are not explicitly taken into account.

A.2. Empirical approach

In this report we have used a standard growth equation from the human-capital augmented Solow-Swan model. When empirically estimating this equation, some simplifications can be made. Specifically, to the extent that *g(t)* is not observable, it cannot be empirically distinguished from the constant term. Thus, the estimated growth equation can be re-written as:

$$\Delta \ln y_{i,t} = -\phi_i\left(\ln y_{i,t-1} - \theta_1 \ln s^k_{i,t} - \theta_2 \ln h_{i,t} + \theta_3 n_{i,t} - a_1 t + \sum_j p_j \ln V_{j,t} - \theta_{0,i}\right) + a_2\,\Delta \ln h(t) + \epsilon_{i,t}$$

This form effectively represents an error-correction model where θ_1 represents the long-run elasticity of steady state GDP per-capita with respect to changes in the rate of capital accumulation, θ_2 the long-run elasticity of steady state GDP per-capita with respect to changes in observed human capital and p_j the long-run elasticity of steady state GDP per-capita with respect to changes in productivity enhancing policy variable $V_{j,t}$.

To estimate this equation the empirical work in this report employs a pooled mean-group (PMG) estimator. The PMG approach provides an effective middle ground between imposing homogeneity on all slope coefficients when using a dynamic fixed effect estimator (DFE), and the imposition of no restrictions when using a mean group estimation approach (MG).[lxxvii] The validity of DFE depends on the assumptions of common technology and convergence parameters that in turn require both common technological change and population growth across countries. These are very strong assumptions which almost certainly do not hold empirically. On the other hand, the MG estimator is consistent, but the number of parameters required to be estimated is so large it makes it implausible for use in cases such as ours with relatively short panels for some countries (small T) and with many independent variables. Given the significant drawbacks both DFE and MG estimators have in situations such as ours the PMG estimator is the best available approach.

It is worth noting the PMG approach is not without its limitations. Chiefly, PMG still requires the estimation of a large number of parameters, which can cause likelihood convergence issues and estimates sensitive to model specification changes.[lxxviii] In practice, this means that controlling for a large number of policy and institutional variables can be difficult. To help avoid this problem we take a parsimonious approach to the controls we include in our estimates and then check that our results are consistent across other specifications with different combinations of control variables.

A.2.1. Digital index motivation

In order to estimate the productivity benefits of digital technology, we have employed an index approach to capture the effect of multiple digital variables. This decision was motived by theoretical and empirical reasons. Theoretically, it is difficult to separate the effect of different digital technologies as there is often significant crossovers between them. For example, mobile internet dongles use the mobile network on PCs and other devices that would usually be considered to be part of the fixed network. Estimating the combined impact of multiple technologies partly captures this integration. Empirically, an index of digital variables also accounts for the limitations of the PMG estimator, through the ability to simultaneously control for, and measure, the impact of several digital variables. Including multiple explanatory variables of interest in the same model often results in convergence problems or estimates highly sensitive to model specification changes. The index of digital variables measures the contribution of the entire digital industry and does so in a more robust manner.

A.2.2. Index methodology

The methodology underlying the creation of the digital index in this report is based on the ICT Development Index (IDI) developed by the International Telecommunications Union (ITU). To capture the effect of digital technology on productivity growth, we use a combination of four measures of digital technology adoption: mobile phone penetration, the percentage of individuals with access to the internet, real ICT spending as a percentage of GDP and fixed broadband penetration. It is important to note that these variables do not provide a perfect measure of changes in digital technology adoption and use. However, in the absence of reliable data that could reflect these underlying changes in technology over a sufficient time period, these variables serve as a good starting point to measure the impact of digital technologies.

In order to combine the four variables into a single index, each is first normalized and then combined using the following weights (Table A.1).

Table A.1: Index weights

Parameters	Direct
Fixed-broadband internet subscriptions per 100 inhabitants	0.25
Percentage of individuals using the internet	0.25
Mobile-cellular telephone subscriptions per 100 inhabitants	0.25
Real ICT spending % GDP	0.25

A.3. Data and modelling results

The modelling in this report uses a sample of 31 countries with data drawn from the period between 2006 and 2019. Where appropriate, data is converted to constant Purchasing Power Parity US dollars, consistent with OECD standards.

Table A.2: Market list

Market list			
Australia	Finland	Italy	South Africa
Austria	France	Netherlands	Spain
Belgium	Germany	Norway	Sweden
Canada	Greece	Poland	Switzerland
Chile	Hungary	Portugal	United Kingdom
Denmark	Ireland	Slovak Republic	United States
Estonia	Israel	Slovenia	

Table A.3 outlines the variables used in the econometric modelling. In addition to controls for primary factors of production such as physical capital accumulation, the stock of human capital and population growth, the model also takes into account the contribution of other productivity enhancing factors, such as a market's degree of trade openness, R&D expenditure and urbanisation.

Table A.3: Data sources

Parameter	Variable	Source
y_t	Gross domestic product per capita	OECD
$h(t)$	Human capital (avg. years of schooling)	Worldbank
$n(t)$	Total population growth	OECD
$s_k(t)$	Gross capital formation (% of GDP)	Worldbank
V_1	Urbanisation (% of population in urban areas)	Worldbank
V_2	Exports and imports of goods and services (% of GDP)	Worldbank
V_3	R&D expenditure (% of GDP)	Worldbank
V_4	Index of digital variables	ITU, Worldbank & IDC Technologies

Table A.4 presents the estimated long run coefficients for the effect of digital technology and other controls on steady state GDP per capita. Importantly, the results suggest that the impact of digital technologies on output per capita is substantial, along with the effect of trade exposure (imports and exports), gross capital formation and increases in human capital. Interestingly, urbanisation does not have a statistically significant effect on GDP per capita, although this may be partly due to the lack of variation overtime in the sample of highly urbanised nations used in this analysis. The negative relationship between R&D expenditure and GDP per capita is also somewhat surprising, although this result mirrors the findings of Qu et al. (2016) and Bassanini et al. (2001), who suggest that such a result may represent the effects of public R&D expenditure crowding out private investment.[lxxix] R&D expenditure may also be a lagging indicator, such that annual changes in R&D expenditure are not reflected in changes in GDP per capita. Given the significance of the estimated effect of R&D expenditure and the fact that the digital productivity results are robust to alternate specifications which do not include a control for R&D expenditure, this model remains our most preferred option.

Table A.3: Results

Parameter	Variable	Source
Long-run coefficients		
ln *h(t)*	Human capital (avg. years of schooling)	0.523(***) (5.08)
ln *n(t)*	Total population growth	-0.504* (-2.01)
ln $s_k(t)$	Gross capital formation (% of GDP)	0.388*** (15.80)
ln V_1	Urbanisation (% of population in urban areas)	0.0271 (0.11)
ln V_2	Exports and imports of goods and services (% of GDP)	0.306*** (8.43)
ln V_3	R&D expenditure (% of GDP)	-0.268*** (-8.23)
ln V_4	Index of digital variables	0.269*** (6.60)

Source: Deloitte Access Economics

Notes: t-statistics are reported in parenthesis * p<0.10,** p<0.05,*** p<0.01.

The estimated coefficient for the digital index, V_4, can be interpreted as the long-run elasticity of output per-capita with respect to changes in the levels of this index. If the digital index increases by *x%*, then the resultant percentage change in long-run steady state GDP per capita, *y*, is approximately given by,

$$y = V_4 \cdot x = 0.269 \cdot x$$

Put another way, a 1% increase in the digital index leads to an approximate 0.269% increase in steady state GDP per capita.

A.4. Forecast

A.4.1. Index forecast methodology

To forecast the future contribution of digital technology, this report combines modelling estimates of the effect of changes in digital technology with individual variable forecasts from Cisco's VNI index and forecasts of ICT expenditure from IDC technologies.[lxxx]

Digital index growth is estimated by aggregating the predicted growth of the individual elements. Growth in ICT expenditure is sourced from forecasts provided by IDC technologies. To predict changes in the percentage of the population with internet access, this report utilises Cisco VNI index forecasts for the percentage of each market's population with internet access. Growth in mobile penetration is based on Cisco forecast growth of Networked Devices (excluding M2M) from 2018-2023. Finally, the growth of fixed broadband connections is estimated using Cisco forecasts for the increase in fixed internet users as a percentage of the population. Given these forecasts do not extend to 2030, to estimate digital benefits over the coming decade, these forecasts are extrapolated out to 2030 using the growth rate over the last three years of available forecast data. Importantly, we believe this assumption of a constant growth rate is likely a conservative one as most current forecasts of the economic benefits of digital, mobile and 5G technology expect a significant acceleration throughout the later parts of the decade.

To forecast the economic impact of digital technology, forecast index growth is combined with the econometric modelling results to predict the effect of digital technology adoption on steady state GDP per capita.

A.4.2. Mobile and 5G forecast methodology

To calculate the current and future proportion of the ICT contribution to GDP per capita which is attributable to mobile, we use information on the proportion of total industry revenue (mobile + fixed) contributed by mobile. These revenue shares are based on IBISWorld estimates of current revenue in wired and wireless telecommunications.[lxxxi] In order to forecast mobile benefits out to 2030, the split between mobile and fixed technologies is assumed to remain constant over the forecast period. We view this as a conservative assumption given mobile's share of total revenue has increased rapidly over the last decade and is likely to grow further with the introduction of 5G increasing the ability for mobile to compete with fixed connections.

To estimate the contribution of 5G as a share of the total mobile contribution to GDP, we use data from GSMA Intelligence on 5G devices as a share of total mobile devices.[lxxxii] In each year, we attribute a share of mobile technology's total contribution to GDP growth to 5G technology based on the share of mobile devices which are 5G capable. This is likely a conservative assumption as 5G devices have many productivity boosting advantages over previous generation devices (lower latency, higher bandwidth etc.) so they will likely deliver a greater than proportional share of the economics benefits.

A.4.3. Estimating the dividend from continued investment and greater use of 5G

To estimate the economic dividend delivered by continued investment and greater use of 5G, we look at data from GSMA Intelligence on the number of 5G devices per capita in 30 advanced economies around the world.[lxxxiii] To predict what a rollout with continued investment and greater use of could look like, we first estimate Australia's current position relative to the 5G world leaders in terms of the number of years we are behind in our 5G rollout. Using GSMA Intelligence 5G forecasts, we estimate that for Australia to be in the position that the 5G global leaders are currently in it will take approximately 1.25 years.

Second, we estimate how much the economic benefits delivered by 5G would be increased if Australia were to maintain this position relative to the 5G leaders, rather than falling further behind as current GSMA Intelligence forecasts predict. This estimate is based on the percentage increase in 5G connected devices this would imply and scaling the 5G benefits proportionally. Finally, we take these annual benefit estimates and use a 7% discount rate to calculate the Net Present Value of the dividend over the next nine years in 2022 Australian dollars.

Appendix B: Business survey

A survey was distributed to 400 businesses in order to develop greater understanding of factors driving 5G take-up and use cases of 5G, as well as barriers to 5G use. The survey was distributed to businesses in October 2021.

Survey respondents were those working in agriculture, manufacturing, health or smart city businesses in a manager role or above.

Businesses considered to be working within the smart city field included businesses with elements from the following industries:

- electricity, gas and water supply
- transport, postal and warehousing
- construction
- rental, hiring and real estate services; and
- professional, scientific and technical services.

The characteristics of surveyed business are summarised in the table below.

Table B.1 – Priority industries

Priority industries	n	%
Agriculture	100	25%
Manufacturing	98	25%
Health	102	26%
Smart cities	100	25%

Source: Deloitte Access Economics and IPSOS (2021)

Table B.2 – Smart cities respondents

Smart cities respondents	n	%
Transport, postal and warehousing	37	37%
Electricity, gas and water supply	4	4%
Heavy and Civil Engineering Construction	8	8%
Property Operators and Real Estate Services	10	10%
Architectural, Engineering and Technical Services	13	13%
Public Order and Safety Services	5	5%
Telecommunications Services	21	21%
Smart Cities technology business	2	2%

Source: Deloitte Access Economics and IPSOS (2021)

Table B.3 – Business size

Business size	Agriculture	Manufacturing	Health	Smart Cities
Less than 20	53%	13%	64%	60%
20-199 employees	7%	16%	15%	11%
200 or more	35%	61%	11%	6%
Prefer not to say	5%	9%	11%	23%

Source: Deloitte Access Economics and IPSOS (2021)

Table B.4 – Regionality of businesses by priority industry

Regionality	Agriculture	Manufacturing	Health	Smart Cities
Metropolitan	69%	85%	65%	86%
Regional	31%	15%	35%	14%

Source: Deloitte Access Economics and IPSOS (2021)

Table B.5. – 5G connection status by priority industry

5G connection	Agriculture	Manufacturing	Health	Smart Cities
Yes, currently using 5G, and have been connected for more than 1 year	18%	17%	22%	26%
Yes, currently using 5G and have been connected less than 1 year	28%	38%	18%	20%
No, but have plans to use within the next year	24%	30%	24%	31%
No, but have plans to use in the next 1 to 2 years	7%	7%	6%	6%
No, but have plans to use in 3 years or more	3%	1%	4%	3%
No, current mobile technology fulfils my business needs	14%	2%	18%	12%
No, my business does not need mobile coverage to operate	2%	3%	5%	2%
Not sure/Don't know	4%	2%	5%	0%

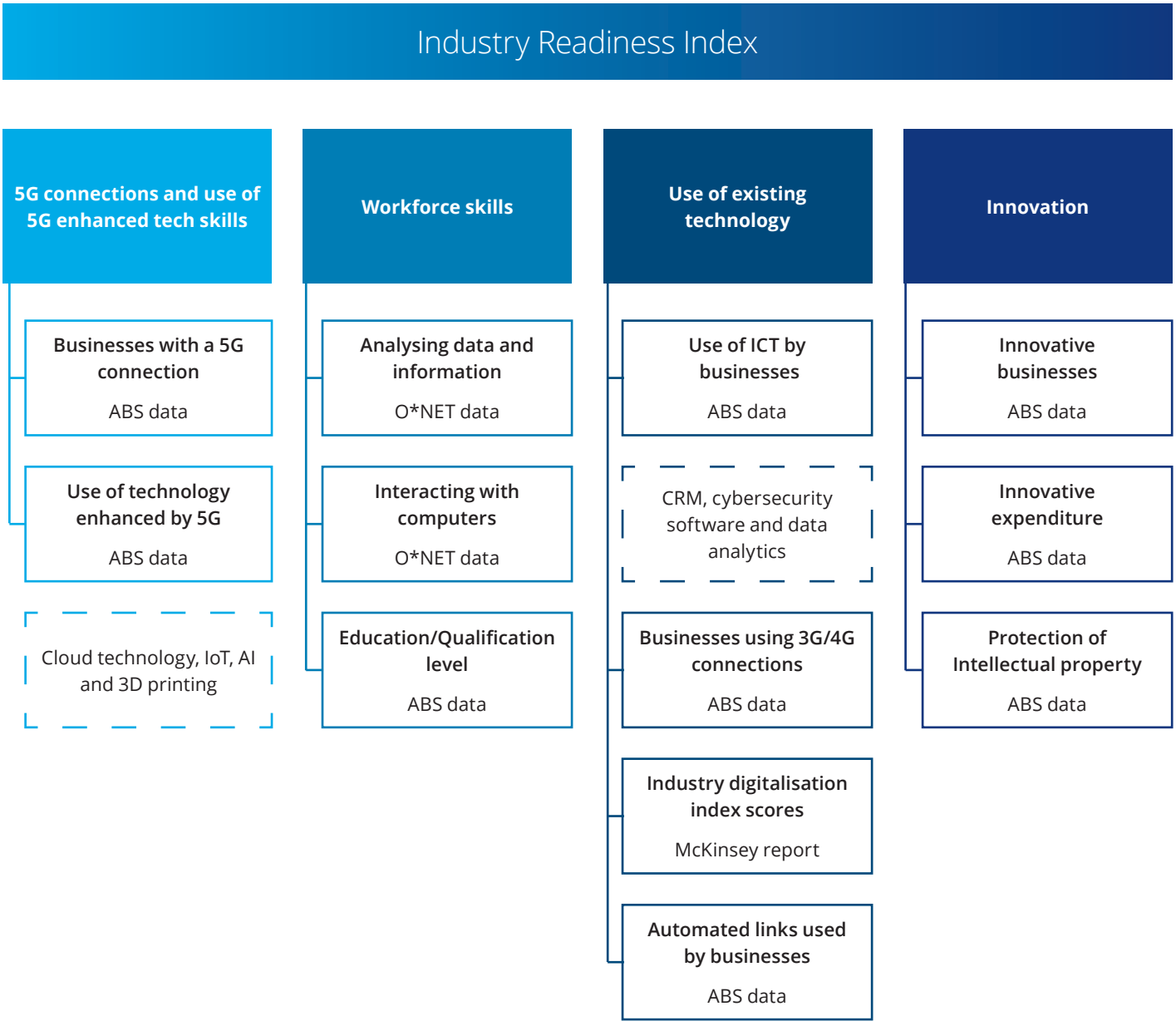
Source: Deloitte Access Economics and IPSOS (2021)

Appendix C: Industry 5G Readiness Index

The 5G Industry Readiness Index uses 12 unique indicators to assess the level of readiness for 5G across Australian industries.

The 12 indicators span across four equally weighted pillars in the index. The four pillars cover the current interaction in 5G connections and use of 5G enhanced tech skills by industry, existing workforce skills by industry, the use of existing technology amongst industries, and the level of innovation involvement by industry.

Figure C.1: Pillar and indicators used to assess industry readiness for 5G in Australia



Source: Deloitte Access Economics (2021)

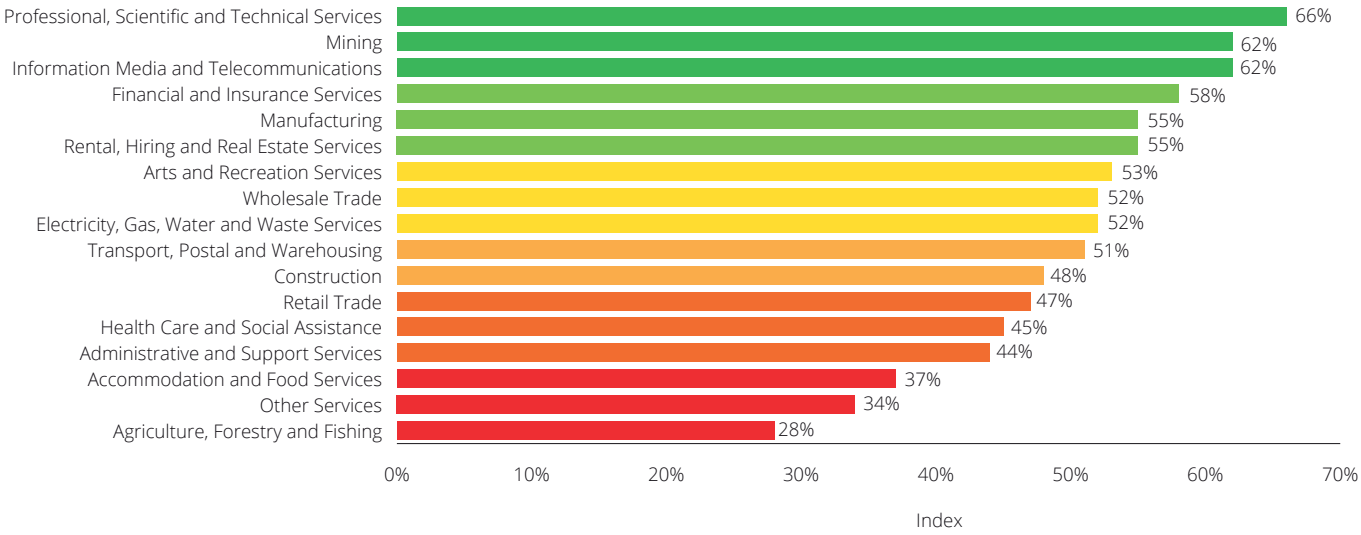
Each of the four pillars were designed to measure how ready each industry was for 5G based on how they have been and will interact with 5G.

- **5G connections and use of 5G enabled technology** accounts for current internet connections and current 5G compatible technology usage amongst businesses to indicate which industries are leading uptake.
- The **workforce skills** pillar considers the types of skills currently used in industry that would be positively correlated with the likelihood of 5G to indicate which industries are better placed to leverage 5G connections and 5G enabled technologies.
- **Use of existing technology** considers the how industries are currently using available technology to inform their likelihood of taking up 5G.
- The **extent of innovation** in an industry is measured by industry expenditure and innovation-active businesses to indicate industry willingness to uptake technology that utilises 5G.

C.1: Readiness index results by pillar

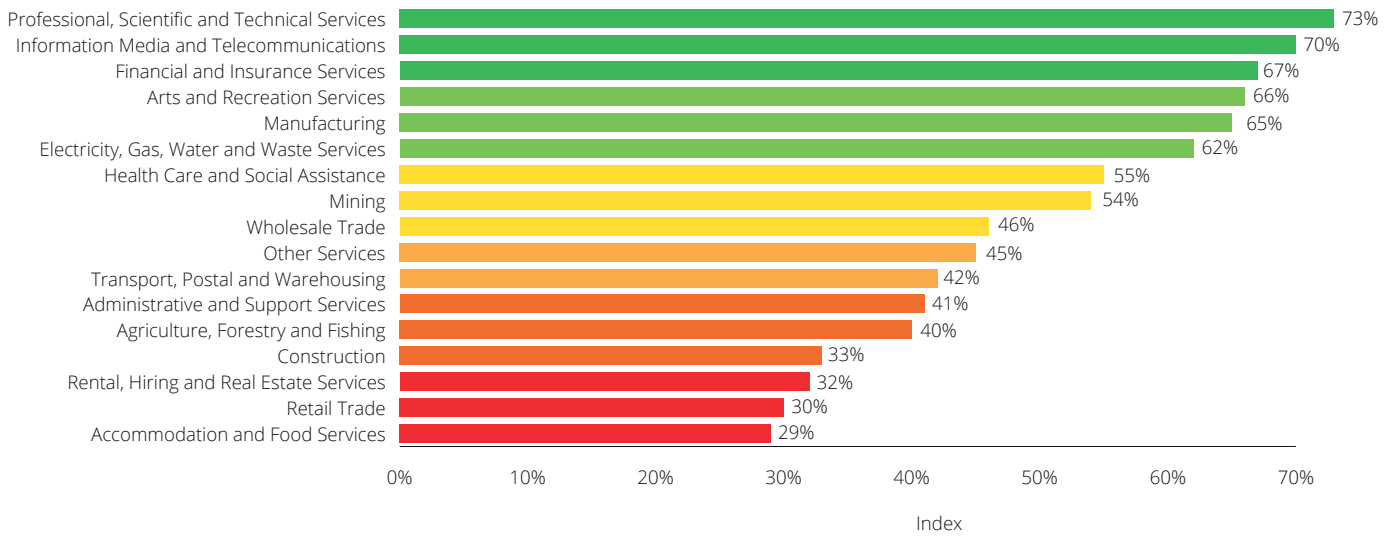
Readiness index scores were derived from four pillars; 5G connections and 5G enabled technology, Workforce skills, Use of existing technology and Innovation pillar. The index scores for each pillar are reported separately by industry below.

Chart C.1: Readiness index score for 5G connections and 5G enhanced tech skills pillar



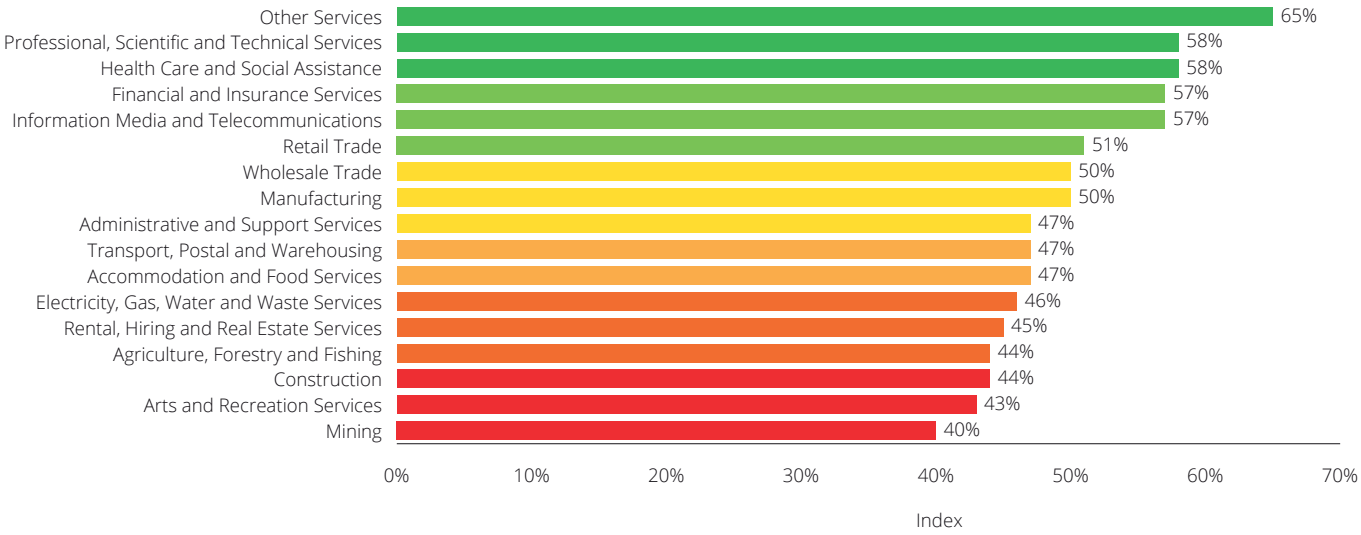
Source: Deloitte Access Economics (2021)

Chart C.2: Readiness index score for workforce skills pillar



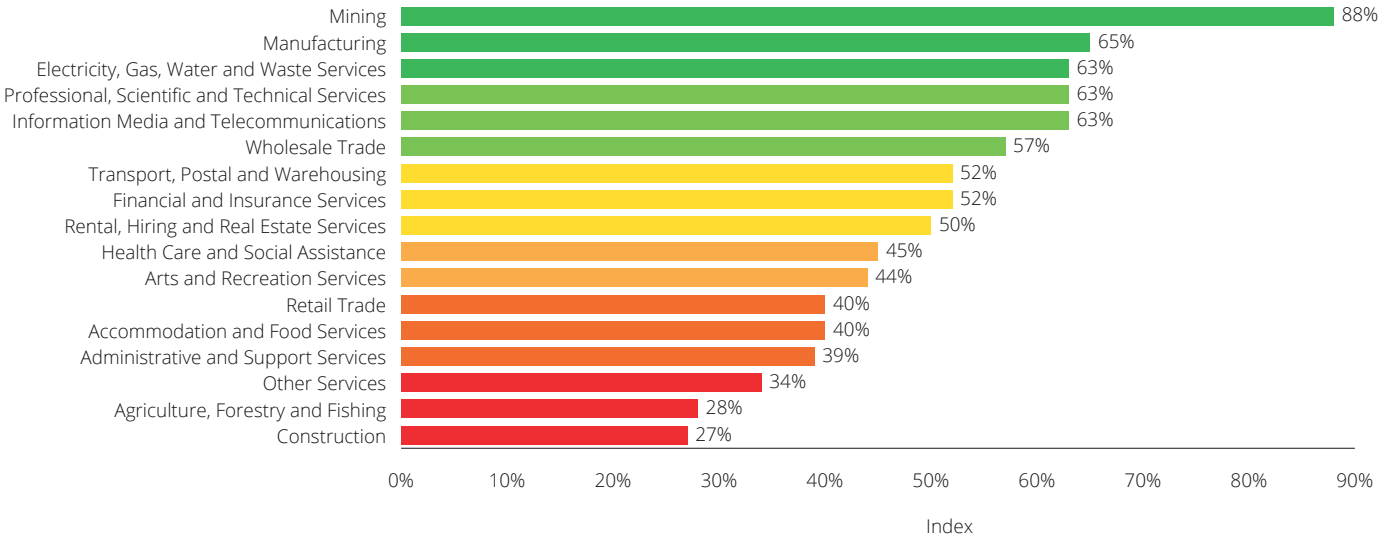
Source: Deloitte Access Economics (2021)

Chart C.3: Readiness index score for use of existing technology pillar



Source: Deloitte Access Economics (2021)

Chart C.4: Readiness index score for innovation pillar



Source: Deloitte Access Economics (2021)

C.2: Readiness index methodology

The readiness index is made up of 12 indicators spanning 4 pillars. Where possible, data has been sourced from Australian databases to ensure consistency in analysis. Where there is missing data, values have been imputed using internationally sourced data reflective of Australian industries with support from subject matter experts.

The indicators used to measure readiness vary in terms of unit and scale. To consolidate these indicators into a single measure, each indicator was allocated a maximum and minimum score. These score ranges were used to transform the data so that each followed a consistent scale, ranging between 0% to 100%. An indicator of 100% suggests that the industry is ready for 5G, while a score of 0% indicates the country is not ready.

Further detail on the indicators and the weighting used to aggregate scores within each pillar are provided in the sections below.

5G connections and 5G enhanced tech skills Pillar

This pillar covers the level of current interaction with 5G related technologies in industries. A higher current interaction is associated with a higher readiness score to continue and increase interaction in emerging 5G technologies.

Table C.1: 5G connections and 5G enhanced tech skills pillar indicators

Indicator	Description	Maximum score (higher likelihood of readiness)	Minimum score (lower likelihood of readiness)	Indicator weighting	Source
Businesses using 5G connections	Industries currently using 5G connections are able to leverage existing infrastructure to continue growing use of emerging 5G connections	100%	0%	50%	ABS data[lxxxiv]
Selected ICTs used by businesses	A higher proportion of use 5G enabled ICT systems (i.e. Cloud technology, IoT, AI and 3D printing) is associated with higher readiness to 5G technologies	100%	0%	50%	ABS data[lxxxv]

Source: Deloitte Access Economics (2021)

Workforce skills Pillar

This pillar accounts for the skills that would increase an individual worker's readiness to adapt to new technologies. Higher levels of skills are associated with a greater likelihood of readiness towards 5G technology in the future.

Table C.2: Workforce skills pillar indicators

Indicator	Description	Maximum score (higher likelihood of readiness)	Minimum score (lower likelihood of readiness)	Indicator weighting	Source
Analysing Data and information	A higher proportion of time spent analysing data/ information is associated with a higher readiness for 5G	20%	0%	33.3%	O*NET[lxxxvi]
Interaction with computers	A higher level of interaction with computers is associated with a higher readiness to new technologies including 5G	20%	0%	33.3%	O*NET[lxxxvii]
Education/ Qualification level	A higher proportion of the workforce with tertiary education is associated with a greater readiness for 5G	100%	0%	33.3%	ABS data[lxxxviii]

Source: Deloitte Access Economics (2021)

Use of existing technology Pillar

This pillar covers the ways in which industries are interacting with currently available technologies. Higher use levels are associated with a greater readiness for industries to leverage existing practices to adapt to emerging 5G technologies.

Table C.3: Existing technologies pillar indicators

Indicator	Description	Maximum score (higher likelihood of readiness)	Minimum score (lower likelihood of readiness)	Indicator weighting	Source
Selected ICTs used by businesses	A higher proportion of use existing ICT systems (i.e. CRM, ERP, Cybersecurity software, Data analytics) is associated with an industry more able to adopt emerging 5G technologies	100%	0%	25%	ABS data[lxxxix]
Automated links used by businesses	A greater use of automated links is associated with higher capabilities in implement new 5G connections	100%	0%	25%	ABS data[xc]
Industry digitalisation index scores	A higher digitalisation score is associated with a higher readiness for 5G	20	0	25%	McKinsey report[xci]
Businesses using 3G/4G connections	Industries currently using 3G/4G connections are able to leverage existing infrastructure to adopt emerging 5G connections	100%	0%	25%	ABS data[xcii]

Source: Deloitte Access Economics (2021)

Innovation Pillar

This pillar accounts for the level of innovation in each industry. Greater proportions of innovation are associated with a greater readiness and willingness to adopt emerging 5G technologies.

Table C.4: Innovation pillar indicators

Indicator	Description	Maximum score (higher likelihood of readiness)	Minimum score (lower likelihood of readiness)	Indicator weighting	Source
Innovation active businesses	A higher proportion of innovation active businesses in the industry is associated with a higher readiness for 5G technologies	100%	0%	33.3%	ABS data[xciii]
Protection of Intellectual property	Greater protection and security over intellectual property is associated with a higher capability to adopt new technologies, including 5G	100%	0%	33.3%	ABS data[xciv]
Innovation expenditure	Greater expenditure on innovation is associated with infrastructures/systems that are ready to adopt new emerging technologies	$550,000	$0	33.3%	ABS data[xcv]

Source: Deloitte Access Economics (2021)

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Limitation of our work

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