THE AUTOMATION ADVANTAGE

How Australia can seize a $2 trillion opportunity from automation and create millions of safer, more meaningful and more valuable jobs.

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All monetary figures reported are in 2015 real Australian dollar terms, unless otherwise indicated.

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Automation is changing the way we work

Machines will unburden the average Australian of **2 HOURS** of the most tedious and manual work a week over the next 15 years

Automation could deliver a

$2.2 TRILLION

boost to Australia's national income between 2015 and 2030 from productivity gains

$1 TRILLION

from accelerating the rate of automation

$1.2 TRILLION

from transitioning the workforce

As automation reduces routine and manual work, our jobs will become…

SAFER

Workplace injuries will fall by 11% as dangerous manual tasks are automated

MORE SATISFYING

62% of low-skilled workers will experience improved satisfaction

MORE VALUABLE

Wages for non-automatable work are 20% higher than for automatable work

Australia currently lags global leaders in Automation

50%

fewer Australian firms are engaged in automation compared to leading countries

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EXECUTIVE SUMMARY

Technological change has long been a source of anxiety for workers. Today, improvements in communication technology, robotics, and machine intelligence are rekindling age-old concerns that technology will soon force millions of people out of work. This report provides a fresh perspective. Automation is, at its core, an opportunity to harness the power of machines to improve human lives.

> ***"Over the long term, automation technologies will be the primary engine of prosperity, lifting wages, living standards and work conditions. But in the short term, these same technologies present risks that must be managed."***

If we get it right, automation could significantly boost Australia's productivity and national income—potentially adding up to 2.2 trillion Australian dollars in value to our economy by 2030.

But this opportunity will not land in Australia's lap. To unlock the benefits of automation we must be bold enough to lead changes. This means embracing technology's potential to make our workplaces more productive, while taking steps to prevent Australia's most vulnerable workers from sliding into unemployment. This report outlines how Australia can turn the trend of automation into a national economic success story.

To understand the impact of automation on Australia's economy this report analyses how automation changes the working life of every Australian. The use of machines is changing what jobs we do. Strenuous physical jobs are disappearing on factory floors, and routine administrative jobs can increasingly be done without human workers. On the flipside, more jobs are being created in community, personal and business services, and other specialised professions that rely on uniquely human skills such as thinking creatively and being able to understand other people's emotions.

However, more than changing what jobs we do, automation is changing the way we do our jobs. This report gives a comprehensive picture of the impact of automation on Australian workers by digging below the job level and analysing how technology is affecting the time that we spend on different work tasks within our jobs. In detail: every one of the 20 billion hours that Australians worked last year was assigned to one of more than 2,000 work tasks, creating a complete picture of how much time Australians have spent on each work task over a 15-year period.

The results provide remarkable insights and allow us to understand likely future work patterns. Technology is already changing the nature of human job tasks. For example, retail workers are spending less time ringing up items at the register and more time helping customers; bank employees are spending less time counting banknotes and more time giving financial advice; teachers are spending less time recording test scores and more time assisting students; factory workers are spending less time on the assembly line and more time optimising production and training other workers.

Over the past 15 years alone, Australians have reduced the amount of time spent on physical and routine tasks by 2 hours each week. Most of that change isn't coming from the loss of physical and routine jobs. Rather, it comes from workers switching to different tasks within the same jobs, as machines take over an increasing load of the repetitive routine work.

Automation isn't a force we can stop. But Australia's economy has a lot to gain if we manage to avert the employment risks that come with growing machine use. **To unlock the full amount of gains, two conditions need to be fulfilled:**

First, **Australia requires a strong policy framework to ensure workers at risk of being displaced are redeployed**. There is no reason why this should not be the case. History shows that past waves of technological disruption have ultimately led to increased prosperity, productivity and employment. Over centuries, machines have progressively replaced labour in agriculture, manufacturing, administration and professional services. Yet, humans always find work to do—partly because technology creates new opportunities for workers and partly because humans are infinitely capable of redefining what we mean by work. Today, there is a myriad of occupations that no one ever heard of a few decades ago: think of social media manager, software engineer, ride share driver, well-being coach, website builder or Zumba instructor. In response to the claim that 'robots will take all our jobs', economist Milton Friedman noted that "human wants and needs are infinite, and so there will always be new industries, there will always be new professions." Centuries of economic progress confirm this view.

This is not to say automation cannot cause unemployment, especially for older and vulnerable workers who lose their jobs and are unable to find a new one quickly. If automation in Australia proceeds at its historical pace, it will deliver a significant economic dividend of around $1.2 trillion over the next 15 years, but this gain is entirely predicated on our ability to redeploy the workers that are displaced by machines into new forms of work.

> *As machines take over our most dangerous, most tedious and least valuable tasks, human work will become more human.*

Second, **Australia must encourage more firms to intensify their automation efforts**. Currently, Australian companies are behind leading global peers in embracing automation. Only 9 per cent of Australia's listed companies are making sustained investments in automation, compared with more than 20 per cent in the United States and nearly 14 per cent in leading automation nations globally. This low rate of investment in automation technology acts as a handbrake on our productivity growth that will ultimately reduce our national income. If Australia accelerated its automation uptake, it would stand to gain up to another $1 trillion over the next 15 years.

Both scenarios together—successfully moving all workers affected by automation into new employment ($1.2 trillion) and accelerating the rate of automation ($1 trillion)—represent a $2.2 trillion opportunity for Australia by 2030.

This economic dividend, however large, is only part of the benefit that automation can bring to Australia. Perhaps most importantly, automation has the potential to improve the work lives of every single Australian in a very tangible way. This report shows that the tasks lost to automation are typically the most dangerous, least enjoyable and the least likely to be associated with high pay. As automation shifts these dangerous, tedious and less valuable tasks from people to machines, work injuries are set to fall and work satisfaction levels bound to rise as workers can focus on more creative and interpersonal activities. Automation will make work safer, more meaningful and more valuable. In other words: machines will make human work more "human".

What is automation?

In this report we define automation as the process of using machines to perform tasks that would otherwise be done by humans. These can be physical, such as a combine harvester collecting grain so that the work does not have to be done by hand, or analytical, such as a 'spell checker' proofreading and finding errors in a document instead of a person. Automation covers broad range of technologies including advances in Artificial Intelligence (AI), robotics, and the Internet of Things (IoT).

1

AUTOMATION IS CHANGING THE WAY AUSTRALIANS WORK

Automation is causing Australian workers to rely more on their brains and personalities than on physical labour. By 2030, machines will likely take over 2 hours of our most repetitive manual job tasks per week.

This report looks at the impact of automation on Australian work. It goes beyond a mere analysis of how automation is changing *what* jobs we do. Rather, it investigates the way automation is changing *how* we do those jobs. It analyses how the use of machines shifts the amount of time spent on different work tasks. For example, anyone who has walked into a bank branch in the last 20 years can see that automation has had a transformative effect. For one thing, there are far fewer tellers standing behind the counter. Automation, through the rise of automatic teller machines (ATMs) and more recently through the growth of online and mobile banking, has reduced the need for staff to dispense cash and process routine transactions.

But the replacement of administrative staff with automated processes doesn't tell the full picture of how the working lives of bank employees have changed. Banks still have tens of thousands of workers in branches across the country, but instead of calling them "tellers", these people are now often called "service consultants". They spend far less time, if any, counting notes and far more time engaging with customers, such as providing complex advice on financial planning or home loans.

To understand the full impact of automation on the way Australians work, we have to dig beneath the occupational level of Australia's 12 million workers to understand not just what jobs they do, but how they spend their time at work. This report analyses how Australians spend a total of 20 billion work hours each year, assigning each of those hours to one of more than 2,000 different work tasks and then bundling these into six "task groups" (see Box 1 for methodology):

- Interpersonal tasks: These tasks primarily involve directly engaging with other people. A shop assistant selling products to customers would be a typical interpersonal task, as well as a manager training staff or a teacher helping students solve a complex maths question.
- Creative & decision-making tasks: These tasks involve a large amount of creativity and out-of-the-box thinking. Typical examples include a painter creating an artwork, a software developer writing a new computer program, and a manager considering a firm's future strategic direction.
- Information synthesis: These tasks require workers to interpret information or extract meaning from simple data points. An analyst making sense of an industry trend and writing a commentary to provide context around this trend would be a typical example.
- Information analysis: These tasks involve gathering and processing of information. Typical examples include a meteorologist measuring rainfall, or a cashier calculating daily sales values.
- Predictable physical tasks: These tasks include repetitive and routine physical work, such as assembly line workers packaging equipment, or agricultural workers picking fruit.
- Unpredictable physical tasks: These tasks consist of a wider array of physical work that is not happening on a routine basis. A car mechanic repairing different types of defects undertakes a physical, yet unpredictable task. The same applies to a doctor performing various types of surgery.

Activities in the first three tasks groups—interpersonal, creative & decision-making, and information synthesis—are generally the least likely to be rapidly replaced by machines. However, activities in the last three tasks groups—information analysis, predictable physical and unpredictable physical—are expected to experience workplace change driven by automation in the near future.

BOX 1

Methodology: Understanding the tasks undertaken in every Australian job

This report analyses how people from all walks of life—teachers and tradesmen, computer programmers and priests—have been spending their time at work since the year 2000. The observed historical trends are then used to draw conclusions on likely work patterns until 2030.

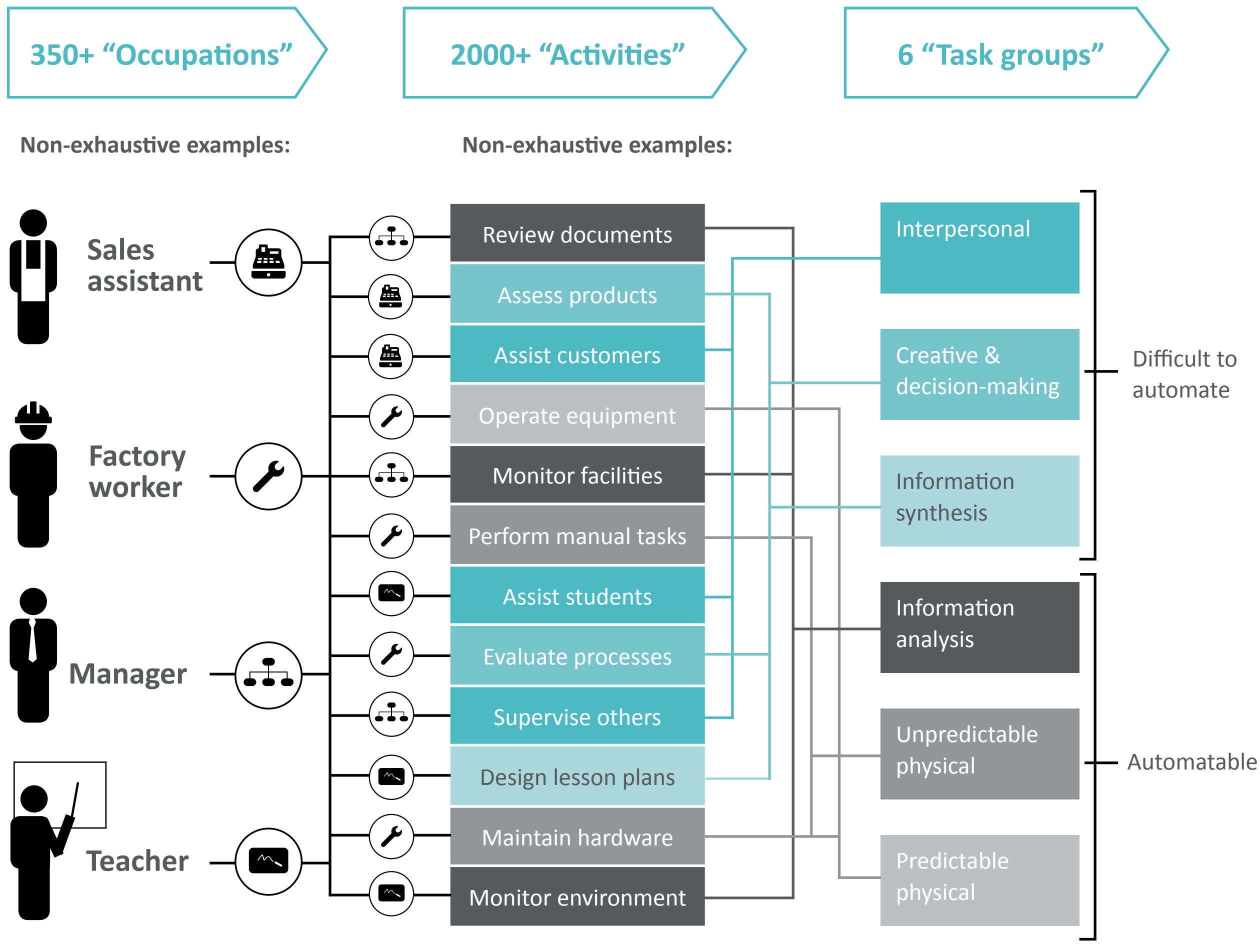
We use a detailed occupational database (O*NET) which breaks down every job into more than 2,000 activities.[1] The database reports the frequency with which each activity is performed in an occupation. Activities and frequencies were fitted to match the total weekly work hours for each occupation to evaluate the amount of time spent on each activity (see Appendix A).

This approach has two significant benefits over approaches which use judgement or survey data to analyse the time spent on tasks. The first advantage is that this approach removes human error from the equation; human judgement is often subject to biases and crowding effects as can be seen from notable failed "predictions" from the past.

The second advantage is that the approach is repeatable over time: whilst surveys can't be conducted in the past, the approach used in this report can be taken to historical data. This methodology can thus be used to discover and interpret historical trends that surveys cannot measure.

EXHIBIT 1

The impact of automation is best understood by breaking the economy down into "tasks"



SOURCE: O*NET, AlphaBeta analysis

1. The US government's occupational data base O*NET contains detailed information on more than 2,000 work-related activities in almost 1,000 US occupations.

1.1 OVER THE NEXT 15 YEARS, THE AVERAGE AUSTRALIAN WORKER WILL SPEND 2 HOURS PER WEEK LESS ON MANUAL AND ROUTINE TASKS

By analysing all the hours Australians workers allocate across more than 2,000 tasks, we get a remarkable picture of how the real working lives of Australians have been changing over the last 15 years.

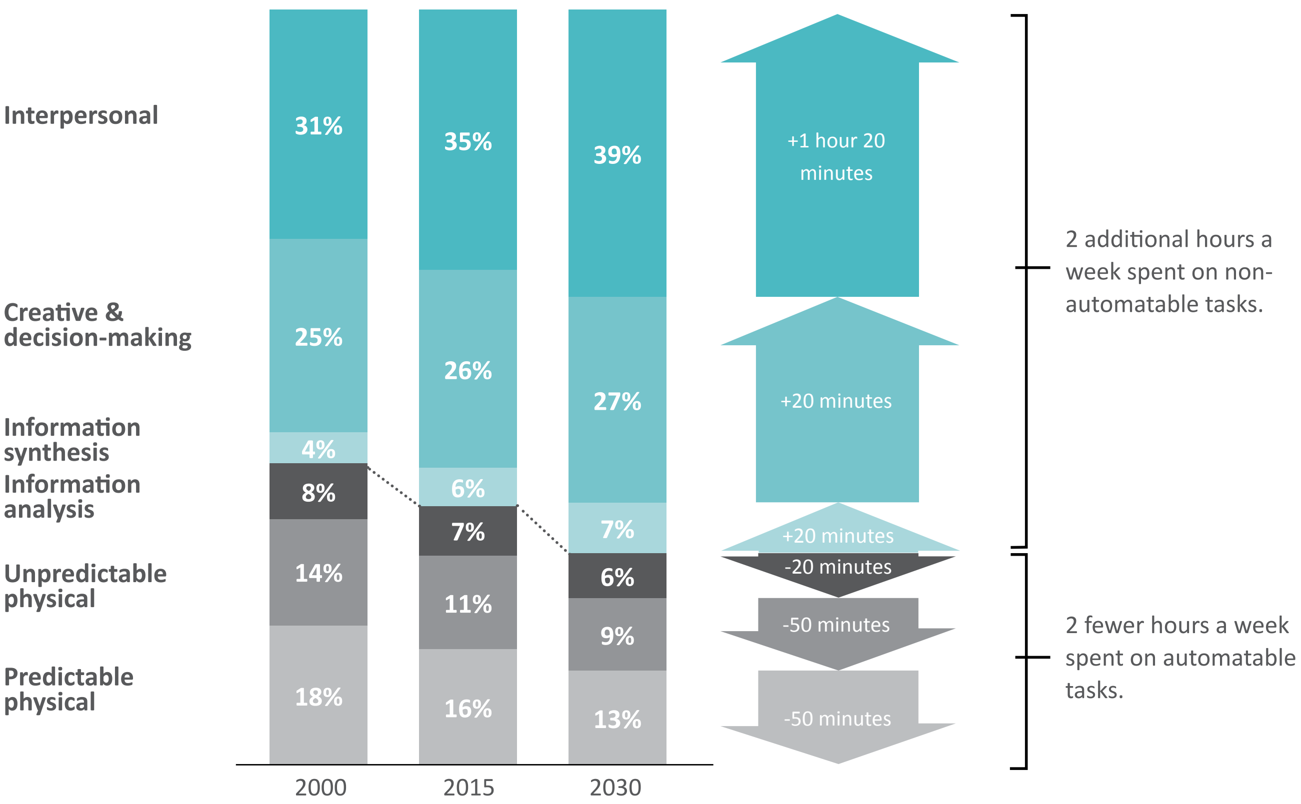
The results of the analysis, summarised in Exhibit 2, paint the picture of a workforce that is changing rapidly. Automation is causing Australian workers to rely on their brains and personalities more than physical labour. Workers have been able to spend less time on routine and manual tasks and more time on complex activities that require a high degree of creative thinking, decision-making, problem-solving, interpretation of information, and personal interaction.

EXHIBIT 2

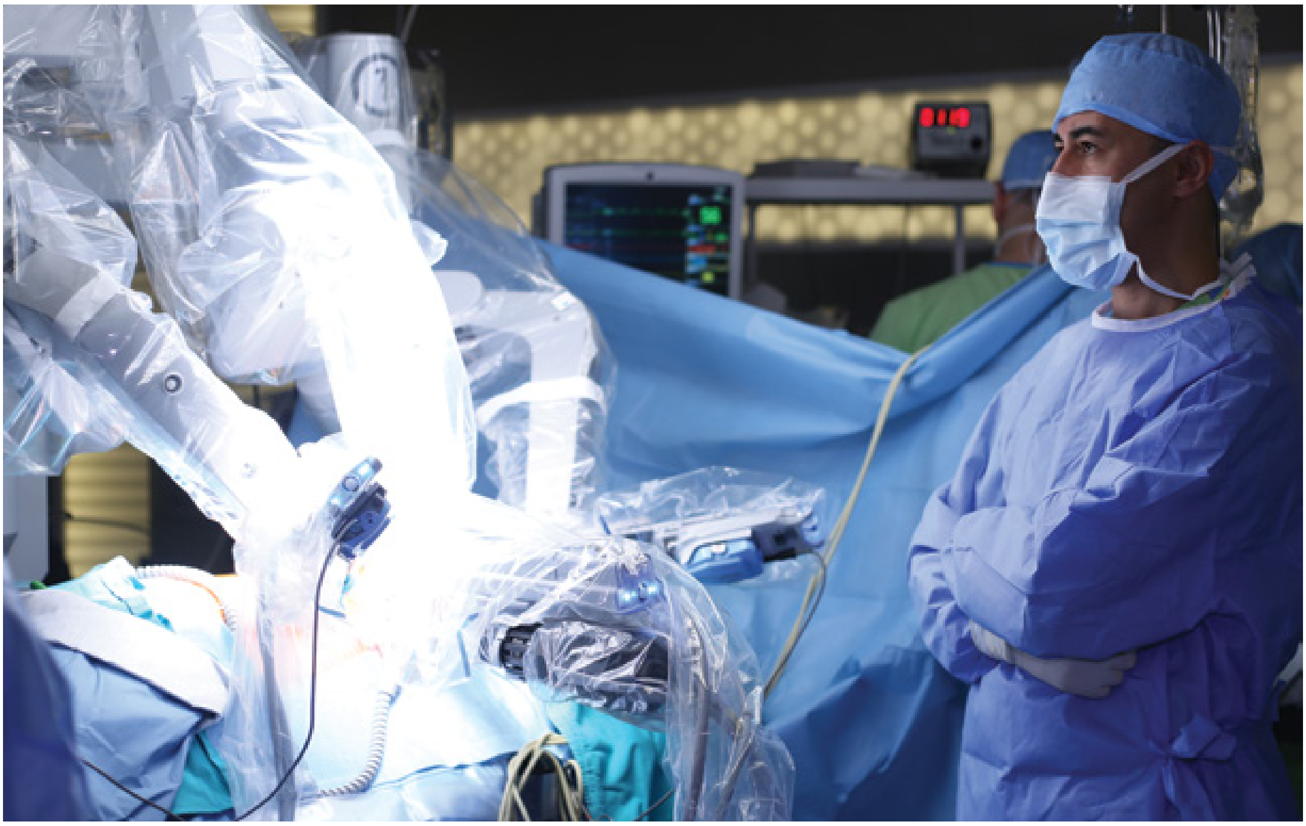
Automation is changing the way we work, reducing the amount of time a worker will spend on routine tasks by up to 2 hours a week

Change in types of tasks performed by Australian workers
Average share of time spent on work activity

2015-2030 change in average work week



SOURCE: O*NET, AlphaBeta analysis



In 2000, automatable activities—a baker cleaning his trays, a warehouse worker driving a forklift, a doctor sifting through piles of scanned images to detect a tumour—used to take up 14 hours (40 per cent) of a typical 35-hour week. Since then, the share of automatable tasks has declined to 11.9 hours (34 per cent) per week in 2015.

On the flipside, Australian workers have begun to fill their days with a growing number of tasks that require interpersonal skills. For example, they are spending more time talking to patients, negotiating with clients or conferencing with colleagues. The relevance of these social interactions at work has risen steadily from consuming 10.9 hours (31 per cent) of a typical 35-hour week in 2000 to 12.2 hours (35 per cent) per week in 2015.

Exhibit 2 also shows a forecast for what new work Australians will carry out over the next 15 years. This forecast is based purely on the historical trend (note that in a later section, we discuss the implication of this trend accelerating). In this scenario, it is estimated that the average Australian will use another 1 hour and 20 minutes of work time for job-related activities involving interpersonal skills by 2030, leading their total share to rise to 13.7 hours (39 per cent) per week. Tasks requiring creative and complex cognitive thinking will also become more important. In all, Australians will spend on average 2 hours per week more on interpersonal, creative and synthesis tasks; and less time on routine and manual tasks.

1.2 AUTOMATION WILL CHANGE THE JOBS WE DO, BUT IT WILL MOSTLY CHANGE THE WAY WE DO OUR JOBS

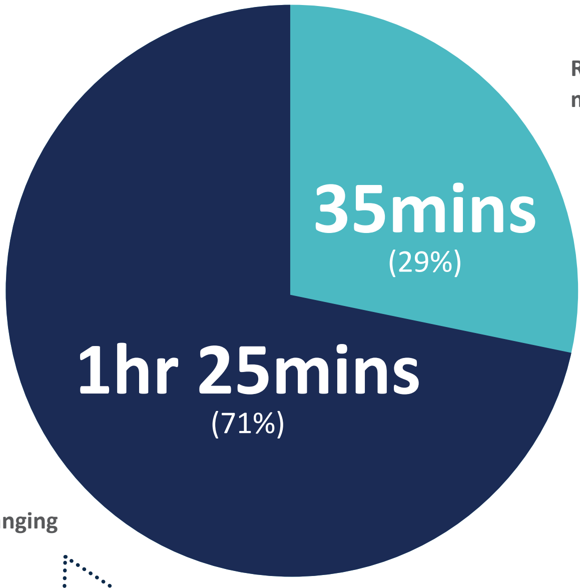
Most of the media commentary on automation focuses on the impact at a jobs level—on jobs destroyed or created. This is only a part of the picture. Exhibit 2 shows that machines are expected to take over an additional 2 hours of routine and manual work in an average Australian work week by 2030. But most of this change won't come from people changing jobs as manual and routine work disappears. In fact, 71 per cent or 1 hour and 25 minutes, of the total expected reduction in work time will come from people doing the same job, but completing fewer manual and routine tasks on the job (Exhibit 3).

Only 29 per cent of the automation driven workplace change will involve workers changing jobs. Whilst these workers are at risk of unemployment, it is important to understand that this does not imply all workers at risk will lose their jobs. Further, automation is likely to create new jobs for displaced workers. For example, technological change often drives workplace innovation: the rise of facebook, twitter, instagram and other social networks led to the creation of 'social media managers'.

EXHIBIT 3

Over two-thirds of the shift away from automatable tasks will be driven by people changing the way they work, not changing jobs

Impact of automation on Australian work
Expected fall in average weekly work time spent on automatable tasks from 2015-2030



Reduction due to moving jobs

Less than one-third of the 2-hour fall in automatable work per person will be due to workers moving between jobs.

Reduction due to changing tasks within jobs

More than two-thirds of the 2-hour fall in automatable work per person will be due to workers remaining in their jobs, but changing tasks

SOURCE: O*NET, ABS, AlphaBeta analysis

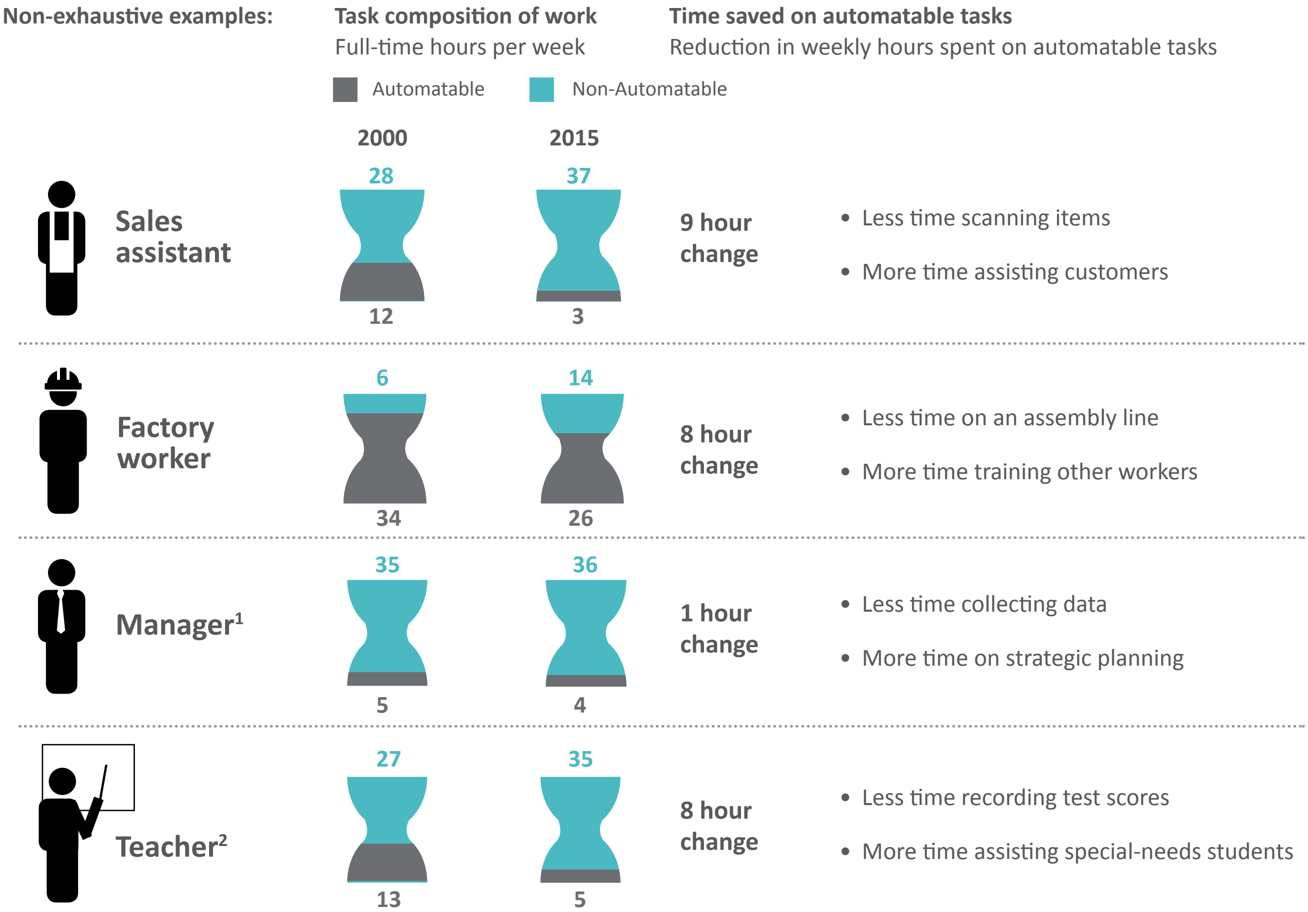
A detailed analysis of how Australian workers have been spending their time in recent years, as seen in Exhibit 4, reveals a substantial shift away from monotonous tasks. Between 2000 and 2015, the average Australian full-time salesperson has spent 9 hours per week less on scanning barcodes and other automatable tasks and instead used that time to assist customers. Similarly, new online education programs and interactive learning software are freeing up teachers to spend more time interacting with their students. Since 2000, an average Australian full-time teacher has been able to delegate 8 hours of dull weekly routine work—such as recording test scores—to computers. Occupational data show that teachers have used the newly gained spare time for tasks requiring creativity, interpersonal skills and strategic problem-solving abilities, such as helping special-needs students.

The roles of employees in the manufacturing sector, by far the biggest user of automation technology according to the International Federation of Robotics, are rapidly changing.[2] As industrial robots and other process-automation technologies are increasingly shouldering the physical part of factory work, labourers doing routine manual work, such as packers or assembly-line workers, have spent eight hours more per full-time work week on training and other non-automatable tasks between 2000 and 2015.

Even managers, which are commonly thought of as being immune to the impact of automation, have gained one hour of work time per week since 2000 to spend on non-routine activities thanks to technology. New management automation software helps them collect huge amounts of complex data and speed up office workflows, allowing them to focus more on creative and interpersonal tasks, such as strategic planning and keeping customers and staff happy.

EXHIBIT 4

Automation will free up time for workers to focus on higher-value tasks



Notes: Assumes a full-time worker works 40 hours per week, figures rounded to nearest hour
1 Unweighted average of ANSZSCO 1 digit code used to estimate manager timeshares (excluding farmers and CEOs)
2 Example based on high-school teacher
SOURCE: ABS, O*NET, AlphaBeta analysis

2 International Federation of Robotics (2016), *World Robotics Report 2016.*

2

AUTOMATION IS A $2.2 TRILLION OPPORTUNITY FOR AUSTRALIA —IF WE GET IT RIGHT

Australian firms adopt automation technologies at less than half the rate of Swiss and American firms. This is a missed opportunity. Accelerating the pace of automation could boost our productivity and economic growth, provided workers remain in employment.

The growing use of machines presents a substantial opportunity for the Australian economy. The previous section spelled out the nature of that opportunity in the simplest terms: at the current rate of automation, the average Australian worker will need 2 hours less each week to do their job by 2030 because machines will liberate them from a range of automatable tasks. Automation is quintessentially a positive productivity shock.

This section quantifies the opportunity for Australia to capitalise on this positive productivity shock and turn the growing trend to automation into a national economic success story (Exhibit 5).

First, there is an immense potential gain from having strong labour-market and education policies in place to ensure that work hours displaced by machines are reinvested in other work or new employment for the minority of displaced workers. To put this in numerical terms: if every Australian was able to spend the extra 2 hours of weekly work time that machines are expected to shoulder over the next 15 years on higher-value activities (rather than simply reduce their work time by 2 hours per week), it could boost Australia's economy by up to $1.2 trillion in value over that timeframe.[3]

EXHIBIT 5

Automation could deliver a $2.2 trillion dividend to Australia if workers are transitioned successfully and the uptake of automation is accelerated

Incremental gains from automation
Net present value of GDP increment, $ trillion

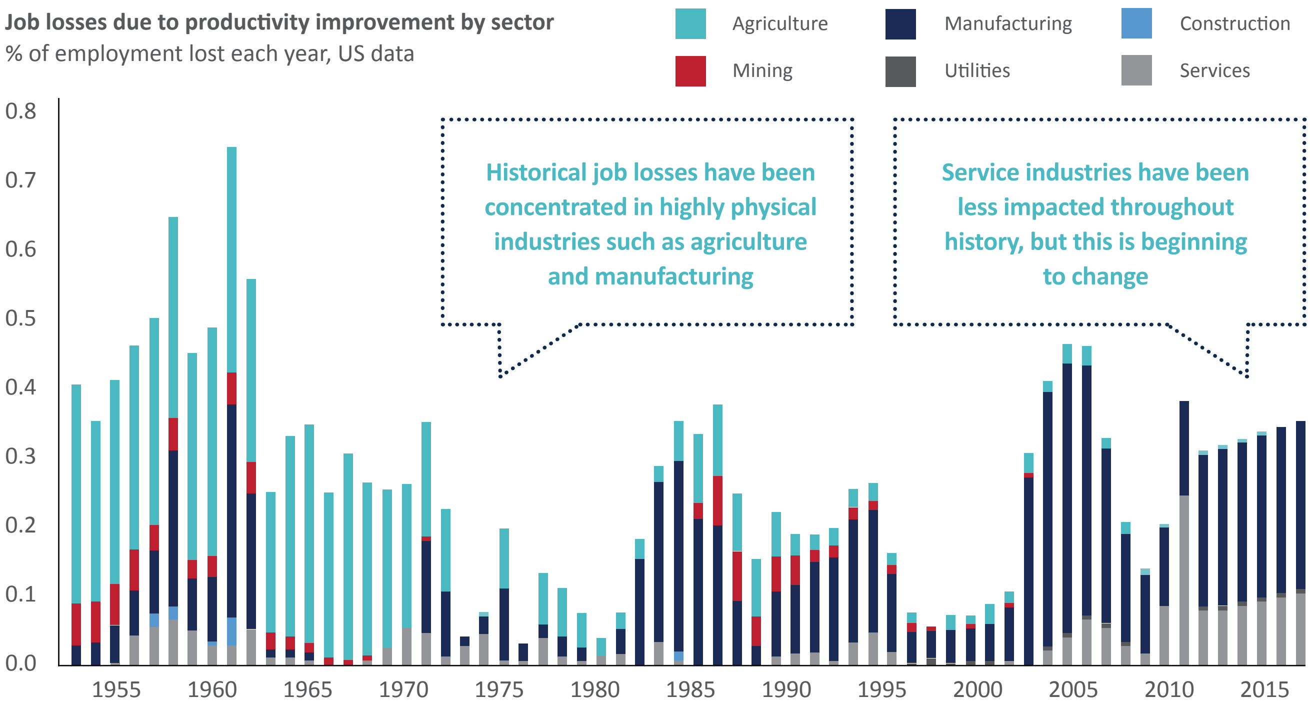
Gains from transitioning workers	Gains from accelerating automation	Total
Scenario: Difference in value between automation displacing workers vs workers transitioned to new activities	Difference in value between maintaining historical rate of automation, and catching up to US rate.	Sum of transition and acceleration

3. Measured in Net Present Value (NPV) terms.

EXHIBIT 6

The rate of automation today is no higher than previous peaks over the last 50 years, but the industries impacted have changed

Job losses due to productivity improvement by sector
% of employment lost each year, US data



Note: 2011 onwards based on the linear trend for each industry since 1990
SOURCE: Groningen Growth and development Centre. World-KLEMS database

Second, there is significant scope to increase the gains from automation if Australian firms deepened their investments in productivity-enhancing technologies. If historical trends continue, automation will improve Australia's labour productivity by 8 per cent over the next 15 years. This means automation would drive around one third of the total expected increase in labour productivity in Australia by 2030.[4] But Australian companies lag behind global peers in embracing automation. If Australian firms were to accelerate their automation investments to match leading countries such as the US, they could add around $1 trillion to Australia's economic output over the next 15 years.[5]

2.1 AUSTRALIA WOULD GAIN $1.2 TRILLION FROM TRANSITIONING WORKERS AFFECTED BY AUTOMATION

For Australia to make automation an economic success, we must ensure that the labour freed up by machines is redeployed, not left idle. For the most part, workers will be able to easily adjust their work routine and remain in their current jobs. However in some instances automation can lead to higher unemployment or reduced work hours. If overall employment is reduced, rather than output increased, then the potential economic gains of automation could evaporate.

4. Labour productivity measured as real GDP per hour worked was $84 in 2015 and is expected to rise to $103 by 2030, $7 of the change can be attributed to automation based on historical trends with the remaining change due to all other factors (see Appendix C).
5. Measured in NPV terms.

History suggests that there is no reason for automation to spark widespread and persistent unemployment. Past waves of technological disruption have ultimately led to increased prosperity, productivity and employment. Over centuries, machines have progressively replaced labour in agriculture, manufacturing, administration and professional services without causing mass unemployment.

Exhibit 6 shows that automation is not a new phenomenon. In the 1950s, automation caused a large number of agriculture workers to lose their jobs. In the 1990s, automation primarily affected manufacturing workers. As modern machines are increasingly capable of undertaking routine cognitive labour, the impact of automation is widening. Advances in artificial intelligence—with machine learning techniques like deep neural networks allowing us to realise outcomes including image and speech recognition—mean computers are now able to drive cars, trade stocks, detect fraud, and recognise speech to answer basic questions.

Exhibit 6 shows that the services sector, traditionally shielded from automation-related job losses, is fast becoming a prime target for technology-driven productivity reforms.[6] Over the past decade, between 1 and 1.5 per cent of services jobs have disappeared due to technological change and other productivity improvements.

While the data illustrates productivity-related job losses in the US, a similar trend can be observed in Australia and other developed nations. In tourism, for example, the share of Australian holidaymakers who used official agents to receive travel advice in 2013 had fallen to 37 per cent—15 per cent less than in the year 2000. The culprit? The internet, which is emerging as the top source of information for travellers.[7] Increasingly, automation is transforming the way we choose to receive services.

Such a disruption, although painful for individual workers displaced by technology, does not necessarily cause widespread mass unemployment, as the history of the US agricultural sector illustrates. In the 1950s and 1960s, new farm equipment such as tractors and combine-harvesters started boosting the productivity of American farms and forced a substantial share of unskilled labourers out of work each year but the nationwide unemployment rate barely budged. The US jobless rate even retreated from a high of 6.8 per cent in 1958 to 3.5 per cent in 1969, indicating laid-off agriculture workers successfully found other jobs elsewhere in the economy.[8]

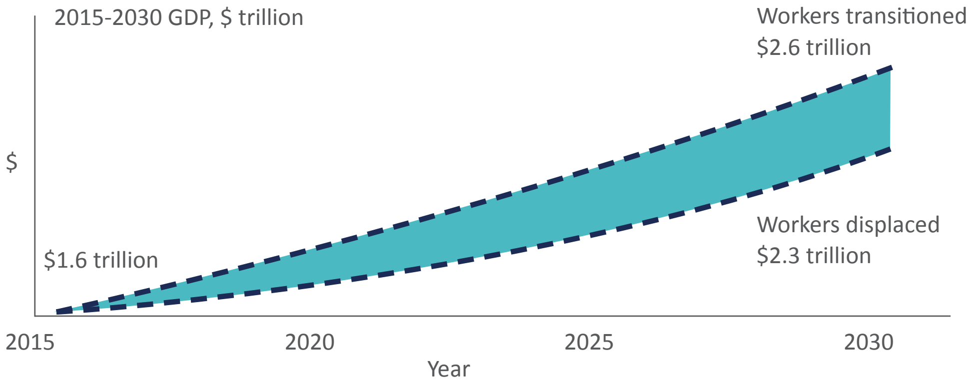
To be sure, there are widespread concerns that this time around the impact of technological change on employment will be much more profound, as advances in artificial intelligence are now enabling computers to take over a growing number of cognitive tasks, rather than simple physical activities.[9] However, whilst automation has indeed begun to impact many white-collar occupations (which were long shielded from the impact of computerisation) computers are still primarily replacing predictable work.[10] The cognitive tasks modern computers are performing—data entry, predictable calculations, or even statistical analysis using machine learning—are still reliant on well-defined rules and structured data.

6. Groningen growth and development centre, World KLEMS database data for US employment and productivity. While not all productivity gains are due to automation, productivity gains that result in job losses are more likely to be driven by machines replacing human labour than factors such as improved education.
7. Roy Morgan Research, (2013): Available from: http://www.roymorgan.com/findings/travel-agents-overseas-holidays-201302270608
8. US Department of Labor. Historical labour force statistics available at: https://data.bls.gov/timeseries/LNU04000000?years_option=all_years&periods_option=specific_periods&periods=Annual+Data
9. Jason Furman (2016), Is this time different? The opportunities and challenges of artificial intelligence. Available at: https://obamawhitehouse.archives.gov/sites/default/files/page/files/20160707_cea_ai_furman.pdf
10. Frank Levy and Richard Murnane (2013), Dancing with robots, human skills for computerised work. Available from: http://content.thirdway.org/publications/714/Dancing-With-Robots.pdf

EXHIBIT 7

Australia’s economic gain from full transition of affected workers is $1.2 trillion

2030 scenario	Workers displaced scenario	Workers transitioned scenario
Key assumptions	**None of the time savings are reinvested:** • Work hours are reduced involuntarily • Workers are displaced without being reabsorbed into other jobs	• All time savings are reinvested to generate more output • Hours worked per capita remains unchanged
Outcomes		



SOURCE: ABS, O*NET, AlphaBeta analysis

This means humans are still indispensable. The algorithm sifting through piles of big data cannot function without a human mind that specifies the rules it must follow, and data used to train deep neural networks must be labelled so the algorithm can learn. Computers are still far inferior to humans in handling unpredictable situations that require out-of-the-box thinking, empathy and understanding other humans.

While today’s automation technologies differ from those employed in the 1960s, historical developments remain as good a guide as possible over how automation will impact work. The experience of the 20th century indicates that it is unreasonable to assume that the current wave of technological progress will displace millions of workers. This is not to say that automation cannot cause any unemployment, especially for older and vulnerable workers who lose their jobs and lack the flexibility to find a new one quickly.

Depending on the economic climate, and the skills and mobility of individual workers, many might struggle to find new work in their region. In a negative scenario of future automation in Australia, the nationwide unemployment rate could rise, even as workers remain in short supply in pockets of the economy. A skills mismatch and lack of re-training opportunities would hinder laid-off workers from being hired in expanding industries with high labour demand. The result: stalling economic growth, as the productivity boost from automation would be offset by workers sliding into unemployment.

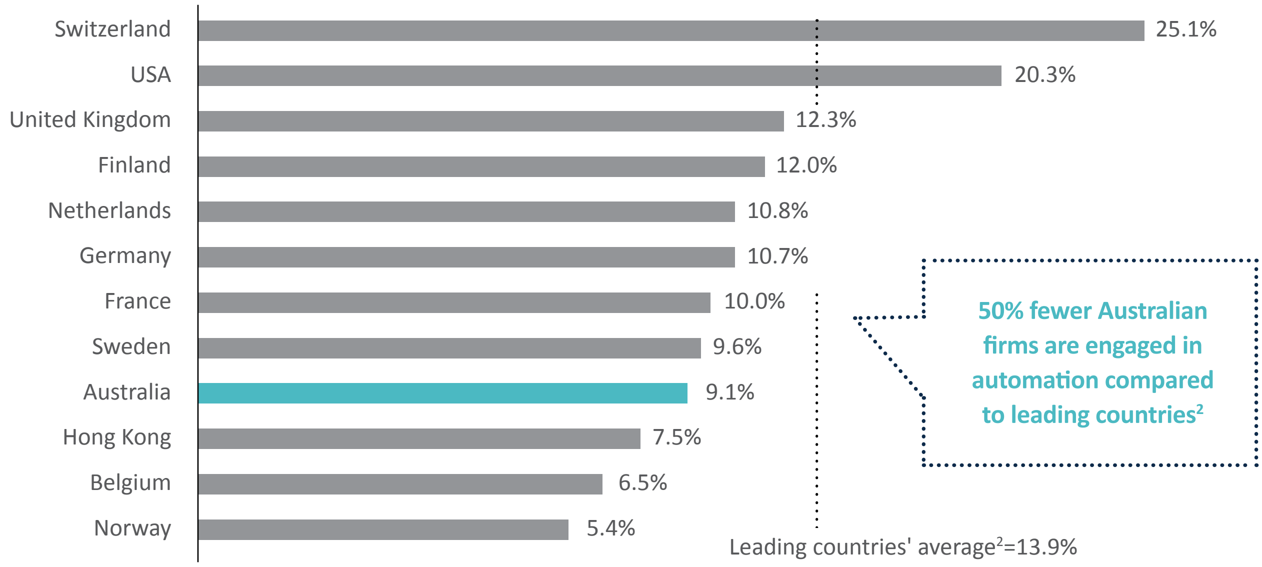
Exhibit 7 describes two scenarios for the employment consequences of automation. In the “workers displaced scenario” the time saved by automation is not reinvested into other activities. In this scenario, Australian productivity would rise but GDP growth would be limited. In the “workers transitioned scenario” all workers reinvest time savings from automation into uniquely human tasks. In GDP terms, the net present value of these two scenarios differs by $1.2 trillion over 15 years. The ultimate outcome is likely to lie between these two worlds.

EXHIBIT 8

Australia lags behind global leaders in automation

Global automation uptake[1]

% publicly listed firms engaging in automation, 2010-2015



Note: Only countries with detailed data for over 60 publicly listed firms included

1. Automation uptake measured as the fraction of publicly listed firms with 5% growth in capital expenditure and labour productivity over 5 years

2. Includes all countries in sample with higher automation rates than Australia

SOURCE: Compustat data, AlphaBeta analysis

2.2 AUSTRALIA WOULD GAIN $1 TRILLION BY ACCELERATING THE RATE OF AUTOMATION

If Australia embraced automation more strongly, rather than fighting it, the economic benefits of using machines at work could be even greater. Compared to other advanced economies, Australian firms appear to underinvest in automation technology. Data on publicly listed firms, comprised in Exhibit 8, show that Australian companies lag behind global peers in investing in robotics and other productivity-boosting technologies.[11]

In Switzerland, for example, more than 25 per cent of publicly listed companies appear heavily engaged in automation. These “automation leaders” have been making continuous capital investments in anything from smarter machines to automation software between 2010 and 2015, which has helped boost the productivity of their workers by at least 5 per cent over that period.[12]

In Australia, the automation uptake among publicly listed companies is around 9 per cent. While this is comparable to the degree of automation engagement among listed firms in Sweden, it is close to three times lower than the automation rate among listed companies in Switzerland and less than half the automation rate of listed companies in the US (20.3 per cent). In some of the most progressive countries globally, as seen in Exhibit 8, at least 10 per cent of listed companies appear strongly committed to automation.

11. Data sourced from S&P Compustat: Global and North America fundamentals databases. Note: Given the lack of available global automation benchmarks, an index measuring change in investment and productivity was constructed instead where sufficient data was available

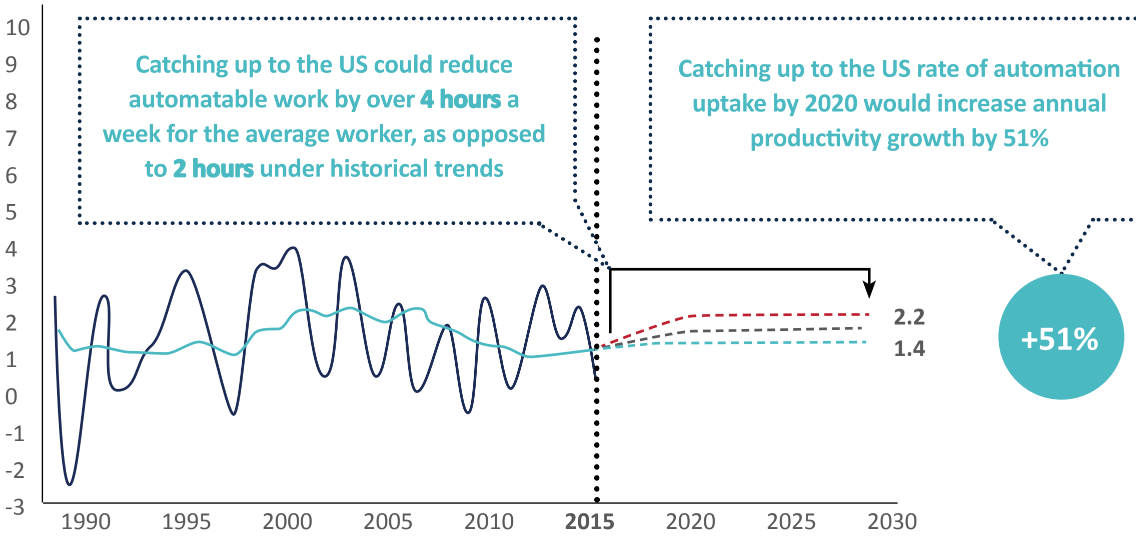
12. Automation leaders are defined as publicly listed firms whose investment and labour productivity have increased by at least 5 per cent between 2010 and 2015. Japan not included in dataset due to lack of detailed employee data

EXHIBIT 9

If Australian firms embraced automation to the same extent as peer economies, productivity growth could increase by over 50%

Labour productivity growth

% of Year on year growth, historical and projected productivity growth



SOURCE: ABS, Compustat, O*NET, AlphaBeta analysis

1 Leading peer economies is defined as an equally weighted average of countries with higher automation uptake than Australia

2 Scenario relates to the proportion of firms embracing automation as defined on Exhibit 8. Scenario assumes Australia catches up to the benchmark rate by 2020 and maintains that rate out to 2030, resulting in an uplift in productivity

Many people, led by fears that robots could trigger mass unemployment, may be considering this relatively low level of corporate automation uptake a boon for Australia. Yet slowing down the pace of automation, rather than accelerating it, may do more harm than good, depriving Australia of the resulting productivity benefits, and potentially reducing the global competitiveness of local industries. The US manufacturing industry may serve as an example: US manufacturing firms have invested heavily in automation technologies in recent years to remain competitive against foreign low-cost rivals. This has led to job losses, but also enabled a large number of workers to move into better-quality roles and remain employed in an industry that many considered precarious. The result: by 2020, the US manufacturing industry is expected to be more globally competitive than China's.[13]

If local firms were as committed to automation as their US peers, which would require the share of automation-focused firms in Australia to roughly double in coming years, Australia's productivity growth could increase by more than 50 per cent to 2.2 per cent annually by 2030, as seen in Exhibit 9.

Higher productivity growth means we can produce the same output with less work. More specifically: doubling the pace of automation to match the US uptake would allow Australian workers to save twice as much time spent on dull and dangerous tasks. It would relieve the average Australian worker of more than 4 hours of repetitive weekly routine work by 2030, as opposed to a saving of just 2 hours per week if past automation rates continued.

Accelerating the pace of automation could provide an even stronger catalyst for Australia's economic growth, provided there are policies and opportunities in place to help affected workers develop in-demand skills and remain productively engaged in the workforce. Smart retraining opportunities can go a long way to supporting workers to stay productive, as discussed in further detail in Section 4. If all workers affected by automation remain employed, increasing the rate of automation in Australia to US levels could add another A$1 trillion to Australia's economic output over the years between 2015 and 2030.

13. Deloitte (2016), Global Manufacturing Competitiveness Index. Available at: https://www2.deloitte.com/global/en/pages/manufacturing/articles/global-manufacturing-competitiveness-index.html

AUTOMATION WILL MAKE AUSTRALIAN JOBS SAFER, MORE SATISFYING AND MORE VALUABLE

Embracing automation is not just about seizing an abstract economic gain. It has the potential to change the lives of millions of Australian workers for the better—as machines free us of our most dangerous, most tedious and worst-paid job tasks.

Seizing Australia's $2.2 trillion automation opportunity isn't only about the strength of the economy as a whole. It will have real, tangible benefits for every worker in Australia. Machines have a huge potential to change the daily work routine of millions of people for the better.

This section provides detailed insights on how machines are advancing human work. Think of a butcher using robotic meat-cutting machines instead of handling sharp knives himself, think of a mining worker getting a good night's sleep while autonomous haulage trucks are doing the long tiring drive across a mine site.

An analysis of recent trends in worker satisfaction, workplace injuries and pay levels for tens of thousands of Australians confirms what may seem like an intuitive finding: machines are shouldering our riskiest, least enjoyable and least valuable tasks within a job, allowing humans to focus on more creative and interpersonal tasks. In short: machines enable humans to be more "human" at work.

The benefits of automation for Australian workers are quantifiable. For one, allowing robots to take on more manual work will deliver a particularly strong gain for anyone involved in painstaking, physical labour, which is currently responsible for the bulk of workplace injuries. Assuming past automation trends continue, the amount of sick days due to accidents involving physical work in Australia could be 11 per cent lower by 2030.

Second, work satisfaction is bound to increase, as machines take over a greater share of dull routine tasks. This analysis shows that the monotonous, automatable tasks performed by typically low-skilled workers are also the least satisfying tasks to perform. If current automation trends persist, low skill workers will take on more stimulating and satisfying human tasks at work, and as many as 62 per cent of them would be happier in their jobs by 2030 compared with today.

Third, allowing more people to focus on tasks that are more difficult to automate has a clear financial benefit. Easily automatable tasks are among the worst paid. In contrast, work activities that are difficult for robots to take over because they require a large amount of creative thinking, human logic and emotional intelligence earn almost 20 per cent more than automatable tasks.

3.1 JOBS WILL BECOME SAFER, AS MACHINES TAKE OVER THE MOST DANGEROUS TASKS AT WORK

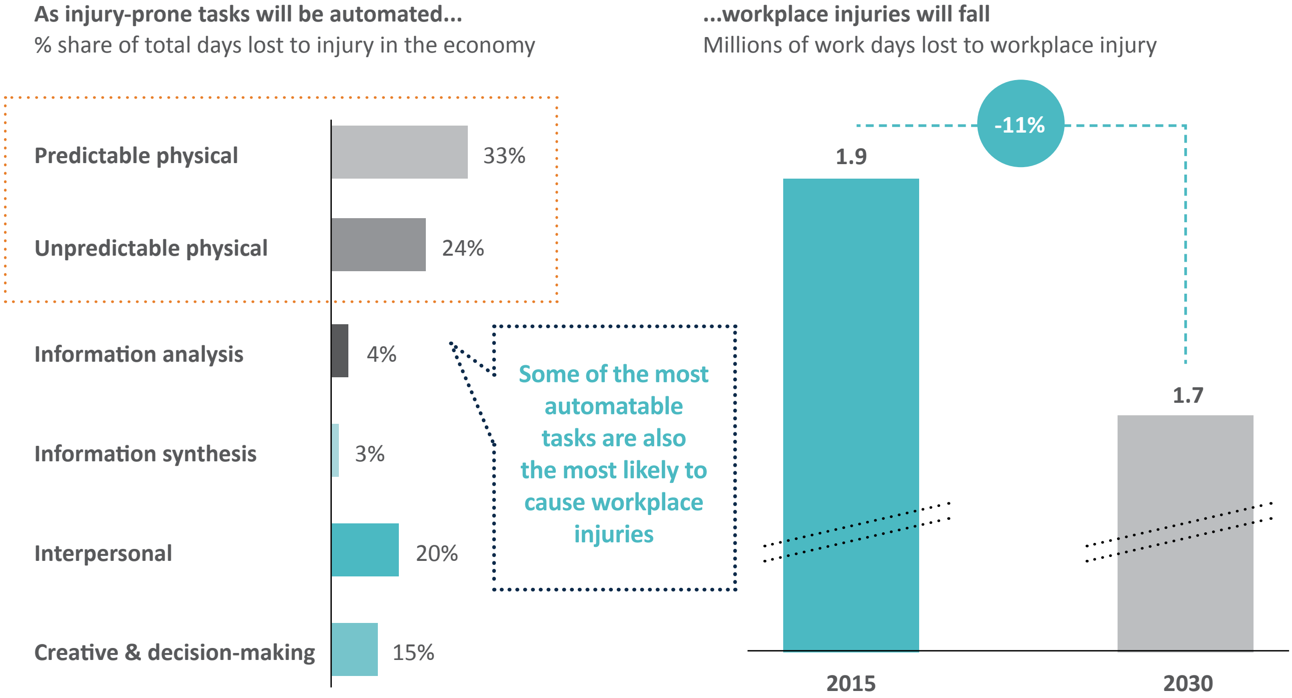
As we use machines to automate physical tasks, workplaces become safer. This is because the activities that are easiest to automate, such as painstaking physical work, are typically among the most dangerous. Considering that physical tasks use up only around one quarter (27 per cent) of all work hours in our economy, as seen in Exhibit 2, they cause an outsized number of work accidents. Exhibit 10 shows that physical tasks accounted for more than half (57 per cent) of all sick days workers took to recover from injuries sustained on the job in 2015.

Robots have the potential to substantially lower the amount of workplace accidents by taking over tasks that often lead to injuries, such as lifting heavy objects or operating dangerous machinery. The use of self-driving trucks, for example has been resoundingly successful for mining company Rio Tinto. Today, 69 fully automated trucks are moving around its remote iron-ore mine sites in the Australian Pilbara desert, making Rio Tinto the world's largest owner and operator of autonomous haulage systems.[14] The company's safety record has improved noticeably since introducing self-driving trucks, with injury rates falling from 1.21 accidents per 200,000 hours worked in 2007 to 0.44 accidents in 2016.[15]

14. Rio Tinto (2017), "Mine of the future". Available at: http://www.riotinto.com/australia/pilbara/mine-of-the-future-9603.asp
15. Rio Tinto (2016), "Sustainable Development Report", page 25. Available at: http://www.riotinto.com/documents/RT_SD2016_our_people.pdf

EXHIBIT 10

Workplace injuries will fall by 11% as automation eliminates some of the most dangerous physical tasks in the economy



SOURCE: ABS, O*NET, AlphaBeta analysis

Assuming past trends continue, the total number of work days lost to injuries sustained from physical work in the Australian economy could fall by 11 per cent to 1.7 million in 2030. The productivity gain will likely be even higher, as machines can also improve the safety of jobs involving non-physical tasks. Any worker, not just those performing physical tasks, is at risk of being involved in a car accident. Autonomous driving technology has the potential to reduce such accidents, given crash rates are lower for autonomous vehicles. [16]

3.2 JOBS WILL BECOME MORE SATISFYING, AS MACHINES TAKE OVER THE MOST ROUTINE TASKS AT WORK

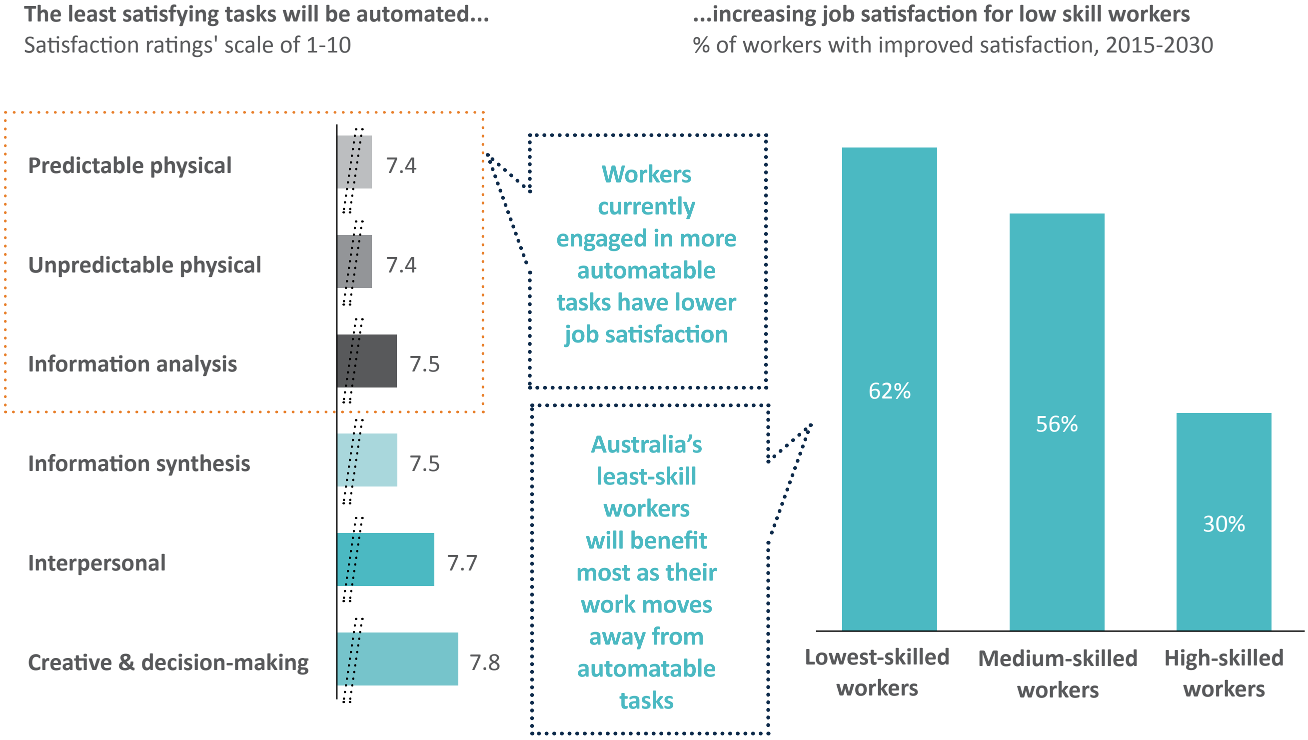
Automation will also increase work satisfaction, particularly for lower-skilled workers, who are often required to perform the most dangerous, strenuous and repetitive jobs in an economy.

The Household, Income and Labour Dynamics in Australia (HILDA) survey, compiled by researchers at the University of Melbourne, measures workers' job satisfaction.[17] To understand which workers are currently most dissatisfied with their jobs and thus stand to gain most if unpleasant work tasks were automated, the latest results of the HILDA survey were applied to the six task groups identified earlier in the report (for details on the methodology see Appendix B).

16. Myra Blanco, Jon Atwood, Sheldon Russell, Tammy Trimble, Julie McClafferty and Miguel Perez (2016). "Automated vehicle crash rate comparison using naturalistic data". Available from: http://www.vtti.vt.edu/featured/?p=422
17. Melbourne Institute of Applied Economic and Social Research, HILDA Survey. Available at: http://melbourneinstitute.unimelb.edu.au/hilda

EXHIBIT 11

Automating routine tasks will improve job satisfaction for 62% of low-skilled workers



SOURCE: ABS, O*NET, HILDA, AlphaBeta analysis

The outcome, illustrated in Exhibit 11, shows that the most easily automatable tasks, such as assembly-line work or data entry, are typically also the least enjoyable. By taking over more and more of these monotonous and tedious activities, automation has the potential to raise the job satisfaction for every worker, albeit to varying degrees. The improvement tends to be strongest for the low-skilled, who typically perform the bulk of automatable work. If current automation trends persist, it is estimated that 62 per cent of low-skilled workers in Australia would be happier in their jobs by 2030 compared with today. High-skilled workers would also benefit: 30 per cent of them would likely report a higher job satisfaction in 2030 if they could swap some of their automatable routine work for more complex and creative tasks.

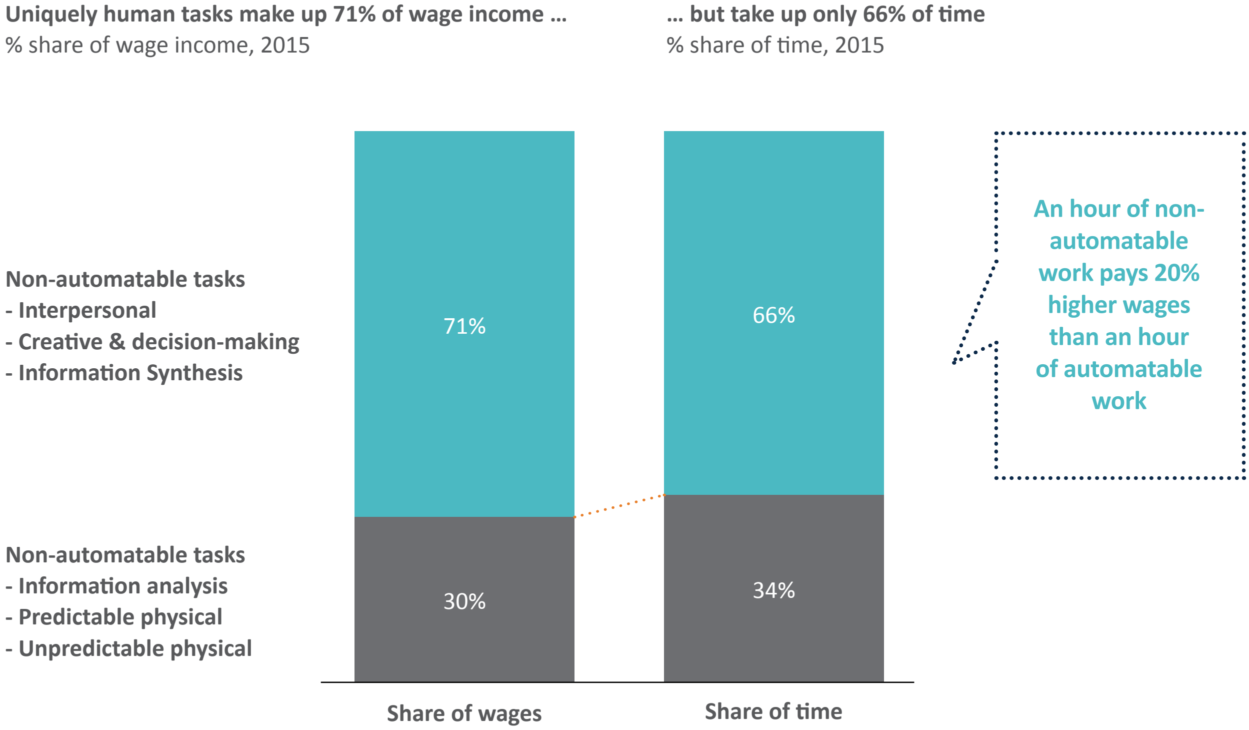
3.3 JOBS WILL BECOME MORE VALUABLE, AS MACHINES TAKE OVER THE LEAST PRODUCTIVE TASKS IN THE ECONOMY

There is a clear financial incentive to shift from repetitive routine work to activities that require more complex, creative and interpersonal skills. Australian wage data shows that the least automatable tasks are typically the best paid (see Appendix B for details on the methodology).[18]

18. Australian Bureau of Statistics (2014), Employee earnings and hours, Cat. no. 6306.0 DO011_201405

EXHIBIT 12

Uniquely human work is more valuable than automatable work



SOURCE: ABS, O*NET, AlphaBeta analysis

Exhibit 12 shows that tasks that are difficult for robots to perform earn almost three-quarters (71 per cent) of the total wage income generated in Australia, despite only taking up two-thirds of total work time in Australia. This means that a worker who spends 40 hours a week on non-automatable tasks—whether teaching students or setting a new business strategy—earns approximately 20 per cent more per hour compared to someone who spends 40 hours a week performing automatable tasks, such as packaging deliveries, preparing food or operating heavy machinery (see Appendix B).

Based on these results, the gains from automation could be particularly substantial for low-skilled workers. If such workers could learn to perform more uniquely human tasks and firms also accelerated their rate of automation, real wages for this group could be 10 per cent higher by 2030, an annual income gain of approximately $6,000 per worker.

4

HOW AUTOMATION CAN BECOME A SUCCESS STORY IN AUSTRALIA

Australia needs a bold and proactive policy approach that treats automation as an economic opportunity, rather than a threat. It is crucial to support the country's most vulnerable workers and prepare today's youth for the future.

Australians have much to gain from embracing the opportunity to offload repetitive routine tasks onto machines. However, these gains cannot be taken for granted. Automation can only become a success story in Australia if policymakers help workers navigate the big shift towards automation. This requires a finely tuned policy response rather than a blanket approach.

For example, low-risk (high skill, and early career) workers are expected to require little policy support to remain employable in the automation age, as most of them already perform a large amount of uniquely human tasks. High-risk workers (low skill, and nearing retirement), in contrast, are at risk of sliding into unemployment if policymakers fail to enact targeted retraining and job transition programs. Ignoring the needs of Australia's most vulnerable workers would come at a large cost for society, potentially driving 20 per cent of them into joblessness.

Educating future workers is equally crucial. An additional 6.2 million people are projected to join the Australian workforce in coming years. They will significantly advance our economy if they have the skills to perform the high-value tasks that robots are unable to master.

Australia needs a bold and proactive policy approach that treats automation as an economic opportunity, rather than threat. There is value in drawing on the experience of other countries, and this section provides some examples as a starting point.

4.1 POLICY SHOULD BE TAILORED FOR DIFFERENT GROUPS AFFECTED BY AUTOMATION

Policymakers in Australia play an important role in harnessing Australia's automation opportunity. They design the framework that allows workers to take advantage of automation and take up safer, more enjoyable and more valuable jobs. But this policy framework also needs to support workers whose jobs are at risk.

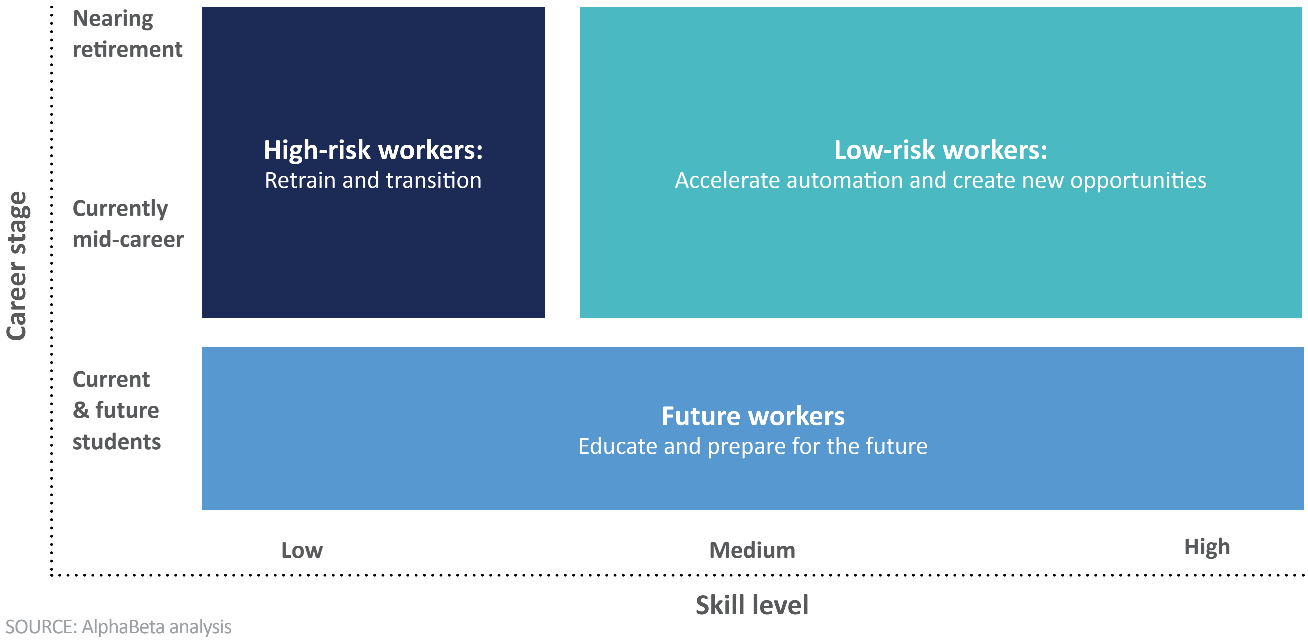
Different groups of workers have different policy needs. The young, well educated, and highly skilled will likely adapt easily to changes in their workplace. Others, including lower-skilled workers and those near retirement age, will likely struggle more when trying to transition from one job to another. Rather than pursuing a blanket approach, policymakers must meet the needs of three different worker groups when providing support, highlighted in Exhibit 13.

- **Current high-risk workers**: These workers are predominantly low-skilled and perform a large share of automatable tasks. If these workers lose their jobs, they would need a lot of support to find new employment.
- **Current low-risk workers**: For these workers, the benefits from automation will likely outweigh its threat. The majority of them are medium- to high-skilled employees who perform a variety of uniquely human tasks. While parts of their jobs might be prone to automation, there is still plenty of work for them that machines cannot eliminate.
- **Future workers:** These workers have not yet joined the labour force, and their skill level can still be influenced by education and training. This gives policymakers an opportunity to be proactive and design strategies to ensure future workers have the right skills to succeed in an increasingly automated world.

EXHIBIT 13

Australia's policy response to automation will need to be tailored to different groups of people

Groups affected by automation



SOURCE: AlphaBeta analysis

The policy response to automation must cater for all three worker groups, as shown in Exhibit 14. Quantitative analysis of the impact of automation on each group reveals that the costs for society will be highest if Australia fails to adequately prepare its future workers for the automation age. An additional 6.2 million people are projected to join the Australian workforce by 2030; ensuring these workers are equipped with the right skills to enter the workforce and perform high value tasks could lead to economic gains of $600 billion dollars by 2030. Accelerating the rate of automation would further increase the economic gains for this group by $400 billion dollars (see Appendix D for further details on the methodology). There are already several initiatives in place to equip young Australians with critical skills for the future and boost their employment opportunities, including early-childhood education programs (see Box 2 for some examples of existing Australian initiatives).[19]

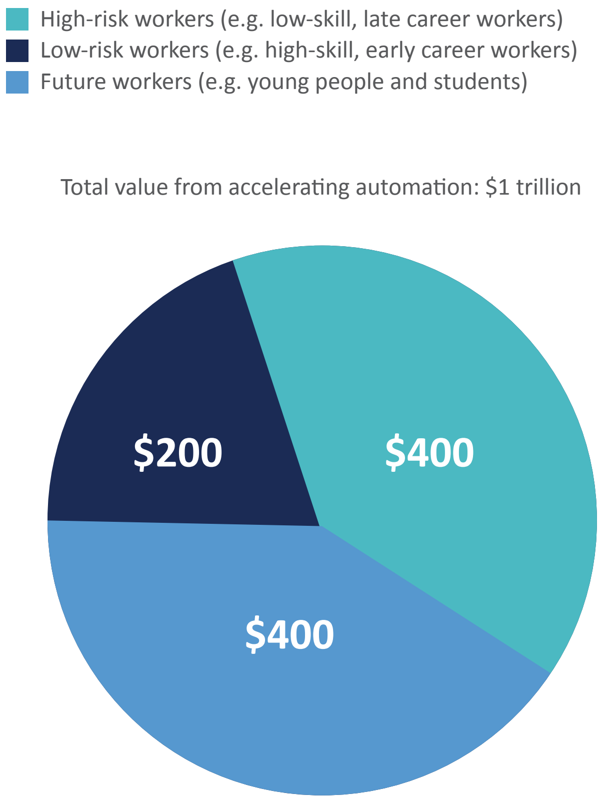
Economic gains from transitioning workers would also be significant if policymakers cater for the estimated 3.5 million workers at high-risk of being displaced by automation in coming years. Policies providing training and assistance to keep these in the workforce between 2015 and 2030 yield economic gains worth up to A$400 billion in net present value.

19. More details on the initiatives can be found at: https://www.mychild.gov.au/agenda

EXHIBIT 14

Automation's $2.2 trillion opportunity can be realised by transitioning vulnerable workers and accelerating automation for skilled workers

Economic gains from automation
NPV of GDP (2015-2030),[1] $ billions



The economic gains from successfully transitioning workers mainly accrue to vulnerable (high-risk) and future workers

The economic gains from accelerating automation mainly accrue to skilled (low-risk) and future workers

Note: Figures rounded to nearest $100 billion, scenario represents the maximum expected gains from automation
1 Future GDP discounted at 3% per annum
SOURCE: ABS, O*NET, AlphaBeta analysis

BOX 2

Australian employment initiatives can be replicated for workers affected by automation

Governments play a crucial role in supporting workers who are affected by technological progress or domestic and global economic forces affecting their industry. Several programs exist in Australia to cushion the impact of such forces. While not designed specifically in response to automation, these programs are currently available to help workers move into new roles. Similar programs aimed at workers affected by automation could help reduce the costs, and maximise the benefits automation brings to Australia.

One of the most prominent employment initiatives is the **Automotive Industry Structural Adjustment Programme** providing training, resumé-writing advice and other assistance to workers affected by the closure of car manufacturing in Australia.[20] Early outcomes are encouraging: although car manufacturers have shed tens of thousands of jobs since 2006, only 3 per cent of automotive workers remained unemployed in 2011. More than half of the laid-off workers found a new job in manufacturing or other sectors.[21]

The programme is funded by the $155 million Australian **Growth Fund**, which is part of the Government's Industry Innovation and Competitiveness Agenda. The Growth Fund helps former automotive workers learn new skills and find new work. It also helps supply chain firms to diversify and regions to stimulate growth in new areas of the economy.[22]

The **Future Industries Manufacturing Program** offers funding to manufacturers in Victoria who want to implement new manufacturing technology to remain competitive, grow and create more jobs.[23] Other government programs offer incentives for employers to boost hiring. The **Wage Subsidies** initiatives pay employers up to $10,000 to hire, train and retain job seekers under 25 or over 50 years of age, as well as long-term unemployed and Indigenous people.[24] A payroll tax rebate is available for employers who employ apprentices and trainees as part of the **Australian Apprenticeships Incentives Program**.[25] In New South Wales, employers are also eligible for a payroll tax rebate when creating new full-time jobs.[26] Several state-based programs invest in projects to diversify regional economies and create new growth and employment opportunities.[27] The Australian Government has also launched the free online tool Jobactive to help employers connect with job seekers and shorten periods of joblessness.[28]

20 See program details at: https://www.business.gov.au/assistance/automotiveindustry-structural-adjustment-programme
21 Australian Government (2017), "Worker redeployment and skills development". Available at: https://industry.gov.au/AboutUs/CorporatePublications/ReviewofSouthAustralianandVictorianEconomies/Pages/Worker-redeployment-and-skills-development.aspx
22 Specific elements of the Growth Fund include the "Automotive Industry Structural Adjustment Programme", a "Skills and Training Inititiave", an "Automative Diversification Program" and a "Next Generation Manufacturing Investment Programme". More details on: https://www.business.gov.au/assistance/growth-fund
23 See program details at: https://www.business.gov.au/assistance/future-industries-manufacturing-program
24 See program details at: https://www.business.gov.au/assistance/wage-subsidies
25 See "Australian Apprenticeships Incentives Program": https://www.business.gov.au/assistance/australian-apprenticeships-incentives-programme and https://www.business.gov.au/assistance/apprentices-and-trainees-payroll-tax-rebate-nsw
26 See "Jobs Action Plan NSW": https://www.business.gov.au/assistance/jobs-action-plan
27 See various "Regional Jobs and Investment Packages" listed on: https://www.business.gov.au/assistance/results?a=578102c2de524d3fa493f264b7a71cd4&a=5240c4c58b324d0998ce7c05e64c3f3e&q=
28 See program website for more details: https://jobsearch.gov.au/

In contrast, workers at low-risk of losing their livelihood due to automation are expected to need only minimal government support. Their relatively high skill level should enable them to switch jobs with ease if employers decide to make their role redundant or use machines for some of the tasks they were hired to perform. The gains from supporting training and transition for this group are only worth $200 billion between 2015 and 2030. However, the benefits of accelerating automation and letting these workers naturally shift to higher value work would be substantial for this group, worth $400 billion by 2030. A recent initiative by the Australian Bureau of Meteorology (BOM) illustrates how skilled workers can remain relevant in their jobs by shifting to slightly different work activities (See Box 3).

BOX 3

How the Bureau of Meteorology is improving productivity and keeping their workers employed

Do machines make human work redundant? The Australian Bureau of Meteorology (BOM) proves the opposite: automation changes how weather observers do their jobs, but it doesn't make them obsolete. In fact, the organisation continues to hire and create new specialist roles, even as it is using a growing amount of high-tech equipment to forecast our weather with greater precision.

When the BOM decided to modernise its network of regional weather observation stations and fully automate more than a dozen of them in 2016, it seemed like a radical move. Yet meteorologists have for decades been relying on technology for their weather predictions.

In the old days, before the 1950s, weather observation was a manual job. Often, just one or two workers were stationed for years in the rugged Kimberley region and other remote parts of the continent to measure rainfall, wind and temperature by hand. Some were tasked to send weather balloons filled with flammable hydrogen into the earth's upper atmosphere—a job that required careful handling and knowledge of risk and safety rules.

Today, however, 20 of the Bureau's 48 upper air observing stations are automated and the trend is set to continue. Over the next four to five years, only about 10 weather stations will remain under manual control, including those in Antarctica and on remote islands, where fully automated equipment would not survive the harsh climate or would be difficult to support. The BOM estimates that the roles of as many as 50 workers will be affected by automation over that period. However, it has set up a redeployment plan to move affected staff into new roles.

Online and face-to-face courses in the Bureau's own training centre ensure workers learn new skills to become masters of the weather robots. As "field technicians" they need to understand how to detect faulty equipment and repair it, how to restock automated stations and calibrate their systems. Many will move from working alone in the bush to working with colleagues in small teams. Their safety risks are lower now that robotic systems can launch weather balloons into the sky.

"Automated systems still require human intervention," said Dr. Anthony Rea, Assistant Director for Observations at the BOM in Melbourne. Dr. Rea says the biggest advantage of using automated weather stations is the rise in productivity. Thanks to the new technology, one person can now achieve where many were needed in the past: monitor the weather in several locations at once.

New roles are also emerging—in customer service, data analysis and systems technology. As a result, employment numbers at the BOM have so far been steady. At the end of June 2016, the organisation counted 1,458 permanent and 206 temporary staff, compared with 1,452 permanent and 201 temporary staff a year earlier.[29]

29. AlphaBeta Interview with Dr. Anthony Rea, Assistant director for Observations at the Bureau of Meteorology, Melbourne, 23rd June 2017

EXHIBIT 15

Many countries have employed a range of strategies that can harness the benefits and minimise the costs of automation

Retrain and transition		
Retraining & education programs	US	Community college subsidies: Findings from Washington state suggest that a year of training in community college can increase lifetime earnings by up to 9-13%
	Denmark	Active labour market policy: Denmark provides basic literacy & numeracy education, higher education support, and vocational training for unemployed workers
	Singapore	Lifetime learning credits: Singapore's 'SkillsFuture' initiative offers lifetime credits of S$500 for all Singaporean citizens aged over 25 for use on enrolling in government approved training courses
	UK	Union supported learning: Britain's national Trade Union Centre (TUC) founded "Unionlearn" in 2006 to provide UK union members learning and skilling opportunities throughout their careers
Accelerate automation and create new opportunities		
Embrace automation	US	Indirect investment in automation: The US Department of Transportation opened 10 autonomous vehicle testing tracks to accelerate cooperation amongst developers
	Japan	Direct investment in automation: Japan is investing in robotics, and deregulating the industry to support a tripling of its robotics market
	Korea	Direct investment in automation: Korea seeks to invest $500 million in robotics over the next 5 years
	Switzerland	Directly support technologies: The Swiss postal service has trialled automated delivery robots and drones instead of traditional delivery methods
Educate and prepare for the future		
Industry & educational institutions partnerships	US	P-Tech schools: Companies partner with high schools to teach students the STEM skills that the future workforce requires
	Germany, Switzerland	Dual training programs: German/Swiss apprentices split time between study and practical work experience in large German/Swiss firms, with a focus on future-proof skills
Early education initiatives	Estonia	Computer programming education: The Estonian "ProgeTiger" programme introduces computer programming in school curriculums from years 1-12
Smarter learning	US	Massive Online Open Courses (MOOCS): Online learning platforms that offer 'nano-degrees' teaching courses tailored to skills that tech companies need

SOURCE: AlphaBeta analysis

4.2 LESSONS FROM ABROAD: HOW OTHER COUNTRIES ARE RESPONDING TO AUTOMATION

International examples can offer Australia some guidance to best harness the benefits of automation: policies range from supporting the adoption of automation technologies to better prepare future workers, and ensuring that the minority of workers whose jobs are threatened by automation can be redeployed elsewhere in the economy. Exhibit 15 provides an overview of selected initiatives around the world that Australia could potentially learn from.

Assisting high-risk workers:

A look at policy examples from around the world can help Australia sharpen its own approach to assist the most vulnerable workers.

- **USA - Higher education subsidies for displaced workers:** Researchers in Washington State found that one year of training in a community college increases the income prospects of laid-off male workers by 9 per cent and of laid-off female workers by 13 per cent.[30] The findings encouraged Washington State to provide targeted assistance to displaced workers by funding their tuition, mapping out education paths, and helping with job searches.[31]

- **Denmark - Active labour market policy:** Denmark spends as much as 2 per cent of its GDP on its active labour market policies, ranging from assistance to improve numeracy, literacy and job readiness to funding of tertiary education and vocational training. Such policies can ensure high-risk workers are able to acquire new, relevant skills and become job-ready quickly after losing employment. The effectiveness of the policy is demonstrated by Denmark's high levels of employment security relative to the rest of Europe.[32]

- **Singapore - Lifetime learning support**: Singapore's "SkillsFuture" initiative grants so-called lifetime credits to all citizens aged 25 and over. These credits can be used to pay for training courses from tertiary education organisations and other approved providers. Older workers benefit particularly, as they can use credits accumulated over a lifetime to upgrade outdated skills.[33]

- **UK - Union supported learning:** Britain's national Trade Union Centre established a program called "Unionlearn" in 2006, which offers on-the-job training for employed union members to ensure their skills remain relevant in a rapidly changing workplace. As many as 87 per cent of employers support the program.[34]

Embracing automation for low-risk workers:

Workers at low-risk of being displaced by automation, most of them well educated and already performing a wide range of uniquely human tasks, typically require only minimal help from governments to switch from repetitive routine activities to more valuable ones. Governments can encourage the structural shift to higher value work patterns by encouraging more businesses to engage in automation or by directly investing in automation.

- **USA - Indirect investment in automation:** The U.S. Government has adopted policies that facilitate private businesses' investments in automation. For example, the US has become one of the most liberal jurisdictions for the use of driverless cars. It has opened 10 test tracks across the country to create shared spaces for high-tech companies to facilitate collaboration in technology development.[35]

- **Switzerland, Japan, South Korea - Direct investment in automation:** Switzerland, in a strong endorsement of automation, recently began trialling the use of mail-delivery robots at its national mail service, Swiss Post.[36] On a more ambitious level, the governments of Japan and South Korea are both investing large sums of taxpayer money in robotics. [37, 38]

30. Louis Jacobson, Robert LaLonde, and Daniel Sullivan (2004), "Estimating the Returns to Community College Schooling for Displaced workers". Available at: http://repec.iza.org/dp1017.pdf
31. https://www.sbctc.edu/paying-for-college/worker-retraining-student.aspx
32. The Danish National Labour Market Authority (2008), "Danish Employment Policy". Available at: https://www.oecd.org/employment/leed/40575308.pdf
33. Singapore Skillsfuture. Available at: http://www.skillsfuture.sg/credit/about#programme1
34. Unionlearn website. Available at: https://www.unionlearn.org.uk/about
35. US Department of Transportation. Available at: https://www.transportation.gov/briefing-room/dot1717
36. Swiss Post (2016), "Swiss Post to test self-driving delivery robots". Available at: https://www.post.ch/en/about-us/company/media/press-releases/2016/swiss-post-to-test-self-driving-delivery-robots
37. Japan's robotics strategy (2015). Available at: http://www.meti.go.jp/english/press/2015/0123_01.html 'Robot Friendly Korea' (2012). Available at: http://www.korea.net/NewsFocus/Sci-Tech/view?articleId=99841
38. Robot Friendly Korea (2012). Available at: http://www.korea.net/NewsFocus/Sci-Tech/view?articleId=99841

Preparing future workers:

Australia stands to gain most from policies that help future workers acquire the skills needed to perform high-value tasks in an automated society. The following examples can provide an incentive for Australia to rethink its current education and training policies and adopt lessons from abroad.

- **Germany/Switzerland - Develop industry & educational partnerships**: Germany and Switzerland have a long history of combining theoretical education and practical workplace training to prepare young people effectively for the real-life job environment. In Germany, about 50 per cent of all school-leavers undergo vocational training provided by companies which consider the dual system the best way to acquire skilled staff.[39] Dual-track partnerships could allow the education system to rapidly adapt to disruptive changes arising from automation.

- **Estonia - early education initiatives:** In 2012, Estonia began introducing computer programming as part of its teaching curriculum for school students as young as six, through its “ProgeTiger” program.[40] Australia could similarly seek to update its education curriculums to better reflect the skills required in the future workplace.

- **USA - Smarter learning**: In the fast-paced digital world, specialised and rapidly deliverable education solutions are necessary to prepare workers for changing work environments. One new educational approach is the development of “nanodegrees”. In the US, and now around the globe, companies such as Udacity[41] and Coursera[42] offer programming and STEM courses through online platforms. These typically cost much less than regular university degrees and can offer a narrow focus on crucial skills. Providers of these “Massive Open Online Courses” (MOOCs) can further use machine learning and data analytics based on its student cohorts to determine which courses are suited for which type of applicants. While the concept is still in its infancy, employers are increasingly open to these new models of learning: a survey of 114 human-resources managers in the US found that an overwhelming majority (95 per cent) considered nanodegrees and other “digital badges” a useful asset for applicants to have. [43]

The future of automation in Australia depends on policymakers. If they enact a framework that will protect the country’s most vulnerable workers, while allowing the highly skilled to perform more meaningful jobs, automation can become a success story in Australia. Ideally, their policy will enable Australia to seize its $2.2 trillion automation advantage.

39 Federal Ministry of Education and Research (2017), "The German Vocational Training System." Available at: https://www.bmbf.de/
40. www.hitsa.ee/it-education/educational-programmes/progetiger
41. More details at: https://www.udacity.com/
42. More details at: https://www.coursera.org/
43. Emily Rimland and Victoria Raish (2016), "Employer perceptions of critical information literacy skills and digital badges". More details at: http://crl.acrl.org/content/early/2015/05/11/crl15-712.full.pdf+html

32

This report provides a fresh perspective on the future of work in an increasingly automated world. Rapid advances in robotics and artificial intelligence have led to widespread fears that automation technology will soon cause entire occupations to disappear and force millions of people into unemployment. However, this report argues that automation offers first and foremost a substantial economic opportunity for all Australians.

Automation is changing how we do our jobs, and historic trends signal that for the overwhelming number of Australians these changes will be positive. Shifts in our work patterns since the start of the millennium confirm that automation is eliminating the least valuable, least enjoyable, and most dangerous parts of our work. In turn, automation allows us to focus on uniquely human tasks: working with people, thinking creatively, solving problems. These are the tasks that people tend to enjoy most, and they also tend to be better paid than the repetitive routine work any robot can perform. If past automation trends persist, the average Australian full-time worker would be able to delegate two hours of automatable work per week to machines by 2030.

But this report also shows that the automation opportunity is not guaranteed. Right now, Australia lags leading nations such as Switzerland and the US in using automation technology. Only 9 per cent of Australian listed companies are showing signs of sustained investment in automation, compared to 20 per cent in the US.

Australia is now at a crossroads. It can continue to respond cautiously to the automation trend and resist the uptake of automation technology, which will deprive a large number of workers of the positive effects of growing machine use. Or, it can embrace automation as an opportunity to increase the quality and safety of work for all Australians.

The long-term benefits of technological progress as an engine for prosperity and higher living standards are beyond doubt. However, these will only materialise if governments set up strong support mechanisms to manage the short-term risks that inevitably exist. The potential economic gain is estimated to be worth $2.2 trillion by 2030. However, for automation to become a national success story, decisive action is required to ensure millions of the most vulnerable Australian workers remain in employment in the coming years.

Policymakers, companies, trade unions, education providers and workers must make a joint effort to prepare current and future employees for the automation age. This means teaching students critical future skills needed to work alongside machines. It also means offering targeted support for workers affected by the automation change. In addition to maintaining support for existing employment and growth programs in Australia, policymakers are encouraged to look overseas and learn from international best practice on how to maximise the benefits automation can bring.

5

APPENDICES

5.1 APPENDIX A: ESTIMATING TIMESHARES OF TASKS IN THE ECONOMY

Measuring the impact of automation on the workplace remains a challenge for researchers. There is no readily available data showing how workers have spent their day at work in the past, compared with today. This report utilises a unique and innovative approach to overcome this challenge. It provides the first published estimates of the impact of automation on the workplace using verifiable historical data.

O*NET frequency data covering 964 US occupations was used to measure the time workers spent on various job-related tasks in recent years. The approach, summarised in Exhibit 16, was repeated multiple times between 2006 and 2014 to determine how automation has affected the work activities in different occupations.[44]

EXHIBIT 16

The analysis begins by assigning each O*NET Detailed Work Activity (DWA) a unique number, and noting that the amount of time a worker in occupation *'j'* spends on '*N*' DWAs in a work week can be expressed by the following equation:

$$f_{1,j} X\, t_{1,j} + f_{2,j} X\, t_{2,j} + \ldots + f_{N,j} X\, t_j = h_j$$

Where $f_{i,j}$ is the number of times a week a worker in occupation *'j'* performs task *'i'*, '$t_{i,j}$' the amount of time it takes the same worker to perform task *'i'*, and h_j the total hours worked a week by the worker.

O*NET provides survey frequency scores on a scale of 1-7 which are converted to weekly frequency scores by AlphaBeta as presented in table 1.

Table 1. Conversion of O*NET frequency scores to weekly frequencies

O*NET score	O*NET description of frequency	AlphaBeta implied weekly frequency
1	Yearly or less	0.02
2	More than yearly	0.12
3	More than Monthly	0.5
4	More than weekly	2
5	Daily	5
6	Several times a day	20
7	Hourly or more	40

It is assumed all workers surveyed work 40 hours a week and that all workers within the same 1 digit SOC code take the same amount of time to perform a task.

44. The US Department of Labor's O*NET database is one of the world's richest sources for labour data. The database contains information on the frequency of over 2,000 Detailed Work Activities (DWAs) grouped under 41 Generalised Work Activities (GWAs) across 964 US Standard Occupation Classification (SOC) codes.

EXHIBIT 16 (continued)

There are ‘N’ unknowns in equation 1, namely the different amounts of time taken to perform a task. The frequencies with which 'J' occupations within a 1-digit US SOC perform tasks, the time taken to performs tasks, and the total weekly hours worked can be expressed as a linear system given by the following equation.

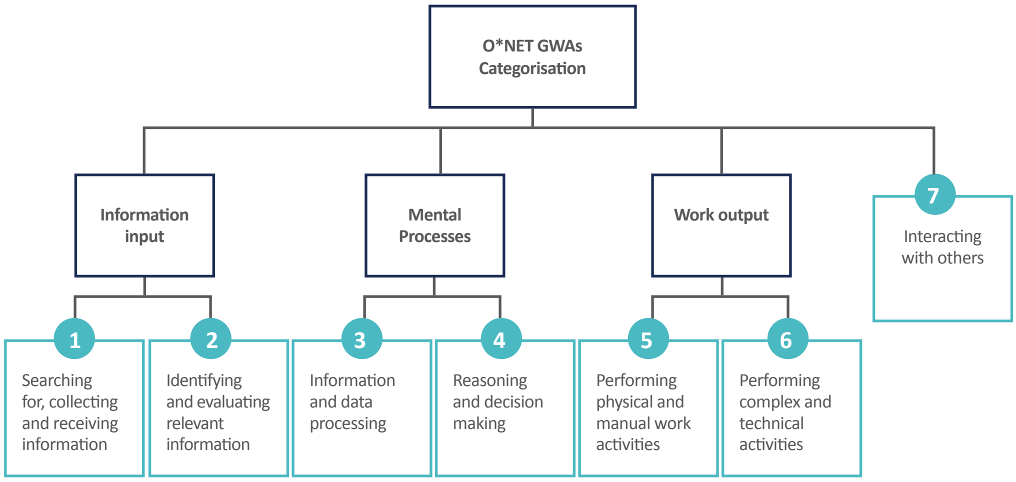
$$\begin{array}{ccccc} h & & F & & t \\ \begin{bmatrix} 40 \\ \vdots \\ 40 \end{bmatrix} & = & \begin{bmatrix} f_{1,1} & \cdots & f_{N,1} \\ \vdots & \ddots & \vdots \\ f_{1,J} & \cdots & f_{N,J} \end{bmatrix} & \times & \begin{bmatrix} t_1 \\ \vdots \\ t_N \end{bmatrix} \end{array}$$

This system has more unknowns (over 2000 activities under vector 't') than there are equations ('J' must be strictly less than 964 occupations). For most scenarios, the system may have infinite solutions.[1] To obtain unique values for the vector of time to perform tasks (t), a regularised least squares solution is used to satisfy the below equation.

$$\min\|Ft - h\|^2 + \mu\|t\|^2 \;\; where \; t_i \geq 0 \; \forall i, \mu \; is \; some \; small \; number > 0$$

In the above, μ penalises large deviations in time taken to perform tasks. Solving the above equation provides a unique estimate of time spent on activities for each occupation. Lastly each DWA is mapped to its Generalised Work Activity (GWA)[2] which are mapped to tasks groups. The mapping of GWAs to task groups is shown in figure 1. [3]

Figure 1. Allocation of O*NET GWAs into task groups



Task groups	Activities in (1) mapped to:	Activities in (2) mapped to:	Activities in (3) mapped to:	Activities in (4) mapped to:	Activities in (5) mapped to:	Activities in (6) mapped to:	Activities in (7) mapped to:
Interpersonal							100%
Creative & decision making		25%	50%	100%		50%	
Information analysis	100%		25%				
Information synthesis		75%	25%				
Unpredictable physical					50%	40%	
Predictable physical					50%	10%	
Total	100%	100%	100%	100%	100%	100%	100%

SOURCE: O*NET, AlphaBeta analysis

1. There are possible permutations which will not have infinite solutions. For example, assume all occupations perform task 1 exactly 40 times a week, and perform no other tasks: the only solution for the system would be that task 1 takes precisely 1 hour to perform.
2. Each detailed work activity falls under 1 of 41 unique generalised work activities as categorised under O*NET.
3. Each of the 41 O*NET generalised work activities is categorised into one of 7 AlphaBeta categories, based on descriptions provided by O*NET

How can we translate the results of the US data analysis into the Australian context? This is the second challenge this report overcomes. It determines how work patterns have changed in the Australian economy by matching US occupations with their Australian equivalent using concordance tables. To complete the picture and determine Australian workplace trends, it combines the occupational timeshare data with ABS statistics on hours worked by occupation.

This report goes one step further than other reports dealing with automation's impact on the workforce. It measures how much of the automation-driven change in work patterns is due to workers changing jobs, and how much is due to workers simply changing the way they work within the same job. This analysis produces a novel finding: automation in recent years has mostly led to a change in work activities, not a change in jobs. Exhibit 17 describes the method of this analysis.

EXHIBIT 17

Let S be a matrix of timeshares of tasks in the economy where $S_{i,j}$ corresponds to the timeshare spent on task type i (interpersonal, creative, physical predictable, etc.) in occupation j. For all J occupations in the Australian economy, the vector of total share of work hours spent on tasks (ts) is given by:

$$\overset{S}{\begin{bmatrix} s_{1,1} & \cdots & s_{1,J} \\ \vdots & \ddots & \vdots \\ s_{6,1} & \cdots & s_{6,J} \end{bmatrix}} \times \overset{h}{\begin{bmatrix} h_1 \\ \vdots \\ h_J \end{bmatrix}} = \overset{ts}{\begin{bmatrix} ts_1 \\ \vdots \\ ts_6 \end{bmatrix}}$$

In the above, h is the vector of fractions of total work hours for each occupation; the elements of which sum to 1.

Taking observations of S and h at different points in time allows for a detailed analysis of changes within and between jobs. For example, by taking the difference between $S_{2014} \times h_{2014} - S_{2006} \times h_{2006}$ the total change in hours spent on each task is given for the elapsed time period. The impact of automation attributable only to changes within a job, and not from workers changing jobs, is determined by comparing $S_{2014} \times h_{2006} - S_{2006} \times h_{2006}$

These various estimates are extrapolated to 2015, 2030 and 2000 to estimate the impact of automation in 15-year periods.

5.2 APPENDIX B: THE IMPACT OF AUTOMATION ON WORK QUALITY

Estimating the impact of automation on the Australian workforce

Prior work on automation typically attempts to answer the broad question of how many jobs will be impacted by automation. This report answers that question, however, it also answers another important, but mostly overlooked question: how will automation impact the quality of working lives? Using the change in work activity patterns, as detailed in Appendix A, and combining the results with extensive data from ABS and HILDA[45] surveys, this report makes three new contributions: it quantifies how automation makes work safer, more enjoyable, and more valuable.

ABS data on workplace injuries reveal that the vast majority of injuries are associated with physical tasks—even when using a conservative method, as shown in Exhibit 18. The impact of automation on safety was measured by estimating how accident numbers would fall if the observed change in work activity patterns continued(holding the size of the workforce constant).

45. Melbourne Institute, the University of Melbourne, Household, Income, and Labour Dynamics in Australia

EXHIBIT 18

Estimating the impact of automation on workplace injury

Steps

- ABS data on number of injuries resulting in missed working days, classified by a description of cause, was used
- ABS workplace injuries are classified as resulting in 1-4 days of missed work, or 5+ days of missed work
- It is assumed that injuries resulting in 1-4 days of missed work lead to an average of 2.5 missed days of work, and injuries resulting in 5+ days of missed work lead to an average of 10 days of missed work
- Causes of injury are assigned for task groups as follows

ABS description of causes of workplace injuries	Assigned to task group[1]
Lifting, pushing, pulling, or bending	Routine/non-routine physical tasks
Repetitive movement with low muscle loading	Routine/non-routine physical tasks
Prolonged standing, working in cramped or unchanging positions	Split proportionally across all task groups
Vehicle accident	Split proportionally across all task groups
Hitting or being hit by an object or vehicle	Split proportionally across all task groups
Fall on same level (including slip or fall)	Split proportionally across all task groups
Fall from a height	Split proportionally across all task groups
Exposure to mental stress	Split proportionally across all task groups
Contact with a chemical or substance	Split proportionally across all task groups
Other	Split proportionally across all task groups

- The implied number of injuries associated with a given task is calculated from the above
- The expected reduction in injuries is calculated by estimating the number of injuries using 2030 projected timeshares, e.g.:

$$\text{Routine physical injuries 2030} = \frac{\text{TS Routine phys 2030}}{\text{TS Routine phys 2015}} \times \text{Routine physical injuries 2015}$$

Note: This method holds labour force size constant to control for labour force trend growth in injuries

1 Where injury causes were not clearly identifiable, causes are assigned proportionally to all tasks in the economy. If causes were assigned in greater detail, the number of physically-caused injuries would be even greater

SOURCE: ABS, O*NET, AlphaBeta analysis

HILDA data on job satisfaction across Australian occupations was used to assess the impact of automation on work quality. For that purpose, the available data was regressed on time spent on different tasks, as shown in Exhibit 19. Ordinary Least Squares (OLS) regression results show that workers performing a greater share of non-automatable tasks achieved higher satisfaction scores. The next step was to examine changes in timeshares across the different occupations (as detailed in Appendix A) and derive implications for job satisfaction. The result: automation has caused low-skilled work to change most rapidly towards including more satisfying tasks, disproportionately improving job satisfaction amongst the lowest-skilled workers in Australia.

EXHIBIT 19

Estimating the impact of automation on satisfaction

Steps

- Satisfaction scores on a scale of 1-10 are provided for each 4 digit occupation through HILDA surveys

  For each observation of individuals in occupation *i,* the satisfaction score is assumed to be a function of timeshares on activity types:

  $Satisfaction_i = \alpha + \beta_1 TS\ Interpersonal_i + \beta_2 TS\ Creative_i + \beta_3 TS\ InfoA_i + \beta 4TSInfoS_i + E_i$

- In the above, physical task shares are excluded due to multicollinearity
- α is interpreted as the expected satisfaction of an individual that only engages in physical work, and βs as the premium over physical work (or discount if negative) in satisfaction scores of performing a given task at work instead of physical work
- An ordinary least squares regression is used to estimate the value of coefficients, and expected satisfaction scores are calculated for 2006 and 2014 for each occupation
- The expected change in satisfaction across time is estimated for occupation terciles (grouped by share of automatable tasks performed at work in 2006)
- For each tercile of workers, an expected share of workers who could experience higher satisfaction as a result of increased automation is determined by comparing 2014 to 2006 expected satisfaction

Note: Since share of workers experiencing change is a binary outcome, it is not impacted by the magnitude of change, hence there is no need to separately estimate satisfaction for 2015 and 2030

SOURCE: HILDA, O*NET, AlphaBeta analysis

The third part of the analysis was guided by the question of whether replacing automatable work with non-automatable work will generate more value and higher wages for workers. ABS weekly wage data was regressed on timeshares of different tasks, controlling for hours worked and age of workers as shown in Exhibit 20.

EXHIBIT 20

How will automation affect wages?

Steps

- ABS data on average weekly earnings is provided for each occupation
- For each occupation i, the expected weekly wage is assumed to be a function of time spent on activity types, average hours worked, and age of workers:

$$Wage_i = \alpha + \beta_1 TS\ Interpersonal_i + \beta_2 TS\ Creative_i + \beta_3 TS\ InfoS_i + \beta_5\ Age_i + \beta_6\ Hours_i E_i$$

- Physical task shares are excluded due to multicollinearity. In the above α can be interpreted as the expected weekly wage (controlling for age and hours worked) of an individual that only engages in physical work, and β as the expected premium (or discount if β is negative) of performing a given task at work instead of a physical task
- An ordinary least squares regression is used to estimate the value of coefficients and expected wages are calculated for a worker performing 100% of a given task, assuming the worker is of the overall average worker age, working the total average weekly hours, e.g. the expected weekly wage for interpersonal work is assumed to equal:

$$W^{inter} = \alpha + \beta_{1+} \beta_5 \overline{Age} + \beta_6 \overline{Hours}$$

- Share of value for each task is calculated for the aggregate economy. E.g. the share of wages paid for interpersonal work is given by: $$\frac{W^{inter}\ X\ TS\ Interpersonal}{ws^1}$$
- In the above $w = [\ w^{unpredictable\ physical}\ w^{predictable\ physical}\ w^{inter}\ w^{creative}\ w^{infoA}\ w^{infoS}\ ]$ is the vector of expected wages for a worker performing 100% of a given task
- In the above s = [TS Unpredictable phys TS Predictable phys TS Interpersonal TS Creative TS InfoA TS InfoS] is the vector of timeshares for tasks in the economy

SOURCE: ABS, O*NET, AlphaBeta analysis

The results show that the income share of non-automatable work relative to the total time spent on such work is substantially higher than the ratio for automatable work, suggesting that non-automatable work pays a wage premium of around 20 per cent compared to automatable work. The premium is determined using the following equation:

$$premium = \frac{\%\ wages\ for\ non\text{-}automatable\ work}{\%\ wages\ for\ automatable\ work} \times \frac{\%\ time\ spent\ on\ automatable\ work}{\%\ time\ spent\ on\ non\text{-}automatable\ work}$$

5.3 APPENDIX C: EVALUATING THE POTENTIAL GAINS FROM AUTOMATION

Estimating the impact of automation on the Australian economy

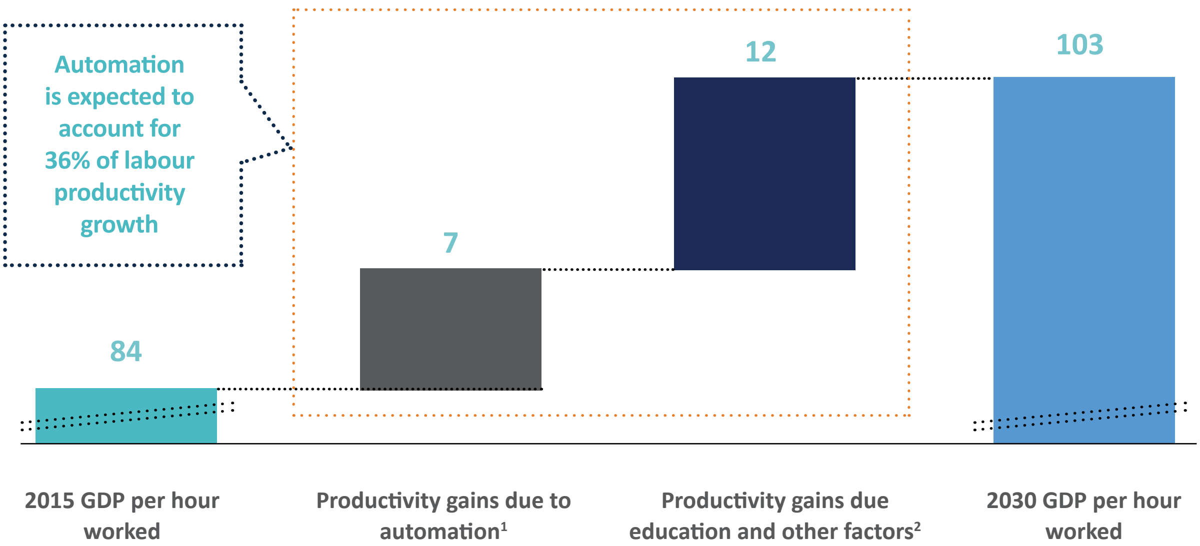
The methodology used in this report differs to existing reports, as it provides a quantifiable estimate of the impact of automation on productivity in recent years. Beginning with the average weekly work hours in 2000, the change in time spent on automatable tasks through to 2015 is converted into a more tangible figure: work hours saved. From this figure, the implied gain in labour productivity can be derived.

The analysis also accounts for the fact that some workers will reinvest the time saved through automation by assuming that non-automatable work generates 20 per cent more value (in line with the wage premium). The gains from automation are then compared with total productivity growth as calculated using ABS data on growth in real GDP per hour worked. Exhibit 21 shows that as much as 36 per cent of average productivity growth since the year 2000 was driven by automation. Remaining productivity gains are attributable to factors such as improved worker education and other efficiency gains.

EXHIBIT 21

If automation continues at historical rates it will account for 36% of average labour productivity growth out to 2030

Expected labour productivity growth at historical rate
Output per hour worked, real 2015 A$



Includes gains due to time saved and reinvestment of labour hours into higher value added activities

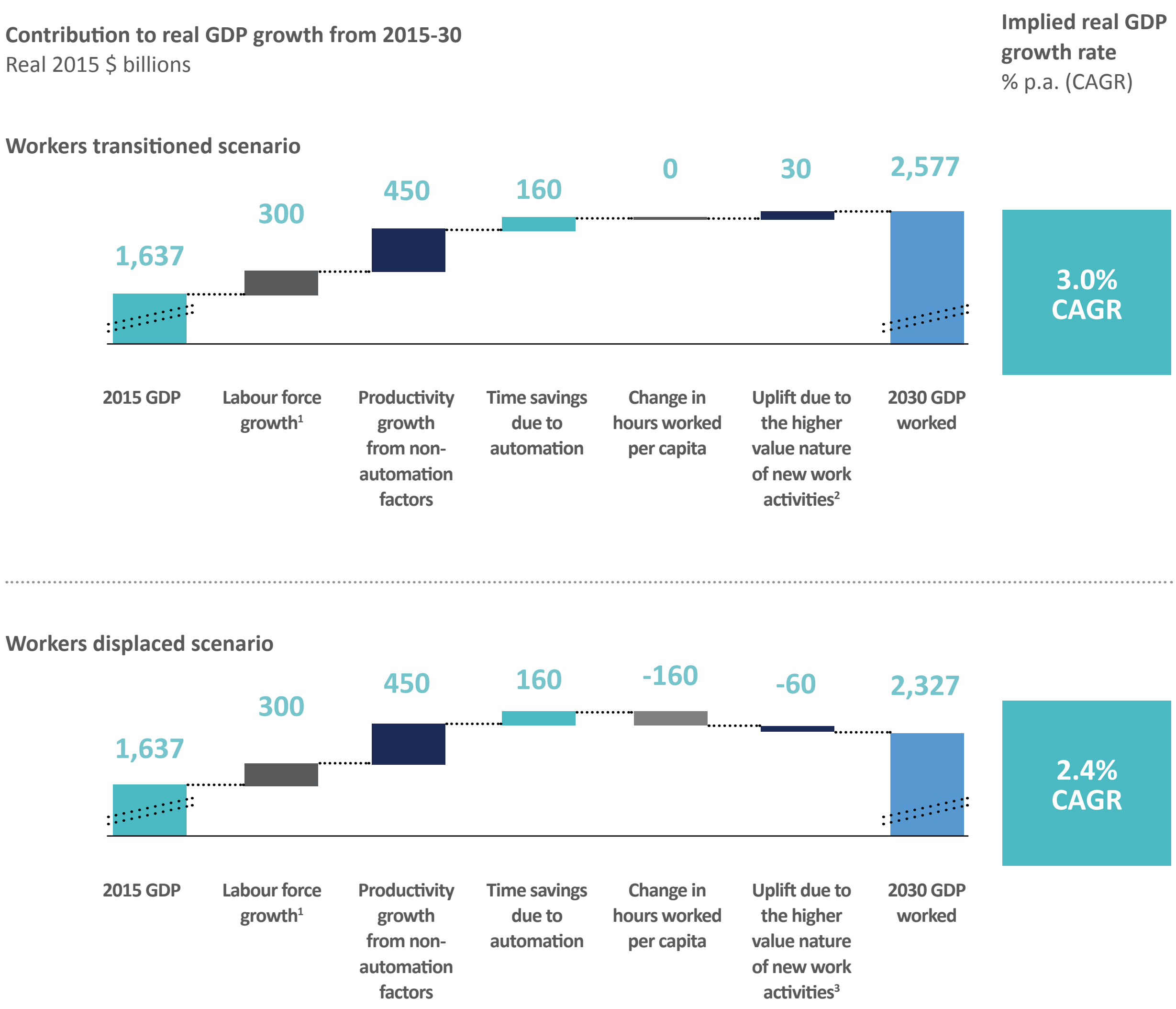
Productivity gains due to other factors inferred by removing productivity growth attributable to automation from total productivity growth 2000-2015

SOURCE: ABS, O*NET, AlphaBeta analysis

This method of estimating the impact of automation has a clear advantage: it disentangles the impact of various types of productivity gains on employment. For example, some means to improve productivity, such as educating workers, are unlikely to adversely impact the number of workers employed. However, automation can result in worker displacement with a range of possible outcomes. Exhibit 22 details two cases—one where automation simply displaces workers, the other where workers reinvest their freed-up time elsewhere in the economy. Comparing such scenarios provides a novel way to quantify the potential gains from automation.

EXHIBIT 22

GDP growth could be 2.4-3.0% p.a. out to 2030, depending on whether labour is transitioned or displaced



1 Inferred from labour force entry rate of 1.9%, Department of Immigration, estimated net migration intake and labour force exit rate of 1.4%

2 Assumes time savings are reinvested into activities that generate 20% more GVA per hour than automated activities

3 Fall in GDP could occur due to future workers taking on lower value work activities in the displacement scenario.

SOURCE: ABS, O*NET, AlphaBeta analysis

5.4 Appendix D: Evaluating the impact of automation for different groups of workers

This analysis evaluates the potential impact of automation on three worker groups. The size and output contribution of each group is determined by combining the three parts of the earlier analysis: how automation changes the time spent on work tasks in occupations; whether it changes the value of work as people switch to more non-automatable tasks; and how it affects the size of the workforce and productivity. The process of determining group sizes is detailed in Exhibit 23.

EXHIBIT 23

Which workers belong in which group, and how does group size change over time?

Which workers belong in which group?
The 2015 labour force was divided into occupations in 2015 and ranked in order of share of automatable work. Workers were divided into two groups

High-risk current workers

- Comprise 1/3 of the workforce
- Average 70% of time spent on automatable work
- Labour productivity in 2015 equal to 95% of economy wide average productivity

Low-risk current workers

- Comprise 2/3 of the workforce
- Average 18% of time spent on automatable work
- Labour productivity in 2015 equal to 103% of economy wide average productivity[1]

A third group of workers was analysed, future workers, comprised of a mixture of low-risk and high-risk workers.

Future workers

- Baseline estimate of 1/3 high-risk and 2/3 low-risk workers
- Proportion of high and low-risk workers may change depending on policy choices and exogenous factors

How does group size change over time?
Current workers are assumed to exit the workforce based on proportion population exceeding working-age of 65

$$\text{Current workers in 20XX} = \text{Current workers in 2015} \times \left(\frac{\text{2015 working-age population younger than 80-XX}}{\text{2015 working-age population}} \right)$$

Future worker cohort size for 20XX is estimated by taking the overall projected labour force size for 20XX (As implied using annual labour force growth, see Exhibit 22) and subtracting current workers in 20XX

Two rates of automation were used to measure the value and productivity gain from automation for each group (see Exhibit 24):[46]

- Constant automation: automation proceeds by historical rates
- Accelerated automation: automation is accelerated until 2020 to catch up to the US

Both automation rates were applied to different scenarios of worker displacement and transition. Modelling for future workers includes changes in the proportion of high- and low-skilled workers. An example of determining a scenario's NPV is illustrated in Exhibit 25. Differences in the NPV of transition/non-transition scenarios were then used to determine the value of successful policy for each group.

This approach breaks down the aggregate trends observed in Appendix C into worker subgroups, while also determining automation's specific value for each worker group. By analysing which segment of the Australian workforce has most to gain from automation, this report provides a clear picture of how policy actions must be tailored to target the Australian workforce today and in the future, and what the value of assisting different worker group might be.

46. Labour productivity growth rates due to automating existing work are assumed to be the same for both groups, even if initial level of productivity is not. Productivity growth rates differ when labour is reinvested (As high-risk workers have greater potential for reinvesting labour in higher-value added activities.

EXHIBIT 24

Gross labour productivity growth due to automation for the year 20XX under no transition is given by the following equation:

$$P_{i,20XX} = \frac{P_{i,2015}}{1 - \overline{F_{20XX,J}}}$$

Where *i* is either low or high-risk, and $\overline{F}_{220xx,j}$ is the economy wide average fraction of automated hours in year 20XX under scenario *j*.

Under transition, workers are able to reinvest their lost hours into new work, and labour productivity due to automation is given by:

$$P_{i,20XX} = \frac{P_{i,2015}(1 + v * F_{i,20XX,j})}{1 - \overline{F_{20XX,J}}}$$

Where *v* is the expected premium of non-automated work over automated work, and $F_{i,220xx,j}$ is the fraction of hours automated in the year 20XX under scenario *j* for group *i*

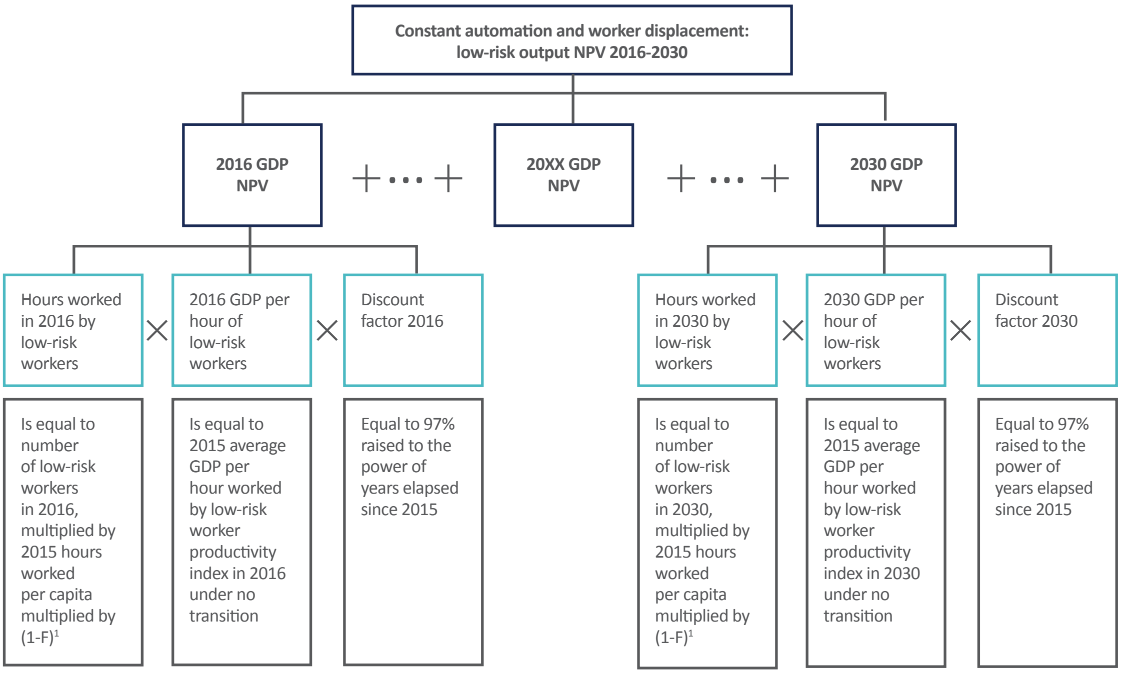
All scenarios include additional productivity growth from factors other than automation

EXHIBIT 25

How is the Net Present Value of output of each group calculated?

The NPV for each group is calculated by estimating the output for each group of workers through to 2030. An example for low-risk workers under no worker transition is shown below.

Estimating the NPV of output for low-risk workers under constant automation and displacement



Note: The above process is carried out for each year separately 2016-2030, and for each group of workers.

1 "F" is the fraction of work hours automated for a given group in a given year since 2015

SOURCE: AlphaBeta analysis

αlphaβeta

strategy x economics