NSW Productivity Commission
NSW Innovation and Productivity Council

NSW GOVERNMENT

Adaptive NSW: how embracing tech could recharge our prosperity

November 2022


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About the NSW Productivity Commission

The NSW Productivity Commission ('the Commission') was established by the NSW Government in 2018 under the leadership of the state's inaugural Commissioner for Productivity, Peter Achterstraat AM. The Commission is tasked with identifying regulatory roadblocks and opportunities to boost productivity across the state. The Commission's priorities include making it easier to do business, lowering the cost of living, making housing more affordable, and making NSW the easiest state to move to. Since its inception, the Commission has undertaken several reviews on productivity matters and published the landmark NSW Productivity Commission White Paper 2021, *Rebooting the economy.*

About the NSW Innovation and Productivity Council

The NSW Innovation and Productivity Council ('the Council') was established by the *Innovation and Productivity Council Act 1996 (NSW)* and is currently chaired by Neville Stevens AO. It advises the NSW Government on priorities for innovation-led economic development and productivity. Council members are leaders from industry, education, and research sectors. NSW Innovation and Productivity Council publications are independent reports and do not constitute NSW Government policy. This is consistent with the role of the Council and its object under the *Innovation and Productivity Council Act 1996 (NSW).*

Contacts

The NSW Productivity Commission and NSW Innovation and Productivity Council welcome feedback and inquiries regarding their publications, websites, and media.

To contact the Office of the NSW Productivity Commissioner:

Phone +61 2 9228 4567
Email ProductivityFeedback@treasury.nsw.gov.au

To contact the NSW Innovation and Productivity Council:

Phone +61 2 4908 4800
Email ipc.secretariat@investment.nsw.gov.au

Acknowledgement of Country

We acknowledge that Aboriginal and Torres Strait Islander peoples are the First Peoples and Traditional Custodians of Australia, and the oldest continuing culture in human history. We pay respect to Elders past and present and commit to respecting the lands we walk on, and the communities we walk with. This report was prepared on the lands of the Gadigal people of the Eora Nation.

Artwork:
Regeneration by Josie Rose, 2020.

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NSW Productivity Commissioner's foreword

Through fires, a pandemic, and floods, the people of NSW have experienced great hardship and shown tremendous resilience over the last few years. We are recovering strongly, but unwelcome surprises continue, from high inflation, to supply chain issues, to skills shortages.

In uncertain times, it's easy to get caught up in the problems of the moment. But if we want a stable and prosperous future, we need to look ahead. That is what this report, *Adaptive NSW*, is about. And as it shows, the future is not all bad news.

It's no secret that we face a productivity challenge. Like other developed economies, NSW's productivity has lagged for some time. The *2021-22 NSW Intergenerational Report (IGR)* projected average productivity growth of just 1.2 per cent a year for the coming 40 years. Unfortunately, this is not nearly enough to meet our 'fiscal gap' — the gap between our Government's revenue and its expenditure. The gap is projected to grow to 2.6 per cent of Gross State Product (GSP) by 2060-61. If we don't tackle this problem with higher productivity growth, we risk our future living standards and public spending capability, not to mention the prospect of burdening future generations with debt.

But the productivity challenge comes with an incredible tech opportunity. Using advanced economic modelling, powered by Faethm AI, *Adaptive NSW* shows how emerging tech could recharge the state's productivity growth to 2.0 per cent a year and lift economic growth to a robust 3.0 per cent a year to 2035. That would be like a repeat of the 1990s ICT boom. We can't be certain it will happen, but we can be ready to take full advantage if it does.

Adaptive NSW lays out the policy principles and insights that could get us to a high tech, prosperous future — from public sector governance to smart regulation, from building an agile and digitally-skilful workforce to measured interventions that could foster tech entrepreneurship and attract world-class talent and expertise.

I am proud to present this report, which builds on the recent *IGR* and the *NSW Productivity Commission White Paper 2021 (White Paper)*. I'm confident that by embracing technology, we can build a flexible and hybrid NSW workforce, equipped and empowered to thrive in the next chapter of the story of global technological transformation.

Adaptive NSW is for policymakers, but it will no doubt provide practical insights to industry and the public about the changes we need to make to prepare for a technological transition that is green, sustainable, fair, and inclusive for the people of NSW. The key will be acting on these insights. The adage you 'reap what you sow' is as relevant as ever.

Peter Achterstraat AM
NSW Productivity Commissioner

IPC Project Champion's foreword

The NSW Innovation and Productivity Council (IPC) comprises leaders from across industry, government, and academia, who come together to provide unique, independent, and evidence-based advice to the NSW Government on innovation-led economic development.

We undertake detailed research on innovation, covering emerging trends and international best practice to inform our recommendations on ways to maximise the competitiveness of NSW for the benefit of the community.

Adaptive NSW, delivered in concert with the NSW Productivity Commission, is our comprehensive contribution to policy thinking about enhanced technology adoption and associated workforce adaptation in relation to the future of work in NSW.

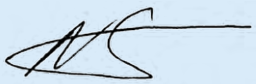
When we commenced this work, we set out to identify:

1. key long-term trends and forces that could shape the future of work in NSW
2. the nature and scale of resultant challenges and opportunities for the NSW workforce
3. long-term policy directions for the NSW Government to meet the challenges and grasp the opportunities of the future of work.

A new wave of technology-driven transformation may be near. An optimal outcome will not occur without public policy support. The pace of technology development, the economics of its adoption, behavioural factors, and market influences all have a bearing. Impacts will differ by industry and occupations. We know that what works in metropolitan areas does not necessarily apply in regional, rural, and remote settings.

Government has a leadership role in developing our collective understanding of the possible workforce and workplace transitions and in mitigating the risks and amplifying the opportunities which arise from technology adoption. A system-wide focus is required to meet the challenges and make the right choices and changes through interventions that can fully realise the opportunities and benefits which flow from an integrated, collaborative approach to technology.

Our goal is that *Adaptive NSW* will provide the framework and impetus for policymakers and stakeholders across government and in industry, education, workforce development, and training, to understand how NSW can build a more adaptive workforce and economy. The productivity gains from progressive technology adoption will see NSW adapt, prosper, and grow, with all citizens benefitting from the improved socioeconomic profile of the state.



Neville Stevens AO
NSW Innovation and Productivity Council Chair and Project Champion

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Key terms

Artificial intelligence (AI) refers to computer systems that perform tasks that previously required human intelligence. AI systems are typically classified according to the kinds of tasks they can perform (see **Table 1**).

Automation means that technology substitutes for labour to complete a task.

Augmentation means that technology complements labour to complete a task.

Emerging technology fall into two broad categories:

1. **Productivity-enhancing technologies** automate or augment work tasks in existing jobs and industries, changing the skills profile of the workforce.
2. **Technological innovations** create entirely new products, markets, services, and industries which lead to the creation of new kinds of jobs.

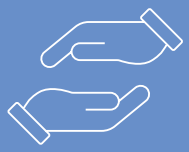
Digital labour platforms provide the technological means for workers to do gig work. The International Labour Organization defines two key types of platforms: online web-based platforms, and location-based platforms.

Key insights

NSW faces a productivity challenge

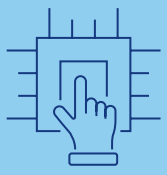
Emerging tech could revive productivity

It would make work more flexible, cognitive, and social



Unemployment won't rise, but some workers need support

Key principles



Aim to be a fast tech adopter

1. Aim to be a fast tech adopter
2. Build trust with strong public sector governance
3. Embrace tech to improve public services
4. Support private-sector tech uptake through smart regulation
5. Intervene only where there is a strong business case

Attract and foster the core tech workforce

1. Nurture entrepreneurship
2. Foster the tech professions
3. Entice the best and brightest from across the world

Build all NSW workers' adaptive capacity

1. Get the basics of literacy and numeracy right
2. Improve general digital literacy
3. Build soft skills for a service economy
4. Use data and industry insights to keep training relevant and responsive
5. Lower barriers to entry by combatting credentialism
6. Create a system for continuous upskilling
7. Create smooth, flexible pathways for multiple career transitions
8. Give individuals the right incentives and information
9. Make sure employers have incentives to train workers
10. Develop workforce strategies for growth sectors (e.g. IT, construction, care)

Ensure tech adoption and adaptation is inclusive

1. Smooth transitions for industries and workers facing technological disruption
2. Use tech to diversify our regional economies
3. Use tech to broaden workforce participation
4. Close the digital divide and ensure diverse, inclusive access
5. Ensure the tech 'productivity dividend' is distributed widely
6. Make sure appropriate protections exist for workers, including in the gig economy

Executive summary

The past few years taught us to expect the unexpected. We have weathered ordeals, from fires and floods, to pandemic and recession, and now we are grappling with global supply chain disruptions, cost of living pressures, climate change, and the challenge of the green energy transition. We live in an era of uncertainty.

But not everything the future holds is bad, and we are not at the mercy of fate.

Adaptive NSW lays out the vast potential of emerging technology to make our future a better one. It argues that if we are prepared, technology could revive our productivity and power a new era of green economic growth, higher living standards, and resilience. To do this, it argues, we will need to embrace technology and build an adaptive workforce. We will also need to make sure that the benefits of technology are felt widely across the community, and that the future of work really is a better one for everyone.

This report does not offer proposals or recommendations for new programs or policies — though these will most certainly be needed. Nor does it offer a detailed review of existing initiatives, though it highlights some key examples.

What *Adaptive NSW* does offer is a flexible framework of guiding principles for policymakers who are thinking about technology, automation, and the future of work to arrive at the **right** programs and policies for the future. It offers an intellectual map for turning the raw potential of emerging technology into a better future for our state. It identifies the key long-term trends and challenges we face and their implications for government, the economy, and society. It lays out the incredible opportunities technology offers and the imperative to take control and make the most of them.

In some cases, policymakers will find that *Adaptive NSW* affirms principles already reflected in their work. In other cases this report may offer food for thought or even be provocative.

Adaptive NSW touches on many topics related to technology including science, technology, engineering, and mathematics (STEM) training; soft skills; Australia's demographic challenges; and issues of equity, diversity, and access. These issues deserve a much more extensive treatment than can be given here and are important areas for further research.

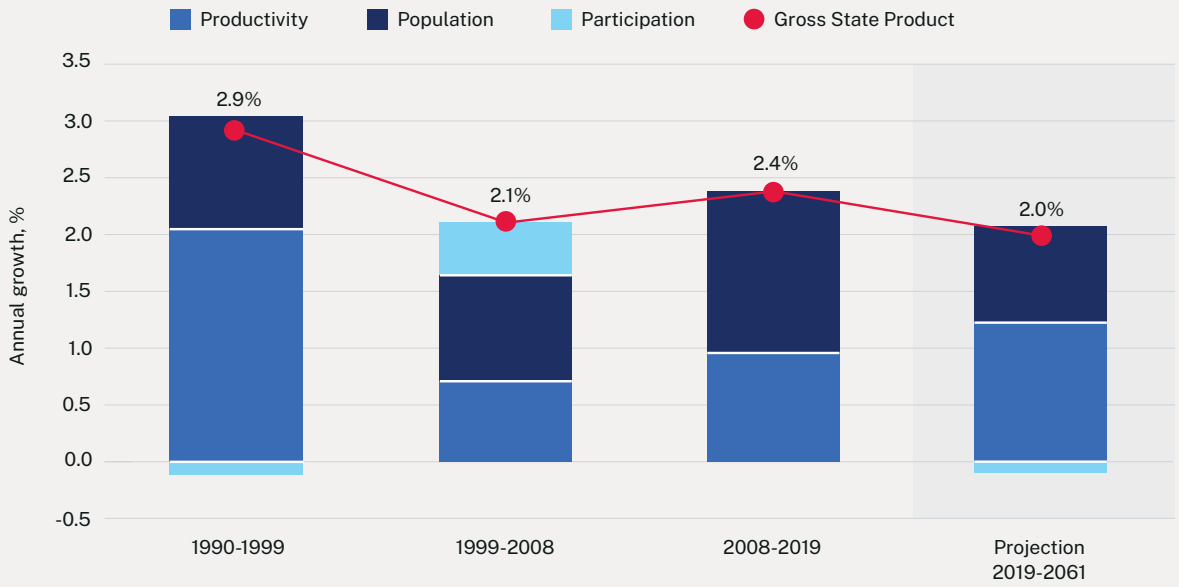
We face a productivity challenge

The *2021-22 NSW Intergenerational Report (IGR)* laid out a series of long-term challenges for our state. It found that a decline in workforce participation — due to an ageing population, lower birth rates, and interrupted migration during the COVID-19 pandemic border closures — poses significant long-term risks to the living standards of our state's people. The Commonwealth Treasury suggests temporary and skilled migration will recover to pre-pandemic levels by 2024-25. Even so, over the next 40 years our population growth will not return to the levels NSW experienced in the 20th century.

Figure

Productivity growth in NSW has declined compared to the 1990s

Contribution of population, participation, and productivity ('three Ps') to real NSW economic growth



Note: Participation is defined as hours worked per person.
Source: *2021–22 NSW Intergenerational Report*

This demographic challenge is coupled with a major fiscal challenge. As the state's proportion of working-age people falls, our traditional revenue sources (like payroll tax and stamp duty) will also decline, impacting public spending capability. Meanwhile, growth in government expenditure, in areas like healthcare, will need to accelerate to support our ageing population. Without corrective measures, the fiscal gap — estimated to be 2.6 per cent of GSP by 2060-61 — will limit what the NSW Government can spend without further increasing public debt. If the gap is not addressed, the ageing population will put pressure on NSW Government services, including the provision of essential services during crises.

All this puts the spotlight on productivity. With declining workforce participation due to demographic change, increasing productivity is our best hope of strong and sustained economic growth and continued improvements in our living standards.

But our productivity growth is not where we want it to be. The *IGR* assumes an average productivity growth for NSW of 1.2 per cent over the next 40 years. While our growth currently lags that of other states, territories, and G7 countries, we know that well-chosen reforms can boost productivity and growth. Indeed, the *White Paper*, identified 60 opportunities to help reboot growth across talent, innovation, housing, and infrastructure in NSW.

But tech could revive our productivity, if we are prepared

It is a mistake to assume recent slow productivity growth must continue forever. Historically, productivity growth has come in waves. We cannot predict when the next wave will come. Productivity growth could continue to decline. But it is also possible that the world is now on the threshold of an enormous technology opportunity. There is a suite of emerging technologies that, if widely adopted, could recharge productivity growth for years to come. Among these technologies are artificial intelligence (AI), quantum computing, 3D printing, and autonomous vehicles. This wave of emerging technologies has been dubbed the Fourth Industrial Revolution or 'Industry 4.0'.

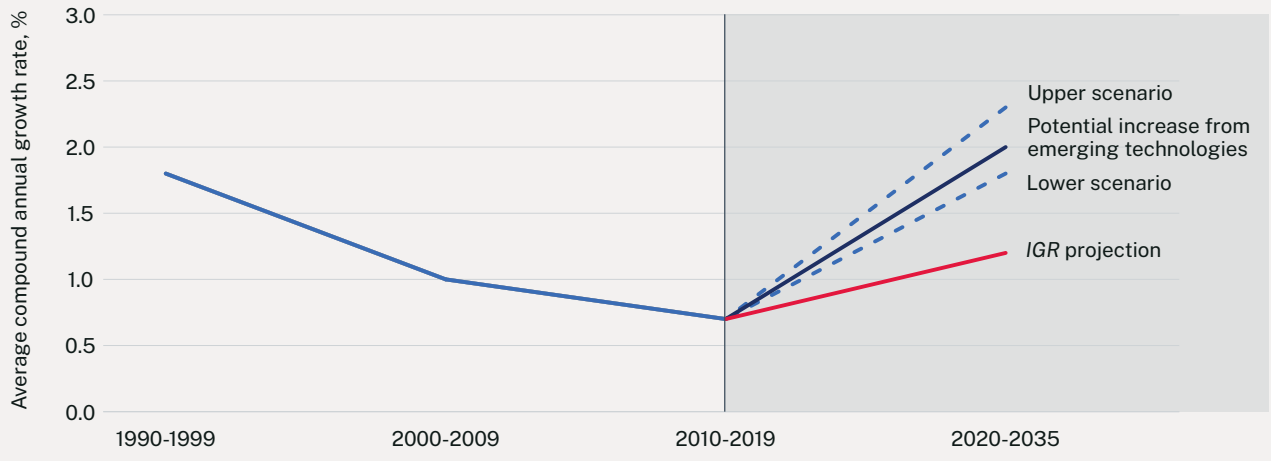
Our modelling suggests that the Industry 4.0 wave presents NSW with huge potential opportunity. These technologies, if adopted widely, could plausibly lift the state's productivity growth to 2.0 per cent a year and lift the growth rate of real GSP to 3.0 per cent a year to 2035. This would be a tremendous (though temporary) boost to productivity growth. GSP would grow by an additional 11.8 per cent by 2034-35. That is equivalent to $11,600 per person or $27,400 per household (in 2021-22 dollars). Government own-source revenues could also grow by as much as $4.5 billion by 2034-35.

We cannot predict if this will happen, let alone when. We can only recognise the potential opportunity, and be ready to take full advantage of it.

Figure

Emerging tech could recharge NSW's productivity and growth

Labour productivity average compound annual growth rate, 1990–2035

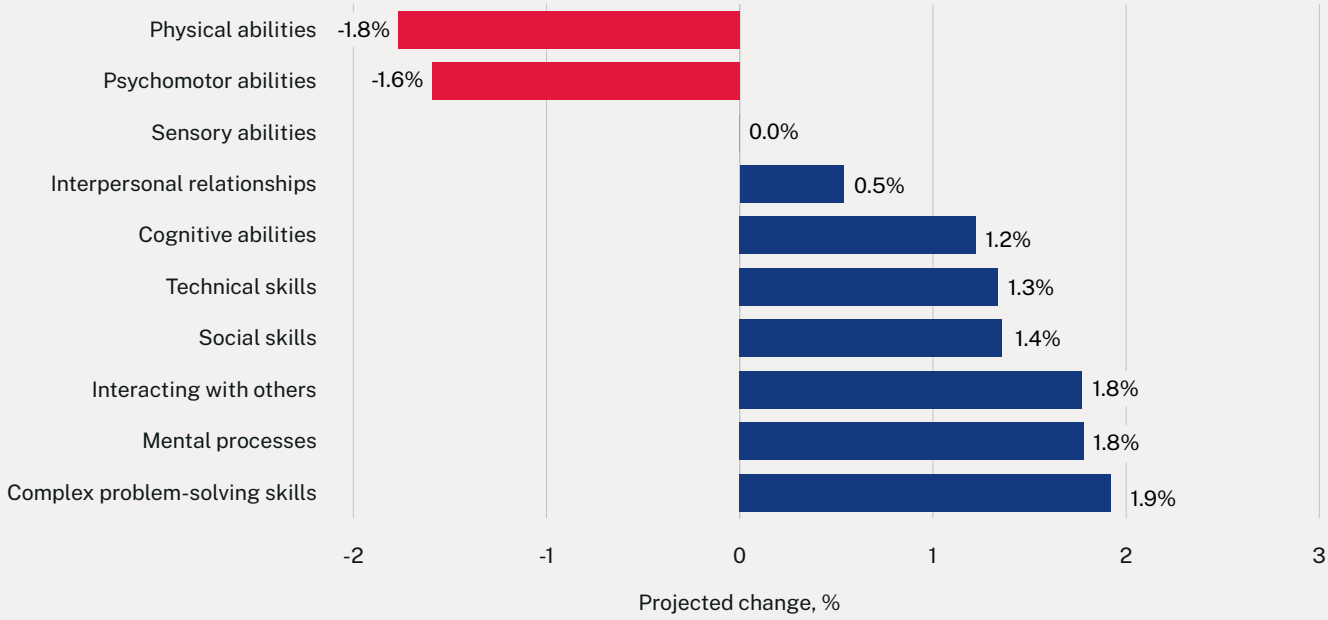


Note: The shaded area indicates the range of possible productivity growth rate scenarios from emerging technology diffusion.
Source: NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI)

Figure

The future NSW economy will require less physical and more cognitive skills

Projected change in relative demand for skills and abilities due to emerging technology diffusion, 2035



Source: NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI)

Emerging technologies fall into two broad categories:

- **Productivity-enhancing technologies** automate or augment work tasks in existing jobs and industries, changing the skills profile of the workforce.
- **Technological innovations** create entirely new products, markets, services, and industries, which lead to the creation of new kinds of jobs.

The creation of new high-skill jobs will, in turn, boost activity and jobs elsewhere in the NSW economy. Technology and investment in emerging and high-growth industries will increase demand for existing technology roles and create new high-skill and high-pay technology-related jobs.

Tech will make work more flexible, cognitive, and social

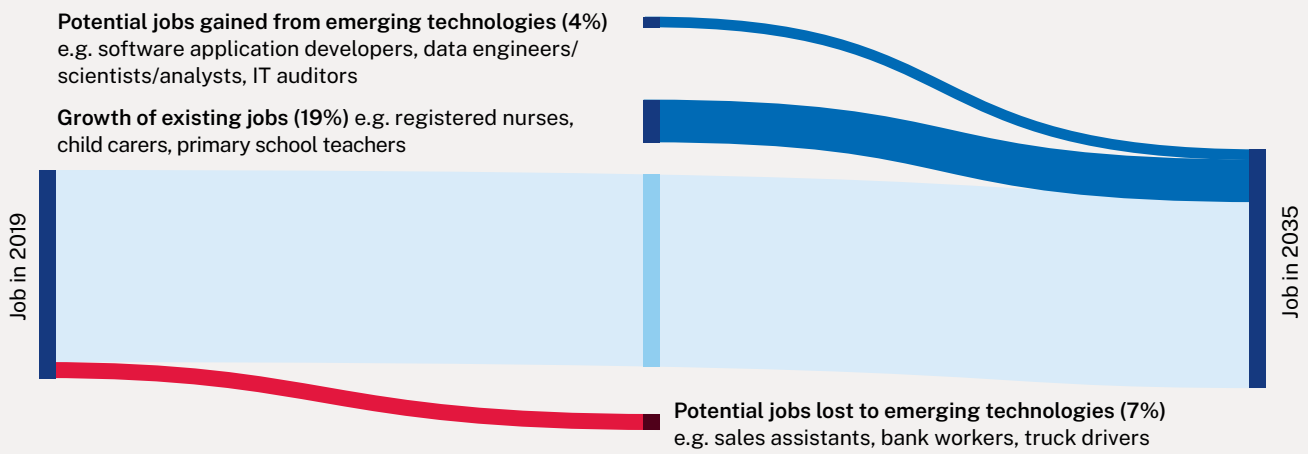
Noting that all work blends physical and cognitive elements to some degree, our modelling shows that the diffusion of emerging technologies will accelerate the trend away from physically-demanding work and make work more cognitive and social. That is, emerging technology will increase demand for complex problem-solving skills, cognitive abilities, and social skills.

The future of work will also be more flexible and hybrid. We will use digital labour platforms more, the gig economy will grow, and remote working will further change how we work.

Figure

Technology will mostly change jobs, not remove them

Predicted sources of job growth and job loss in NSW from emerging technology diffusion, 2019–2035



Source: NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI)

Unemployment will not rise overall, but some workers will need support

Despite technology's positive potential, many people worry about the risks it may pose, in particular that automation will lead to widespread unemployment. Work done for this report should help to allay some of these fears. It shows that, even with rapid automation, most existing jobs will remain. Automation and augmentation are likely to change jobs and work tasks, rather than erase entire occupations.

History shows that as automation reduces jobs in some industries, the demand for labour shifts to others. A century or so ago, half of all NSW workers held jobs in agriculture. Now less than 2 per cent do. Yet employment overall has steadily risen, especially in the service industries. The *IGR* predicted that the services sector will make up 52 per cent of all jobs by 2035 in NSW (up from 36 per cent in 1989–90). Increasing technology adoption would lift the share of service employment even further.

While technology is unlikely to raise unemployment overall, some individuals and groups will be vulnerable to losing their jobs to automation. This risk should not be downplayed. Government, industry, and our education and skilling systems need to create smooth pathways for these workers to access new skills and employment. Policymakers need to actively manage technology-driven industry transitions so that no one is left behind.

Aim to be a fast technology adopter

As a small but highly developed player in a much larger global economy, NSW's primary advantage lies in being a fast technology adopter, rather than developing technologies from scratch. For NSW policymakers this means ensuring NSW has a dynamic and competitive economy — one where firms and workers have the right incentives to adopt and deploy useful technologies.

To accelerate the uptake and support adoption of productivity-enhancing technologies and new innovations, the NSW Government can:

- build trust with strong public sector governance
- embrace technology to improve public services
- support private sector tech uptake through smart regulation.

Support for particular emerging technologies or industries can be part of the mix. But we should weigh the costs and benefits carefully. On the one hand, relatively modest government support for an emerging industry can yield large benefits when the industry matures. On the other hand, government runs a high risk of backing the wrong businesses and industries, because we cannot easily predict — particularly at the R&D stage — which developing technologies will falter or fail. And once support is committed, vested interests can make it very difficult to withdraw. For these reasons, support for emerging technologies and industries would benefit from being limited and targeted, and subject to careful, case-by-case assessment.

Attract and foster the core tech workforce

Emerging technologies require a workforce that knows how to implement and support them. To attract and foster this workforce, the NSW Government can nurture entrepreneurship through entrepreneurial skills programs. It can also support innovative businesses as they grow.

To become a leading jurisdiction, NSW needs to harness local talent with expertise in STEM. The NSW Government can work with schools, the tertiary education sector, and industry to attract more students and enlarge the STEM talent pool. The Government can entice the best and brightest from across the world by building on NSW's status as a destination of choice for migrants. It can make more targeted efforts to attract leading-edge overseas tech talent and build strong expatriate sector and business networks.

There are areas where government needs to tackle structural challenges in the workforce or labour market. The NSW IT and cyber security workforce needs to grow. Our modelling, powered by Faethm AI, projects that the NSW IT workforce is expected to double by 2035. If NSW took steps to speed up technology uptake, the size of the industry could increase by another 60 per cent, providing 2.6 times more IT workers than in 2019. The NSW Government has taken several steps to foster digital skills such as the digital stream, Digital Skills Pilot Program, and the TAFE NSW Institute of Applied Technology (IAT) Pilot for Digital Technology.

Build adaptive capacity across the entire NSW workforce

To adopt technology rapidly and reap the benefits, NSW requires an adaptive workforce. This means a workforce that is skilled, confident, and capable enough to embrace and use emerging technologies. Policymakers can build an adaptive workforce by:

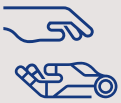
- ensuring our school students are equipped with foundational reading, writing, maths, and science, as well as general digital literacy and soft skills
- harnessing economic and industry insights to better identify and meet areas of skills demand
- making the training and professional recognition system relevant and responsive, for example by combatting credentialism and supporting recognition of microcredentials
- promoting lifelong learning and continuous upskilling and providing high-quality career information and support
- giving employers stronger incentives to train workers
- developing new, flexible pathways that facilitate mid-career transitions, allowing workers to move out of jobs at risk of automation and into high-demand occupations like the construction trades.

Ensure that tech adoption and workforce adaptation is fair and inclusive

Inclusive adaptation is not just nice to have, it is an essential principle for policymaking. If technology adoption is not fair and inclusive, there is a real risk of undermining community support for technology adoption and squandering the technology opportunity.

Inclusive adaptation requires active and judicious policymaking and management. It requires looking forward and seizing the many opportunities technology offers to make society fairer and more inclusive and supporting communities to adapt.

We identify six dimensions of inclusive adaptation:



1. Smoothing transitions for industries and workers facing technological disruption

2. Using tech to diversify our regional economies

3. Using tech to broaden workforce participation

4. Ensuring the tech productivity dividend is distributed widely

5. Closing the digital divide and ensuring diverse, inclusive access to tech

6. Ensuring appropriate protections exist for workers, including those in the gig economy

1

The productivity challenge

With an ageing population and a slowdown in migration, workforce participation is set to fall in NSW. If we want continued economic growth and higher living standards, we need to raise productivity.

At a glance

The *IGR* assumes that NSW's productivity growth rate will grow by 1.2 per cent per year over the next 40 years, in line with our 30 year average. If this happens, NSW's productivity would likely lag other states, territories, and G7 countries. More broadly, NSW's economic growth is already expected to slow due to lower workforce participation driven by an ageing population, lower fertility rates, and interrupted migration during COVID-19 pandemic border closures.

If the productivity challenge is not addressed, the gap between NSW Government revenues and expenses is projected to grow to 2.6 per cent of GSP by FY2060-61. This poses long-term risks to the living standards of NSW residents and would limit how much Government can spend without further increasing public debt.

1.1 Productivity is one of three Ps that drive growth and prosperity

The *IGR* explains that the prosperity of NSW depends on the size and age of its *population,* its level of workforce *participation,* and its level of *productivity* (NSW Treasury 2021). The report refers to these cornerstones of long-term economic growth as the 'three Ps' (see **Box 1**).

'Productivity isn't everything, but in the long run, it is almost everything.'

— Paul Krugman

Box 1

What are population, participation, and productivity?

Population is the number of people living in NSW. It includes:

- natural increase — births minus deaths
- net migration — overseas and interstate arrivals minus departures.

Participation measures how much of the population is in the workforce — that is, the proportion of people aged 15 years and over seeking or in employment.

Productivity measures how efficiently people participating in the workforce produce goods and services, given the resources and effort invested. The types of productivity include:

- labour productivity measures the value of economic output per hour of work
- multifactor productivity is the overall efficiency with which labour and capital combine to carry out production.

Source: *2021-22 NSW Intergenerational Report*

The first of the three Ps, *population,* has added most to growth in recent years. Over the 20 years to 2019, the NSW population grew at an average 1.2 per cent a year. That growth index is higher than in most Organisation for Economic Co-operation and Development (OECD) nations (Australian Bureau of Statistics 2021b; OECD n.d.). And we expect that population will begin rising again as the pandemic ebbs. But the *IGR* projects that population growth over the coming decades will be lower than it has been so far this century, and will contribute less to the state's prosperity, as shown in **Figure 1.**

Meanwhile *participation,* the second P, is predicted to fall as the population ages. This is because increased workforce participation rates among women and older people are not enough on their own to offset the numbers of retiring workers.

So policymakers have turned back to the third P, *productivity,* as the key measure for expanding the economy and increasing people's prosperity (see **Figure 1**).

1.2 The COVID-19 pandemic underlined our reliance on immigration

Over the past decade, two-thirds of NSW's population growth has come from immigration (Australian Bureau of Statistics 2021b). The COVID-19 pandemic and border closures, however, have suppressed this source of workers and economic growth.

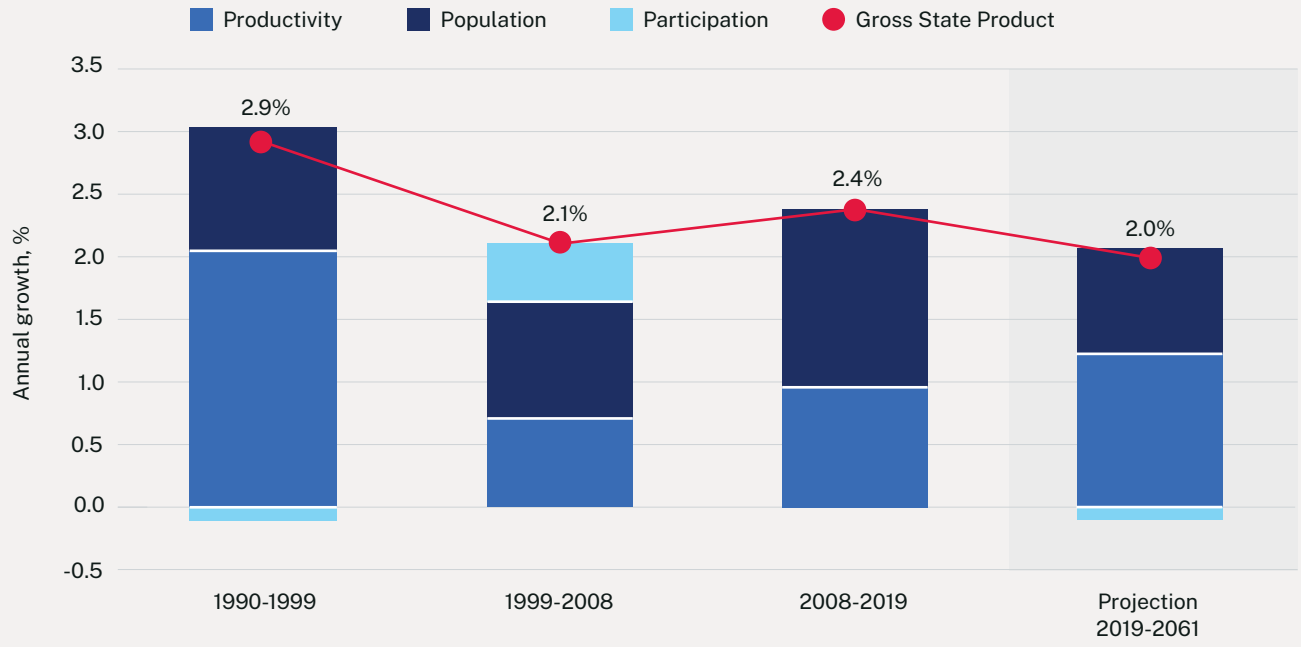
In the year to March 2021, Australia's population grew by only 0.1 per cent. That rise came entirely from natural increase — births slightly outpaced deaths. On top of this, border restrictions meant Australia lost people to other countries for the first time since 1946. In the September 2020 quarter, this migration from Australia outweighed natural increase. As a result, Australia's population in that quarter dropped — the first fall in more than a century:

> 'The last time we saw population decline was the year to December 1916, during World War 1.'
>
> **— Phil Browning, ABS Demography Director (Australian Bureau of Statistics 2021a)**

Figure 1

We need productivity growth to drive NSW's next 40 years of prosperity

Comparative contribution of population, participation, and productivity ('three Ps') to real NSW economic growth



Note: Participation is defined as hours worked per person.
Source: *2021–22 NSW Intergenerational Report*

Australia's low level of migration during the COVID-19 pandemic will change the NSW economy in both the short and long term.

In the short term, closed borders also cut off NSW's supply of new temporary visa workers — like students and working holiday makers — a group that normally makes up 7.5 per cent of the NSW workforce. In a responsive labour market, a shortage of key visa workers prompts wage rises that attract local workers to step in and fill the gap. But instead, there has been an acute shortage of labour to fill lower-skilled jobs — like hospitality, cleaning, manufacturing, and labouring — and economic activity is being forgone.

Employers who have historically relied on skilled migration to fill high-skilled roles have also had to adjust (Chand and Tung 2019). With limited access to skilled workers from overseas, companies have had to compete more aggressively for a limited supply of local talent — a difficult feat with unemployment at record lows.

With migration levels not projected to return to pre-pandemic levels until 2024-25, lower migration may hold back economic growth and worsen skill shortages (Commonwealth Treasury 2021).

Restoring previous migration flows is also not enough, on its own, to restore our previous population trajectory. In the longer term, this period of lower migration intake will lead to a smaller and older population. NSW's population is projected to be smaller by 350,000 people by 2031 than it would otherwise have been, because migration was constrained in the early 2020s (see **Figure 2**).

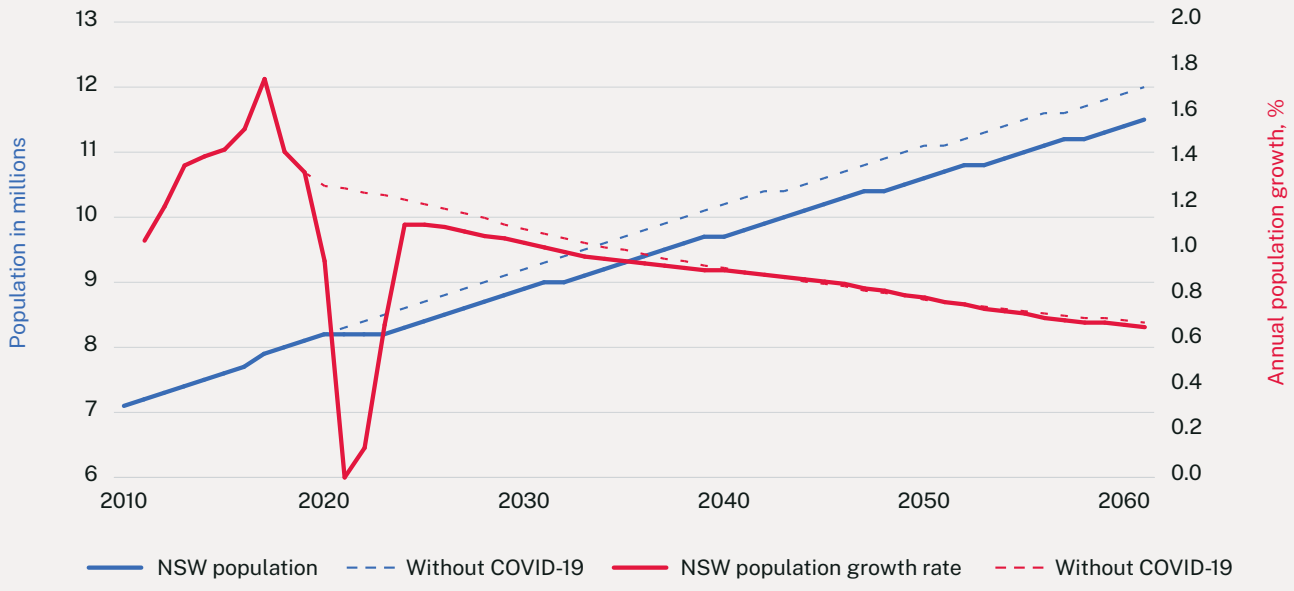
As well as being smaller, the state's population is projected to be marginally older. This is because NSW will have fewer new young migrants working in an otherwise ageing population (Centre for Population 2020; CEDA 2019). An older population means a higher proportion of retirees and a lower rate of workforce participation.

In short, with migration interrupted as a source of both population and participation, the state's prospects for economic growth depend more than ever on the third P: productivity.

Figure 2

International border restrictions have interrupted NSW population growth

Projected 2010-2061 NSW population and population growth rate, with and without COVID-19



Dotted lines are population estimates had the COVID-19 pandemic not occurred.
Source: *2021–22 NSW Intergenerational Report*

1.3 The growth of our population and workforce is slowing

Like many other developed economies, NSW faces an ageing population. Women in NSW are having fewer babies, and the people of NSW are living longer. The latter is due to tremendous advances in medicine over the past century, including the development of antibiotics, vaccines, and better sanitation and public health. For instance:

- Infant mortality rates plummeted from 103 deaths per 1,000 live births in 1900 to just 3.3 in 2017 (Australian Institute of Health and Welfare 2020; Australian Bureau of Statistics 2002).
- Mortality from infectious diseases like tuberculosis only accounted for 1.3 per cent of deaths in 2000 compared to 12.8 per cent in 1907 (Australian Institute of Health and Welfare 2005).

The cause of declining fertility rates is less certain. But major factors include the contraceptive pill becoming widely available and that families are forming later, because women have more opportunities in education and work.

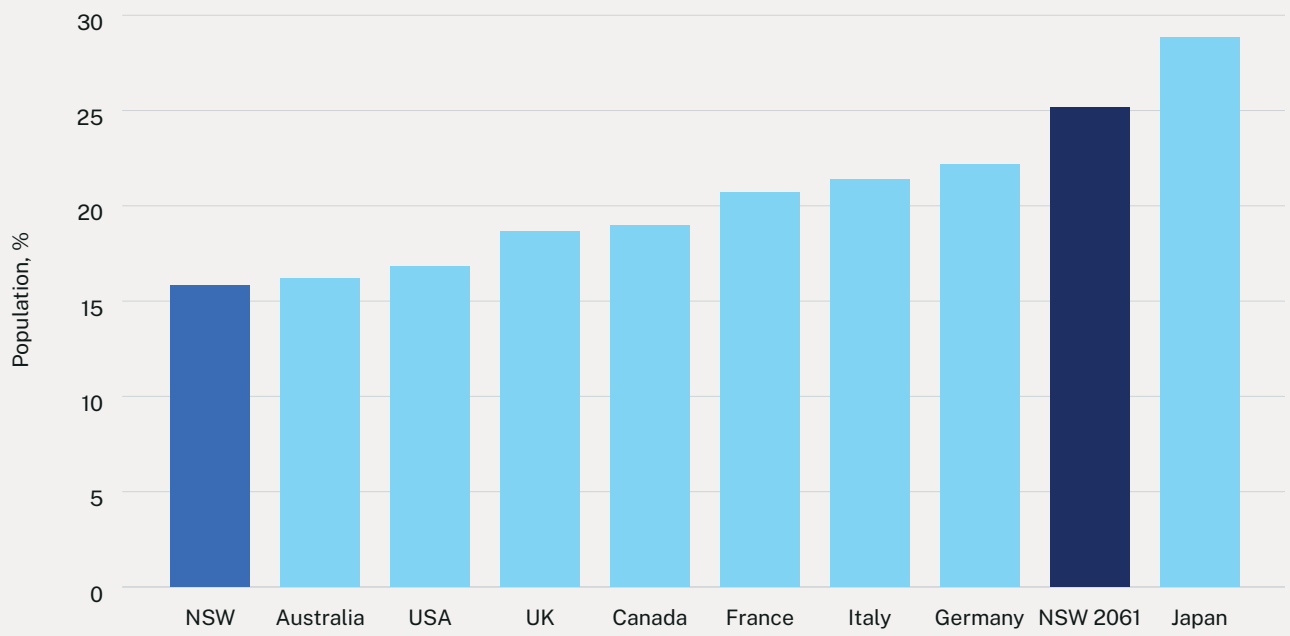
The *IGR* projects our population in 2060-61 to be larger and older. The average age of the NSW population is expected to rise from 38 years in 2021 to 44 years in 2061. And our age dependency ratio — the ratio of people 65-and-older to people of the traditional working age (15 to 64) — is expected to rise from 26 per cent today to 42 per cent in 2061. This will leave the equivalent of just 2.4 working-aged people supporting each of our retired population, compared to 3.9 today. In fact, by 2061 it is estimated that more than 25 per cent of NSW citizens will be aged 65 and over, up from 16 per cent in 2021 (NSW Treasury 2021).

Population ageing will also affect our workforce participation rate. This rate has risen in recent decades — from 60 per cent in 1978 to 65 per cent in 2021 — as women's workforce participation has risen. However, it is expected that older people will begin to leave the workforce faster than young people can replace them. As a consequence, the overall participation rate is projected to decrease from 65 per cent in 2019-20 to 62 per cent in 2060-61 (NSW Treasury 2021).

Figure 3

NSW's age profile in 2061 will resemble that of Japan and Germany today

Proportion of population aged 65 and over in 2021, by developed economy, compared to NSW 2061 *IGR* population projection



Notes: All population figures are 2021 except NSW 2061. The G7 economies have been used as comparators.
Sources: *2021-22 NSW Intergenerational Report*, ABS, Italian National Institute of Statistics, Federal Statistical Office of Germany, Statistics Canada, Statistics Bureau of Japan, United States Census Bureau, The National Institute of Statistics and Economic Studies (France)

As **Figure 3** shows, with less migration, our future age demographic composition will resemble that of Germany and Japan today (International Institute for Applied Systems Analysis 2018). These developed economies have the oldest average populations in the world. As NSW begins to face the same trends as these other countries, we should look more closely at how these countries have approached demographic change. This provides the opportunity to use their experiences to inform NSW Government policy to address our own changing population.

This population shift will have a significant impact on the NSW economy, with consequences for our public spending and living standards. The *IGR* projects growth in state revenue sources like payroll tax and stamp duty to decline as the proportion of working-age people falls.

Meanwhile growth in government expenditure, like healthcare, will have to accelerate to support our ageing population. Increases in government healthcare spending will likely only be partially offset by relative falls in education expenses. Without corrective measures, the fiscal gap[2] is estimated to be 2.6 per cent of GSP by 2060-61, excluding debt servicing costs.

This fiscal gap will limit how much the NSW Government can spend without further increasing public debt. If the gap is not addressed, the ageing population will put pressure on NSW Government services. And it will limit our state's ability to respond to crises with business and income support, like COVID-19 support grants.

2 The projected change in revenues less expenditures as a percentage of GSP, including net capital expenditure but excluding interest.

1.4 The spotlight is on productivity

With participation rates expected to fall and the impact on working-age migration due to COVID-19, increasing productivity is likely to be the main source of economic growth.

Encouraging productivity growth is critical in the long run to driving economic growth and lifting living standards in NSW (NSW Productivity Commission 2021a). This is true even if we experience setbacks such as periods of high inflation (see **Box 2**).

NSW's productivity growth averaged just 0.9 per cent per annum between 1999-00 and 2018-19 (see **Figure 5**). This lags the average for Australia (1.2 per cent) and the G7 (1.2 per cent), during the same period (NSW Treasury 2021).

Economists differ in their thinking about how fast productivity will grow in coming years (Mizen, 2021). Future productivity growth depends on so many factors that we cannot predict it. Because of this, economists generally apply broad assumptions consistent with past performance when projecting into the future. This method has a limited evidence base: the future can turn out to be very different to the past. But it is a straightforward approach that has as good a track record as any other.

Box 2

If real wages have gone backwards, does productivity still matter?

Real wages are what we earn, adjusted for inflation (rises in the price of goods and services). By allowing the economy to produce more goods and services with fewer inputs, productivity growth helps our wages grow faster than inflation over time.

But unfortunately, for the past few years, real wages have been going backwards (see **Figure 4**), even with productivity growing modestly. Between June 2021 and June 2022, real wages fell by 2.5 per cent, and many people across the state are experiencing cost of living pressures.

Some may ask: is productivity worth pursuing if real wages fall regardless?

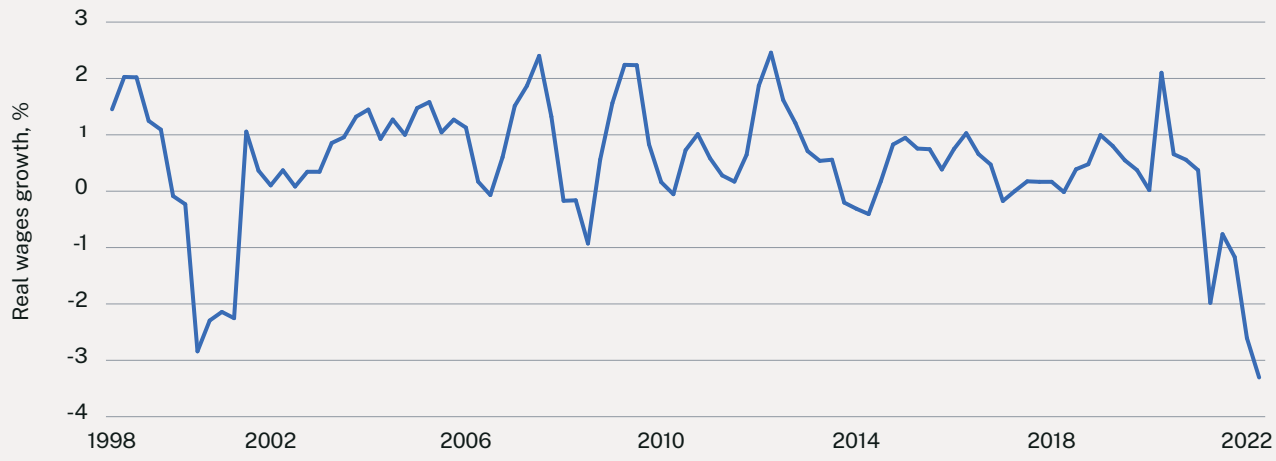
To answer this question we must understand why real wages have fallen. In the wake of COVID-19, supply bottlenecks, labour shortages, war in the Ukraine, and increased consumer spending, have all contributed to high inflation. Wages have grown, but they have not kept up. As a result, the real wages of NSW citizens are falling. Citizens of many developed economies face a similar experience.

The past few years show that productivity growth does not guarantee real wage rises. But the fact remains that, in the long run, our real wages cannot grow without it. If we want to return to strong and sustained real wages growth, the spotlight remains on productivity.

Figure 4

NSW real wages have gone backward since the pandemic began

Real wages growth 1998-2022: NSW

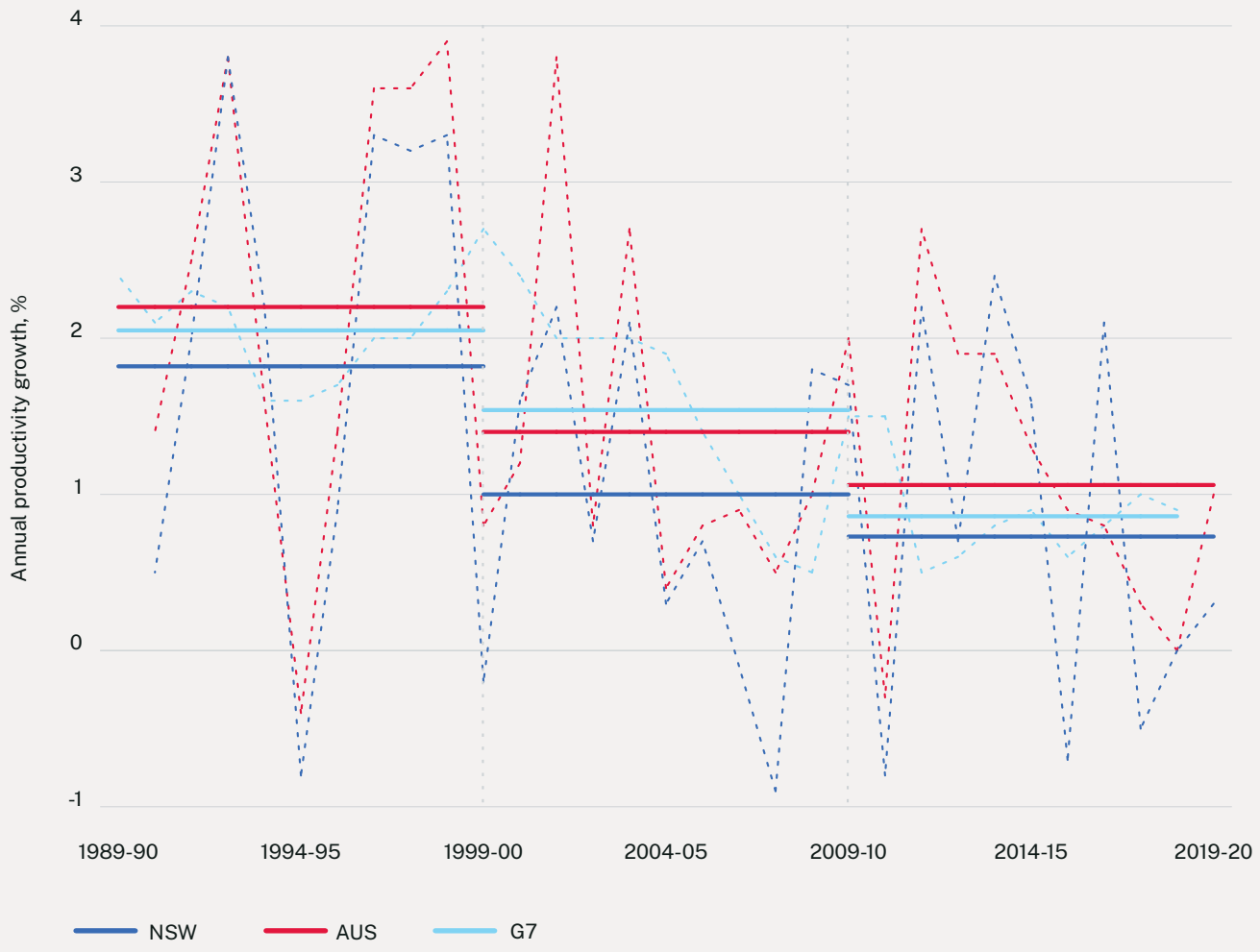


Source: Australian Bureau of Statistics (2022b)

Figure 5

NSW's productivity growth has slowed and is lagging the G7's

Comparative productivity growth: NSW, Australia, and the G7



Note: Unbroken lines indicate average productivity growth for each decade.
The G7 is made up of the US, Japan, Germany, the United Kingdom (UK), France, Italy, and Canada.
Source: *2021–22 NSW Intergenerational Report*

Using this method, the *IGR* projects average productivity growth for NSW of 1.2 per cent over the next 40 years (NSW Treasury 2021). The *2021 Commonwealth Intergenerational Report* assumes, based on past performance of the national economy, a slightly higher 1.5 per cent annual average productivity growth for Australia over the same period (Commonwealth Treasury 2021). Our future productivity growth could easily turn out higher or lower than these projections.

Regardless of future rates, we know that well-chosen reforms can boost productivity growth. The *White Paper,* identifies 60 opportunities to help reboot growth across talent, innovation, housing, and infrastructure. *Adaptive NSW* builds on the *White Paper* to show the huge potential of emerging technology to revive productivity across the state and transform the world of work.

2

The tech opportunity

A group of emerging technologies known as ‘Industry 4.0’ could boost productivity to levels not seen since the 90s. There are no guarantees, but we can recognise the opportunities and be ready seize them.

At a glance

Emerging technology diffusion has the potential to lift NSW's productivity growth rate to 2.0 per cent a year and lift the growth of real GSP to 3.0 per cent a year to 2035. In other words, emerging technology could be a productivity boost comparable to the 1990's Information and Communication Technology (ICT) boom. We have no way to predict if this will happen, but we can recognise the possibility and be prepared to take full advantage of it.

The emerging technologies fall into two broad categories:

- **Productivity-enhancing technologies** — these automate or augment work tasks in existing jobs and industries, changing the skills profile of the workforce.
- **Technological innovations** — these create entirely new products, markets, services, and industries which lead to the creation of new kinds of jobs.

Technology automates some work tasks and augments human effort for others. While many worry about technological unemployment, history shows that technology tends to change the mix of tasks we do at work rather than the level of overall employment.

Today, most new jobs are created in services, and emerging technology diffusion would accelerate that trend. It would also accelerate the trend away from physically-demanding work and make work more cognitive, social, and flexible. Emerging technology adoption could boost demand for existing tech roles and create entirely new high-skill, high-pay, technology-related jobs.

2.1 A new wave of emerging technology and productivity may be close

Some worry that the current productivity slump is permanent, and that hopes for a technological solution are pie in the sky.

History, however, tells a different story. It tells us that technological development comes in fits and starts. From the printing press to the automobile to the internet, transformational technologies have appeared at intervals, each time fundamentally changing our society and economy. We do not know exactly what the next wave of transformational technologies will be. We cannot say when it will arrive, nor how quickly it will crest. But we should expect the next wave is coming, and we can be ready to take advantage of its opportunities.

We also know that technological transformation takes time (David 1989). After each transformational technology appears, a quieter period follows, as this technology spreads through society and is slowly improved. In the early 1900s, economists Kondratiev and Schumpeter developed the concept of 'Kondratiev waves', reflecting multidecade cycles in which stages of economic expansion, collapse, stagnation, and recession track closely to technological development (Grinin, Korotayev, and Tausch 2016).

Some recent work has looked at the history of productivity growth across many advanced economies, including Australia (Philippon 2022). It found that productivity tends to increase by a constant amount each year, implying a declining growth rate, unless a new wave of technological development created a 'historical break', accelerating productivity growth for years or decades.

Periods of strong economic growth clearly correlate to major technological developments, like steam power, electric power, personal computing, and other general-purpose technologies. But these technological revolutions are infrequent. Their timing and size are difficult to predict.

Over the last century, Australia has seen two notable boosts to productivity growth, both associated with technology (Bergeaud, Cette, and Lecat 2016). The major one started in the 1930s, driven by technologies like electricity and the internal combustion engine. It represented a historical break, setting productivity growth on a different path to the previous era. A smaller shift happened in the 1990s, attributed to the ICT revolution. This later boost was only temporary. By the end of the decade productivity growth had fallen to previous levels and it has trended downward ever since.

Today we often talk about large waves of technological and economic change as 'industrial revolutions' (see **Box 3**). Between such periods of rapid innovation, economic growth has often slowed (Ayres 1988).

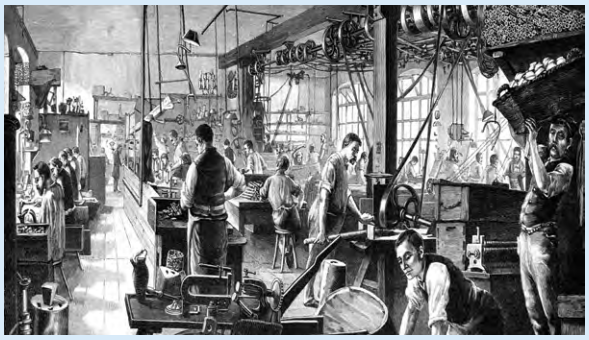
According to the World Economic Forum, we are on the eve of a Fourth Industrial Revolution or 'Industry 4.0'. Industry 4.0, many believe, will build on the Third Industrial Revolution with '"cyber-physical systems" involving entirely new capabilities for people and machines' (Davis 2016). Futurists think this Fourth Industrial Revolution could be characterised by machines that could talk to each other and exchange and use information to act independently of human control; as well as those that could analyse, diagnose, and fix their own problems without human intervention. It would be supported by emerging technologies including artificial intelligence (AI), quantum computing, 3D printing, autonomous vehicles, and the Internet of Things, to name just a few (Schulze 2019).

'[The Fourth Industrial Revolution] is characterized [*sic*] by a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human.'

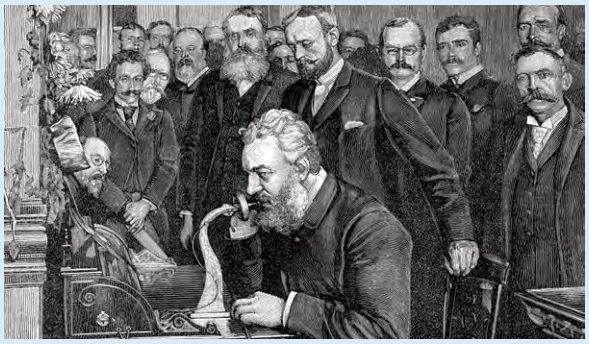
— Klaus Schwab (Schwab 2017)

Box 3

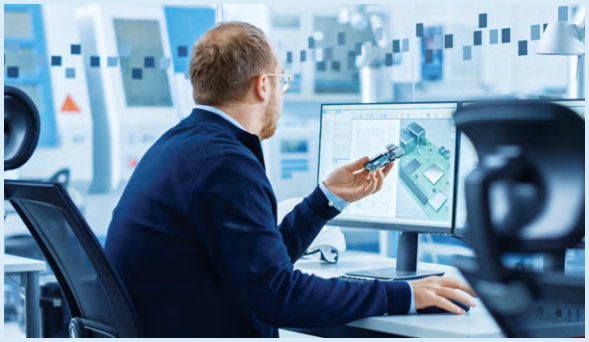
What did the previous industrial revolutions look like?



The **First Industrial Revolution** (beginning c. 1760) marked the transition from hand to mechanical production methods, using water and steam power.



The **Second Industrial Revolution** (beginning c. 1870) was characterised by using electric power to mass-produce goods. The key inventions of this period include the light bulb, telephone, and internal combustion engine.



The **Third Industrial Revolution** (beginning c. 1950) or 'digital revolution' involved an upsurge in digital systems and technologies. Key inventions from this period include the semiconductor, personal computer, and the internet.

Sources: Schulze (2019); Schwab (2016); Schwab (2017); Davis (2016)

Some believe NSW will adopt automation more quickly after COVID-19, as it did after previous recessions (Economist 2021). In previous recessions, the revenues of firms decreased while wages (locked in by awards and enterprise agreements) tended to remain sticky. Therefore, automation gave companies a strong financial incentive to save on labour costs by automating tasks previously performed by employees. Economic shocks also enable firms to do things differently, because they break down barriers to social change.

NSW Productivity Commission modelling, powered by Faethm AI, examines the potential of four major groups of productivity-enhancing technologies (see **Table 1**) to impact the NSW economy. The model looks across all occupations and industries in the NSW economy, examining which tasks the emerging technologies could automate (see **Appendix 6.3**). The model quantifies these impacts to illustrate how much emerging technologies could boost NSW's overall output per worker.

Our modelling suggests these technologies have great potential. The central scenario we modelled saw the state's productivity growth rising as high as 2.0 per cent a year, lifting GSP growth to 3.0 per cent a year to 2035 (see **Figure 6**).

A productivity boost of this size could significantly improve both household incomes and the budget. NSW Treasury modelling indicates that, under this scenario, GSP would be 11.8 per cent larger by 2034-35, equivalent to $27,400 per household (in real 2021-22 dollars).

The stronger economy could also improve the NSW Budget outlook, with own-source revenues projected to be $4.5 billion higher in 2034-35 relative to the baseline scenario.

In our central modelling scenario, productivity growth would rise to levels not seen since the 1990s. And like the 1990's ICT boom, high productivity and economic growth rates would be sustained for several years, before things reverted to their previous trend. This scenario is broadly consistent with models of so-called 'intermittent automation' (Aghion, Jones, and Jones 2019). In other words, emerging technology could potentially give us a welcome (though temporary) hiatus from the falling productivity growth seen in recent decades.

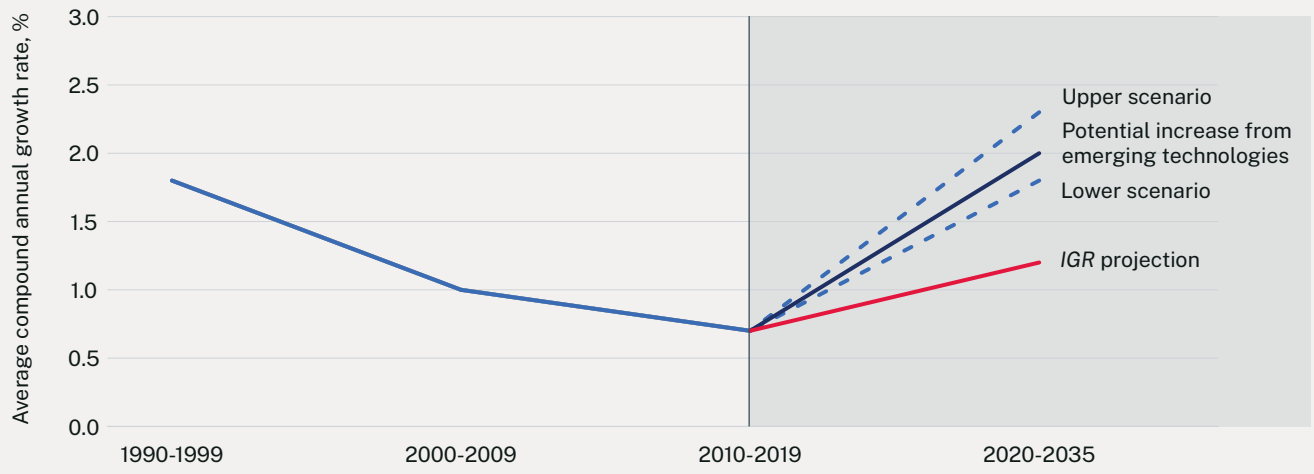
Of course, we cannot be certain of whether an emerging tech boom will occur, let alone when. But we can recognise the possibility and be well-prepared to take advantage of it.

To realise the tech opportunity, policymakers will need to consider mechanisms to accelerate automation and the digital economy, consider the skills needed, and set up inclusive policies that help those workers whose roles may be affected to adapt and adjust.

Figure 6

Emerging tech could recharge NSW's productivity and growth

Labour productivity average compound annual growth rate, 1990–2035



Note: The shaded area indicates the range of possible productivity growth rate scenarios from emerging technology diffusion.
Source: NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI).
2021-22 NSW Intergenerational Report

2.2 What are the emerging technologies and how will they drive prosperity?

Emerging technologies fall into two broad categories:

1. **Productivity-enhancing technologies** automate or augment work tasks in existing jobs and industries, changing the skills profile of the workforce (see **Table 1, Figure 7**).
2. **Technological innovations** create entirely new products, markets, services, and industries which lead to the creation of *new kinds of jobs* (see **Table 2**).

Faethm's AI platform groups 17 major emerging productivity-enhancing technologies (see **Appendix 6.3**) into four broad categories, classified by what they do. These are in various stages of development and have wide applications across many industries.

The Office of the NSW Chief Scientist & Engineer has developed a *NSW 20-Year R&D Roadmap*. The roadmap identifies NSW's competitive advantage — which it defines as 'attributes that allow a business or state to outperform its competitors' — in four innovative technologies (see **Table 2**) that have a range of different applications from robotics to MedTech to energy storage.

Table 1

Four types of emerging technologies will enhance productivity

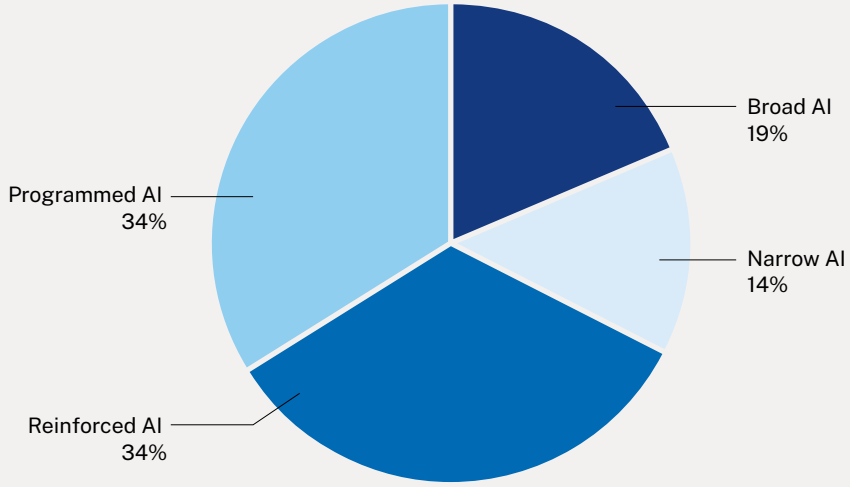
Technology category	Description	Technologies	Examples
Broad AI	AI that can operate with no human input. These technologies perform unstructured tasks and engage with their environment using perception and sensory processing of external input data.	• Conversation exchange • Decision generation • Dextrous robotics • Sensory perception	• Motion tracking • Safety monitoring • Automated medical diagnosis • Chatbots • Advanced manufacturing robots
Narrow AI	Semi-autonomous AI able to perform structured familiar tasks of a certain type when prompted.	• Predictive analysis • Recognition vision • Suggestion provision • Voice response	• Database manipulation and visualisation • Facial recognition • Medical image recognition • Search engines
Reinforced AI	AI that can learn from trial and error to perceive and complete new tasks. They can operate in unfamiliar environments by using reinforced learning.	• Assistive robotics • Collaborative robotics • Creative origination • Generative design • Navigation robotics • Solution discovery	• Production cobots • Art generation software • Design simulation • Aged care robots
Programmed Intelligence	Pre-programmed intelligence relying on human input. They perform repetitive tasks by employing rules-based logic, processes, instructions, and simple robotics.	• Fixed robotics • Mobile robotics • Process automation	• Robots assembling vehicle parts • Autonomous warehouse picking robots • Automatic HR and payroll processing

Source: Faethm AI; See Appendix 6.3 for a detailed explanation of each technology category

Figure 7

Reinforced and Programmed AI will have the largest impact

Proportional impact of emerging technology types on 2021 work tasks by 2035, %



Note: See **Appendix 6.3** for a detailed explanation of each technology category.
Source: NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI)

Table 2

Innovations that could create new products, markets, services, and industries

Technology category	Description	Examples	Industries most impacted
Digital technology	Technologies that support advanced applications of computers	• Software • AI • Data analytics • Quantum computing • Blockchain • Robotics • Communications • Sensing • Internet of Things • Semiconductors	All
Biotechnology	Technologies that use biological organisms, systems, or processes	• Biochemical technologies • Cell technologies • Genetic and molecular technologies • Medical technologies	Agriculture, forestry and fishing; manufacturing; healthcare and social assistance
Energy	Technologies that store, transport, manage, convert, and use energy	• Renewable energy generation • Energy storage • Power to X	Agriculture, forestry and fishing; electricity, gas, water and waste services; construction, transport, postal and warehousing; manufacturing
Materials/chemistry	Technologies that use chemical properties and interactions	• Nanotechnology • Smart materials • Circular economy • Nuclear science	Electricity, gas, water and waste services; mining; manufacturing; transport, postal and warehousing; healthcare and social assistance; agriculture, forestry and fishing

Source: Office of the NSW Chief Scientist & Engineer (2022); NSW Productivity Commission analysis.

2.3 Unemployment will remain low, but jobs and tasks will change

When contemporary societies discuss automation, one subject almost always arises: a jobless future in which robots replace people in almost all work. Public concern about this possibility has been termed 'automation anxiety'. A recent survey found that 32 per cent of Australians believe their job will be obsolete within five years, and 51 per cent do not feel positive about the future of work (PwC, 2021).

Automation concerns have been with us since the earliest days of economics. The early Swiss economist J.C.L Simonde de Sismondi (1819, 2:331) wrote that: '[I]t remains only to desire that the king, who has been left quite alone on the island, should, by continuously cranking up a number of automatons, get all England's work done.'

Today, however, economists can find little evidence that technology reduces the overall demand for labour over the long run, or that it causes long-term structural unemployment. Rather, it creates widespread wealth and prosperity (Autor 2015). In the shorter term, transitions need to be carefully managed, so that everyone gets to benefit from technological change to the economy. We discuss the importance of inclusive transitions in **Chapter 5**.

History confirms this. In 1911, around a third of Australian males were employed in agriculture. But by 2011, because of technological innovation, this share had fallen to 6 per cent and, according to the 2016 Census, now only 2.1 per cent of the NSW workforce works in agriculture (Ting 2017; Australian Bureau of Statistics 2016).

Over time, workers have tended to move from physically-demanding, often monotonous, farm work into other areas of the economy, particularly services.

While it employs a smaller part of the workforce today, agriculture has continued to flourish. Nationally, the sector has grown by seven per cent in real terms over 20 years, with 72 per cent of its agricultural output exported (ABARES 2022).

And while some jobs will be entirely vulnerable to automation — estimates vary substantially from five per cent to 47 per cent of all jobs (Mosseri, Cooper, and Foley 2020) — it will not lead to widespread joblessness. This is because automation raises productivity, which increases the demand for workers performing non-automated tasks (Acemoglu and Restrepo 2019) (see **Box 4**).

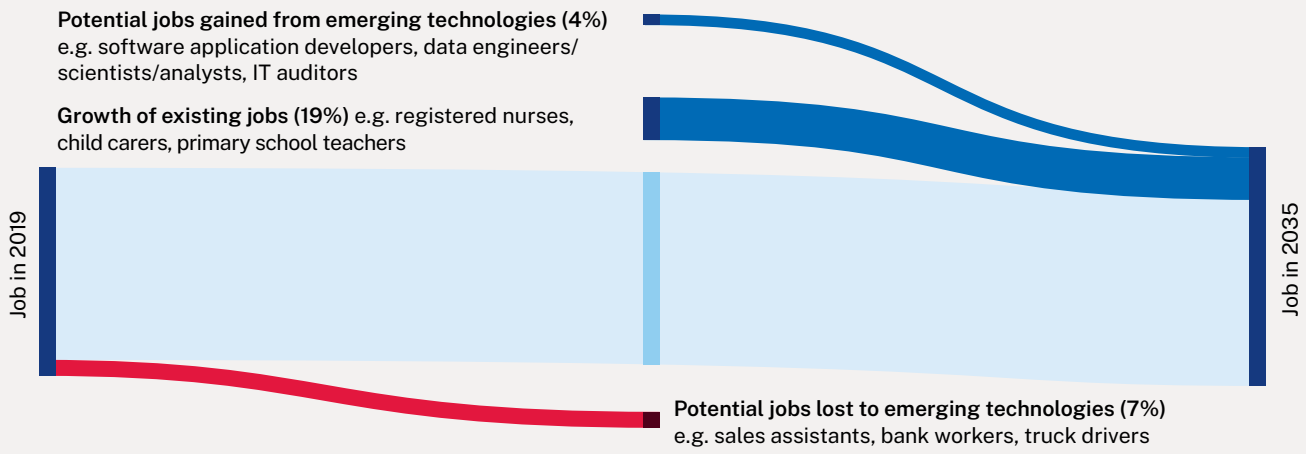
As **Figure 8** shows, emerging technologies are predicted to dampen the demand for some occupations. Yet, this decrease will be more than offset by increasing demand associated with a growing economy, as well as rising demand for new jobs added to support industries adopting emerging technologies.

Because the active working-age population is growing so slowly, emerging technologies are even less likely to lead to mass unemployment. Indeed, in some cases they may instead help alleviate labour shortages.

Figure 8

Emerging technology diffusion will result in more jobs overall

Predicted sources of job growth and job loss in NSW from emerging technology diffusion, 2019–2035



Source: NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI)

Box 4

If technology saves labour why aren't we working less?

In 1930, economist John Maynard Keynes famously predicted that technological advancements would make us so productive we could reduce the average work week to just 15 hours.

Part of the prediction came true. Significant productivity gains over the last 90 years have greatly raised real incomes and enhanced standards of living. In fact, an average US worker in 2015 who wanted to live at the income level of an average worker in 1915 could do so by working around 17 hours a week[3].

So *why* is the average working week still around 40 hours long?

One reason is that we are living longer so need to save for retirement. We also expect to live better than we did in the past. As Autor points out, while our wages are much higher, we also consume a lot more. Our discretionary spending includes leisure activities like shopping, travelling, and eating out at cafes and restaurants.

Over time, the share of income gains from productivity growth going to workers' wages has also fallen, while that going to owners of capital has increased.

Another reason is that technology has relieved us of much of the hard physical labour that shortened lives (including working lives) in the past.

But productivity growth still benefits workers. Over the last century, governments of developed economies have taken on a growing role redistributing the benefits of productivity gains to workers through new and improved government services, the tax system, and social support payments. Most Australian workers share the benefits of productivity not only through wages but through profits. Workers often receive profits from interest, dividends or capital gains on superannuation, savings and investments, and from capital gains on dwellings.

Source: Krook (2017); Autor (2015); NSW Productivity Commission (2021a)

3 Autor uses analysis by Douglas (1930; reproduced in US Bureau of the Census 1949) to calculate that it would take the average US worker 17 weeks in 2015 to earn a full-time annual 1915 income. Based on Douglas (1930) data showing that the average worker worked 53.5 hours a week in 1915, this equates to around 17 hours a week [(17 weeks x 53.5 hours) / 52 weeks].

2.3.1 Work tasks will change within occupations

Automation and augmentation are more likely to change work tasks, rather than erase entire occupations. In 2021, the OECD conducted a study on the impact of AI on the labour market and concluded that 'much of the impact of AI on jobs is likely to be experienced through the reorganisation of tasks within an occupation' (Lane and Saint-Martin 2021, 4). Australian economics commentator Ross Gittins recently summed up our own experience with automation:

> 'Many people think automation destroys jobs. But in 250 years of installing ever-better "labour-saving technology" we've managed to increase unemployment only to 6 per cent or so. That's because automation doesn't destroy jobs, it changes and moves them. From the production of physical goods to the delivery of human services. In the process, it's made us hugely better off.'
>
> **— Ross Gittins, The Sydney Morning Herald (Gittins 2021)**

An analysis of the NSW workforce using Faethm's 'AI Engine'[4] also projects that most existing jobs will remain (see **Figure 8**). But as well as freeing up time for the tasks we still perform, the analysis notes that automation may change the underlying nature of some jobs, like bank tellers and radiologists (see **Box 5**).

In other words, if we time-travelled to NSW in 2042, we would likely find many people doing the same jobs as today — but they would often be using emerging technologies to get more done with less effort. We would also likely see some people doing new kinds of jobs, involving technologies that do not exist today. We would be unlikely to see much technology-related unemployment.

Box 5

What bank tellers can tell us about the future of radiologists

The evolution of bank tellers in the US illustrates how technology can change the nature of an occupation. The advent of automated teller machines (ATMs) bred fears that large numbers of bank tellers would be made redundant. But while ATMs decreased the number of tellers required per branch, they also reduced branch operating costs, which led to an increase in the number of branches and thus tellers overall. ATMs also freed up bank tellers to focus on more complex, service-based tasks that add more value, like talking to clients about investments or banking services.

Today AI technologies are learning to accurately diagnose diseases from medical images — for example, pneumonia from chest X-rays. That has called into question the future of radiologists. Yet as with bank tellers, technology is unlikely to remove the need for radiologists entirely. Analysing images is only *part* of the job. Of the 29 tasks[5] radiologists perform, just two are directly impacted by image recognition AI. Most still require human intervention. For example, radiologists need to decide which images should be taken, direct technologists, and communicate results to patient-facing doctors. These tasks require social skills, which will likely become increasingly important.

Such change also delivers benefits to patients, medical professionals, and health outcomes. Radiologists are able to spend additional time problem-solving and analysing a more complex, targeted, and accurate set of images. Patients receive more accurate diagnosis, more time with their radiologist, and better health outcomes.

Source: Agrawal, Gans, and Goldfarb (2019); Bessen (2015); Kubota (2017)

4 The 'AI Engine learns' what jobs are automatable or augmentable based on a job's underlying attributes and tasks.
5 According to the occupational classification database O*NET.

2.3.2 Most new jobs will be created in services

The creation of new, high-skill jobs associated with emerging technologies will have strong multiplier effects throughout the economy. That is, more high-skill jobs will in turn cause increases in economic activity and create jobs elsewhere. Research has shown that every high-skill technology job can create up to five new local service jobs (O'Toole 2013).

Services have been the main source of employment growth in NSW over recent decades. According to the *IGR*, the services sector is projected to make up 52 per cent of all jobs by 2035, up from 36 per cent in 1989–90 (NSW Treasury 2021). Emerging technology diffusion would lift the share of service employment even further (see **Figure 9**).

Some of these service jobs already exist, like nursing and aged-care work. Others will be entirely new occupations, created in service industries including healthcare and social assistance, education and training, and arts and recreation (Moretti and Thulin 2012; Moretti 2010; O'Toole 2013). Data analytics, at the intersection of IT and services, is an industry which will no doubt burgeon (Gupta et al. 2019).

The same has been true historically — one in 10 Australian workers today have jobs that did not exist in 1911, with these new occupations ranging from personal trainers to baristas to IT workers (Atkinson and McKay 2007).

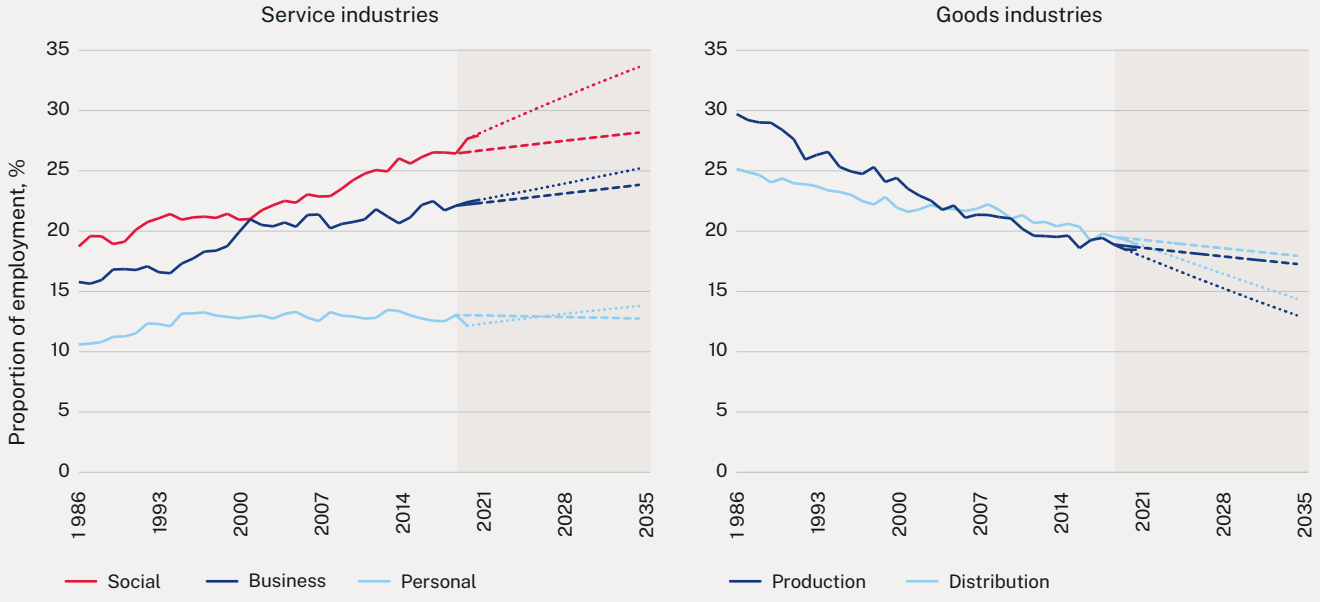
Some people are concerned about whether these new services jobs will be well paid. We discuss the importance of distributing the benefits of technology widely in **Chapter 5.5**.

But why is the share of service employment rising?

As the amount of money people spend on services increases with their income, the new highly-paid tech workers will spend big on services (Schettkat and Yocarini 2006). They will also pay more income tax, supporting the provision of non-market government services. Many services are human-centric and difficult to automate, meaning rises in demand for services will translate closely into employment (Schettkat and Yocarini 2006).

Figure 9

Emerging tech could further accelerate the growth of services jobs



Projected share of NSW employment by sector, 1986–2035

····· Dotted lines represent impact of emerging technology diffusion ---- Dashed lines represent *IGR* projection

Note: *IGR* projection begins in 2018-19. The impact of emerging technology diffusion was projected from 2019-20.
Source: *2021–22 NSW Intergenerational Report*, NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI)

2.3.3 The workforce will need more education and training

When simpler work tasks get automated, the work tasks that remain tend to be those that are more complex, requiring advanced skills. For this reason, over time, there are more jobs in the economy that require advanced qualifications, and less that can be done with only a high-school education. If emerging technologies became widespread, this trend would accelerate (see **Figure 10**). It is important to be aware that this trend could also be driven, in part, by rising credentialist barriers across the economy (see **Section 4.3**).

2.3.4 New and expanding industries will create high-skill, high-pay tech-related jobs

The advent of personal computing over the last century both complemented many existing office-based professions and created entirely new occupations, like programmers, network technicians, and web designers (Atkinson and McKay 2007).

In the twenty-first century, technology and investment in emerging and high-growth industries will likewise increase demand for existing tech roles and also create new high-skill, high-pay technology-related jobs (see **Figure 11**).

World Economic Forum (2020) analysis of annual growth across 20 major economies shows that job opportunities in emerging data and AI professions grew 41 per cent a year on average between 2014 and 2019. The *Technology Impacts on the Australian Workforce* report by the Australian Computer Society and Faethm (2020) predicts that 25 per cent of the 5.6 million new jobs that could be added to Australia's economy over the next 15 years will be technology-related roles.

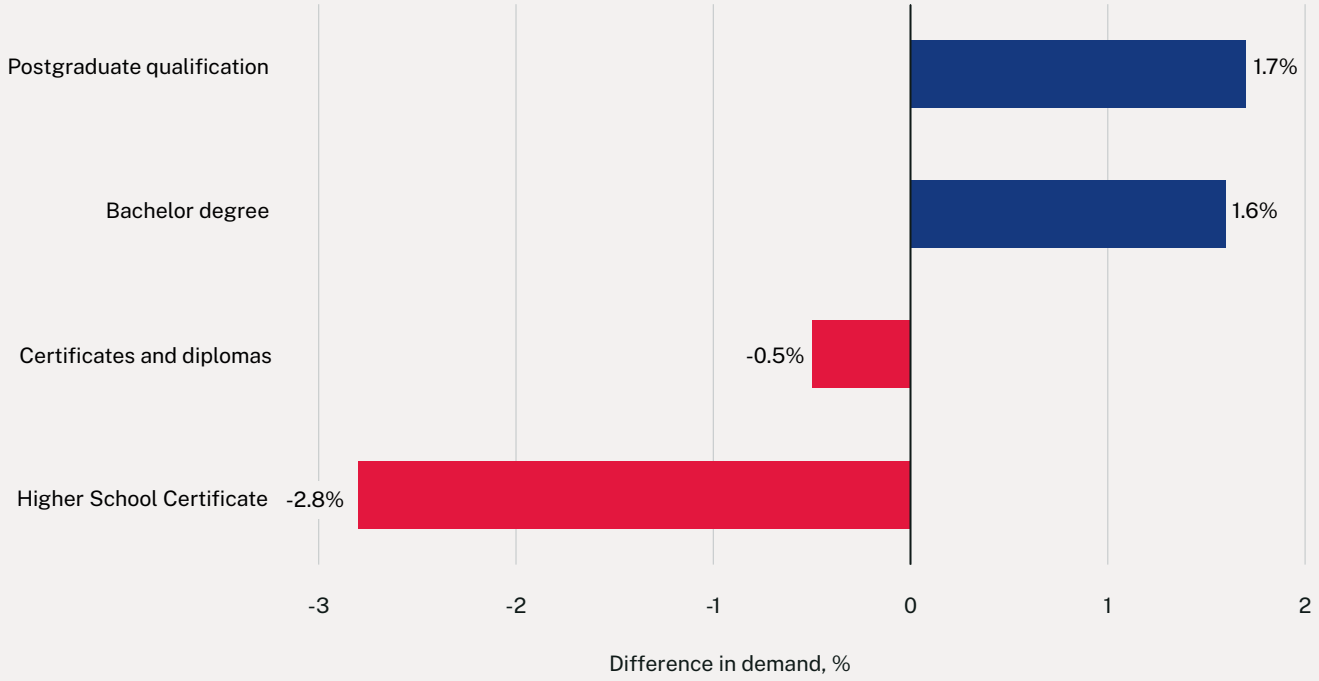
New jobs will be created to develop, maintain, and administer emerging technologies. One example: as warehouses automate, they use robots to stock shelves, pick orders and, in some cases, package shipments. This reduces the need for warehouse workers, whose skills could be absorbed in new areas like customer service. It would also create a variety of engineering, programming, and technical jobs to develop, install, and maintain the technology (Madine 2020). These jobs are highly skilled and well paid.

Data analytics is another area where emerging technology is expected to create new work and high-skilled, high-paid jobs. Emerging technologies like AI and process automation generate new forms of data as they are implemented. Analysing and using this data will become important, high-skilled work as emerging tech becomes widespread.

Figure 10

Workers will need more education if emerging tech becomes widespread

Projected difference in demand for qualifications due to emerging technology diffusion, NSW, 2035

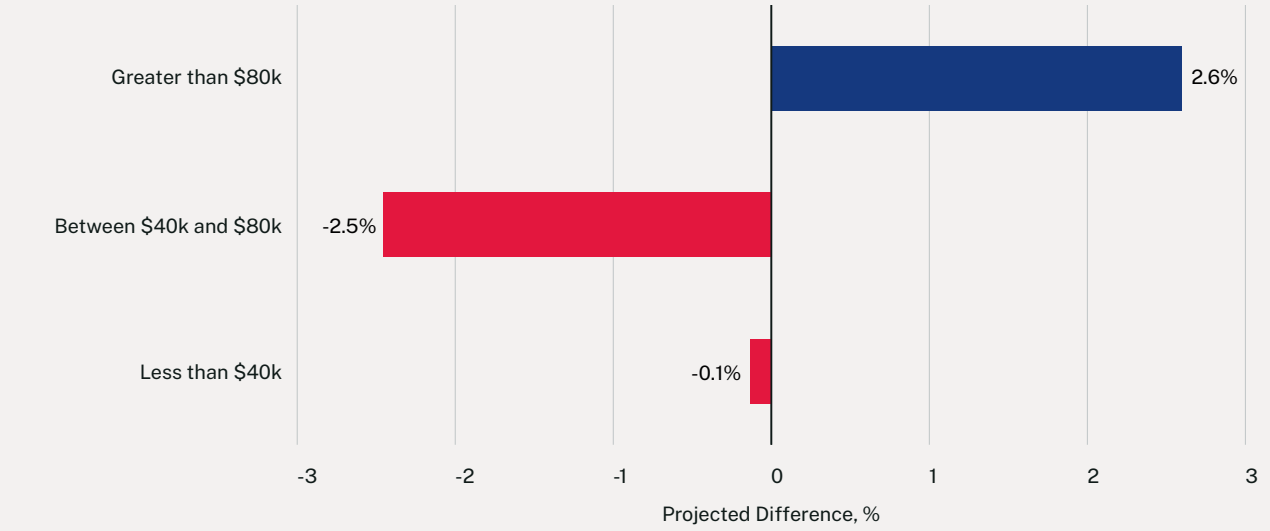


Source: NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI)

Figure 11

Emerging tech diffusion will increase the proportion of high-pay jobs

Projected difference in job demand by annual wages due to emerging technology diffusion, NSW, 2035



Source: NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI)

2.4 Tech will make work more cognitive and social

As technology has advanced over the decades, jobs have tended to require less elbow grease and more know-how. The proportion of knowledge-based workers[6] in the NSW economy grew from 16.6 per cent in 1986 to 27.8 per cent by late 2021 (Australian Bureau of Statistics 2022a). Meanwhile, the share of jobs involved in producing goods fell from 31.6 per cent to 19.7 per cent over the same period. Tools and machinery have completely replaced certain tasks and reduced the time needed for others.

Agriculture provides many examples. A milking machine can now milk multiple cows at once, where a farmer formerly hand milked one cow at a time. A week of back-breaking work reaping a wheat field takes a day or less with a combine harvester. A farmer's job, once physically-demanding and laborious, now asks more for cognitive skills needed to operate and maintain the machinery. Other examples include the use of robots in car manufacturing, and the use of driverless trains to transport ore from mines.

Physically-demanding tasks are more likely to be repetitive, so they are likely to be easier to automate: machines can simply follow explicit rules (Autor, Levy, and Murnane, n.d.).

However, a second group of tasks is far more difficult to computerise and automate:

- Some of these are the tasks that need the problem-solving capability, intuition, and creativity known as 'abstract thinking'.
- Others are manually-dexterous tasks that rely on situational adaptability and in-person skills that automated machines do not possess (Autor 2015).

As robotics researcher Hans Moravec (1988) famously noted: 'it is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility.'

6 Defined as 'Professionals' in Australian and New Zealand Standard Classification of Occupations (ANZSCO).

In our previous example of milking cows, automation is straightforward: apply suction until the flow of milk stops. Compare this to maintaining a combine harvester, where a robot would need to physically diagnose and repair possible issues, and have the mechanical capability to fix the problem. This is a much more complex task than milking a cow so is unlikely to be completely automated. But it is a task that technology can help a person perform — for example, by providing a list of possible causes for diagnosed issues.

The partial or complete automation of these tasks creates capacity for higher-value, higher-income tasks that rely more on cognitive abilities (Schwabe and Castellacci 2020).

The worker who previously milked cows can instead focus on ways to improve milk production, while faster machinery repairs let farmers spend more time optimising crop yields.

Advances in AI, machine language, and robotics are beginning to solve even the most complex cognitive tasks. But until these come to fruition, manually-dexterous and cognitive tasks are still unable to be completely automated.

The adoption of emerging technologies will accelerate the trend away from physically-demanding, often repetitive work. Our modelling shows that a higher uptake of technology will increase demand for complex problem-solving skills, cognitive abilities, and social skills (see **Figure 12**).

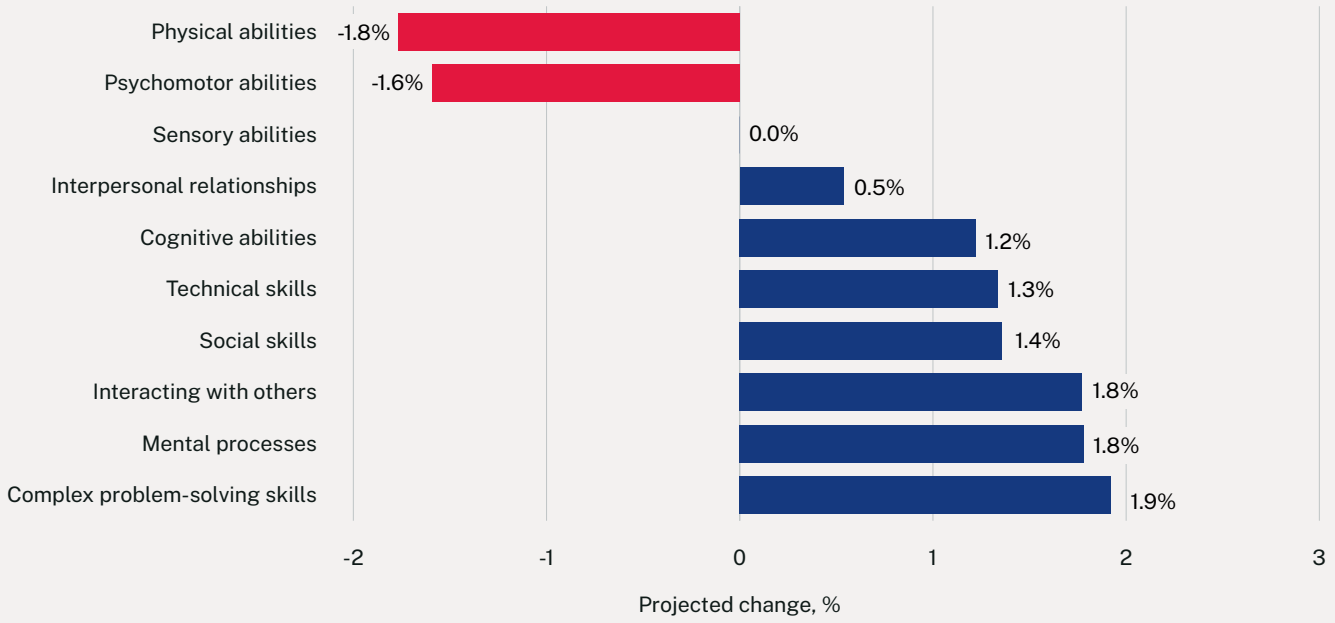
The average job in the 2035 NSW economy will be less physically demanding than it is now. Work tasks requiring limb strength and coordination — like lifting pallets — will be six per cent less common. So will tasks requiring psychomotor abilities — fast reaction times and fine motor movements. By contrast, demand for cognitive abilities will increase — diagnosing problems, interpreting data, and brainstorming solutions. The need for social skills to communicate new ideas or help customers solve problems will also grow.

Some worry that the loss of physically-demanding jobs because of automation may divide the workforce further, with labour markets increasingly favouring those who already specialise in cognitive work. **Chapter 5** explores ways to ensure adaptation is inclusive and that benefits of automation, augmentation, and technological transformation of our economy are broadly distributed and shared.

Figure 12

Emerging tech will accelerate the shift from physical to cognitive skills

Projected change in relative demand for skills and abilities due to emerging technology diffusion, NSW, 2035



Source: NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI)

2.5 Work will likely be more flexible and hybrid

Workers are increasingly pursuing 'portfolio careers', where they hold multiple roles at once (Castrillon 2019). They are also engaging with work through different employment models, including casual and freelance 'gig' work.

The gig economy is growing rapidly in size. In Australia, it grew ninefold between 2015 and 2019, to $6.3 billion. It employs up to 250,000 workers. From 2018 to 2019, together with the Australian Capital Territory, the NSW gig economy grew by 31 per cent with 44 per cent of the population transacting through digital platforms (Actuaries Institute 2020). The Commonwealth Government has announced a forthcoming White Paper on employment, which may include reforms affecting the gig economy (The Hon. Dr Jim Chalmers MP and The Hon. Anthony Albanese MP 2022).

Unions NSW (2016) identifies some key features of gig work. In summary, workers:

- are engaged on a task-by-task basis
- may be commissioned by an individual or business
- are linked with an individual or business via a digital labour platform (see **Box 6**) run by a facilitating company
- are classified as independent contractors by the facilitating company.

While the gig economy offers many positive opportunities, it also raises the challenge of ensuring that emerging technologies and ways of working are accompanied by appropriate protections for workers. This challenge is explored in detail at **Chapter 5.6.**

During the COVID-19 pandemic, remote and hybrid working have also become trusted allies for workers and employers globally. The NSW Innovation and Productivity Council launched the NSW Remote Working Insights Project in 2020 to explore the implications of this dramatic shift to remote working (see **Box 7**).

The experience of early 2021 suggests that remote and hybrid working have become more than just a Plan B and will likely be a major part of the post-COVID-19 economy. This can enhance NSW's ability to:

- diversify our regions (see **Chapter 5.2**)
- break down barriers to participation (see **Chapter 5.3**).

Box 6

What are digital labour platforms?

Digital labour platforms are the technological backbone of the gig economy, providing a means for workers to do gig work. The International Labour Organization defines two key types of platforms:

Online web-based platforms typically let workers perform high-skilled tasks online. These tasks can range from graphic design to management consulting to medical advice. In many cases, workers use these platforms as their primary source of income. Examples of online web-based platforms include Freelancer, Upwork, and Expert360.

Location-based platforms generally involve workers performing low-skilled tasks at a specific location and time, in parallel with traditional labour markets. Many workers on these platforms work more than one job or across multiple platforms. Examples of location-based platforms include Uber, Airtasker, and Deliveroo.

Source: International Labour Organization (2021a)

Box 7

Remote and hybrid working are here to stay

A NSW Innovation and Productivity Council research report estimates that 43 per cent of all work tasks in the NSW economy were done remotely during the 2020 lockdown — up from 18 per cent before the pandemic. The report finds that the average NSW worker both saves time and is more productive when working remotely.

A subsequent joint report with the NSW Productivity Commission finds that when health restrictions eased in early 2021, 30 per cent of all work tasks in the NSW economy continued to be done remotely. Most workers do not want to work remotely full-time and have embraced hybrid working patterns, where they work on-site and remotely at different times.

This shift to hybrid working may also mean we can:

- get more bang for the **office-space** buck, with larger companies reducing their footprints and smaller companies moving into the CBD to take up the space
- get more from our **housing and infrastructure**, with some households moving out of the urban centre into outer suburbs and regions
- increase **workforce participation**.

The transition to hybrid working has focused many organisations more than ever on the mental health and wellbeing of their employees and on creating effective onboarding processes for new starters.

We still face challenges. Many employers told us they did not yet see clearly whether hybrid working would make innovation and collaboration better or worse.

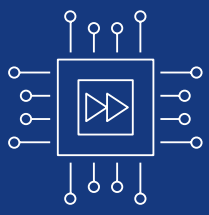
But leading organisations are not trying to put the hybrid working genie back in the bottle. They acknowledge that hybrid is here to stay. And they are adopting innovative policies, processes, and initiatives to support this new world of work. These include:

- tailoring flexible working arrangements to individuals, roles, and teams
- experimenting with different policies and arrangements
- reshaping the office and work practices
- finding new ways to measure work
- building strong and inclusive hybrid working cultures.

Source: NSW Innovation and Productivity Council (2020); NSW Productivity Commission and NSW Innovation and Productivity Council (2021)

3

How to accelerate tech uptake



To seize the tech opportunity, NSW can support fast tech adoption across the public and private sectors, while attracting and nurturing our core tech workforce.

At a glance

The NSW ICT workforce is projected to roughly double by 2035.

If technology uptake accelerated in NSW, the size of the industry could increase by another 60 per cent to 2.6 times the 2019 workforce.

To support early adoption of emerging technology, the NSW Government can: build trust with strong public sector governance; embrace tech to improve its own public services; support private sector tech uptake through smart regulation and careful investment and intervention; and ensure that appropriate protections exist for workers.

To become a leading jurisdiction, the NSW Government can: nurture entrepreneurship; harness local talent with expertise in STEM; and work with schools, the tertiary education sector, and industry to attract more students and increase the STEM talent pool. It can make targeted efforts to attract leading-edge overseas tech talent by improving NSW's status as a destination of choice for migrants and supporting strong expatriate networks.

3.1 Aim to be a fast tech adopter

The speed at which we adopt, adapt to, and develop technology is critical for the state's long-term growth, productivity, and employment. To sustain and improve NSW's economic, social, and environmental wellbeing, we can quickly adopt both the labour-saving technologies that exist today and become an early adopter of the emerging technologies that will underpin the economy of tomorrow.

The success of high-profile innovation precincts like Silicon Valley means governments often fixate on becoming *early* adopters — leaders in inventing, developing, and commercialising technology, usually in targeted parts of the economy. But this path has often disappointed (see **Box 8**). For most economies the road to prosperity is via *fast* adoption of, and adaptation to, technologies developed elsewhere.

Australia is one such economy. Compared to other OECD nations, its share of employment coming from digital-intensive sectors is low, and its ICT sector contributes just 2.4 per cent of value-add, ahead of only Mexico and Chile.

We do not know exactly why other developed economies out-compete NSW and Australia in technology creation, nor why our highly advanced economy has flourished in other areas. But some explanations could include:

- Other developed economies have a head start on many of the technologies in question, and once behind it can be difficult to catch up without a large captive market and government support.
- Australia's historically constrained labour supply means it has never competed well in industries like manufacturing as Australian labour has generally been far more valuable in the extractive or construction industries.
- Australia's smaller, more isolated economy is unlikely to have the advantages of Europe, Asia, or the US where complete supply chains can be established close to large consumer markets. This means that even when we do invent a signature technology, we may not be well placed to capitalise on it.

This is not to say that NSW cannot play a role in technological invention and creation in industries where we have a competitive advantage. But the literature suggests the tyranny of distance is alive and well — and experts have long maintained that Australia does particularly well at applying and commercialising technology invented elsewhere.

The Commonwealth Productivity Commission (2022) recently affirmed this conclusion in its report *Innovation for the 98%*. It argues that '[m]uch productivity improvement involves the wider adoption of established, even dated, technologies and practices among those millions of businesses' that are not at the innovation frontier (Commonwealth Productivity Commission 2022, ix).

In 2007, researcher Dr Thomas Barlow argued that market results show Australia has a high proportion of skilled 'systems integrators', who excel at putting technology to work:

> '[W]hat Australians have traditionally been particularly good at is what's termed as systems integration… [S]ystems integrators are not the people developing the technologies and having the ideas; they're the people that are taking other people's technologies and combining them in interesting ways.'
>
> **— Dr Thomas Barlow (2007)**

So, although it can seem a less glamorous option than invention, concentrating primarily on **adoption** of technology has many economic benefits.

The evidence of benefit underpinning an adoption strategy is also longstanding. More than two decades ago, a key OECD research paper on national innovation systems identified the link between a jurisdiction's economic growth and the rate at which it learns how to use new ideas, techniques, and technologies to solve problems (OECD 1997).

Contactless payment technology provides a striking example of Australia's success as a fast adopter. Contactless payments improve productivity and user experience by speeding up consumer and retail transactions.

US researchers invented the technology. Yet in 2016 just three per cent of US cards were contactless. In Australia, the 2016 figure was 67 per cent —an adoption rate more than 20 times higher (A.T. Kearney 2018).

More recent indicators confirm Australia's strong position as a technology adopter. It ranked:

- second in the share of small businesses making e-commerce sales in the previous 12 months (OECD 2020)
- ninth in the share of internet users who purchased online in the previous 12 months (OECD 2022)
- seventh in the share of adults proficient at problem-solving in technology-rich environments (OECD 2015)
- tenth on the International Telecommunication Union's (2019) Global Cybersecurity Index of national commitment
- placed among the most advanced 'Amplify stage' of global digital readiness (Cisco 2020).

There is a strong case that, for economic prosperity, adoption can be as, or more, important than invention.

Unfortunately, the speed at which Australian firms adopt technological innovations pioneered by world leaders has been slowing down over time (Andrews et al. 2022). This decline is more pronounced in the service sector compared to the manufacturing sector, which is not the best news for NSW given its service-dependent economy.

This chapter considers how to reverse this trend and accelerate the uptake of productivity-enhancing technologies and new innovations.

Box 8

Why the tech-creation path often disappoints

Silicon Valley's technology successes have made it one of the world's most prosperous economic regions and an important engine of the US economy. Those successes became obvious by the 1980s. For decades since, economists have sought the secret to recreating them elsewhere in the world.

Most analysts, however, now see technology creation as highly path-dependent. That is, small and apparently minor differences in origins and early development quickly create large and complex differences in growth patterns. Our understanding of social relationships does not allow us to predict how economies will develop. We still do not know how to recreate Silicon Valley.

Even Europe, despite its large common market, has repeatedly failed to create innovation precincts with Valley-style success. That failure has persisted despite a wide array of government technology strategies, and despite deep pools of successful established businesses, highly-educated citizens, large cities, and sophisticated consumers. Europe today possesses just three technology companies worth more than US$100 billion: Dutch-based photolithography systems giant ASML, founded in 1987; German software firm, SAP, founded in 1972; and Dutch-based technology investment firm Prosus, founded in 1997.

Source: Storper (2005); ASML (n.d.); SAP (n.d.); Atomico (2020); Kearney (2015); CB Insights (n.d.).

3.2 Favour policies to support tech adoption and adaptation

You *invent* by coming up with an idea. You *innovate* through the more difficult process of applying and commercialising an idea, typically a pre-existing one.

To support technology adoption and adaptation in NSW, we need to create a supporting environment through smart regulation, strong governance, appropriate protections, and leading by example.

3.2.1 Build trust with strong public sector governance

Public aversion to technology can prevent its uptake. If NSW residents perceive new advances as harmful, fewer new digital products and services are likely to come here. And that could in turn stifle private innovation and productivity.

While technology can hugely improve public services (see **Chapter 3.2.2**), rushed adoption can be harmful and damage public trust in government, and can slow down its uptake in the long term. We are often wary of new technologies because we worry that these technologies will invade our privacy. These concerns are not unreasonable: for example, the Chinese Government has used automated facial recognition technology to develop its country-wide surveillance network 'Sharp Eyes' (Gershgorn 2021).

Governments can use machine learning to automate many common decision-making processes. When it works well, this can result in better quality, more efficient, and cheaper government services. But policymakers also need to be very careful that automated process are not unfair or biased. This can happen by accident, as the US example of 'predictive policing' shows (see **Box 9**). Even when unintentional, such mistakes erode public confidence in the government's use of technology.

Policymakers can build public confidence and trust in new and emerging technologies through strong public governance and regulatory systems, and by trialling and evaluating new technologies thoroughly before scaling them up.

This work has started nationally with the Commonwealth Government's release of Australia's AI Ethics Framework in 2019 (Department of Industry, Science, Energy and Resources 2021). This framework contains eight ethics principles to guide the design, development, and implementation of AI in Australia.

'We need to be particularly conscious of security … transparent about our use of data and AI and … remain focussed [*sic*] on privacy.'

— Dr Ian Oppermann, NSW Chief Data Scientist (Binning 2021)

Box 9

Predictive policing — a lesson for governments

In 2013, the US states of California, Florida, and Maryland implemented PredPol, a predictive policing software. PredPol used data and machine learning to inform how and to which locations law enforcement officers would be deployed. PredPol was intended to help prevent urban crime and ensure impartial, evidence-based policing decisions.

In practice, however, PredPol's algorithms inaccurately predicted true crime rates. It sent law enforcement officers to neighbourhoods which typically had low-level crime but higher proportions of racial minorities.

It did this because it relied on historical data about previous arrests, which were greater in areas where more police had been deployed in the past.

Instead of solving the issue of human and racial bias in policing, as was intended, PredPol reinforced biases that had been made in the past. This example shows how poorly-designed and poorly-managed automation can erode public trust in new, productivity-enhancing technologies — and in the governments and agencies that invest in and implement them. Mistrust in governance can then act as barrier to the development and adoption of further innovations.

Source: Ensign et al. (2018); O'Neil (2016); Reynolds (2018)

The NSW Government has adopted a complementary framework, the NSW AI Assurance Framework, to guide AI implementation in the NSW public sector (Customer Service NSW 2021). The framework includes:

- an **AI Strategy**, which outlines the NSW Government's vision to use AI to improve service delivery and decision-making
- an **AI Ethics Policy**, which focuses on trust, transparency, customer benefit, fairness, privacy, and accountability to ensure best practice use of AI
- an **AI Assurance Framework**, which helps NSW Government agencies to design, plan, implement, and manage large (over $5 million) AI projects. An **AI Review Body** must also review AI projects and those funded by the Digital Restart Fund.

The NSW Government's 2019 *NSW Customer & Digital Strategy* articulates another key principle for successfully implementing technology in public sector settings: centring the customer experience (Customer Service NSW 2019). This is achieved by making services easy to engage, acting with empathy, respecting customers' time, explaining what to expect, resolving issues that arise, and engaging the community.

The private sector can also help to develop governance with sector-specific measures (see **Box 10**).

Box 10

Ethics for sustainable AI adoption

The Association of Chartered Certified Accountants and Chartered Accountants Australia and New Zealand recently released a joint report, *Ethics for sustainable AI adoption*. The report explores how accounting and financing professionals can help drive an ethical, responsible transition to mass AI adoption. It draws findings from a global survey of more than 5,700 respondents.

Tips for professionals include the following:

- set the right tone at the top by adopting AI in a way that aligns with organisational values, fairness, and transparency
- consider long-term value when assessing the business case for AI
- use professional judgement, instead of relying solely on checklist-based approaches
- look out for 'greenwashing', where an organisation pretends to be more environmentally friendly than it is
- comply with regulation and ethics policies
- recognise the importance of data management
- be strategic regarding oversight and delivery
- become familiar with AI vendors
- develop knowledge and skills around AI ethics and sustainability.

Source: Association of Chartered Certified Accountants and Chartered Accountants Australia and New Zealand (2021)

3.2.2 Embrace tech to improve public services

Government organisations can encourage adoption of technology by moving early to adopt and model it themselves. Integrating emerging technologies into government services can help people get used to these technologies and can improve the customer experience. For instance, using COVID QR check-in codes on the Service NSW app made people more familiar with QR codes more generally and may have allowed for better uptake of other digital services, like the NSW Digital Driver Licence.

More broadly, well-implemented technologies can help the public sector to improve policymaking, enhance service delivery, and boost efficiency. This will allow it to better meet the needs of NSW citizens while making better use of taxpayer dollars (Abillama et al. 2021). A recent example is NSW Health's **ED Sepsis Alert**, an AI program, which monitors real-time patient medical data to assist with the early detection of sepsis (Tatham 2019; eHealth NSW 2020).

Pilots and trials are powerful tools, because they let government test and perfect new technologies with limited risk and cost. By running a number of different trials, governments discover which applications will be most feasible, scalable, and economical.

Several trials are underway across the NSW Government. For example:

- **School Infrastructure NSW** is piloting a digital platform to develop fast, accurate data-driven master plans and school designs.
- **Transport for NSW** (TfNSW) is leading an Asset AI™ trial, which involves installing a combination of cameras and sensors on public transport vehicles across Greater Sydney to help predict the rate of road deterioration and prioritise road asset maintenance (NSW Department of Customer Service 2022).

Government agencies may find that developing a technology roadmap can help guide their priority projects. For example, TfNSW has recently released its *Future Transport Technology Roadmap 2021-2024* (see **Box 11**). Investment NSW is also developing the *NSW Emerging Technology Strategy* to identify the technologies of the future, barriers to their adoption and commercialisation, and ways to harness their potential (NSW Government n.d.).

There is also an emerging field of RegTech — the application of technology to improve how governments and other institutions deliver regulatory services. The World Economic Forum's (2022) *Regulatory Technology for the 21st Century White Paper* outlines common success factors in the development and implementation of RegTech, including:

- engagement through champion-driven trust
- regulation for risk, safety, and mitigation
- balancing human and machine insights
- increased investments in AI, analytics, and general digitisation.

Box 11

The Future Transport Technology Roadmap

TfNSW released its *Future Transport Technology Roadmap 2021-2024* in March 2021. This roadmap sets out that by 2024, TfNSW intends to:

- implement Mobility as a Service — an integrated platform for customers to plan, book, pay for, and provide feedback on mobility services — through Opal Connect, partnerships with rideshare providers, and digital ticketing
- adopt connected and automated vehicles
- transition to zero-emissions buses and electric vehicles
- install real-time information, digital ticketing, and other innovative transport technologies in regional NSW
- increase the efficiency of freight supply chains by capturing and analysing data and using automated and sustainable last-mile vehicles
- deploy smart sensors and intelligent systems.

Source: Transport for NSW (2021)

3.2.3 Support private sector tech uptake through smart regulation

Regulations and legal frameworks often struggle to keep pace with new or rapidly evolving technologies. This lag in regulatory evolution can interfere with private sector innovation. The lack of formal frameworks governing the adoption of digital technologies and AI can also leave the public with concerns about their privacy and cyber security and, in some cases, can hold back adoption. For example, there is a lack of consistent national guidance in Australia about who is at fault if an autonomous vehicle has an accident (Transport for NSW 2018). This makes it difficult for firms and consumers to quantify or manage legal risk.

To encourage rather than stifle the uptake of emerging technologies, we need a more forward-looking approach, underpinned by the following principles (NSW Productivity Commission 2021b):

1. Outcomes-focused, technology-neutral regulation. Focus on meeting the underlying aims of the regulation, such as greater safety. Do not unnecessarily prescribe *how* these objectives are met. Such an approach lets businesses choose technology and processes that meet the regulation's aims with the least interruption to business.

2. Regular review of regulation. Identify barriers to adopting emerging technologies in current legislation. For example, the word 'driver' may needlessly limit the use of driverless cars.

3. A culture of regulatory experimentation. Trial new rules in a real-world setting, to obtain evidence on what works and what could be improved. This can reduce the uncertainty in regulating emerging technologies.

Box 12 shows how we can apply these principles.

The NSW Government can build upon existing industry relationships and consult widely to ensure regulatory frameworks are fit for purpose when it comes to emerging technologies. It can either develop state-based regulatory frameworks or contribute to and adopt wider frameworks, in collaboration with other governments and international organisations.

Box 12

Applying the principles of smart regulation in NSW

COVID-19 prompted a natural regulatory experiment: the NSW Government temporarily eased some regulations to help businesses and consumers adapt to the challenges posed by the pandemic. For instance, the Government removed some barriers to digital processes, such as online meetings of strata bodies and digital execution of conveyancing documents.

The NSW Productivity Commission recommended that the Government evaluate these temporary changes, and retain them unless it could be shown they give no public benefit. A subsequent whole-of-government evaluation found that making many of these temporary changes permanent would deliver NSW net benefits of $3.1 billion over 10 years. Many of these measures are now being made permanent in whole or with modification, because of feedback and evidence gathered during the evaluation process.

These principles could also be applied to drone, personal mobility device, and e-bike use:

- Simplifying the regulations for **drone use** in low-risk agricultural settings could deliver up to $500 million (in 2021 dollars) in safety and efficiency benefits for NSW by 2041. The NSW Government should work with the Civil Aviation Safety Authority to trial alternative drone rules in priority sectors, starting with agriculture.
- Revising laws that restrict the use of **personal mobility devices** (PMDs) to private property would bring NSW into line with other jurisdictions and could provide up to $87 million (in 2021 dollars) in net benefits by 2041. PMDs such as e-scooters can reduce congestion and carbon dioxide emissions where they replace car trips.
- The carrying capacity of **e-cargo bikes** is limited by regulations, at a time where e-commerce and food deliveries are booming. Adjusting e-bike regulation could pave the way for less congestion on our roads, cheaper deliveries by our booming e-commerce sector, and lower greenhouse gas emissions.

Source: NSW Productivity Commission (2021a, 2021b); NSW Department of Planning, Industry and Environment (2021)

3.3 Attract and foster the tech-adoption workforce

For NSW to be at the forefront of technology adoption, the state needs a ready supply of talented people who will drive the process. So government needs to foster:

- **entrepreneurs** and **investors** with the skills, experience, and capital to found start-ups, assemble teams, and bring leading-edge products from development to market
- **tech professionals** with state-of-the-art expertise, technical resources, and the imagination to solve the hardest technical challenges.

3.3.1 Nurturing entrepreneurship

The entry of new firms into a market heightens the competitive pressures that existing firms face, forcing them to either improve — by innovating and adopting new technologies — or leave (Andrews et al. 2022).

In this way, entrepreneurship cultivates what is known as "dynamism", which the Chair of the Commonwealth Productivity Commission, Michael Brennan (2019), describes as:

> '[T]he capacity to generate new ideas, products, business models, production techniques and diffuse them quickly through the economy.'

Many economists see dynamism as an important feature of high-growth economies. In a highly dynamic economy, firms come and go frequently, their ideas and investments influencing whole sectors of that economy.

NSW has already made strong progress on entrepreneurial activity. According to the 2020 *Survey of Commercial Outcomes from Public Research* (SCOPR) report we had the largest share of start-up and spin-out companies from universities and research institutions of any Australian state between 2017 and 2020 (Knowledge Commercialisation Australasia 2021). NSW was also the only Australian ecosystem in Startup Genome's Top 30 list for the 2021 Global Startup Ecosystem Ranking, with Sydney awarded first place in Oceania for ecosystem talent and experience and funding (Startup Genome 2021).

But economists from the Commonwealth Productivity Commission, the Reserve Bank, and Commonwealth Treasury worry we are becoming less dynamic over time (Andrews et al. 2022; Brennan 2019).

So a key question is, how can NSW further nurture entrepreneurship to foster dynamism?

Entrepreneurial capability is broadly determined by an individual's personal and cultural characteristics, and their knowledge and skills.

Policy analysts have not come to a firm consensus on which of these is most influential or most cost-effective to foster. However, in terms of personal characteristics, entrepreneurs are typically conscientious, have high risk tolerance and patience, and can identify opportunities.

Emerging literature suggests training programs that target proactive and motivational mindsets can nurture these entrepreneurial traits (Francisco Campos et al. 2017; Lafortune, Riutort, and Tessada 2018; Higuchi, Nam, and Sonobe 2015; Lord Young 2014).

But without the right education, training, and opportunities, even the most driven, risk-seeking, opportunity-aware individuals will struggle to innovate. As Cusolito and Maloney (2018) suggest, entrepreneurs need:

- high-level *analytical* skills. They enable individuals to process information efficiently and make strong decisions when faced with the uncertainties of innovation
- strong *managerial* skills. Strong business strategies, sound human resource policies, and long-term planning skills are critical to productivity and innovation
- experience at the '*technological frontier*'. Members of Australia's technology diaspora who worked in innovation hubs like Silicon Valley have been able to exploit untapped opportunities when they have returned home
- *actuarial* capabilities. The ability to make informed decisions through continuous, rigorous, cost-benefit analysis to decide whether to continue to experiment or to stop.

Two further areas where entrepreneurs need strong capabilities are governance and risk management.

Some recent examples of government-funded programs to support entrepreneurship include the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Kick-Start Grant, Innovation Connections Program, and the SIEF Ross Metcalf STEM+ Business Fellowship. Over 2020-2021, 249 companies received over $35 million for research and development (R&D) for innovative projects (CSIRO 2021).

Governments can also seek to enable entrepreneurship by supporting innovative business as they grow (see **Box 13**).

In the process, however, policymakers, need to take care to avoid creating "zombie firms" — firms that cannot service their debts, yet survive on a combination of public credit or subsidies, low interest rates, weak banks, and poor insolvency regimes (Banerjee and Hofmann 2018). These firms crowd out more productive, entrepreneurial firms by competing for the same resources. Zombie firms may be a major cause of the productivity slowdown seen across OECD countries in recent years (Adalet McGowan, Andrews, and Millot 2018; Banerjee and Hofmann 2018; Caballero, Hoshi, and Kashyap 2008).

Box 13

How to create a pro-entrepreneurship environment

Building an entrepreneurial ecosystem requires a holistic approach that supports businesses throughout their lifecycle, from launch to exit. Policymakers must first identify the local industries and employment centres with potential for development.

At *launch*, it is important to have:

- information available about existing technologies, market conditions, and relevant policies to encourage the formulation of ideas
- access to large established tech firms, incubator organisations, and other entrepreneurs to facilitate knowledge spillovers by enabling mentoring, advice, and resource sharing.

From *infancy* to *growth*, businesses need:

- limited 'red tape', like low barriers to entry that make it easy to start and finance a business; and immigration laws that allow businesses to acquire overseas talent
- strong institutions, including secure property rights, stable regulations and political context
- a support network of specialist business services (like accountants and lawyers), technical services (like laboratory technicians and engineers) and finance providers (like venture capitalists and bankers)
- favourable R&D tax benefits.

From *maturity* to *exit*, it is important to have:

- favourable capital markets — including private equity and stock markets — that let entrepreneurs sell their enterprises and reinvest the gains and expertise in other businesses
- bankruptcy laws that support efforts at innovation and entrepreneurship
- cultural and social norms that celebrate entrepreneurial experimentation and enable entrepreneurs to re-enter the salaried workforce.

Source: Guerrero, Liñán, and Cáceres-Carrasco (2021); Mason and Brown (2014); Cusolito and Maloney (2018)

3.3.2 Foster the tech professions

There is no point in NSW fostering dynamism if no-one possesses the skills to turn entrepreneurs' ideas into reality. The state needs local talent with expertise in STEM to become a leading jurisdiction in technology adoption.

By many measures, NSW has a strong education sector. According to the QS World University Rankings, NSW has the most top 200 universities per million population of any jurisdiction globally, and six of its 11 public universities appear in the top 200 (NSW Innovation and Productivity Council 2022b).

But there has been some concerning evidence that STEM uptake in Australian schools has fallen. Australia's National Science Statement 2017 reported that student participation in STEM subjects was declining, with enrolments at a 20-year low, despite guidance offered by the National STEM Education Strategy 2016–2026 (Commonwealth of Australia 2017; Education Council 2015).

NSW is currently leading change on STEM curriculum and programs, with STEM for students in preschool through to Year 12 and the STEM Industry Schools Partnership (SISP) Education (NSW Department of Education 2018; NSW Government 2022g). This complements recent national curriculum reform for mathematics which aligns curriculum better with international standards and focuses on better understanding of basics during younger years (The Hon. Stuart Robert MP 2022).

The NSW Government has also recently invested in a ten-year $25 million endowment to the Science and Industry Endowment Fund (SIEF) to establish Generation STEM to attract, support, retain, and train NSW students in STEM and school into further education and employment (CSIRO 2022).

Government can work further with schools, the higher education and Vocational Education and Training (VET) sectors, and industry to attract more students to, and educate them about, STEM. It can increase the talent pipeline through programs such as School-Based Apprenticeship/Traineeships (SBATs) or cadetships. It could also build on existing Commonwealth Government programs, including:

- **Pathways in Technology** (P-TECH) was established as a pilot program in Australia in 2016. It has since expanded to 16 schools across the country (P-TECH 2021; Department of Education, Skills and Employment 2020). P-TECH is a public-private partnership between schools, tertiary education providers, and industry partners, which gives secondary school students the opportunity to participate in project-based learning, mentoring, internships, and apprenticeships or traineeships. A 2019 evaluation of the program found it has improved student engagement with STEM and has benefitted schools, tertiary education providers, and industry partners (Social Compass 2020).
- The **Next Generation AI Graduates Program** and the **Next Generation Emerging Technology Graduates Program** are competitive national scholarship programs. The Commonwealth Government is investing $47.3 million in them over the next six years (Department of the Prime Minister and Cabinet 2021). They will support up to 468 tertiary students pursuing honours and doctoral studies in AI and emerging technologies (such as robotics, cyber security, and data). Students will also be given opportunities to participate in industry-led research projects and placements so that they can develop job-ready skills (Silverpond 2019).

The Commonwealth Government's Job-ready Graduates package, announced in 2020, has increased the emphasis on STEM in higher education. It reduces student contributions in degrees such as mathematics, IT, engineering, and science (Australian Government 2022b). Following the reform, in 2021, NSW universities saw an increase of over 5,000 enrolments or 14 per cent in science courses, compared to 2020 (Audit Office of NSW 2022).

The NSW Government can also help STEM students gain experience at the leading edge of innovation. Recently-established high-tech clusters in Ireland, India, Taiwan, and China originated in diasporas of technology experts who studied and worked in innovation hotbeds like Silicon Valley in the US. They were able to use their personal experience to exploit untapped opportunities in their home countries, where technological uptake was not as high (Cusolito and Maloney 2018).

NSW can do the same by increasing the exposure of local tech professionals to leading-edge international practices. An example of this approach is the Sydney Quantum Academy, a partnership among four leading Sydney universities to foster and grow the quantum talent pipeline and build a quantum industry in NSW.

The experience of Japan in the Meiji period shows how these skills were crucial in modernising the country and making it a modern manufacturing powerhouse (see **Box 14**).

3.3.3 Entice the best and brightest from across the world

Studies show immigrants are disproportionately innovative and entrepreneurial, and more likely to have advanced qualifications, especially in STEM. If NSW wants to be a technology leader, we can get there fastest by using a strategic migration policy that taps overseas talent.

Exposure to overseas-trained professionals can give domestic talent access to leading-edge knowledge and practices from abroad, bringing Australia closer to the technical frontier. Indeed, migration could be seen as a way to complement, enhance, and accelerate domestic talent development, not as a substitute for it. Harnessing knowledge spillovers from skilled migrants could be a key element of NSW's strategy for developing domestic talent.

Box 14

How Japan learnt from US manufacturing

Emerging from isolationism in the 1860s, Meiji-period Japan (1870–1910) found itself significantly behind other world powers in industrialisation and uncompetitive in the cotton-spinning industry. The most successful textile firm, Osaka Spinning Company, had the managerial foresight to send their top engineers overseas to study far more advanced technologies being used in the West.

These engineers were then able to use their experience at the frontier of innovation to help kickstart Japan's textile manufacturing industry, which became a global competitor.

A century later, Japan was synonymous with advanced technology and manufacturing, and US companies were sending representatives to learn the latest Japanese manufacturing techniques.

Source: Braguinsky and Hounshell (2016)

Three overarching factors determine NSW's ability to attract and retain talent, as outlined in the NSW Innovation and Productivity Council's (2022a) *Global Talent Wars* report:

- *locational and economic* factors, such as our geographical location, local market size, ease of access to international markets, job competitiveness, the languages we speak, and our socioeconomic and political conditions
- *regional and institutional* factors, such as our skilled immigration policies, sector-specific visas, tax rates and financial incentives, local education standards, support for international students, workplace cultures, and global reputation and branding
- *personal and social* factors, such as migrants' individual circumstances, lifestyle preferences, and family considerations.

Some of these factors are influenced by government policy, while others — such as languages and location — are not.

To compete globally for talent, NSW needs to be among the best places in the world to live, work, and start a business. We are already a destination of choice for migrants. Australia receives three per cent of annual global migration despite making up just 0.3 per cent of the world's population (NSW Innovation and Productivity Council 2022a). We offer migrants high standards of living, a unique natural environment, an attractive climate, high-quality infrastructure, strong health and education systems, a strong employment market, and a business-friendly environment (NSW Productivity Commission 2021a).

NSW can defend these strengths and build on them. It means aiming to make NSW the best place to start a business and raise a family, not just in Australia, but in the world.

NSW can also make more targeted efforts to attract leading-edge overseas talent. This means reaching out to foreign skilled migrants who can enhance Australia's most competitive industries. It also means ensuring that Australian technology professionals living overseas maintain strong connections at home. Expatriate networks can be powerful conduits for workforce development. When expats return to Australia, they bring with them more developed skills and connections to global sources of knowledge, capital, goods, and talent — a process commonly referred to as 'brain circulation' (NSW Innovation and Productivity Council 2022a).

3.4 Intervene only when there is a strong business case

Government can help ensure NSW's economic landscape encourages firms and workers to embrace productivity-enhancing technologies and nurtures technological innovation.

Governments can intervene across the economy, or in specific sectors. Either way, interventions typically fall into four key categories (Rodríguez-Pose and Wilkie 2019):

- expanding *infrastructure* by creating roads, buildings, and power supplies
- attracting *inward investment* by creating a favourable environment for investors. Many of these levers, like tax incentives, are held by the Commonwealth
- promoting *innovation* by investing in skills development and collaborative networks
- encouraging *clustering* by fostering physical co-location, for example using precincts. The NSW Government is responsible for planning and therefore actively pursues these types of interventions.

Table 3 provides examples of each type of intervention for the NSW context.

But such interventions require careful, case-by-case assessment.

Because innovation and agglomeration are complex phenomena, it can be hard to isolate and quantify the impact of measures intended to promote them. This is an area where governments face a serious risk of making investments with poor economic returns.

Table 3

Examples of types of interventions in NSW[7]

Intervention type	NSW examples
Expand infrastructure	• Investing $12 million in the **NSW Health Statewide Biobank**, which uses robotic technology to store and process millions of bio-specimens and supports world-class health and medical research (NSW Government 2021). • Spending $95 million on a new facility to develop **mRNA and RNA vaccines** locally to continue innovations in the immunisation against and treatment of COVID-19 (Raper 2021; BiotechDispatch 2021). • Investing $29.5 million in a pilot to convert 40 diesel buses into **electric buses** and upgrade supporting infrastructure to smart charging stations, solar panels, and large-scale energy storage (Taylor, Kean, and Stokes 2021).
Attract inward investment	• Establishing the $250m **Job Plus program** to support companies wanting to establish and expand their footprint in NSW. The program offers concierge services, temporary payroll tax relief, subsidised training package rebates, infrastructure rebates, access to subsidised, short-term government accommodation and spaces, and assistance with planning approvals. • Establishing **NSW Research Networks**, networks of NSW universities that work collaboratively to attract public and private R&D investment in key domains from outside NSW to NSW universities and businesses. Current networks include the NSW Defence Innovation Network, the NSW Smart Sensing Network, NSW Circular, the NSW Space Research Network, and the NSW Connectivity Innovation Network.
Promote innovation	• Investing $15.4 million in the **Sydney Quantum Academy**, which aims to foster collaboration between industry, academia, and government to advance the quantum economy (Barbaschow 2019). The Academy is a partnership between Macquarie University, UNSW Sydney, the University of Sydney, and the University of Technology Sydney. • Investing $12 million a year in the NSW **Small Business Innovation & Research program**, which provides competitive grants to NSW small businesses to develop and commercialise innovative solutions to challenges facing the NSW Government. • Offering **Minimum Viable Product grants** to pre-revenue technology start-ups to help them engage with a potential business customer, or channel to market, to achieve market validation and first sale. • Providing support through the COVID-19 **TechVouchers program** to start-ups, scaleups, and SMEs to collaborate with publicly-funded research organisations, like CSIRO.
Encourage clustering	• Creating **Tech Central**, an innovation and technology precinct in Sydney's CBD that will provide up to 250,000 square metres of space for technology companies, including anchor tenant Atlassian. Affordable rates will be offered to start-ups and scaleups. • Establishing the **Semiconductor Sector Service Bureau** (S3B) to bring together NSW semiconductor companies to increase demand for semiconductor fabrication, share connections and market intelligence, and improve access to critical semiconductor skills. • Co-locating hospitals, university campuses, and medical research institutes in **biotechnology precincts** across the state — including in Randwick, Westmead, Camperdown, Darlinghurst, and New Lambton — to foster engagement between industry and the research community. • Creating a joint venture of more than $20 billion of investment into the **Western Parkland City**, which includes building Bradfield City Centre and the Western Sydney Aerotropolis, a hub for advanced manufacturing, AI, agribusiness, and logistics networking.

7 These examples are provided to illustrate types of interventions. We have not evaluated the net benefits of the programs listed.

Government can respond by favouring approaches with strong evidence of proven net benefits. The conditions for economic development are varied, so rarely can a single 'silver bullet' deliver it. The most successful approaches tend to establish a broader development strategy and select a suite of complementary measures that advance it (Rodríguez-Pose and Wilkie 2019). This reduces the risk of poorly coordinated, targeted, or prioritised interventions.

Government also needs to consider local conditions. For example, an industry precinct is unlikely to be successful without market drivers, areas of competitive advantage, collaboration between organisations, infrastructure, amenity, enterprise culture, and leadership (NSW Innovation and Productivity Council 2018).

Where evidence for an intervention is weak or approaches are unproven, government can limit the size of investments, diversify its investments, and focus on building the evidence base through small pilots with built-in evaluation.

3.4.1 Assess market failure arguments carefully

Competitive markets can produce astonishing levels of technological advancement without the government doing anything more than enforcing intellectual property rights, agreements, and sensible regulation. The evidence is literally in front of our eyes: the digital device on which you may be reading this report is as powerful as the supercomputers of decades past.

But competitive markets can also suffer from 'market failures' in which commercial opportunities and economic outcomes are not fully realised, including a less than optimal rate of technology adoption. In these cases, government intervention may produce better results:

- in the case of *public goods* — for example, companies developing technology for defence purposes may merit incentives beyond what the market offers, because their products have positive implications for national sovereignty and security
- where there are positive or negative *externalities* — for example, solar power may merit a subsidy because it mitigates the injurious but usually unpriced pollution of fossil fuels
- in situations of *market power* — for example, the Commonwealth Government subsidises select medicines under the Pharmaceutical Benefits Scheme, as their price is controlled by large international pharmaceutical companies
- when there is *imperfect information* — for example, there may be inadequate public knowledge about the benefits of quantum computing.

But the existence of a possible — or even proven — market failure is not an open licence for governments to intervene to support technological development. Alongside the problem of market failure sits the problem of 'government failure'. This happens when the government intervenes to correct a market failure, but the intervention's costs outweigh its benefits and leave society worse off. The fact that a market does the job badly does not mean government will do it better.

Like individuals, governments are prone to underestimating costs and overestimating benefits (Flyvbjerg, Glenting, and Rønnest 2004). Governments would benefit from taking this into account when critically assessing interventions based on market failure dynamics.

3.4.2 Treat emerging industry arguments sceptically

Aside from market failure, there are other widely recognised arguments for government interventions as a way to achieve technological innovation and uptake: most notable is the emerging industry argument.

The emerging industry argument posits that new and promising industries can struggle to thrive, even if markets are free and competitive. According to this argument, relatively modest government support for an emerging industry can yield large benefits when the industry matures. These benefits can take the form of economic growth, jobs, or tax revenue. Conversely, when governments fail to support emerging industries, the community may miss out on technological development, economic growth, and jobs.

For example, Australia was an early global leader in solar energy R&D, but our commercialisation of renewable energy did not capitalise on this (Bahadori and Nwaoha 2013). Today, China is the world leader in solar technology production.

Government support for emerging industries can take many forms. A common form of support is imposing tariffs on foreign competitors to limit their competition with the local emerging industry and encourage consumers to 'buy local'. While the NSW Government does not control this lever, it has many others including public procurement policy, planning and regulatory policy, infrastructure funding and delivery, and the ability to make grants and provide state tax incentives.

Using the procurement lever, for example, the NSW Government's Electric Vehicle (EV) Strategy uses government purchasing power to bring a range of cheaper EVs into the state, encouraging local manufacturing and a second-hand EV market.

Different emerging industries face different challenges, and interventions can be targeted accordingly. For example, the challenge faced by the Australian solar industry was commercialisation. For quantum computing and synthetic biology, on the other hand, the challenge is at the R&D stage.

As with market failure arguments, emerging industry arguments need to be assessed carefully. Governments face a high risk of backing the wrong industries. Many new businesses and industries fail to take off and it is difficult to predict which ones will fail in advance. This is particularly so for businesses in the R&D stage. Moreover, once support is committed, vested interests can make it very difficult to withdraw.

Governments can manage these risks by acknowledging them at the outset. As emerging industry support is inherently speculative, governments can respond by limiting investments to industries where there is a clear market failure, by limiting the size of investments in particular industries, using risk-sharing strategies, and by adopting a diversified portfolio approach. Governments can also specify clear end dates for support at the outset, with a gradual reduction over time (Melitz 2005).

4

Building an adaptive workforce

To be a fast tech adopter, NSW needs a confident, adaptable workforce. A flexible and responsive training system can support adaptation by enabling upskilling, reskilling, and smooth career transitions.

At a glance

By 2035, 4.6 per cent more jobs in the NSW economy will require digital skills. The need for soft skills will also grow. Policymakers can support this shift, making sure the training system is good at identifying and overcoming barriers to upskilling and reskilling. Training offerings should be data-driven and responsive to what the economy needs.

Key strategies to promote workforce adaptation include: combatting credentialism; supporting lifelong learning and continuous upskilling; and supporting the spread of digital education opportunities, microcredentials, and other forms of non-formal learning.

Structural reform can grow NSW's infrastructure workforce by making the supply of skilled workers more responsive to investment demand. The NSW Government can attract a more diverse range of people into the trades by continuing to develop flexible learning options and alternative and/or accelerated training pathways.

4.1 Ensure workers are equipped with the skills of the future

At the time of writing, NSW, like the rest of Australia, faces acute labour and skills shortages, reflecting tight labour markets in the wake of COVID-19. These shortages stretch across many occupations and industries. They are a major productivity issue and are rightly receiving intense policy attention. The Commonwealth Government recently held a Jobs and Skills Summit, with emerging policy and funding responses to be incorporated into a projected White Paper in 2023.

This chapter complements current work by addressing longer-term workforce challenges. As discussed in **Chapter 2**, the skills the population needs will undergo permanent, long-term change as NSW develops and adopts new productivity-enhancing technologies. It works both ways: a population that acquires new skills quickly will develop and adapt to technological innovations faster and more productively.

This chapter explores the skills that the general population needs if we are going to adapt well to change. These include: foundational literacy, maths, and science skills; general digital literacy skills; and soft skills. When we talk about skills needs, we need to distinguish between the skills the general population needs, and those needed by technology specialists.

The challenge of building an adaptive workforce is long term and systemic. It will require government, workers, employers, training providers, and other stakeholders to work together.

In this chapter, we lay out principles and strategies for building an adaptive workforce, highlighting selected examples and case studies. Many of the principles and strategies in this chapter affirm existing policies and initiatives. In other cases, they may offer food for thought, or even provocation.

4.1.1 Get the basics right

Governments often think they need to 'future-proof' the workforce by teaching young people about every new technological phenomenon, from blockchain to AI. But it is really the early *foundational skills* — in literacy, maths, and science — that most help people to pick up new concepts quickly and navigate the future of work (Sakamoto and Sung 2018).

According to the OECD Programme for International Student Assessment (PISA), Australia is experiencing declining performance in school-level reading, maths, and science, both in absolute terms and relative to other participating countries. Compared to other states and territories, NSW has also recently experienced absolute and relative falls in its students' average test scores (NSW Productivity Commission 2021a).

Many factors affect student performance. But among factors within our schools, teaching quality has the biggest influence on student outcomes (Deloitte Access Economics 2017).

'Improved student outcomes from better quality teaching would boost GSP by $11.5 billion in 2041. This translates into a rise in GDP per capita of over $1,100.'

— NSW Productivity Commission (2021a)

The NSW Government controls the most important lever for lifting teaching quality — because it both directly employs the bulk of teachers across the state, and funds and regulates NSW-based schools (NSW Productivity Commission 2021a). To improve teaching quality, the *White Paper* recommended:

- establishing a long-term teacher supply strategy containing evidence-based measures and innovative pilot programs
- broadening the supply of quality teachers by reviewing the requirement for a two-year Master of Teaching and piloting employment-based pathways to the teaching profession
- improving teacher performance evaluation to give teachers more meaningful feedback
- creating a Centre for Teaching Excellence to lead and support improved teaching quality across the system
- developing an 'instructional lead' career pathway that keeps highly effective teachers in the classroom, as an alternative to an administrative career.

The NSW Government has already funded and progressed some of these initiatives:

- In October 2021, the Minister for Education and Early Childhood Learning announced a $125 million NSW Teacher Supply Strategy, which aims to grow the overall supply of teachers, encourage teachers to train in high-need and specialist subject areas, and provide targeted teaching support (NSW Department of Education 2021).
- The NSW Government has also invested $400,000 into co-designing a bespoke model with Teach for Australia to attract mid-career and high-achieving professionals into teaching (NSW Government 2020b).
- The NSW Government has implemented the Commonwealth Government's increase to the Literacy and Numeracy Test for Initial Teacher Education standards in July 2016, which required all new teachers to be in the top 30 percent of the adult population in both components (Australian Government 2022a).

4.1.2 Improve general digital literacy

Many people believe the youth of today are digitally savvy and will naturally pick up new technologies. And young people do competently use social media, apps, and smart devices. But many struggle with general digital literacy skills, such as editing charts in Excel spreadsheets or paragraph styles in Word documents (ECDL 2014). In fact, research finds no difference between younger and older generations of students in their ability to develop general digital literacy skills (Kirschner and De Bruyckere 2017).

General digital literacy is increasingly important for employment. The Royal Melbourne Institute of Technology (2021) estimates that 87 per cent of jobs now require digital literacy skills. Yet a survey of 413 employers in Australia found 23 per cent of businesses lacked employees with digital skills (RMIT Online and Deloitte Access Economics 2022). Among those employers that did have them, around one in five (21 per cent) said their employees' digital skills were out of date.

This issue will only worsen as emerging technologies spread. Our analysis found that by 2035, 4.6 per cent more jobs in the economy will require digital skills.

Improving digital literacy is important because digitally literate workers have an advantage in the labour market. A recent analysis of job advertisements reveals occupations requiring digital skills pay nine per cent more on average than those that do not — equivalent to an extra $7,700 a year on average for workers (RMIT Online and Deloitte Access Economics 2022).

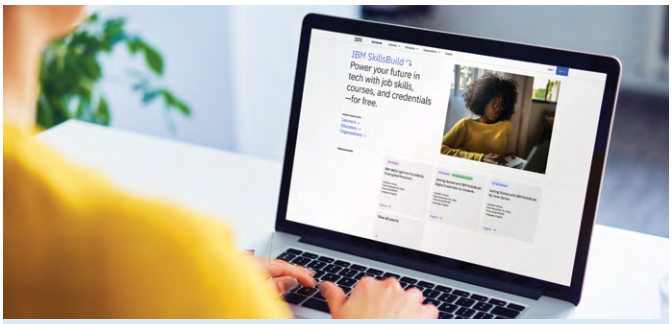
So what, then, is the best way to teach these skills?

According to a survey of 1,078 Australians, general digital literacy and data analysis skills are best learnt through short courses or microcredentials (RMIT Online and Deloitte Access Economics 2022).

The Australian Curriculum, Assessment and Reporting Authority (ACARA) conducted a review of the Foundation to Year 10 Australian Curriculum in 2020-21 (Australian Curriculum, Assessment and Reporting Authority 2022b). In the latest version — Version 9.0 — digital literacy is embedded as a general capability with four elements (Australian Curriculum, Assessment and Reporting Authority 2022a):

- **practising digital safety and wellbeing** — involves managing online safety, digital privacy and identity, and digital wellbeing
- **investigating** — involves locating information and acquiring, collating, and interpreting data
- **creating and exchanging** — involves planning and executing a process and respecting intellectual property
- **managing and operating** — involves managing and protecting content and selecting and operating tools.

As well as building general digital literacy skills for an adaptive workforce, NSW schools could also build awareness of tech careers among students and teachers by leveraging publicly available information repositories like IBM SkillsBuild (see **Box 15**). Careers advisers and agencies like Careers NSW will also have an important role to play (see **Chapter 4.6.3**).



Box 15

IBM SkillsBuild trains students and teachers on the tech of tomorrow

IBM has committed to addressing the high-tech skills gap and upskilling 30 million people globally by 2030.

It is working to achieve this through its digital learning platform, IBM SkillsBuild (formerly known as Open P-TECH). This platform offers secondary school students and teachers free learning, support, and resources on the digital skills of tomorrow. The platform reflects IBM's belief that 'entry-level tech … require skills, not just degrees'.

Learners take courses to improve their understanding of new technologies — AI, cloud computing, blockchain, cyber security, data science, quantum computing, and emerging technologies — and to earn digital badges to signal their competency to future employers.

To date, 2.1 million people worldwide have completed a learning path or course with IBM SkillsBuild.

Source: IBM (2021; n.d.)

4.1.3 Build soft skills for a service economy

Soft skills are becoming a more important requirement in the economy. Our analysis shows that as the workplace uses more technologies, the number of jobs requiring soft skills will increase significantly (see **Figure 13**). Soft skills are broad and not specialised; all jobs use them in one way or another. Soft skills involve social skills such as negotiation and instructing, social perceptiveness, and building interpersonal relationships, and cognitive skills such as critical thinking, problem solving, decision making, and time management.

The job market reflects this need for soft skills. Analysis in the report, *The New Work Smarts*, of 2.4 million Australian job advertisements found that, since 2012, demand for critical thinking has increased by more than 150 per cent, demand for creativity by more than 60 per cent, and demand for presentation skills by 25 per cent (Foundation for Young Australians 2017). Similarly, a 2017 analysis of national job advertisements by the National Skills Commission (NSC) found communication, building relationships, problem solving, teamwork, and customer service were the most common skills to appear (National Skills Commission 2021a).

Soft skills help to raise workers' incomes. One study found advertisements for early-career jobs that mentioned problem solving paid $7,745 a year higher than those that did not (Foundation for Young Australians 2017). Another found that building soft skills into education could accelerate the entry of a school leaver into full-time work by 17 months (Foundation for Young Australians 2018).

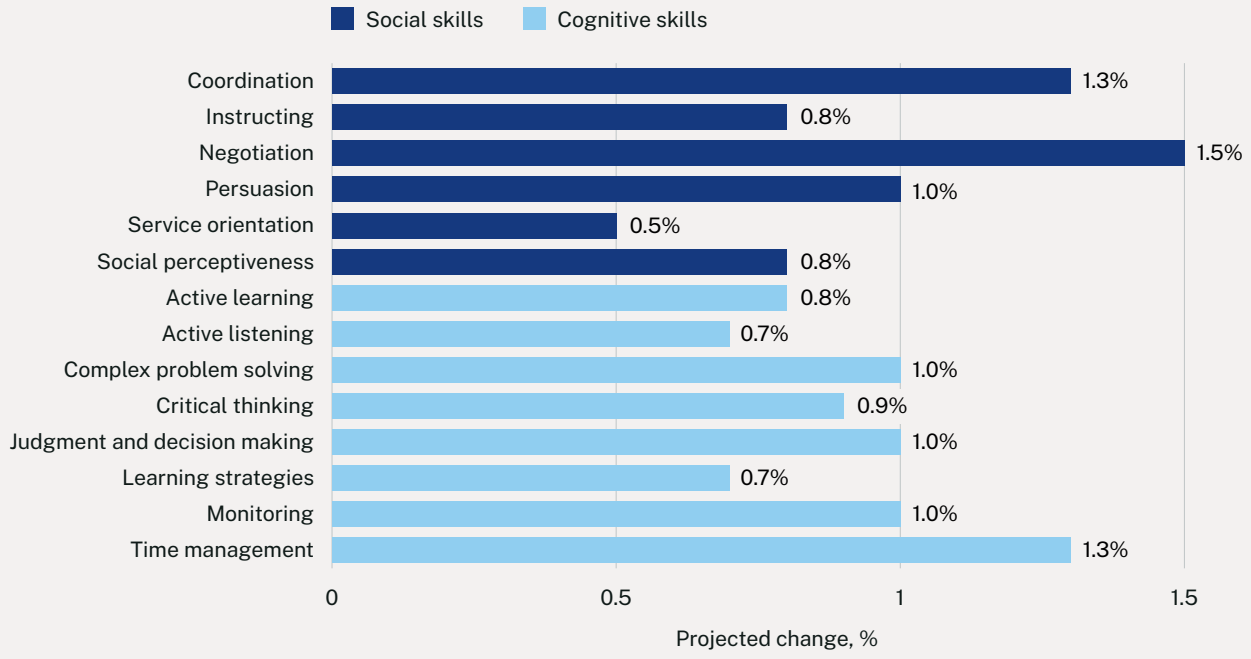
But there is a gap between the demand for soft skills and the supply of workers with these skills. An Australian study found a 45 per cent gap between the number of job listings for employees with communication skills, and the number of people who listed this as a skill in their application (DeakinCo 2017). A quarter of employers reported difficulty filling entry-level vacancies because applicants lack adequate soft skills.

The acquisition of soft skills often necessitates on-the-job experience. RMIT Online and Deloitte Access Economics (2022) found that soft skills — like leadership and teamwork, organisation and time management, critical thinking, problem solving, and communication — are better learnt on the job rather than through formal training.

Figure 13

Both social and cognitive skills will be in higher demand

Projected change in relative demand for skills and abilities due to emerging technology diffusion, NSW, 2035



Source: NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI)

4.2 Use data and industry insights to keep training relevant and responsive

Governments need to stay across short-term shifts and fluctuations in demand for different skills to ensure the training system is responsive and delivers what the economy needs. This can be achieved using data and industry insights.

The process of identifying skills shortages differs across jurisdictions in Australia. In NSW, Training Services NSW updates the NSW Skills List annually 'to ensure it meets the changing skill needs of industry' (NSW Government 2022d). But as this list includes more than 700 qualifications — more than any other Australian jurisdiction — it is clearly far from targeted.

The Commonwealth Productivity Commission (2020) noted that: 'Skills shortages lists used to prioritise funding are often outdated and not rigorously measured, reflecting problematic conceptual frameworks and poor data.'

The Commission has recommended that Australian jurisdictions adopt a consistent methodology for measuring skills shortages (Commonwealth Productivity Commission 2020).

The recommendation was part of the Commission's Review of the National Agreement for Skills and Workforce Development (NASWD) — an agreement between the Commonwealth, state, and territory governments that identifies skills and workforce development objectives.

A consistent methodology has been partially addressed by the establishment of the NSC in July 2020. This was the Commonwealth Government's response to *Strengthening Skills: Expert Review of Australia's Vocational Education and Training System,* known as the Joyce Review (Joyce 2019). The NSC reviews skills needs across Australia and publishes a Skills Priority List, which outlines the current labour market and future demand ratings for almost 800 occupations (National Skills Commission 2021b).

However, the NSC is still being integrated with the policy and service delivery architecture of the states and territories. To inform detailed forecasting of future skills needs, the NSW Productivity Commission has recommended that NSC labour market analyses be made more robust and specific (NSW Productivity Commission 2021a). This information could then be integrated into NSW policy planning and used to inform:

- funding and incentives to avoid future skills shortages
- secondary school curriculum design
- VET funding and purchasing guides
- other skills policies.

Industry engagement is also central to a responsive and relevant training system. According to the National Centre for Vocational Education Research.

> 'Social partnerships negotiated between governments, employers, unions and training providers, where each partner is highly valued and willing to take responsibility for their component, are key to effective VET governance and, ultimately, improved outcomes for learners.'
>
> **— National Centre for Vocational Education Research (Siekmann and Circelli 2021)**

Many developed economies, including Australia, do this through industry or sectoral skills councils (Siekmann and Circelli 2021). NSW, for example, has the NSW Skills Board.

Australian states and territories use Industry Training Advisory Bodies (ITABs) for advice on industry training and skills needs. The 10 NSW ITABs cover a diverse range of industries like financial services, health, and manufacturing (Training Services NSW n.d.).

At the Commonwealth level, the Australian Industry and Skills Committee is supported by 67 industry reference committees and six skills service organisations (NCVER 2020a; Australian Industry and Skills Committee 2021).

According to the Australian Government Department of Education, Skills and Employment (2021), in response to numerous calls for stronger industry involvement in skills reform, this system will change from 1 January 2023. New 'industry clusters' will be created to:

- identify and assess current and emerging skills and workforce needs
- work with providers to establish training products that meet industry needs
- advise on skills and workforce needs and the effectiveness of VET system policies and standards.

But the mechanisms of engagement have changed frequently over the past 20 years — from national ITABs to industry skills councils to the current system — and it remains to be seen whether this latest overhaul will have a tangible impact.

The *White Paper* affirmed the economic importance of VET and the careers it trains people for. Yet it identified a bias towards school leavers opting for university, even where they would earn more pursuing VET (NSW Productivity Commission 2021a).

To promote VET, the NSW Government is drawing on the lessons of NSW JobTrainer in pursuing longer-term VET reform. It is also experimenting with Institutes of Applied Technology (IATs) which blend vocational and higher education. Careers NSW supports those looking to transition or upskill/reskill and is being piloted to school students (years seven to 12) — with the aim of supporting greater participation in VET careers, emerging industries, increasing women in construction, and supporting individual aspirations. New HSC reforms will allow high-school students to get an ATAR for tertiary education entry no matter the number of VET subjects they take, as long as they take English as a compulsory subject (NSW Education Standards Authority 2022).

4.3 Lower barriers to entry by combatting credentialism

Credentials play an important social role. We ask tradespeople and professionals to acquire and present credentials to ensure they have the right skills to perform their roles. Used appropriately, credentialling can build public trust in the safety and quality of services. Credential requirements can give learners and workers a clear understanding of the skills they need to do a job, and clear training and career pathways. They can give consumers and employers more confidence that work will meet minimum standards.

State and territory governments play a major role in our system of credentials by regulating professional registration and occupational licencing in many settings. Often this involves establishing mandatory qualifications or training, which professional bodies also support and maintain through professional standards. When working well together, these regulations and professional standards protect and benefit workers, consumers, and the public.

It is easy to recognise the danger of inadequate training requirements, or workers operating without appropriate credentials. But fewer people recognise that the opposite situation also has its dangers.

When training and qualification requirements become unnecessarily onerous, expensive, or lengthy — where their costs outweigh their benefits — credentialling shades into 'credentialism'.

Credentialism is a significant problem because excessive training requirements can deter capable people from entering occupations they are well suited for — see **Box 16**. Credentialism prevents people from performing tasks they are capable of doing safely and competently. This generates artificial skills shortages and drives up business costs, consumer prices, and the cost of delivering government services and infrastructure.

Perversely, credentialism can lower the quality of services by reducing competition in the labour market, or leading people to use unlicenced services. By making training unnecessarily long, credentialism also delays entry to the workforce and prevents the labour market from responding quickly to changing skills needs. It limits individuals' job satisfaction, productivity, and lifetime earning potential. It lowers the rate of return on investments individuals, businesses, and governments make in training.

Another harmful effect of credentialism is that, in some occupations, a large or growing proportion of time is allocated to a worker performing tasks for which they are overqualified. For example, between 70 to 80 per cent of nurses report that they are overqualified for a substantial number of tasks they perform (Pearson 2016). To the extent this is true, NSW wastes the much-needed skills of its nursing workforce.

Despite its pernicious effects, many stakeholders have incentives to support credentialism (see **Table 4**).

Box 16

Creeping credentialism in initial teacher education

Initial teacher education (ITE) provides a prime example of creeping credentialism. Two key reforms have occurred in the space:

- Following a Teacher Education Ministerial Advisory Group (TEMAG) review in 2014, the requirement for a one-year graduate diploma was changed to a two-year Master of Teaching. Lengthening of ITE with national reforms and agreements in 2008 led to the creation of the Accreditation Standards and Procedures in 2011 — which in turn prescribed the requirement for the Master of Teaching.
- The TEMAG review continued to add to ITE by recommending content to align with the 'knowledge, skills and capabilities beginning teachers need for the classroom'.

Both these reforms aimed to increase the quality of graduate teachers.

However, these reforms have had little impact. Student outcomes in NSW and Australia continue to decline relative to other states in NAPLAN and international PISA scores respectively. The higher barrier to entering teaching has lowered the attractiveness of the profession for high achievers who hold a bachelor degree. This has worsened NSW's statewide teacher shortages.

Recognising this, the NSW Productivity Commission and Commonwealth Quality Initial Teacher Education Review have both suggested new one-year pathways be explored.

Sources: NSW Productivity Commission (2021a); Expert panel chaired by Ms Lisa Paul AO PSM (2022)

Table 4

If credentialism is so bad, why does it happen?

Stakeholder	Incentives
Governments	Governments sometimes support credentialist initiatives, believing credentials improve safety, boost service quality, or raise the status of the occupations in question (see **Box 16**)
Students, trainees, and jobseekers	In tight labour markets, trainees can be compelled into an expensive and time-consuming 'arms race', perceiving that holding more or better qualifications will give them a competitive edge into entry-level positions
Employers	Faced with a surfeit of suitable candidates, employers often use higher-level credentials as a filtering mechanism
Incumbent workers and their industrial associations	Incumbent workers and their representatives — unions and professional associations — have incentives to support raising minimum credentials for new entrants because this creates barriers to entry which allow incumbent workers to command higher wages/prices
Universities and training providers	Universities and training providers can benefit financially when aspirants are required to undertake longer courses of training before gaining a qualification

Credentialism can also arise passively. Technology, automation, and changing regulatory requirements and industry standards can change the skills, knowledge, and tasks required for a role, with training offerings being unable to keep up. A disconnect between training providers and practitioners can also result in training that is not fit for purpose.

Despite the incentives driving credentialism, it **can** be unwound, unlocking significant additional capacity and potential in the existing workforce and benefits for consumers, business, aspiring workers, productivity, and economic growth. The length and content of training can be reduced where the benefits of doing so outweigh the costs. We may also be able to achieve a better balance between initial and continuing education.

Roles can also be broken down and restructured, with simpler or safer tasks performed by workers who are less credentialled or qualified. The training system can acknowledge competency and recognise prior learning; it can offer more flexible pathways, and more flexible, shorter, and on-the-job forms of professional development and skills attainment.

Assistants in Nursing (AIN) provide an example of this strategy. AINs were introduced in the early 2000s to enable simpler tasks, previously required to be done by registered nurses, to be delegated to staff with more basic training (Shearer 2013). AINs 'assist in the provision of basic nursing care, working within a plan of care under the supervision and direction of a registered nurse' (NSW Nurses & Midwives' Association and Australian Nursing & Midwifery Federation NSW Branch 2020). AINs perform lower-skilled tasks which require less training, allowing fully-qualified nurses to spend more time on higher-skilled, higher-value tasks. Aspiring AINs seeking a formal VET pathway can pursue a Certificate III Health Services Assistance.

The fight against credentialism requires constant review of occupational qualification and licencing requirements, and an investigation into whether they produce benefits that justify their costs. Regulatory experiments and pilot programs may assist in this process. Conversely, proposals for new or longer training requirements should also be piloted and evaluated before embedding them in formal standards. In many cases the NSW Government will need to work with state, territory, and Commonwealth regulators, accreditation bodies, and aligned industry associations to redefine and redesign roles.

4.4 Create a system for continuous upskilling

In a world of rapid innovation and technological uptake, the technologies and systems that workers use will evolve over time. They may change dramatically, and even be revolutionised more than once across the course of a person's working life.

To flexibly and rapidly adapt to this changing world of work, NSW needs to enable workers to upgrade their skills and develop new capabilities (World Economic Forum and Boston Consulting Group 2018; Gereffi, Fernandez-Stark, and Psilos 2011; Sakamoto and Sung 2018). This approach is known as lifelong learning.

Lifelong learning means workers do not just train once at the beginning of their working lives. Instead they upgrade their skills continuously. By keeping skills up to date, they lower the risk of losing work to automation. By continuously adopting new technologies that augment their efforts,lifelong learners become more productive and employable over time.

Thankfully, education has never been more accessible. The COVID-19 pandemic has accelerated digital delivery, meaning many universities and technical colleges now offer short courses — or even entire degrees — through online or blended learning methods. There has also been a rapid rise in digital education providers — like edX, Udemy, and Khan Academy — offering access to a wide range of relatively inexpensive online courses (Koksal 2020; Palvia et al. 2018).

Rapid uptake of digital education opportunities has coincided with an increase in 'microcredentials' and other forms of non-formal learning. According to the Department of Education, Skills and Employment's (2022) National Microcredentials Framework, a micro-credential is a certification of assessed learning or competency, with a minimum volume of learning of one hour and less than an AQF award qualification, that is additional, alternate, complementary to or a component part of an AQF award qualification'.

The NSW Productivity Commission (2021a) believes microcredentials have the potential to be a highly targeted and efficient method of learning, making them well suited to lifelong learning. Microcredentials can also be used to target in-demand skills and offer a cost-effective means of upskilling older workers.

The NSW Government can work with the Commonwealth Government, which shares responsibility for education and training, to realise the value of microcredentials. Partnerships with professional associations, unions, industry bodies, and the tertiary education sector will also be crucial.

There is also much the NSW Government can do on its own. The Government is, for example, piloting the use of microcredentials in the Western Parkland City (see **Box 17**). To further encourage uptake, the NSW Government can also continue to extend government-subsidised training — for example, through the *Smart and Skilled* program — to microcredentials and other short courses.

Uptake, however, is not the only barrier. Microcredentials are not consistently recognised, constraining industry trust in their effectiveness. The 2019 Review of the Australian Qualifications Framework (AQF) made recommendations to improve the recognition of microcredentials, including to assist with mapping them to the AQF. Recommendations from the Review are being implemented by a national working group led by the Commonwealth. In this context, co-development of microcredentials with industry and professional associations could be considered as a way to offset the issues of trust and application.

Both Commonwealth and state and territory governments can work to encourage the use of microcredentials by employers and industry in skilling and reskilling. In this area, stakeholders we consulted identified that the NSW Government could act as an employer of choice by recognising microcredentials in professional development programs across the public sector. This would provide a targeted way to upskill public employees and raise the status of microcredentials across the economy.

The NSW Government has acknowledged the important role of microcredentials in upskilling workers and responding to the needs of industry with its pilot of the New Education and Training Model in the Western Parkland City (see **Box 17**).

Workers can also gain new skills through other avenues, like secondments and job rotations, and internships and apprenticeships (Moon and Goff-Dupont 2019). For example, an employee working in frontline operations may do a rotation in head office or be seconded to another department. These opportunities give workers a greater breadth and depth of experience. One study found that when a person trains or works in one job, they can acquire skills for as many as 13 others (Foundation for Young Australians 2018).

Box 17

The New Education and Training Model

The NSW Government is piloting a new education and training model for the Western Parkland City — the New Education and Training Model (NETM).

The NETM will give industry a key role in designing and delivering tailored learning packages in the form of microcredentials. These will enable people to build knowledge, skills, and experience in priority industries aligned to employer needs. The NETM will offer flexible learning and give learners the option to stack microcredentials to support their career goals and business objectives.

Source: Western Parkland City Authority (2022)

4.5 Create smooth, flexible pathways for multiple career transitions

Long service awards are out, and multiple careers are in. Research suggests young people will have significantly more careers and employers over their lifetimes than their parents have had — on average, five careers across 17 employers (McCrindle 2014).

Traditional education and training delivery models, designed to prepare school leavers for single-track careers, are not always as fit for purpose as they once were. To prepare workers for multiple careers, governments can work together with employers to create smooth, flexible transitions between jobs and across a worker's life course.

Pilots and trials of non-traditional pathways have shown promising results in Australia and overseas (see **Box 18**).

For example, the *White Paper* found Teach for Australia's (TFA) alternative employment-based pathway to be successful in attracting mid-career professionals to teaching (NSW Productivity Commission 2021a). Rather than completing a two-year Master of Teaching, candidates begin teaching after only six months of training. They receive a salary while doing so, and complete their Master of Teaching during the two-year program. This pathway is in high demand. But a lack of funds prevents TFA from enrolling all quality candidates.

The NSW Government has since announced, and is piloting, the Mid-Career Transition to Teaching Program (NSW Government 2022e). It enables high-performing professionals to work at a school part-time as a paraprofessional after only six months of study while they finish their qualification.

In its *White Paper*, the NSW Productivity Commission (2021a) argued that the current apprenticeship model is not always suitable for mature-aged workers, many of whom are put off by low apprentice wages and the length of time needed to complete a qualification. The Commission recommended introducing new and flexible pathways into trades through the Trade Pathways Program (formerly the Trade Skills Pathways Centre). This program — currently being trialled in the construction sector — uses Recognition of Prior Learning and fee-free gap training to assist experienced but unqualified workers to gain a qualification (NSW Government 2022f).

Box 18

Become an apprentice at Google

Google's apprenticeship program provides an equitable pathway to develop digital skills for people without a university degree or work experience in computer science. The program, offered at Google offices around the world, aims to bridge the gap between education and employment by allowing apprentices to earn income while they learn.

Apprentices choose a specialisation — data analytics, digital marketing, information technology, project management, software engineering, or user experience design — and dedicate 40 hours a week over 20 months to a structured development journey involving:

- a three-week virtual onboarding experience
- a six-week bootcamp with Multiverse — Google's apprenticeship partner — to build a foundational understanding of the profession
- on-the-job training in different areas and teams at Google relevant to their track
- career workshops, coaching, and holistic support throughout the program.

When they complete the program, apprentices have the skills they need to apply for a full-time position in the industry.

Source: Google (2022)

As our working lives get longer, and the eligibility age for the pension is raised, the rate of return for investments in career transitions increases. Employers can use their workers' new skills for longer, making it more likely they will invest in training. And employees will be more likely to reskill when longer careers mean they will progress further in their new industry, offsetting the cost of retraining and initial lower wages.

Higher credential requirements reduce the return on skills investments by both employees and employers. Longer entry qualifications deter potential workers from reskilling, because their costs outweigh the future benefits, and workers cannot afford the longer time to reskill. This is likely contributing to teacher shortages in STEM in NSW. In teaching, the requirement for a minimum two-year postgraduate degree, phased in recent years, has probably also deterred mid-career professionals from becoming teachers.

4.6 Give individuals the right incentives and information

While individuals need to be in the driver's seat of adaptation, the NSW Government can play a role in changing attitudes to upskilling and foster a growth mindset through targeted subsidies, training quality, and the provision of relevant information and support.

4.6.1 Targeted subsidies

Australia's Constitution makes education the responsibility of state and territory governments (Parliament of Australia 1900). The Commonwealth Government, however, often exerts control over the education sector using conditional grants.

The Commonwealth Government influences Australia's tertiary education system through the Commonwealth Grant Scheme, which subsidises course fees for eligible students. It makes the largest contributions in fields which it expects will see future jobs growth (Ferguson 2021). For example, economics students fall into funding cluster 1 and receive a contribution of $1,100 from the Commonwealth, while engineering students are in funding cluster 3 and eligible for a $16,250 contribution.

The Commonwealth Government also subsidises other grant programs, including the Job-ready Graduates Package. This package funds up to 30,000 new university places and 50,000 new short course places in areas of national priority — such as STEM, IT, health, and education (Department of Education, Skills and Employment 2021). It provides additional support for students in regional and remote areas.

The VET sector works slightly differently; here the Commonwealth Government funds state and territory governments to support delivery (Ferguson, Ey, and Maslaris 2020). In NSW, the Government influences student choices through its Smart and Skilled VET policy, which offers government-subsidised training from Certificate I to Advanced Diploma courses for eligible students completing courses on the NSW Skills List.

But as discussed in **Chapter 4.2**, the NSW Skills List is poorly targeted, which leads people to enrol in courses that industry does not need or value. For example, a Certificate II in Hospitality was the fifth most popular VET course in 2018, and 76 per cent of enrolled students received government funding (NCVER 2020b). Yet many businesses have said the qualification is not required or desirable for jobs in the hospitality industry (Commonwealth Government 2020; National Centre for Vocational Education Research 2020).

The NSW Productivity Commission (2021a) has recommended the NSW Government target Smart and Skilled subsidies more effectively to incentivise people to undertake study that has a demonstrated value to industry in nominated skills shortage areas.

The NSW JobTrainer program is a good example of how the Commonwealth, state, and territory governments can use NSC analysis to provide training in areas of anticipated employment growth. NSW JobTrainer was introduced in September 2020 in response to COVID-19. It offers fee-free training to job seekers, young people, veterans, and to individuals seeking training in aged care, childcare, disability care, digital skills, and the training and assessment field (NSW Government 2020a; 2022c).

4.6.2 Training quality

Higher-quality training gives people stronger reasons to improve their skills.

Under Smart and Skilled, public and private VET providers in NSW cannot compete on price and must charge students the same fees. Students therefore do not receive quality signals through price variations. The NSW Government could help students make the most of their training investment by providing them with better information on training quality. This would result in increased enrolments for high-quality providers and would force low-quality providers out of the market.

The NSW Productivity Commission (2021a) recommends providing better information by capturing and publishing Smart and Skilled student feedback on training provider quality, employment outcomes, and overall student experience.

4.6.3 Information and support

People also make better career choices when they can access high-quality career information and support.

To address this need, the NSW Government launched Careers NSW in October 2021 (Service NSW n.d.). This service aims to provide high-quality, tailored career advice to NSW residents at all career stages. Available resources include:

- a self-service website with supporting resources, tools, and information
- access to careers advisors and industry experts
- dedicated support for women seeking to enter the construction industry
- access to Skills Hub Customer Care Specialists, who can provide advice on how to upgrade skills and access fee-free training.

The NSW Government has expanded the pilot to deliver a full-scale service for adults and will deliver a pilot in secondary schools in late 2022. The NSW Government can continue to use this platform to experiment with different modes of delivery, target cohorts, and service offerings, with appropriate evaluations. The NSW Government can additionally leverage this platform to promote lifelong learning, and to raise awareness of initiatives, subsidies, and other measures available for people to plan their careers and access training.

4.7 Make sure employers have incentives to train workers

Employers who consider training workers face conflicting incentives. Employers want skilled workers. But workers with new skills are more likely to be poached by another employer or to change jobs (Mohrenweiser, Zwick, and Backes-Gellner 2013). Employers who invest in training could, in other words, risk losing their investments.

Our stakeholder consultations also highlighted perceived disadvantages for employers in skilling workers, including bearing the direct costs of formal training, and the paid or unpaid time employees spend away from the job while training, which can reduce a firm's productive capacity or its productivity.

It is therefore unsurprising that PwC Australia's (2021) *24th CEO Survey* finds 66 per cent of Australian CEOs are concerned about the availability of key skills, but only 29 per cent see building skills as an organisational priority. The proportion of work-related training provided by Australian employers has also fallen over time, from 35.9 per cent in 2005 to 25.5 per cent in 2016/17 (Australian Bureau of Statistics 2017).

Australia attempted to boost workplace training in its trial of the Training Guarantee Levy (TGL) between 1990 and 1994 (Hall, Buchanan, and Considine 2022). The TGL levied a 1.5 per cent tax on employers who did not provide structured on-the-job training.

The levy was suspended in 1994 and later abolished. Analysts noted several problems:

- there were too few training providers to meet the sudden rise in employer demand
- the scheme did not provide enough information and support to help employers find training providers or develop their training programs
- it failed to demonstrate the value-add of training opportunities, meaning employers opted for short, stand-alone, task-specific courses rather than higher-skill courses
- if the levy was passed onto workers as lowered wages and senior executives were picked for training, it shifted the cost of training from employers to disadvantaged groups — such as lower-skilled, migrant, small firm and precarious workers.

The rise in low-skilled labour with high turnover rates through the gig economy may now be making employers less likely to invest in training opportunities. If this is true, it means workers will need to undertake external training to keep pace with the changing work environment, shifting the cost of training from employers to individual workers.

Australia's current competency-based training regime narrowly focuses on training people for the current job market, rather than building adaptive capabilities (Buchanan 2020). When employers do invest in workers' skills, they often aim to meet organisational needs in a relatively narrow, firm-specific, or reactive context, as there is less incentive to build general, transferable skills (Koster and Benda 2020).

Rather than basing skills ambitions on this siloed training model, policymakers could look at how our training system could identify and support skills development for clusters of jobs to enable workers to switch between different types of work. One proposal along these lines, flagged by our workshop participants, is that governments and educators could collaborate with employers to create publicly-funded teaching workplaces within the VET system to provide practical training for potential workers.

Some of our workshop participants suggested that governments could provide direct financial incentives to employers to encourage further investment in skills. This could include compensating employers for the time employees spend on training or providing rebates, subsidies, and tax deductions to employers who invest in training. This approach has been adopted by some international jurisdictions (see **Box 19**).

The NSW Government could also identify barriers to upskilling and reskilling. For example, employers previously had to pay fringe benefits tax (FBT) if they provided training to their employees that was not directly relevant to their current occupation (The Hon. Michael Sukkar MP and The Hon. Josh Frydenberg MP 2020). In June 2021, however, the *Fringe Benefits Tax Assessment Act 1986* was amended to give employers an exemption from FBT 'if they provide training or education to a redundant, or soon to be redundant, employee for the purpose of assisting that employee to gain new employment' (Parliament of Australia 2021).

Efforts to enhance employers' incentives to train workers should be evidence-based, and supported by cost-benefit analysis and evaluation.

Box 19

How international jurisdictions incentivise employers

In **France**, employers must contribute between 0.55 and one per cent of gross monthly salaries to an external personal training account (*compte personnel de formation,* CPF). Employees can draw upon the training entitlement in their CPF to receive training beyond the needs of their current job. By pooling the levy, the system eliminated the problem of poaching. France strictly governs training quality by limiting the number of training providers to ensure consistent practices and reduce confusion for trainees and employers.

Sweden's system pools contributions from employees, employers, and the Government into individual learning accounts. Employees can claim the entire contribution as a tax deduction and employers can deduct 10 per cent of their co-contribution from payroll tax.

Employees receive a 'competence grant premium' when drawing their contribution for an eligible training program.

The **Danish** lifelong learning policy was developed in consultation with trade unions and employers' organisations and involves publicly-funded training institutions and the Job Rotation Scheme. Employers contribute to a reimbursement scheme and cover 15 per cent of the cost of employee vocational training. Under the Job Rotation Scheme, employers receive a subsidy for temporarily hiring an unemployed person while their current employees receive further education and training. The scheme gives unemployed people work experience and upgrades the skills of incumbent employees.

Source: Eurofound (2019); CEDEFOP (2018); Hall, Buchanan, and Considine (2022); OECD (2019); Rolls, Cort, and Craescu (2012)

4.8 Develop workforce strategies for growth sectors facing skills shortages

While giving individuals and employers the right information and incentives, government needs to proactively tackle structural challenges in the workforce and labour market.

These challenges can be created by technology — for example, technology use drives demand for ICT workers. Or they can arise from demographics — such as when an ageing population drives demand for aged-care workers.

4.8.1 Grow our ICT and cyber security workforce

As IT plays a growing role in work and life, the NSW ICT workforce will also need to grow. We will need more technicians to troubleshoot our IT problems and more trainers to teach us how to use new digital tools. We will need programmers and software engineers to create and maintain the new technologies we use in businesses and homes.

Our modelling, powered by Faethm AI, projects that the NSW ICT workforce is expected to grow by 71 per cent by 2035. If emerging technology takes off, the size of the industry could increase by another 15 percentage points, 1.9 times more workers than in 2020.[8]

More than doubling the ICT industry workforce over 15 years will require a strong pipeline of talent. The NSW Government has already begun several programs to foster digital skills:

- the **digital stream** of the NSW Government Graduate Program, which trains graduates to provide digital government services
- the **Digital Skills Pilot Program**, which upskills workers in at-risk industries in digital literacy
- the **Institute of Applied Technology for Digital Technology Pilots**, which will provide courses in big data, cyber security, and AI at multiple academic levels.

The Commonwealth Government is likewise supporting digital skills in its $10.7 million Digital Skills Cadetship Trial. This trial funds four-to-six-month cadetships for career changers, school leavers, and graduates to gain formal certifications and practical experience in priority digital fields. Among these fields is cyber security (see **Box 20**).

The NSW Government can monitor these programs to ensure they are effective. With new technologies constantly emerging, it can also ensure that participation and enrolment are high enough, and that syllabuses are up to date, so graduates are job-ready.

Together with the practical skills acquired in these cyber programs, IT graduates need a supportive and inclusive immediate work environment geared towards encouraging women's participation. As it stands, 74.5 per cent of achievers of non-school qualifications — certificates, diplomas, or degrees — in IT are men, while only 25.2 per cent are women (Australian Bureau of Statistics 2021c). Increased participation by women could help supply the diverse insights and creative solutions needed to harness the full potential of technology.

Box 20

Expanding our cyber security expertise

Alongside benefits, technology also brings new risks. Government agencies, financial institutions, and important industries are increasingly targeted by online attackers and cybercrime has become a significant ongoing national security issue. Attacks can involve stealing confidential information, locking critical systems until a ransom is paid (ransomware), or 'hijacking' websites. The cyber security workforce will need to grow to mitigate the impact of these and other malicious actions on NSW.

Both the Commonwealth and NSW Governments have made substantial commitments to expanding sovereign cyber security capabilities. The Commonwealth's *Cyber Security Strategy 2020* commits to investing $1.67 billion over 10 years to protect critical infrastructure, research new techniques, increase the skills pipeline, and provide advice to businesses and individuals. The NSW Government has established the NSW Cyber Hub to support businesses build cyber security capabilities. This includes:

- **Cyber Connect**, a collaboration forum for cyber security professionals
- the **Cyber Security Industry Placement Program**, to support small businesses to invest in cyber talent and larger businesses to increase their cyber security workforce
- the **Cyber Checkme** pilot, providing university students with stronger practical experiences.

Source: Commonwealth of Australia (2020); NSW Government (2022a)

8 Source: NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI), central emerging technology diffusion scenario

4.8.2 Increase our infrastructure workforce

The *NSW State Infrastructure Strategy* highlights considerable public investment in roads, rail, airports, and educational precincts. So does the $112.7 billion infrastructure committed over four years in the *2022-23 NSW Budget*. These projects have the potential to enhance the quality of life, boost productivity, stimulate economic activity, and create jobs.

But these investments will also exacerbate existing infrastructure workforce shortages. Infrastructure Australia (2021) estimates that shortages will peak at 19,000 project management professionals; 70,000 engineers, scientists, and architects; 16,000 structural and civil trades and labour; and 14,000 finishing trades and labour over the next three years. Along with Victoria and Queensland, NSW faces the greatest risk of workforce shortages, even though these states have the largest workforces.

Structural reform is needed to broaden the supply of tradespeople and make supply respond better to demand. Currently trades pathways are oriented towards young male early school leavers who can take on low-wage apprenticeships for three to four years. The NSW Productivity Commission has highlighted the need for alternative or accelerated pathways as apprenticeship enrolments remain lower than desired and attrition remains high. The NSW Government could attract a more diverse range of people into the trades through more flexible learning options, such as the Trade Pathways Program discussed in **Chapter 4.5**.

The NSW Government could also explore opportunities to use this infrastructure pipeline to provide practical experience in construction and trades pathways. For example:

- The **Infrastructure Traineeship Program** offers more than 100 high school leavers the opportunity to complete paid work experience in infrastructure-based roles while gaining a VET qualification (NSW Government 2020c).
- The **Infrastructure Skills Legacy Program** aims to boost the number of skilled construction workers by setting skills, training, and diversity targets for NSW Government infrastructure projects (NSW Government 2022b). Projects of $10 million or more, for instance, must employ sufficient apprentices to make up 20 per cent of the trades workforce.

4.8.3 Use tech to augment the aged-care workforce

An ageing population means a rising demand for aged-care workers. The *2021 Royal Commission into Aged Care Quality and Safety* predicted that 80,000 additional aged-care workers will be needed by 2030 and 180,000 by 2050. The shortage has been exacerbated by the COVID-19 pandemic, as border restrictions have limited the supply of skilled migrants, who are important contributors to the healthcare and social assistance workforce.

Part of the solution is augmenting the existing aged-care workforce's use of emerging technologies. Japan, whose ageing population challenge is more acute than that of NSW, provides a leading-edge example (see **Box 21**). The Commonwealth Government has recently announced its digital transformation for the aged-care sector agenda, in which it aims to simplify, automate, and digitise communication between clients, the software industry providers, and government (Department of Health and Aged Care 2022).

Robots, however, are not a substitute for staffing. Workforce supply issues in the aged-care sector need to be addressed for NSW to uphold the standards of care its citizens expect. **Chapter 5.5.2** discusses the need to ensure competitive pay and conditions in social services.

Box 21

Japan — how technology can augment the aged-care workforce

Japanese aged-care facilities have started using autonomous robots to deliver social and physical care to residents. Examples include:

- **robotic companion and conversation partners** — provide communication stimuli and emotional responses to participants. These can take the form of animals or even humans for residents to hug and interact with
- **smart walkers** — rehabilitate and assist those who have difficulty walking
- **mechanical lifting devices** — assist staff in lifting, positioning, and turning residents, the source of most injuries in the sector.

Further technological development can strengthen the supply of workers in the sector and help employers make the most of the staff they currently have:

- **digital workforce platforms** — improves rostering and workforce management in the aged-care sector, providing staff with the hours they desire, and reducing the administrative burden of managers who roster staff
- **digital care management tools** — reduces the amount of time aged-care staff spend on administrative reporting, improves the accuracy of records, and allows for the sharing of records across care providers
- **remote monitoring** of care recipients — alerts staff when assistance is required, removing the need for staff to conduct manual checks. Avoiding unnecessary interventions allows care recipients to have privacy when care is not required and leaves staff free to focus on providing care to those who need it most.

5

Adaptation is for everyone

Inclusive adaptation means ensuring that processes of technological adaptation and transition are fair, inclusive, and effective. Active and judicious policymaking is required to ensure the benefits of technology are shared widely across the NSW community.

At a glance

Emerging technology can radically revive NSW's lagging productivity growth and create a flexible, adaptive, tech-augmented workforce. However, fostering technology adoption and building tech skills are not enough in themselves. The processes of adaptation and transition must be fair, inclusive, and effective.

The six pillars of inclusive adaptation in *Adaptive NSW* include: smooth transitions for industries and workers facing technological disruption; using tech to diversify our regional economies; using tech to broaden workforce participation; closing the digital divide and ensuring diverse, inclusive access to tech; ensuring that the tech 'productivity dividend' is distributed widely; and ensuring appropriate protections exist for workers, including those in the gig economy.

Inclusive adaptation means that the benefits of technology are shared widely across the community. Inclusive adaptation is not about compensating those left behind in technological transitions. Nor will inclusive adaptation happen by itself. It requires active and judicious policymaking and management so that the many opportunities technology presents can be enjoyed by everyone.

Adaptive NSW lays out how emerging technology can radically revive our state's lagging productivity growth. It lays out principles that NSW policymakers can adopt to foster a pro-technology environment and support a flexible, adaptive, tech-augmented workforce.

This chapter makes the case that fostering technology adoption and building tech skills are not enough in themselves. Policymakers also need to ensure the process of tech adoption and workforce adaptation is fair and **inclusive**, and that the benefits of technology are shared widely across the community. It requires actively including groups such as Australia's First Nations Peoples, culturally and linguistically diverse communities, socioeconomically disadvantaged people, and people in regional and remote areas.

In this chapter we outline six pillars of inclusive tech adoption and adaptation by which NSW can:

- smooth transitions for industries and workers facing technological disruption
- use technology to diversify our regional economies
- use technology to broaden workforce participation
- close the digital divide and ensure diverse, inclusive access to tech
- ensure the tech 'productivity dividend' is distributed widely
- ensure appropriate protections exist for workers.

Inclusive adaptation is not about *compensating* those left behind in technological transitions. It requires looking forward and seizing upon the many opportunities technology offers to make society fairer and more inclusive. It means making every effort to ensure that nobody is left behind at all.

Inclusive adaptation, we argue, is not just nice to have. Failing to achieve it could result in squandering the technology opportunity. Throughout this chapter we highlight that, if adoption is not inclusive, there is a real risk of undermining community support for it.

Nor will inclusive adaptation happen by itself. As will be seen, it requires active and judicious policymaking and management.

5.1 Ensure active and orderly industry transitions

In some industries, taking up productivity-enhancing technologies and technological innovations may reduce demand for workers. In particular, forecasts are that employment will fall in industries associated with the production and distribution of goods, such as agriculture and mining. Meanwhile, demand for social and business services will increase (NSW Treasury 2021). In most cases, businesses in shrinking industries will simply train fewer new workers or choose not to replace those workers who leave.

But as **Chapter 2** explained, technological change tends to come in waves. This means that industries, businesses, and workers can experience long periods of stability followed by sudden technological disruption. When this happens, it is possible for large groups of workers to be displaced in a relatively short time.

In the long term, technology adoption creates many more jobs than it destroys—but this is cold comfort for any worker made redundant by automation. Losing a job, whether for technological or other reasons, can be a huge economic and emotional blow. Recent research shows Australian workers earn an average of 30 per cent less after losing their job, with their wages only recovering to pre-job-loss levels after an average of four years (Lancaster 2021). A worker who loses their job often struggles to find one that uses a similar skillset with comparable wages and hours.

The distress of disruption is equally real whether a worker is part of a very small group or a very large one. On a large scale, poorly-managed transitions have the potential to cause severe social unrest. One famous example is the Luddite Rebellion in early industrial England between 1811 and 1816, centred on what was then new wool industry technology (Mokyr 2005).

In the two centuries since the Industrial Revolution, economically advanced nations like Australia have built up many social and economic mechanisms to soften the blow of sudden unemployment and help people transition to new jobs. These include subsidised education and training, healthcare, housing, income support, and tax relief.

These protections make technological disruption less likely to cause the kind of large-scale social unrest it did in the early 19th century. But the effects of sudden, disorderly transitions involving large groups of people are still possible. These not only leave affected workers, businesses, and industries worse off; they also undermine community confidence and support for technological change.

The sensible course is not to try to suppress new technologies, as the Luddites did. It is rather to actively manage industry transitions to minimise the harm they do to people and communities and the social stress that can result.

Government has a role to play in assisting with industry transitions to minimise unnecessary adjustment costs (i.e. retraining schemes or assistance for displaced workers) and in facilitating adjustment within (or out of) the industry. The closure of Australia's last major carmaking factories provides a case study of how a managed transition can work (see **Box 22**).

The key element in this successful transition was the first factor listed in **Table 5**: time. With several years' notice provided by the companies that were closing factories, governments were able to co-operate with those companies and their suppliers on programs to support the large labour transition needed in a timely and constructive way.

Jobs Queensland (2018) classifies interventions into four categories:

1. **industry restructuring programs** — help industries adjust to new conditions to remain viable
2. **enterprise assistance programs** — focus on individual, often large, firms instead of entire industries
3. **labour market programs** — offer displaced workers career advice and support
4. **investment attraction strategies** — attract investment for new firms or the expansion of existing ones.

Jobs Queensland has also developed a list of key elements to consider when assisting workers during industry transitions (see **Table 5**).

Each transition is different. Once it is clear that a transition will affect a large number of workers, the NSW Government can work with other Australian governments, employee associations, and with the private sector to tailor successful elements and other evidence-based, best-practice measures to the transition at hand.

More generally, Government can support industry transitions by making the labour market more flexible. This requires lowering barriers to changing careers by combatting credentialism and creating smooth, flexible pathways for career transitions (see **Sections 4.3** and **4.5**). For example, an automotive manufacturing worker might transition to a role in construction that uses many of their existing skills (see **Box 22**).

Box 22

Actively managing transitions for workers in automotive manufacturing

In 2013 and 2014, Australia's three 'original equipment manufacturers' (OEMs) — Ford, Holden, and Toyota — announced their intention to cease automotive manufacturing operations in Australia by the end of 2017.

At the time, the Commonwealth Government estimated this would result in 27,000 Victorian and South Australian workers losing their jobs. These workers were employed either directly by the OEMs or by other companies in the supply chain.

But the extended notice period gave the Commonwealth, Victorian, and South Australian Governments and the OEMs time to work closely together to plan a coordinated response. They provided around $380 million to:

- support the transition of OEM workers through upskilling, tailored career advice, and job search assistance
- mitigate further job losses by encouraging other companies in the automotive supply chain to diversify their operations.

This was highly successful. Due to diversification efforts by other companies in the supply chain, only 14,000 workers had lost their jobs a year after closure — much lower than the initial 27,000 estimate. Of these displaced workers, 82 per cent had already found new jobs, primarily in manufacturing, transport, postal and warehousing, and construction.

Source: Department of Employment, Skills, Small and Family Business, ACIL Allen Consulting, and Wallis (2019)

Table 5

Elements of success for industry transitions

Element	Reasoning	How to implement
Time	Workers need sufficient time to comprehend their redundancy and to take advantage of the transitional support available.	Programs should have sufficient lead and lag times so workers can prepare for displacement and access support services afterwards.
Anticipatory planning	Major industry transitions are not isolated events. Often there are signs that change will occur.	Draft policies and plans should be prepared and ready to implement in the case of major closures. These can include a workforce skill profile of the area so training can be readily provided.
Governance and information dissemination	Successful case studies involve the creation of a committee comprised of a broad range of representatives to assist the industry transition.	This committee should lead consultations, collaborate on solutions for concerns, and communicate these to the local community.
Local focus	Workers are not always able to relocate to where jobs are.	Industry transition programs should focus on creating opportunities in the affected region.
Human capital	Training and education to help transition workers should be tailored to the individual and aligned to potential careers.	Resume writing, interview skills, financial advice, and business advice should be provided.
Economic diversification	Regions cannot rely on one key industry for economic growth.	Efforts to diversify the local economy should be recognised and supported.
Local coordination and case management	An understanding of the local community is needed to effectively manage a transition program.	Programs and teams formed to manage industry transitions should be based in the local area and work with local groups.
Evaluation	Ongoing evaluation of transition programs is needed to ensure best practices continue to be used in industry transition programs.	Evaluations should be longitudinal and begin pre-transition. Employment and quality of life outcomes for affected workers following transitions should be focused.

5.2 Diversify our regions

The decline in employment that technological change is bringing to some industries (discussed in sections **2.3** and **5.1**) will be particularly felt in those parts of regional NSW that rely heavily on them for employment. Lest these communities be left behind, the NSW Government may need to expend significant resources to bring these communities along on the journey of technological change.

The closure of BHP's steel manufacturing plant in Newcastle exemplifies the danger of a region being too reliant on a sole industry for employment. When the plant closed in 1999, almost 3,000 workers lost their jobs, the unemployment rate in the Hunter region reached 12 per cent — the highest in NSW at the time — and there was an estimated $1.6 billion cost to the local economy (Lewer 2013).

The NSW Government can anticipate potential adverse impacts of technological change by closely monitoring trends in employment across industries in regional NSW. The National Skills Commission is experimenting with a new tool, a monthly Nowcast of Employment by Region and Occupation (NERO) (Shamiri et al. 2021). NERO allows users to track employment by occupation in regions across Australia, providing frequent, timely, and detailed labour market estimates.

If policymakers can identify regions vulnerable to industrial change in advance, they can respond with targeted policies to encourage diversification, technology uptake, and workforce flexibility. Of course, ensuring that basic infrastructure, such as stable and accessible internet, is widely available in regional areas, must be a priority that underpins any tailored policy approaches.

Box 23

Irish workers paid to move to rural towns in a plan to decentralise

In response to the rise of remote working from COVID-19, the Irish Government released its 'Our Rural Future' plan. It outlines incentives to attract remote workers and mobile talent to live in rural towns, representing a major decentralisation of more than 68,000 public workers from main offices on a permanent basis. Workers must provide proof from their employer that they can work remotely, and that they are moving to a rural town.

This mirrors similar initiatives in the US. For example, the local Economic Development Authority gave workers $2,000 USD to relocate to the city of Savannah in Georgia.

As part of the plan, the Irish Government will establish a network of over 400 remote working hubs nationwide to enable more people to live and work in rural communities.

Source: McConnell (2021)

In instances where regional economies are not diverse enough, technology may help . Recent research by the NSW Productivity Commission and the NSW Innovation and Productivity Council (2021) demonstrates that remote working can help diversify the employment base of regional NSW. The invention of cloud-based team collaboration software such as Microsoft Teams and digital meeting platforms like Zoom enables people to live in regional areas while working remotely for CBD-based businesses.

Remote working also makes much larger potential labour pools available to regional employers. This allows them to access skills otherwise unavailable in their region, making them more productive and competitive.

The NSW Government is the state's largest employer. It could follow the lead of other international jurisdictions (see **Box 23**) and act as a role model for the private sector, by developing flexible workforce practices which enable people to work remotely from regional NSW.

The NSW Government could also apply the lessons learnt in **Chapter 5.1** to the communities of regional NSW and build upon the Regional Economic Development Strategies (REDS) to develop a skills strategy that guides agricultural and manufacturing workforces in the transition to jobs associated with emerging technology.

Such a strategy could focus on creating viable career pathways into new agriculture and advanced manufacturing technology R&D as well as increasing the attractiveness of upskilling to those already in the industries.

Existing region-based technology R&D facilities include:

- the NSW Department of Primary Industries (n.d.) collaborative research and technology facility — Global Ag-Tech Ecosystem (GATE) — in Orange to develop and commercialise ag-tech innovation
- Australia's first fully automated farm, Global Digital Farm, will be built at Charles Sturt University's AgriPark in Wagga Wagga. The farm will use robotics, AI, and other technologies to improve farming outcomes (Claughton and Condon 2021).

5.3 Use tech to broaden workforce participation

Productivity-enhancing technologies and technological innovations can break down barriers to participation by overcoming the tyranny of location but also offsetting the challenges associated with physical limitations, creating virtual mobility, increasing flexibility, and removing barriers to access and entry.

The story of women in the workforce is a striking example of technology's enormous power to catalyse workforce participation. In the early 20th century, inventions like the washing machine and dishwasher began automating labourious domestic tasks traditionally performed by women, freeing up time for paid employment.

5.3.1 Overcome physical limitations

As discussed in **Chapter 2.4**, automation and augmentation are likely to make work tasks more knowledge-intensive and less physically-demanding.

This presents an opportunity for people with physical limitations — like mature-aged workers and those with a disability — to participate in the workforce (Thompson and Mayhorn 2012). KPMG's (2022) recent report, *When will I retire?*, finds the transition away from physically-demanding work to be a key factor contributing to the increase in the expected retirement age.

For example, Australian dairy farmers have been using robots to milk cows automatically since 2014, reducing the need for human labour and improving working conditions (Wu et al. 2019). Conversation exchange technology, speech, and visual aid devices also allow people to interface with computers using their voice rather than a mouse or keyboard (Czaja and Moen 2004).

Advances in sensor technology can help workers with a disability or with medical conditions to monitor their health status while working (Czaja and Moen 2004). For example, biosensors (such as insulin pumps) and wearable medical monitoring devices (like heart rate monitors) make it easier for people to track their vital signs in real time. Telehealth technology allows patients to transmit data to healthcare providers and seek virtual consultations. Patients can avoid travelling and reserve more time for work (Snoswell et al. 2020). These technologies provide a safer workplace for workers of different ages, genders, and healthcare needs.

Given NSW's ageing population, policymakers could consider how emerging technologies can be part of models of support that help individuals defer retirement, or transition to retirement more gradually. Technology and incentives can work hand in hand to extend opportunities for older people to keep participating. Support for late career transitions would also form a part of such a strategy (see also **Chapter 4.5**).

5.3.2 Increase flexibility

Technological advances are making work more flexible, giving carers and other groups who need flexibility more opportunities to participate in the labour market.

In the healthcare sector, shift-scheduling technologies are helping to increase flexibility for workers and to resolve staff shortages. According to the *2016 National Aged Care Workforce Census and Survey*, 30 per cent of residential and 40 per cent of home care and support staff would like to work more hours than they currently do (Mavromaras et al. 2017). Digital rostering tools help workers find more work by matching available workers with unfilled shifts posted by aged-care providers (Committee for Economic Development of Australia 2021). This allows workers to take on shifts that best suit their schedule and reduces the administrative burden for providers.

The technological innovations underpinning remote working have also made it easier for people with limited mobility — due to age, disability, caring commitments, or geographical location — to participate in paid employment.

Research by the Commonwealth Productivity Commission (2021) finds that, compared to those who did not do so, the small proportion — eight per cent — of people who worked remotely prior to the pandemic were more likely to be women, mature-aged, have caring responsibilities, or live in regional or remote areas. This can be attributed to Section 65 of the *Fair Work Act 2009*, which gives workers the right to request flexible working arrangements if they are parents to young children, carers, people with a disability, aged 55 years or older, or experiencing family violence.

The normalisation of remote working through COVID-19 may increase the pool of remote jobs available and encourage a more diverse group of people to take up employment. As the Diversity Council Australia (2015) outlined in its submission to the National Inquiry into Employment Discrimination Against Older Australians and Australians with Disability:

> 'As … the technologies enabling home based work improve, there is ever increasing opportunity for employers to tap into the currently untapped market of talented people with disability.'
>
> **— Diversity Council Australia**

5.3.3 Remove barriers to entry

Technology has broken down barriers to entry and given people without formally recognised skills and qualifications the chance to work outside traditional employment models.

For example, as discussed in **Box 6**, location-based digital labour platforms — like Uber, Airtasker, and Deliveroo — allow workers to perform lower-skilled tasks like driving, flat-pack construction, domestic work, and food delivery.

Online banking, cloud-based management software, and e-commerce platforms — like Etsy — also make it cost-effective to turn a hobby into a microbusiness (Mason et al. 2017). Approximately nine in 10 sellers on Etsy are women (Hegewisch, Childers, and Hartmann 2019). These platforms give women the opportunity to become entrepreneurs. And they allow mature-aged workers to continue using their knowledge without the burden of setting up a physical retail distribution network.

5.4 Expand access and close the digital divide

The Australian Digital Inclusion Index (ADII) maps inclusion across three dimensions — access, affordability, and digital ability — and across different social groups. The 2021 index revealed that, despite an increasing rate of digital inclusion, a substantial digital divide exists, with one in four Australians currently experiencing digital exclusion (Thomas et al. 2021).

The 'digital divide' is the gap between those who do and do not have the essential digital skills and affordable access to devices and data they need. Risk factors for experiencing digital exclusion include: having a low level of income, education, or employment, living in particular rural or remote areas of Australia.

Additionally, First Nations people, people with disabilities, who are culturally and linguistically diverse (CALD), aged over 65, and women, are all more vulnerable to being excluded. The COVID-19 pandemic exacerbated the digital divide because many non-digital service options were suspended or restricted due to public health measures.

The Good Things Foundation Australia (2022) has identified several key flow-on effects of the digital divide, extending to poorer physical and mental health and wellbeing, fewer work prospects and to worsening conditions of poverty and inequality. The Foundation's *Blueprint to close Australia's digital divide* uses evidence from the ADII and other data to identify three digital inclusion priorities:

1.

Community-led digital skills support for everyone

2.

Creation of a coordinated national digital inclusion strategy

3.

Affordable access to digital devices and data for all.

5.5 Distribute the benefits of tech widely

While the adoption of emerging technologies can greatly increase the size of the economic pie, it also has the potential to change how that pie is distributed. In recent decades, we have seen a group of tech entrepreneurs become incredibly wealthy, while some workers in industries hit by automation shocks (for example, in manufacturing) have been negatively affected. Based on this, some fear that, as machines replace work, the benefits of automation will flow increasingly to the owners of machines and workers will increasingly miss out.

It is true that the share of income going to workers' wages has been decreasing globally over time, falling from 62 to 58 per cent between 1992 and 2020 in NSW (NSW Productivity Commission 2021a). And the share of incomes going to profits has risen correspondingly.

But there is little evidence technology is to blame. In Australia, for example, the increased profit share appears to have come from three other sources: higher residential property prices; higher profits in the finance sector; and higher mining profits in the period 2008-2014 (La Cava 2019). After two centuries of rapid technology adoption, there is little evidence that technology impoverishes workers. Indeed, the opposite appears true.

Nonetheless, if policymakers want to encourage continued and accelerated automation, they should ensure that its benefits continue to be felt. To garner community support for emerging technology diffusion, governments should proactively consider the distributional impacts of technological advancement and, where appropriate, intervene to ensure that the benefits are shared widely.

Within the architecture of Australia's Federation, different levels of government have different levers for ensuring that the benefits of technology are felt widely. The Commonwealth controls the most powerful levers for redistributing income and wealth, including the power to tax income and capital gains, and provide support through the social welfare system.

State governments, by contrast, promote equity through the provision of universally accessible services such as public hospitals, public education, the public transport system, and a host of public infrastructure. In order to provide these things, of course, state governments need a sustainable revenue base.

By driving productivity and expanding the economy, emerging technologies can expand the potential revenues available to state governments, allowing them to provide more and better services. NSW Treasury modelling indicates that, if emerging technology boosted productivity growth to 2.0 per cent to 2035, NSW government own-source revenues could be as much as $4.5 billion above the baseline projection by 2034-35.

5.5.1 Avoid automation taxes

Some stakeholders identified that one way of redistributing the benefits of technology is by taxing firms that replace workers with automated technologies. Proponents of such 'robot taxes' say that:

- they will safeguard employment by discouraging firms from replacing workers
- if firms decide to use robots anyway, a tax will generate revenue to compensate the decline in payroll tax (Seamans 2021).

However, automation taxes are unlikely to become widespread because of their potentially harmful impacts on productivity and economic development. Automation taxes effectively penalise firms that invest in equipment. This flies in the face of decades of analysis suggesting we can best expand business activity and jobs by **encouraging** equipment investment and hence automation (see for example De Long and Summers 1991). Several research papers have found firms that adopt automated technologies increase employment compared to their non-adopting peers, because automated technologies often complement rather than compete with human labour (Seamans 2021).

A robot tax may also be difficult to apply consistently. Within industry, the term 'robot' is most applied to tools like programmable articulated arms used in activities such as car body assembly and painting. It is unclear why these tools should be treated differently to others — like sewing machines, power tools, computers, and software applications.

Although various jurisdictions have considered enacting automation taxes, only South Korea has implemented one in any form. And that 'tax' simply reduces pro-automation tax incentives which had been put in place earlier (McGoogan 2021).

A better course for supporting workers impacted by automation is to tax the gains from economy-wide productivity improvements in the least disruptive way possible and use the proceeds to fund measures that support smooth career and industry transitions (see **Chapters 4.5** and **5.1**). Policy work is also needed to break down unnecessary barriers between professions and support transition pathways (see **Sections 4.3** and **4.5**).

5.5.2 Ensure competitive pay and conditions in social services

As discussed in **Chapter 3.3.2**, most new jobs would be in services, particularly in social services like education and training, healthcare and social assistance, and public administration and safety. This means employment in occupations like registered nurses, child carers, and aged and disabled carers is projected to grow.

Stakeholders identified a need to ensure the benefits of technology do not just stay in high-tech industries being revolutionised but spread to the growing services sector through competitive wages and conditions. Policymakers can encourage this by making labour markets flexible, so that workers can smoothly transition between industries and occupations (see **Sections 4.3** and **4.5**). When labour markets are flexible, employers face pressure to offer competitive wages to attract and retain workers.

This issue also has a gender dimension, with women underrepresented in high-paying industries and overrepresented in low-paying ones (see **Figure 14**). With high-pay jobs predicted to grow substantially from the diffusion of emerging technologies (see **Figure 11**) there is a need to ensure women get a fairer share of these opportunities. The Workplace Gender Equality Agency summarises this predicament (Mosseri, Cooper, and Foley 2020):

> '[F]eminised fields like healthcare, education and social assistance have low risk for automation and are predicted to grow in the future, but many of the jobs are defined by low pay and poor working conditions.'
>
> **— Workplace Gender Equality Agency**

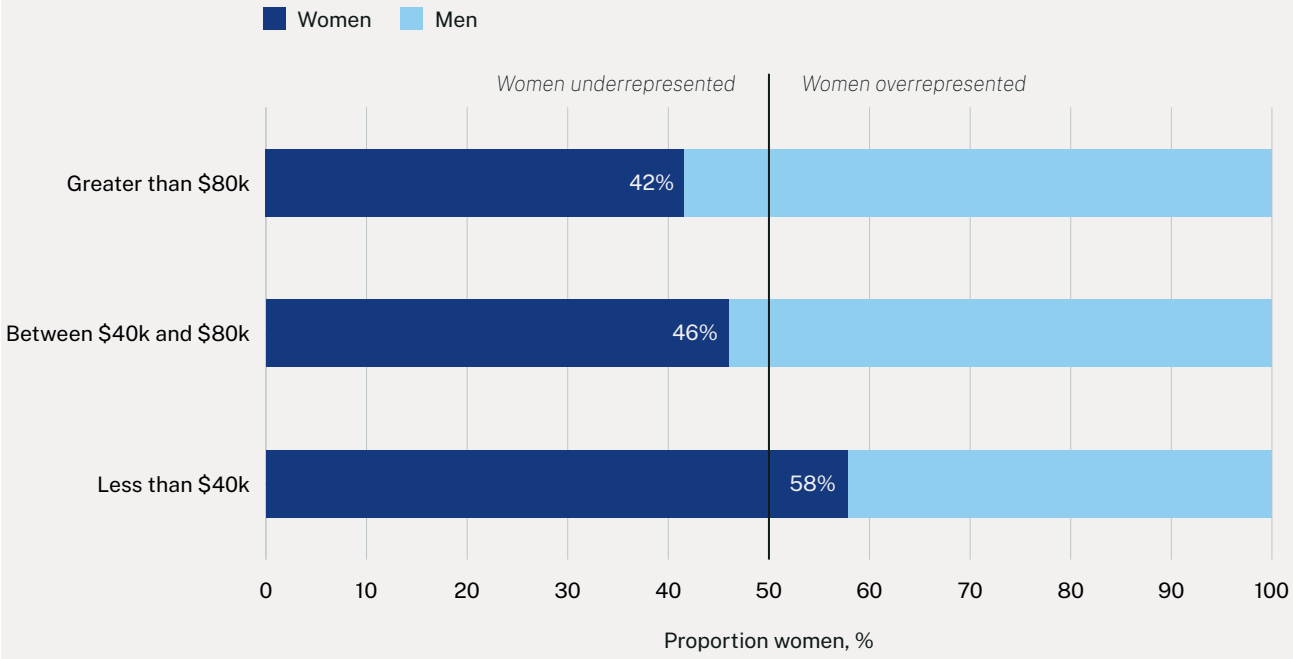
Stakeholders highlighted that, despite the significant social value of these roles, some care workers are undervalued in terms of remuneration, entitlements, and the perceived attractiveness of their occupation.

In 2012, the Fair Work Commission made an Equal Remuneration Order that raised minimum weekly rates for many employees in the social, community, home care, and disability services industry (Fair Work Ombudsman, n.d.).

Figure 14

Women are underrepresented in high-pay jobs

Proportion of men and women, by income bracket, NSW, 2020.



Source: NSW Productivity Commission / NSW Innovation and Productivity Council modelling (powered by Faethm AI)

In 2021, the Royal Commission into Aged Care Quality and Safety's Final Report contained 148 recommendations to reform the aged-care sector, including improving wages in the sector. To improve recruitment and retention of the aged-care workforce, the NSW Government could work with the Commonwealth Government to implement some of these recommendations.

On 4 November 2022, the Fair Work Commission made an interim decision to increase minimum wages by at least 15 per cent for aged care workers in direct care roles on a number of different awards (The Hon. Mark Butler MP 2022).

5.6 Ensure appropriate protections exist for workers

As discussed in **Chapter 2.5**, the emergence of digital labour platforms has resulted in a rise in gig work. Workers appreciate several aspects of the gig economy. It can offer opportunities to earn extra income, access to new markets and kinds of work, and greater flexibility in how and when work is done. Consumers and businesses alike enjoy the convenience of being able to access a wide variety of services, often at competitive prices. Gig platforms often enable customers to easily rate and share user experiences.

Yet gig work also presents new policy challenges, especially in the areas of industrial relations and worker health and safety. For example, workers using digital labour platforms typically have no rights to traditional collective bargaining and national employment standards as they are often determined to be contractors and not employees. They do not receive paid leave and superannuation, and are afforded limited protections against underpayment or unfair dismissal (International Labour Organization 2021b).

As Unions NSW said in 2016:

> ‘[T]echnology has unlocked new, innovative and efficient ways of working and doing business. However, in embracing this, governments, workers, unions and business must be able to work together to ensure legislative frameworks adapt to promote equity and balance.’
>
> **— Unions NSW (2016)**

Without appropriate regulation, there is a real risk that, particularly for vulnerable workers, the gig economy could erode conditions that workers in NSW currently enjoy. This also risks undermining community support for the gig economy and the technologies that support it, as well as limiting its potential contribution to the NSW economy. Because of this, it is essential that policymakers safeguard minimum standards of remuneration and workplace health and safety in the gig economy.

Application of current Australian law to the status of gig workers has so far been inconclusive. In the majority of cases heard by the Fair Work Commission, the gig workers concerned have been found to not be employees, with a single exception.[9] Consequently, according to current case law, gig workers are not entitled to, for example, the national minimum wage or protection from unfair dismissal.

As cases of this kind are largely matters of fact rather than law, this situation is unlikely to change, absent changes to relevant legislation. Recent High Court decisions regarding worker status suggest that case law is unlikely to move beyond its present situation, reinforcing this point.

A recent agreement between the Transport Workers Union and Uber seeks to support the establishment of arrangements providing minimum entitlements and protections. The new Commonwealth Government has indicated it will explore mechanisms to provide entitlements for gig or on-demand workers and seek to recognise them as employees rather than independent contractors.

In April 2022, the Select Committee on the impact of technological and other change on the future of work and workers in NSW proposed recommendations (see **Box 24**) to cover gig workers.

In regulating the gig economy and related technologies, governments must strike a careful balance between ensuring adequate worker protections and allowing workers, entrepreneurs, and consumers to benefit from the growth of the sector. Any potential regulatory interventions should be subject to cost-benefit analysis and only be adopted where the benefits outweigh the costs (see **Chapter 3.2.3** on smart regulation and supporting technological uptake).

9 See Joshua Klooger v Foodora Australia Pty Ltd [2018] FWC 6836

Box 24

Concerns about protections for NSW gig workers

In March 2020, the NSW Legislative Council established a Select Committee to inquire into and report on the impact of technological and other change on the future of work and workers in NSW.

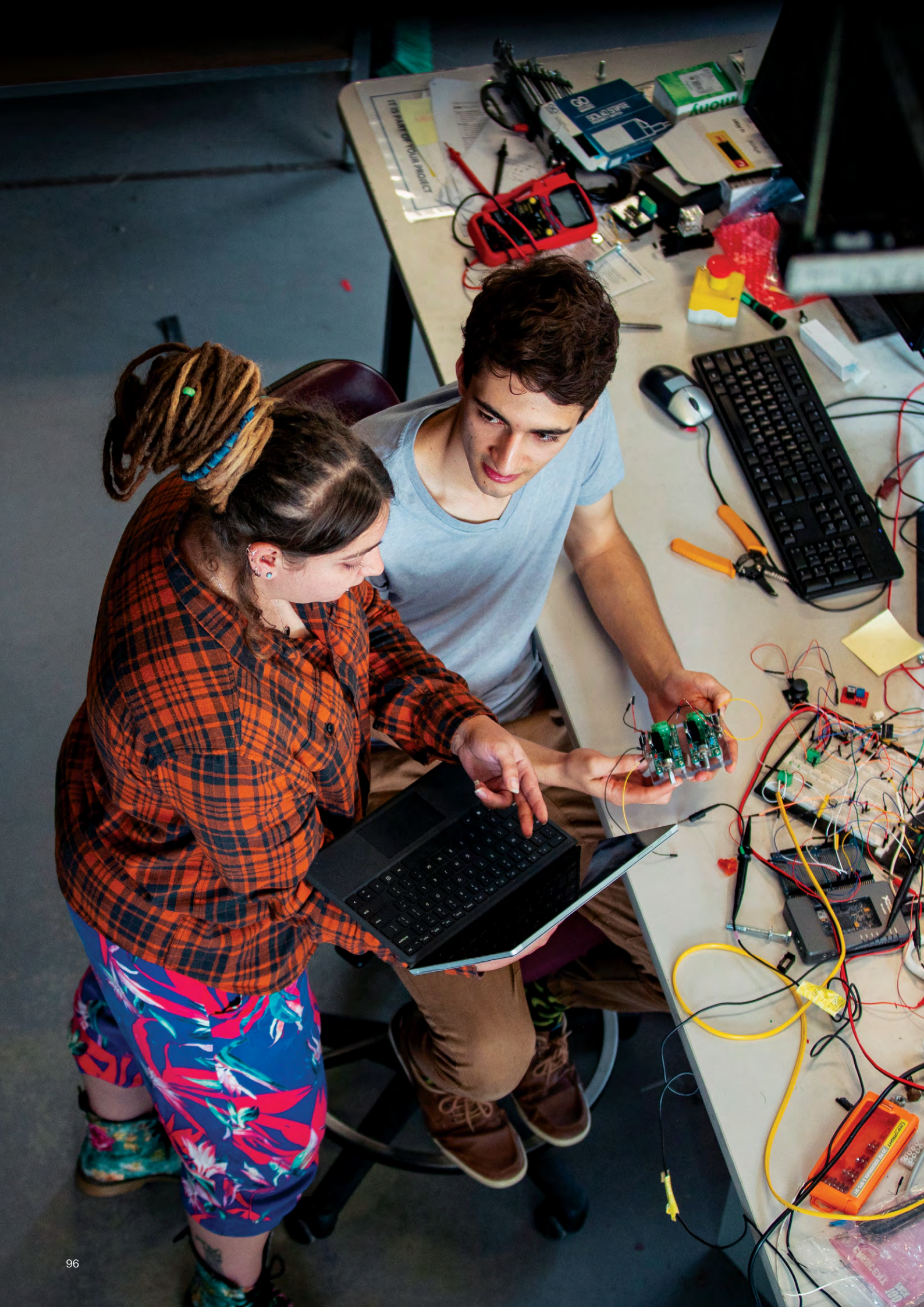
The Committee released its first report in April 2022, based on eight hearings and 53 submissions. The report concluded that NSW is:

- lagging behind other states and countries in legislating gig economy working conditions
- increasing inequality by failing to give gig workers basic workplace entitlements like a minimum wage and paid leave
- not giving gig workers sufficient power to interact and negotiate with on-demand platforms
- causing injustice by not giving gig workers access to a low-cost independent dispute resolution tribunal.

The Committee made 22 recommendations to secure greater protections for gig economy workers. These include access to basic entitlements, dispute resolution and transparency, collective bargaining, state taxation, work health and safety, and workers' compensation. The Committee also called on the NSW Government to take more of a leadership role in setting the gig economy's future agenda.

On 4 October 2022, the NSW Government responded to the Committee's first report. The response affirmed that all workers should benefit from minimum standards of remuneration and workplace safety protections, but emphasised that any regulation of gig workers should be enacted, administered, and enforced by the Commonwealth. This aligns with the aim of a uniform national system of industrial relations for the private sector.

Source: NSW Legislative Council (2022)


IT'S PART OF YOUR PROJECT

6

Appendices

Further information on this project, our stakeholder consultations, modelling, and research sources.

6.1 Background to this project

The NSW Government's last major project on the future of work was undertaken in 2016 by Jobs for NSW in partnership with McKinsey and Company. Its findings were reflected in the 2016 position paper *Jobs for the Future*. That paper focused on stimulating what, at the time, were projected as growth sectors: food exports to Asia, tourism, start-ups and digital, innovation, and international education.

Research on the future of work dates quickly, however, as more powerful modelling tools become available, and developments like the COVID-19 pandemic, the green energy transition, and the rise of flexible and remote working alter old projections.

As the NSW Government requires up-to-date, evidence-based advice on the future of work to inform policymaking and public sector planning, the NSW Innovation and Productivity Council launched the Adaptive Workforce Project in June 2020.

The purpose of the Project was to identify:

1. key long-term trends and forces that will shape the future of work in NSW
2. the nature and scale of resultant challenges and opportunities for the NSW workforce
3. long-term policy directions for the NSW Government to meet the challenges and grasp the opportunities of the future of work.

As part of the Project, the NSW Innovation and Productivity Council supported the delivery of the *IGR* by contributing to its *Future shape of the NSW economy* chapter. The NSW Innovation and Productivity Council undertook baseline modelling on future industries and skills aligned to the *IGR's* productivity and economic growth assumptions and methodology. This modelling became a major output of the Adaptive Workforce Project and was published in the *IGR*.

When it became part of Investment NSW in July 2021, the NSW Innovation and Productivity Council partnered with the NSW Productivity Commission to deliver this report, concluding the Adaptive Workforce Project.

As part of the Project PwC Australia was engaged to draw targeted quantitative and qualitative insights from the literature on the future of work and to conduct a stakeholder workshop, which have both informed the report.

6.2 Stakeholder consultations

In June 2021, PwC Australia, on behalf of the NSW Innovation and Productivity Council, held a workshop with 38 participants from the NSW and Commonwealth Governments, academia, industry, and unions, as well as PwC's own subject-matter experts.

The workshop presented the interim report findings and sought stakeholder feedback and ideas. Many of these ideas informed the present report. The NSW Innovation and Productivity Council thanks participants in the workshop for their contribution.

6.3 Modelling of emerging technology diffusion

The NSW Productivity Commission and NSW Innovation and Productivity Council have modelled emerging technology diffusion scenarios using Faethm AI's Economic Scenario Model (FESM) and the NSW Treasury Intergenerational Report Model (TIGR).

All modelling results in this report reflect the NSW Productivity Commission and NSW Innovation and Productivity Council's **central emerging technology diffusion scenario**. The rates of technology adoption and productivity growth in the central scenario were determined as plausible based on Faethm's 'bottom-up' analysis of the potential productivity impacts of emerging technologies, combined with 'top-down' sense checking against recent historical events, namely the 1990's ICT boom. It is not possible to attach any probability to whether the central emerging technology diffusion scenario might occur. In practice, the rate of emerging technology diffusion and its productivity impacts are influenced by various technical, social, political, and economic factors.

The FESM combines scenario assumptions regarding future industry revenue growth and the impact of emerging technologies on jobs to derive projected future demand for jobs, skills, and tasks by industry, and thus economic growth. Faethm AI uses the O*NET taxonomy and their own proprietary research and analytics to decompose jobs (occupations) into tasks, and identify which tasks have the potential to be augmented or automated by a suite of emerging technologies (see **Table 6**). The proportion of tasks affected at any time is determined by technology adoption rates modelled by Fathem AI. The Faethm AI model allows the modelling of different technology adoption rate scenarios. All scenarios, however are assumed to follow an 'S-curve', where the speed of diffusion is relatively slow initially, accelerates to a maximum rate, and then tapers off as saturation is approached.

The TIGR projects NSW's long-term outlook if existing policy setting and trends were to persist. Population, labour force participation, GSP, productivity, inflation, government revenue and expenses, and climate impacts were modelled for the *IGR*. The parameters of the base scenario of the FESM (no increase in technology adoption) were based on the TIGR's long-term population growth, GSP, and productivity projections.

The productivity shock from the Economic Scenario Model was input into the TIGR to derive potential impacts of diffusion of emerging technologies on GSP per capita, GSP per household, and impacts on projected NSW Government revenues. The shock was presumed to be an increase in productivity growth between 2022 and 2035.

Table 6

Modelling of emerging technology diffusion

Technology	Description	Examples	Industries most impacted
Broad AI			
Sensory perception	Programs that detect and interpret external stimuli.	• Safety monitoring • Security monitoring systems • Machine vision and motion tracking	Education and training; public administration and safety; rental, hiring, and real estate services
Decision generation	Programs that interpret input data and determine the best course of action.	• Automated medical diagnosis • Finance funds and portfolios	Professional, scientific, and technical services; financial and insurance services; transport, postal, and warehousing
Conversation exchange	Systems that can interpret speech and engage in conversation.	• Home assistants • Chatbots	Financial and insurance services
Dextrous robotics	Robots capable of adapting dynamically to less structured tasks.	• Aged-care robots • Robotic waiters/chefs • Advanced manufacturing robots	Other services
Narrow AI			
Predictive analysis	Tools that conduct analysis and make related predictions.	• Business intelligence tools • Database manipulation • Data visualisation	Professional, scientific, and technical services; financial and insurance services
Recognition vision	Tools that can recognise and interpret images.	• Computer vision API • Facial recognition • Medical image recognition	Rental, hiring, and real estate services; education and training
Suggestion provision	Tools that prioritise data to identify relevant recommendations.	• Video recommendations • Search engines • Targeted advertising	Education and training; information media and telecommunications

Table 6: Modelling of emerging technology diffusion (continued)

Technology	Description	Examples	Industries most impacted
Reinforced AI			
Navigation robotics	Robots able to navigate autonomously in unstructured environments.	• Self-driving cars • Autonomous drones	Agriculture, forestry, and fishing; transport, postal, and warehousing; electricity, gas, water, and waste services; mining
Collaborative robotics	Robots that can work safely in a shared space with humans and generate shared meaning.	• Production cobots • Collaborative robots	Rental, hiring, and real estate services; financial and insurance services; accommodation and food services
Solution discovery	Agents that digest large amounts of data and solve unstructured complex problems.	• Research software • Drug discovery • Prediction and simulation software	Professional, scientific, and technical services; information media and telecommunications; education and training; rental, hiring, and real estate services
Generative design	Agents that interpret creative data and generate concepts.	• Journalism writing software • Story writing software • Music, video, and film recreation • Artwork creation	Rental, hiring, and real estate services; education and training; information media and telecommunications; financial and insurance services; arts and recreation services
Creative origination	Agents that invent new and original concepts beyond known data.	• Design simulation software • Product design programs	Rental, hiring, and real estate services; financial and insurance services; arts and recreation services
Assistive robotics	Robots able to physically interact with humans in an emotive manner.	• Movement therapy robot • Aged-care robots • Robot prosthetics	Healthcare and social assistance; agriculture, forestry, and fishing
Programmed Intelligence			
Process automation	Programs to complete pre-defined, logical, and rules-based processing tasks.	• Robotic process automation • Agile process automation	Financial and insurance services; transport, postal, and warehousing; retail trade; wholesale trade; professional, scientific, and technical services
Fixed robotics	Robots that handle and manipulate objects in a pre-defined way.	• Assembly robots • Construction robots • Home and service robots	Mining; manufacturing; construction
Mobile robotics	Mobile machines programmed to move between points in a controlled environment.	• Mobile materials handling • Basic point-to-point transport systems • Autonomous inventory robots	Administrative and support services; accommodation and food services

Source: Faethm AI

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NSW Productivity Commission

Phone +61 2 9228 4567
Email ProductivityFeedback@treasury.nsw.gov.au
Website www.productivity.nsw.gov.au

NSW Innovation and Productivity Council

Phone +61 2 4908 4800
Email ipc.secretariat@investment.nsw.gov.au
Website www.investment.nsw.gov.au/ipc

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