

The Robots are NOT Coming

(And why that's a bad thing...)

By Dr. Jim Stanford

Centre for Future Work at the Australia Institute

August 2020

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Introduction: Putting Automation in Perspective

Public discussion about the ‘future of work’ has been strongly influenced by a widespread fear that accelerating technological change is likely to result in the displacement of large numbers of workers by robots and other machines. The application of many new technologies – like machine-learning, new optical and mobility technologies, and nanotechnology – allows machines to undertake a much wider range of productive tasks. It also allows them to be assigned duties which require flexibility and judgment, not just specific programmable instructions. YouTube videos and social media memes pay tribute to the incredible potential of robots in controlled laboratory circumstances.

Once these machines are deployed in the real-world economy, surely the implications for employment must be dire. Robots are capable of performing a greater variety of tasks, faster and better than humans, in many cases for lower cost. And they never go on strike. Some studies have estimated that as many as half of all jobs in modern industrial economies are subject to a high probability of automation within the next decade.¹

The most common advice for surviving this coming age of robots, at least at the individual level, is usually that workers should ‘learn new skills’. Workers with more training and education – preferably in technical or computer fields – will purportedly have their pick of jobs in the brave new automated economy. Workers who do not attain these skills will face discouraging employment prospects as they are left behind in this new era of automation. For policy-makers, the implications are that providing additional funds and other support for training and retraining (such as through vocational education programs) will enhance the ability of the labour market to ‘adjust’ to this new high-tech reality.²

While the adoption of new production technologies can certainly disrupt and in some cases reduce employment, there are many reasons why feared mass technological unemployment is unlikely to prevail in practice:

¹ See, for example, projections made by Frey and Osborne (2016) and Durrant-Whyte et al. (2015).

² A critical review of the gap between this common rhetoric about the importance of training, and Australia’s sorry record in real-world VET policy, is provided by Pennington (2020).

- Most machines and technologies have significant labour input demands associated with them, that offset some or many of the production jobs they ultimately may displace. There is much human labour required in developing, engineering, manufacturing, installing, operating and maintaining robots and other forms of automated machinery. While there is likely to be a shift in the nature of overall employment (from direct production positions, to these indirect engineering and support roles – which will certainly have different skill requirements), it is not clear that the total amount of labour demanded will necessarily fall as most of these technologies are deployed.
- New technologies, once they are invented and deployed, typically open up opportunities for new forms of work and production that were not possible (or even conceivable) before that technology was rolled out. A current example is the growing number of jobs developing various programs and applications for smart phones. Hundreds of thousands of new jobs around the world have been spurred by the opportunity to apply these new programs and applications – opportunities that did not exist before smart phone technology came into widespread use. The same spin-off effects on employment are possible with many other new technologies. In this sense, new technologies can be a *complement* for labour, rather than just a *substitute*.
- Appropriate macroeconomic management could ensure that workers displaced by technologies are quickly and productively re-engaged in alternative vocations. Labour-saving or labour-replacing technologies (and the resulting growth of labour productivity) creates the potential for faster growth of total output. Macroeconomic strategies to keep the economy operating at its full potential would create a steady flow of new employment opportunities in other industries and occupations, offsetting the dislocation of work in some jobs. Supports for retraining, relocation, and early retirement would help to further smooth the resulting transitions. Of course, there is no guarantee that appropriately expansionary macroeconomic strategies would be followed; governments might emphasise other policy goals (such as deficit reduction or inflation control) rather than the maintenance of full employment.
- Historically, another buffer which helped to avoid employment disruptions from advancing technology, while simultaneously enhancing the quality of life, was gradual reductions in working hours. Since mechanisation makes it possible to produce more total output with less work, one way to capture the potential social benefits from that technology is to reduce average working hours. Rather than producing concentrated pools of unemployed workers, in this case automation could support a gradual reduction in everyone's working time –

and corresponding increases in leisure time. Shorter working time can be attained through many different avenues: including a shorter work day, a 4-day work week, more annual leave, opportunities for mid-career family and education leaves, earlier retirement, and other measures. Again, while this avenue for constructively managing the effects of labour-saving technology has been important in the past, in more recent years this goal has not been emphasised in labour market and macroeconomic policy. And the attainment of shorter average working hours has been complicated by the intense inequality in working hours that has resulted from the unprecedented growth of part-time and irregular work in Australia.³

As documented in this report, the pace of labour-saving technological change was actually considerably faster in the earlier decades of Australia's postwar history (from the 1950s through the 1990s) than it is at present. Yet the spectre of mass technological unemployment did not dominate public discourse in those years. To the contrary, Australians in that period tended to see new technology as a positive source of opportunity, rather than something to be feared and resisted. The consistent application of the various supportive policies listed above (including macroeconomic policies to maintain full employment, well-resourced training and adjustment policies, and ongoing reductions in working hours) ensured that automation and mechanisation translated into welcome social progress – not dislocation, underutilisation, and polarisation.

However, today's labour market is a more hostile and insecure place, and government has generally retreated from its responsibility to ensure full employment in decent jobs. In a context of precarious work, growing inequality, and pervasive insecurity, Australian workers can be forgiven for concluding that robots and new technologies represent just one more threat to their already uncertain livelihoods. This helps to explain the shift in popular attitudes regarding automation: from optimism to pessimism. However, whether one's conception of an automated future is utopian (dreaming of abundant leisure time and comfortable wages), or dystopian (fearing mass unemployment and desperate inequality), the assumption underlying both characterisations is that the 'robots are indeed coming'. The shared conviction that technology is accelerating, and is the fundamental force transforming modern work, is the starting point of both views.

This paper argues that the debate over whether accelerating technology is beneficial, harmful or neutral actually misses an important and prior question. The underlying

³ See Carney and Stanford (2018) for a detailed empirical description of part-time and insecure work in the Australian context.

assumption that technology is in fact accelerating, let alone that it is the driving force of workplace change (rather than other determining factors, like changes in government policies, management strategies, and popular expectations), deserves critical scrutiny. The empirical evidence assembled here shows that at the concrete level of Australian workplaces, it is not evident that the use of robots and other forms of automated machinery and technology is accelerating at all. To the contrary, according to several different indicators, development and application of new technology by Australian employers is slowing down, not speeding up. Relative to previous periods in our economic history, and to the experience of other industrial countries, automation is proceeding at a snail's pace in Australia. And by some measures (such as the overall capital-intensity of production, and recorded labour productivity), the economy is *actually going backwards*.

Some might interpret this as good news: if the robots are *not* coming, then perhaps my job is safe after all. But far from justifying complacency, the glacial pace of innovation and technological transformation in Australia's economy in fact attests to a deeper set of structural failures and problems that, in turn, pose more obvious and imminent dangers to the quality and security of employment. The fact that investment in new technology (both intangible knowledge and tangible machinery and equipment) has been historically slow for most of the past decade, reflects a broader failure of Australian business sector to innovate, accumulate capital, create jobs and advance living standards. There is little risk that many Australians will be thrown out of their jobs because of robots – and even if that risk existed, it could certainly be offset with appropriate macroeconomic and labour market policy interventions. On the other hand, there is a clear risk that more and more Australians will be consigned to low-tech, insecure, and poorly-paid jobs in private service sectors like retail and hospitality.

This paper will review eight concrete indications that together refute the standard assumption that work is being fundamentally transformed by accelerating technology and automation. Investment and innovation in Australia is slowing down, not speeding up. This creates significant economic and social risks for the country, and undermines the quantity and quality of work available in Australia's labour market. The implications of this perhaps counter-intuitive analysis are then considered, for several important policy areas: including skills and training, macroeconomic policy, international trade, and science and technology.

The Non-Invasion of the Robots: Eight Exhibits

There is a growing body of empirical evidence that the popular infatuation with robots, automation and artificial intelligence is increasingly at odds with the rather less dynamic reality of Australia's economy. Below we review eight empirical indicators suggesting that the pace of automation and technological change in Australian workplaces has not sped up. To the contrary, Australia's recent innovation and technological performance has been less impressive than in previous periods, and lags well behind the benchmarks set by other industrial countries. And by some measures, the technology-intensity of work in Australia is actually regressing.

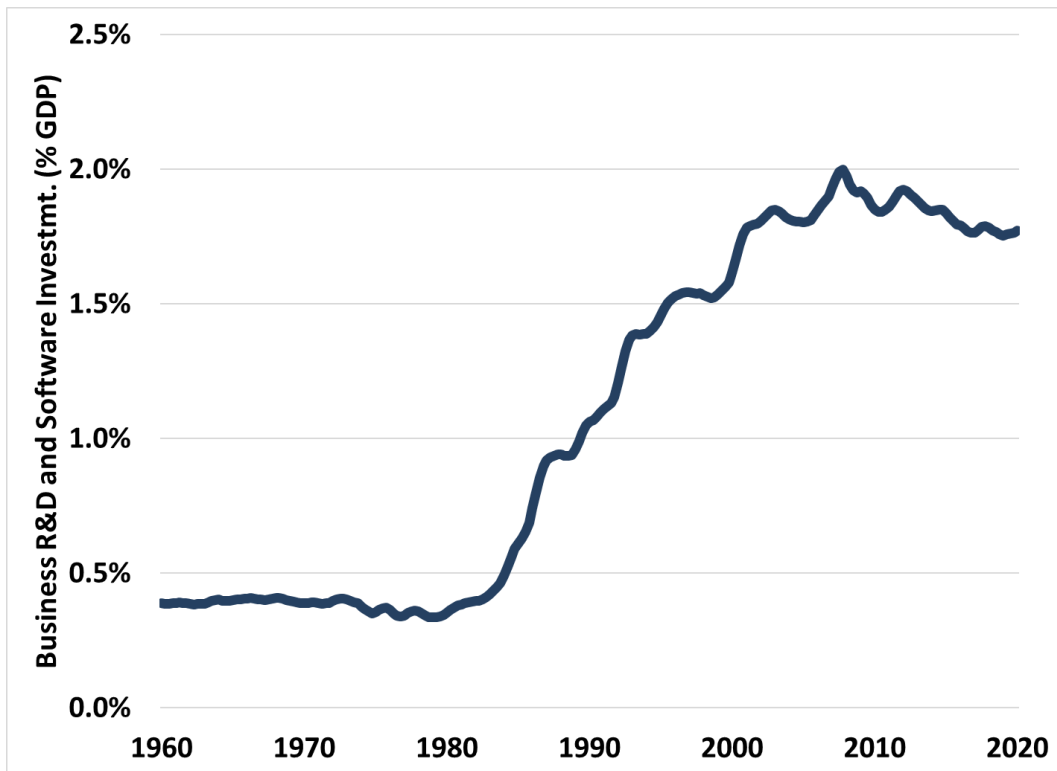
EXHIBIT 1: SLOWING BUSINESS INVESTMENT IN INNOVATION

In announcing a new national innovation strategy, supposedly heralding the dawn of a new era of innovation, former Prime Minister Malcolm Turnbull famously declared: "There has never been a better time to be an Australian business."⁴ He expressed faith that by investing in new ideas, technologies, and innovations, Australian business would usher in a striking and positive transformation of the national economy. The new Australian economy would be driven more by the knowledge and creativity of Australians, rather than by the mineral wealth buried beneath our feet.

Unfortunately, the hard evidence indicates that the commitment of Australian businesses to this laudable spirit of innovation has been waning for over a decade – and Mr. Turnbull's vaunted national innovation strategy did nothing to alter that negative trajectory. Figure 1 illustrates the trend in business investments in innovation-intensive intangible capital over the last 70 years, measured as a share of national GDP. The graph includes research and development expenditures and investments in computer software: two crucial channels of innovation activity, whose value is not directly reflected in tangible capital assets (such as machinery and equipment) measured in other data on business capital spending.

⁴ See Koziol (2016).

Figure 1. Business Investment in Innovation, 1960-2020



Source: Author's calculations from ABS Catalogue 5206.0, Table 2.

Beginning in the early 1980s, Australian businesses began to increase their investments in intangible innovation capital. Those investments subsequently quintupled as a share of GDP, from 0.4 percent of GDP to a peak of 2 percent of GDP in 2008. In the wake of the global financial crisis, however, the innovation activity of Australian business began to erode – and it has kept falling. By 2019 these investments equaled 1.75% of GDP: down by one-eighth since the 2008 peak, and the lowest at any time since the turn of the century.

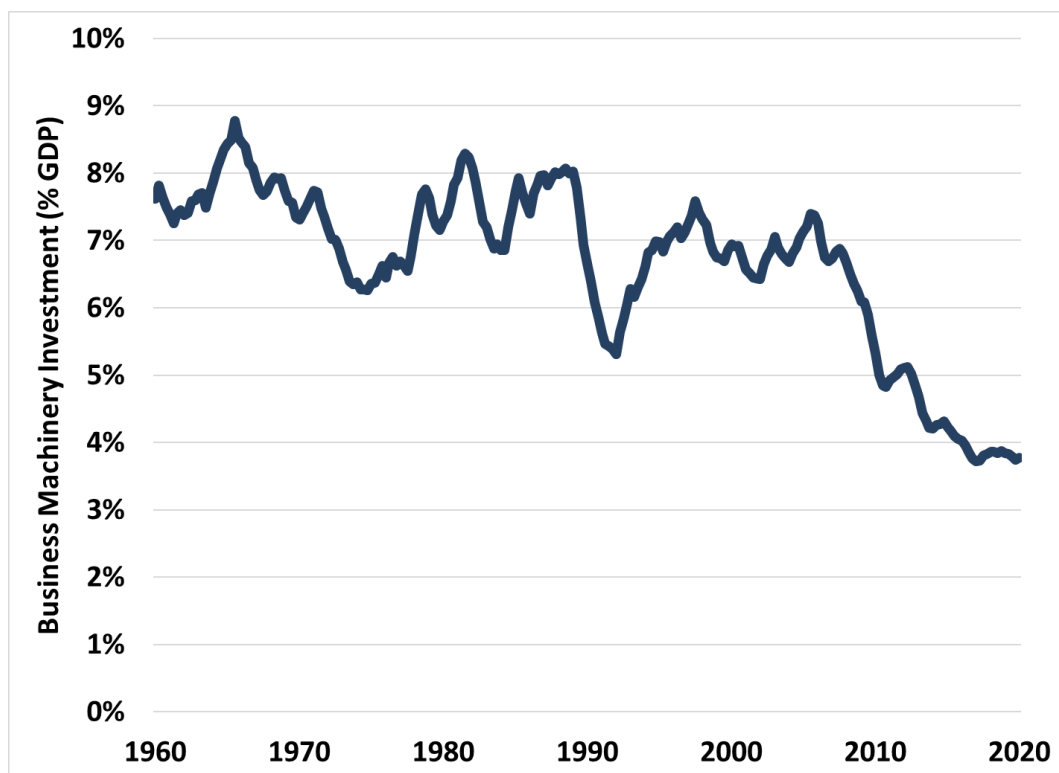
If innovation is the wave of the future (and in some dynamic industries, that is certainly true), then Australian businesses clearly risk being left behind. They are reducing their investments in new knowledge and programming, at a time when they should be ramping up.

EXHIBIT 2: SLOWING BUSINESS INVESTMENT IN MACHINERY AND TECHNOLOGY

It is not just in intangible intellectual property that the investment effort of Australian businesses is faltering. Applied innovation cannot occur in real workplaces without being embodied in tangible high-tech goods: machinery, equipment, electronics, and – yes – robots. Rapid investment in new capital equipment and machinery is essential to allow businesses to capture the benefits of new products and new processes. Unfortunately, investments by Australian businesses in new machinery and equipment has been even weaker than the trend in pure innovation activity.

Figure 2 illustrates business capital investment in machinery and equipment, once again measured as a share of national GDP. In this case, the downward trend in business capital spending is both more evident, and longer-lasting.

Figure 2. Business Investment in Machinery and Equipment



Source: Author's calculations from ABS Catalogue 5206.0, Table 2.

Through most of the initial decades of the long postwar economic expansion, Australian firms invested very rapidly in new equipment and technology. Machinery and equipment investment averaged 7.5% of national GDP from 1960 through 1990. After a sharp but temporary dip during the recession of the early 1990s, business

machinery investment recovered: hovering around 7% of GDP until the global financial crisis of 2008.

Since the GFC, however, business investment in modern machinery and equipment – the most tangible manifestation of new technology – has plunged dramatically, with painful consequences for Australian economic growth, productivity, and innovation. Since 2017, business investment in machinery and equipment has averaged just 3.75% of GDP. That's the weakest pace of M&E investment during the entire post-war era, and just half the pace recorded during the initial vibrant decades after the Second World War.

It is ironic indeed that there is so much apparent public concern with automation and robotisation, when the actual pace of business investment in new machinery is weaker than at any time in the past 75 years. In contrast, during those earlier postwar decades, when the introduction of modern machinery occurred much more rapidly, Australians felt more secure in their jobs – and were more likely to see mechanisation and new technology as an opportunity, rather than a threat. That more positive attitude was reinforced by the settings of labour market, macroeconomic and social policy at the time. With a consistent commitment to maintain full employment at the macroeconomic level, strong institutional measures to ensure that rising labour productivity was indeed reflected in rising real wages, the expansion of social security programs to support and protect households incomes, and a national commitment to gradually reducing working hours, Australians could be confident that technological change would indeed lead to better living standards. as another dividend of technological advance. In that context, technological advances were more legitimately seen as a source of social progress, rather than as a threat.

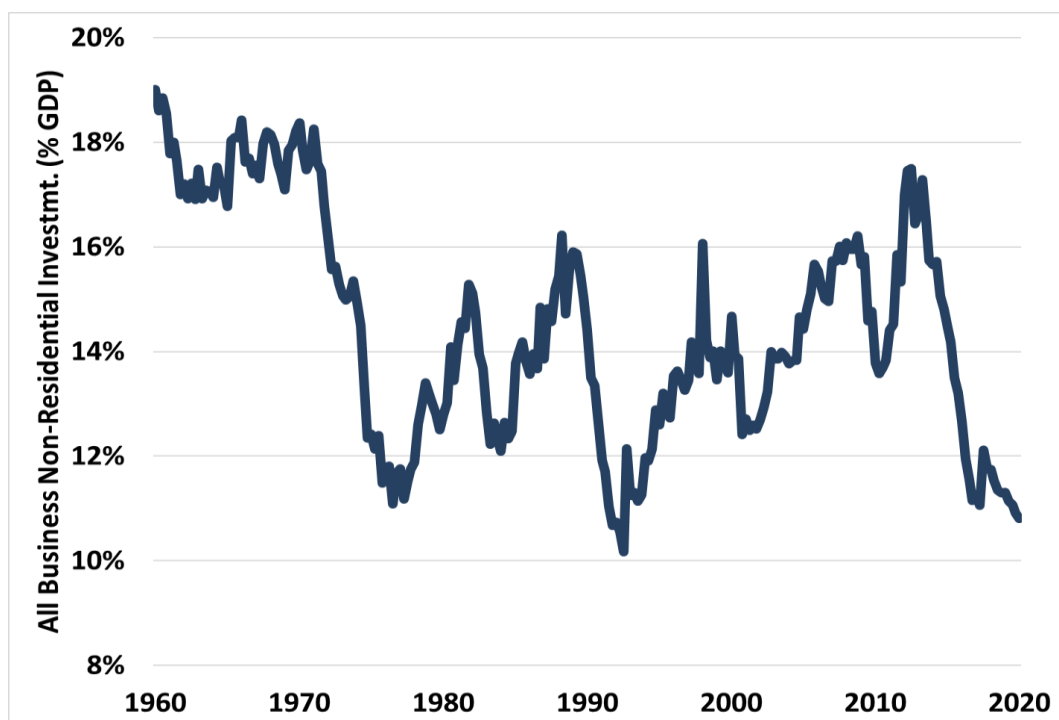
Today, with endemic insecure work and underemployment, the prospect that even a small number of jobs might be replaced by machines – despite the historically sluggish pace of actual business investment in machinery – has shifted public attitudes considerably. Today Australians are more likely to view automation as just one more reason to worry about the future of their jobs. This is doubly unfortunate. First, it foregoes the potential benefits to their lives (higher wages, safer jobs, more leisure time) that could be supported by automation: *if* the process was managed correctly and fairly, Second, it misdiagnoses the source of the current insecurity and hardship faced by so many workers in Australia. The lack of stable, decent work, with normal increases in wages, is not attributable to automation and mechanisation (which have slowed down, not sped up). These problems reflect other causes, especially changes in labour and economic policy that have undermined the capacity of Australian workers to find and keep decent work.

EXHIBIT 3: SLOWING BUSINESS CAPITAL SPENDING IN GENERAL

The preceding data indicates that the commitment of Australian businesses to modern technology (reflected in their investments in both intangible intellectual property and tangible machinery and technology) has weakened markedly over the past decade, even as popular hype about the incredible feats of robots and artificial intelligence reached a fever pitch. That slowdown in high-technology investments parallels a broader trend in business capital spending of all kinds – including on more conventional capital assets such as buildings and structures. This similarity in the trajectory of all forms of business investment is important to recognise, because it will inform and shape our conclusions regarding the causes of weak business investment and possible policy responses.

Figure 3 illustrates the trend in all forms of business non-residential capital spending: including structures, machinery, R&D, software, and other smaller categories of investment spending.⁵

Figure 3. Business Investment in Non-Residential Capital



Source: Author's calculations from ABS Catalogue 5206.0, Table 2.

⁵ The data on total business investment includes several small categories such as plants and seeds, mineral exploration, and artistic originals.

During the initial vibrant economic expansion of the postwar era, business investment averaged 18% of national GDP each year. Business capital spending certainly fluctuated with macroeconomic conditions (including major downturns associated with recessions in the mid-1970s, early 1980s, and early 1990s). But in general, business capital spending was a reliable and powerful engine of growth and job-creation; it also facilitated structural change in the economy, the emergence of new industries, and the application of new technologies.

After the harsh recession of the early 1990s, business investment gradually recovered, and got even stronger in the latter years of the 2000s and early 2010s – interrupted only temporarily by the Global Financial Crisis in 2008-09. Huge investments in resource extraction projects (such as very expensive LNG facilities) were a major source of investment injections in those years. After 2013, however, business investment shifted into negative gear. Since peaking in 2012 at 17.5% of GDP, business investment has fallen by over one-third, to below 11% of GDP by end-2019. The sharp contraction in business investment over the past several years reflects the completion of major resources projects, the decline in global commodity prices (which discouraged further resource investments), and the more generalised failure of businesses in non-resource sectors to step up their own capital spending effort.

Note that the downturn in capital spending since 2013 pictured in Figure 3 does not (yet) include the deeply damaging effects on business spending that will result from the COVID-19 pandemic and resulting recession. There is no doubt that business investment declined sharply as the recession took hold in Australia (likely falling below 10% of GDP, setting a new post-war record low), and is likely to remain weak for some years to come. Australian business investment was already historically weak even before the pandemic; things will certainly get worse in the years ahead. This means the sluggish implementation of new technologies in Australia's economy will become a long-lasting feature of our economy.

EXHIBIT 4: AUSTRALIA LAGS THE WORLD IN R&D

It is not just that the pace of research and technology investment in Australia is now slower than it has been in the past. International data confirm that Australian innovation activity is lagging increasingly behind benchmarks set in other industrial countries. Until recently, Australia was recognised for its sophisticated and successful research and innovation capacities. But as indicated above, Australia's R&D commitments (especially business research spending) have been declining over the last decade. Australia's research investments are now significantly smaller than typical for other industrial countries, and the gap is growing.

Table 1 reports consistent international data on total R&D spending: including spending by businesses, government and higher education institutions. In 2017 (most recent data available) Australia ranked 18th among the 36 industrial countries that belong to the OECD, and Australia's combined R&D spending (1.79% of GDP that year) was one-quarter smaller than the OECD average (2.37%). Of the OECD countries that spend less on R&D than Australia, most are the less developed economies of Latin America and Eastern Europe. Relative to the leading industrial countries of Western Europe, North America, and Asia, Australia compares even more poorly.

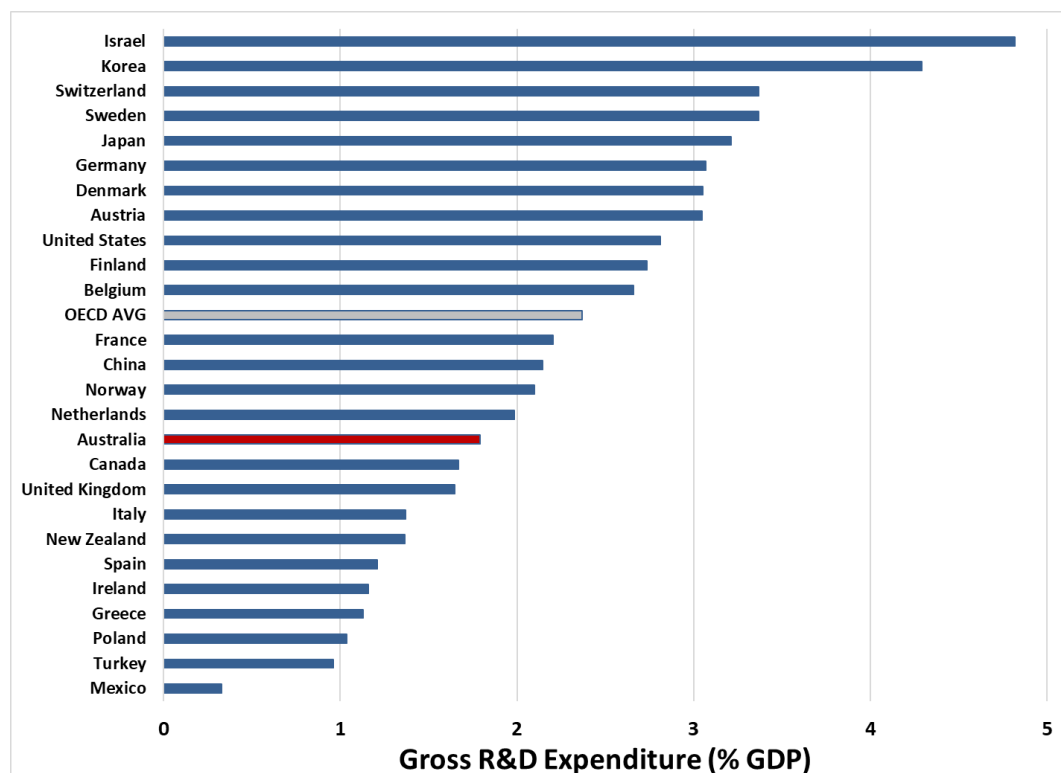
Table 1 R&D Spending, OECD Countries & China, 2017					
Country	Gross R&D Spending 2017 (%GDP)	Change Since 2010¹ (% pts)	Country	Gross R&D Spending 2017 (%GDP)	Change Since 2010¹ (% pts)
Australia	1.79	-0.39	Latvia	0.51	-0.10
Austria	3.05	0.32	Lithuania	0.90	0.11
Belgium	2.66	0.60	Lux.	1.27	-0.23
Canada	1.67	-0.16	Mexico	0.33	-0.17
Chile	0.36	0.03	Neth.	1.98	0.28
Czech Rep.	1.79	0.45	NZ	1.37	0.11
Denmark	3.05	0.13	Norway	2.10	0.45
Estonia	1.28	-0.29	Poland	1.03	0.31
Finland	2.73	-0.97	Portugal	1.32	-0.22
France	2.21	0.03	Slovak Rep.	0.89	0.27
Germany	3.07	0.34	Slovenia	1.87	-0.18
Greece	1.13	0.53	Spain	1.21	-0.15
Hungary	1.33	0.19	Sweden	3.37	0.19
Iceland	2.10	-0.31	Switz.	3.37	0.18
Ireland	1.16	-0.43	Turkey	0.96	0.16
Israel	4.82	0.88	UK	1.65	0.00
Italy	1.37	0.15	US	2.81	0.08
Japan	3.21	0.08	OECD Avg.	2.37	0.09
Korea	4.29	0.98	NB: China	2.12	0.43

Source: Author's calculations from OECD, Main Science and Technology Indicators.

1. Or closest year when 2010 data unavailable.

The significant decline in Australian R&D spending over the last decade has widened the gap between Australia and other industrial countries. Australia experienced the third worst decline in R&D spending since 2010 of the 36 countries included in Table 1 – with the combined R&D effort by all sectors shrinking by 0.39 percentage points of GDP (equivalent to about \$8 billion in reduced spending in current-dollar terms). Only Finland and Ireland experienced more significant reductions in the share of R&D spending relative to GDP (and technology-intensive Finland still invests almost a full percentage point of GDP more than Australia). Meanwhile, other innovation leaders like Korea, Germany, Japan and the U.S. are widening their technological lead over Australia. Once a world leader in innovation, Australia now lags the average of industrial countries (as illustrated in Figure 4), and is fading further back.

Figure 4. R&D Spending Relative to GDP, OECD Countries, 2017



Source: OECD Main Science and Technology Indicators

Even some emerging economies now invest more in R&D than Australia. For example, Table 1 reports R&D spending in China, which allocated 2.12% of GDP to new research in 2017: a substantial increase since 2010, and vaulting that country past Australia in the global innovation ranking. Australians tend to think of China as a source of ‘cheap labour’ and international tourists and students. But increasingly, if Australia does not quickly step up its own innovation effort, we will be surpassed by China in the quality and capability of technology.

Australia's weakening research effort is relevant to the future job security of Australian workers, but in an unexpected way. The superior innovation performance of other countries has not translated into mass technology-induced unemployment there. To the contrary, world leaders in automation (like Germany, Korea and Japan) have demonstrated stronger labour market outcomes: with lower unemployment than Australia, and steadily rising wages. Far from causing widespread job loss and dislocation, global experience indicates that developing and implementing advanced technologies can contribute to better labour market performance: by enhancing competitiveness in international trade, facilitating improved productivity (and hence, potentially, lifting wages), and facilitating the acquisition of advanced skills. Of course, none of those positive outcomes happen automatically: they must be deliberately targeted with direct application of appropriate macroeconomic, labour and skills policies (including measures to facilitate smooth transitions in workplaces as technology is rolled out, and strategies to ensure that the benefits of automation and higher productivity are fairly shared across society). In this light, it is clear that the problems faced by Australian workers do not stem from too much automation. More likely, they are due (at least in part) to the *failure* of Australian innovation and investment policies.

EXHIBIT 5: GOOD ROBOTS ARE HARD TO FIND (IN AUSTRALIA)

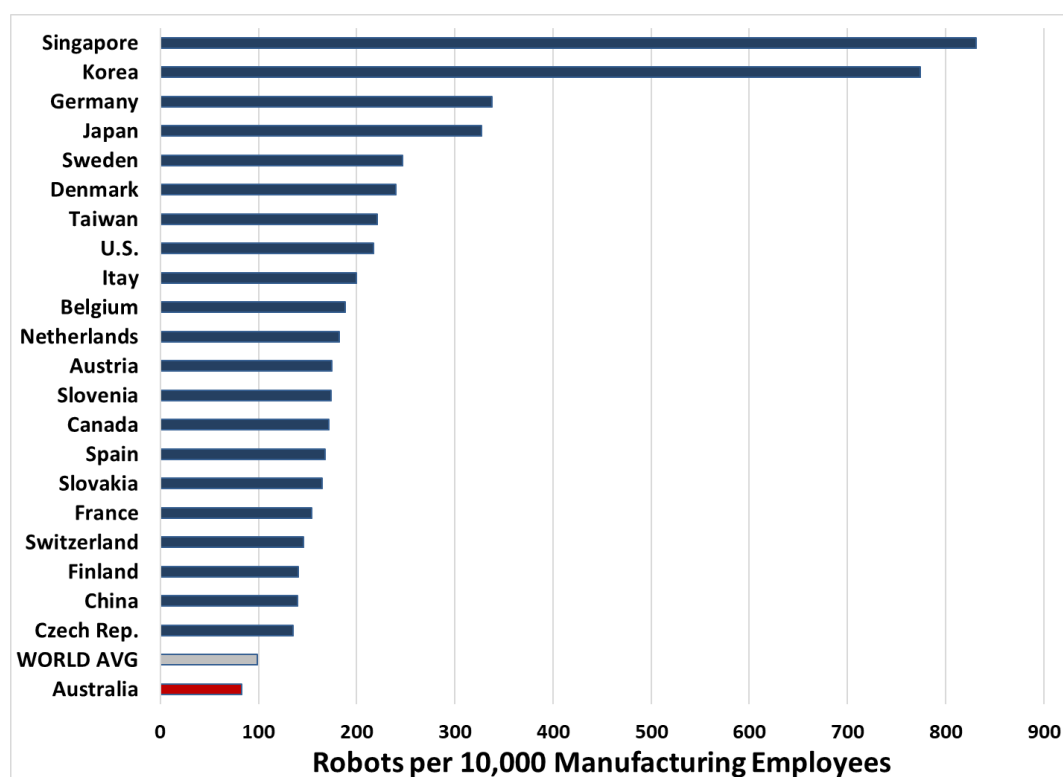
This discussion about automation and mechanisation has so far referred to the general application of new technologies, ultimately embodied in new machinery and equipment, to enhance the capacity and productivity of work. Robots are just one specific example of labour-saving or labour-replacing technology: a programmable machine which can conduct relatively complex tasks, involving motion and manipulation of other objects. Robots are not, of course, the only way jobs could be replaced by machines. But the prospects of workers losing their jobs, replaced by robots which can do the work faster and more accurately, is evocative of broader popular fears about machines 'taking over', and exerts a powerful influence in popular culture.

But if we focus the analysis of automation more specifically on actual robots, it turns out that Australian workers have very little to worry about. To the contrary, once again it seems that the deeper problem is the slow pace of innovation in automation and robotisation by employers, rather than the reverse. Figure 5 illustrates comparative

international data from the International Federation of Robotics, which gathers information on the installation of industrial robots in countries around the world.⁶

The Federation's statistics indicate an accelerating shift to robot-based technology in manufacturing operations in many countries. Annual installations of industrial robots more than doubled between 2013 and 2018, with an estimated 422,000 new robots installed worldwide in 2018. About 1.8 million robots were installed from 2013 through 2018, inclusively. The Federation expects installations to continue growing at an annual rate of 10% or more, reaching over 600,000 by 2022 (although that forecast, of course, will be affected by the COVID-19 pandemic and worldwide recession).

Figure 5. Worldwide Use of Industrial Robots.



Source: International Federation of Robotics (2019).

The problem is not that the accelerating use of actual industrial robots (now used commonly in a range of manufacturing sectors, including automotive, electronics, and food processing) is displacing Australian workers from their jobs. A more obvious problem, rather, is that very few of those robots are being used in Australia. Australia ranks well down the ladder among countries in its use of industrial robots. This reflects

⁶ The IFR also conducts research into the use of robot-like devices in various consumer and home-based applications, but the implications of these products for employment and labour markets seem less worrisome.

the deeper weakness in innovation and technological capabilities among Australian firms, described above.

There were almost 2.5 million installed industrial robots in use in various countries around the world in 2018, based on IFR data. Figure 5 lists the 15 countries with the greatest use of industrial robots, ranked by the number of robots in use per 10,000 manufacturing workers. Singapore and Korea lead all countries in use of robots, with around 800 robots for every 10,000 workers. Germany and Japan also have relatively widespread robot use (over 300 robots per 10,000 workers), followed by other technology-intensive manufacturing countries (such as Sweden, Denmark, Taiwan, the U.S., and Italy).

The worldwide average utilization of robots in 2018 was estimated at 99 robots per 10,000 workers. Figure 5 indicates that Australia is not anywhere near the leading edge of robot use in the world. In 2017 (most recent data for Australia), Australia had just 83 industrial robots in service for each 10,000 manufacturing workers. That implies only around 7000 industrial robots in use in the whole country – about 0.3% of the world total use of robots. Australia's use of robots pales to that in industrial powerhouses such as Korea, Germany and now China (which had 650,000 industrial robots in use by end-2018, despite China's supposed abundance of 'cheap' labour).

The countries which lead the world in use of robots in production, also lead the world in exports of sophisticated, high-value manufactured products. Those countries also uniformly demonstrate consistently stronger labour market outcomes than Australia (with lower unemployment and faster wage growth), in part precisely because of their more successful interaction with global trade.

The fact that the robotics revolution has largely bypassed Australia attests to the broader weakness in the innovation capacity of Australian industry, and its failure to invest in new technologies and advanced products. Instead, Australia continues to rely on the basic extraction and export of unprocessed raw materials to pay our way in world trade – while tolerating a trade deficit in manufactured goods that reached \$180 billion in 2019.⁷ To be sure, there has been some applications robotic technology in other sectors in Australia, including resource extraction (such as self-driving heavy trucks and trains), with some implications for employment patterns and transitions.⁸

⁷ See Stanford (2020) for details on the imbalance in Australian manufacturing trade and its consequences.

⁸ It is hard to conclude that this modest use of automated technologies in mining has had a significant impact on total labour demand, but it has certainly affected the location and nature of employment – with on-site drivers and machine operators replaced, to a limited extent, by remote technicians and computer operators.

But on the whole, the application of robotic technology in Australia has been virtually invisible. Meanwhile, Australia's manufacturing industry has shed some 200,000 jobs since the turn of the century, despite (or in part *because of*) its very slow adoption of new automated technologies. The shut-down of mass automotive manufacturing in Australia (one of the most robot-intensive sectors) has certainly contributed to the relatively scarcity of robot use in domestic industry.

Robots are just one relatively specialized dimension of the broader phenomena of automation and mechanisation, but they are an important indicator of the general technological capacity of both firms and countries. And Australia's poor record in adoption of robots is a microcosm of more general failures in innovation and investment. On the whole, it is clear that the failure to use robots (and other advanced productive technologies) has undermined the quantity and quality of work in Australia, much more than robots have displaced workers from their jobs.

EXHIBIT 6: THE CAPITAL-LABOUR RATIO IS FALLING

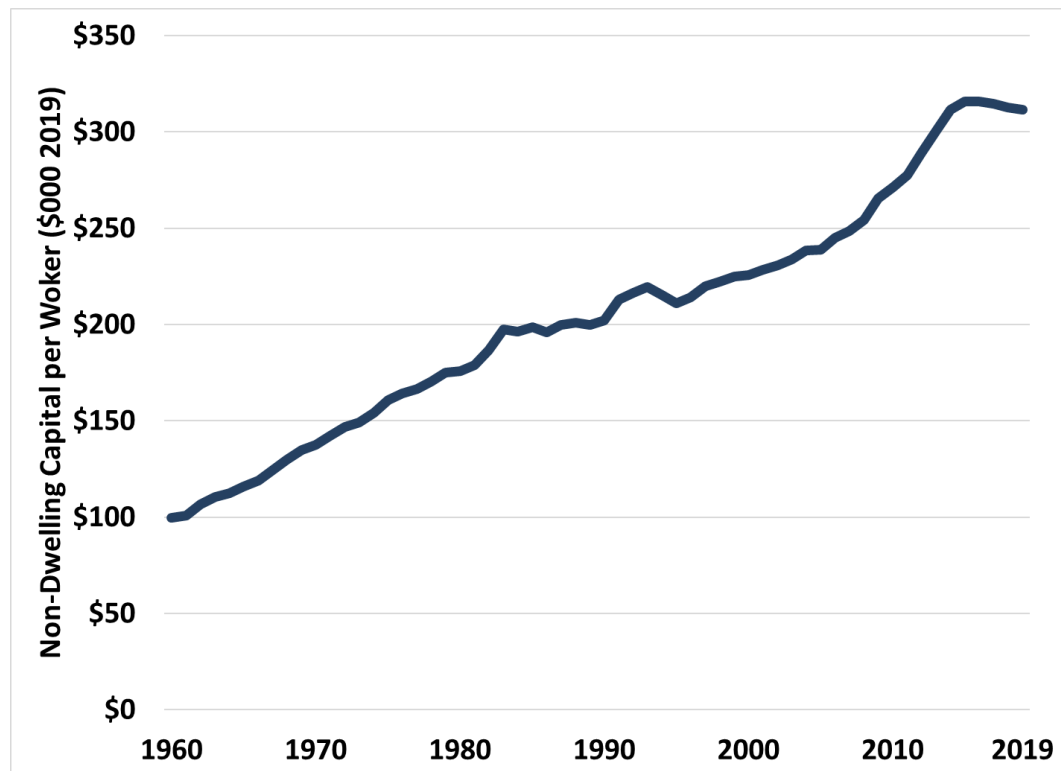
If workers were truly being replaced by machines, this should have an unambiguous impact on the relative proportions of tangible capital and labour employed in production. Automation implies substantial increases in the amount and value of machinery in use. If it replaces labour (rather than complementing it, as some forms of technology do), then the number of human beings employed would also decline. The ratio of capital to labour used in the economy (which is a broad indicator of the sophistication of production) should thus rise for two reasons: both because the numerator rises, and because the denominator shrinks.

Curiously, this has not been occurring in Australia in recent years. To the contrary, the aggregate ratio of capital to labour in use in the economy has actually been declining since 2016. This is an unprecedented development in Australia's postwar economic history, and suggests deep structural weakness in the process of investment and technological change in the broad economy.

Figure 6 illustrates the aggregate ratio of Australia's real net capital stock (measured after adjusting for depreciation of older assets, and expressed in inflation-adjusted terms) to the number of Australians employed. Following the post-2013 slowdown in new capital investment (influenced heavily by reduced resource investment), the net capital stock (after depreciation) stagnated. Yet employment continued to increase during this time – led by the creation of relatively low-wage jobs in low-technology private service sectors (such as retail and hospitality). Employment was increasing

faster than the overall stockpile of capital. Since 2016, the overall capital-labour ratio in the economy has declined for three straight years, falling by a cumulative 1.4% over that period.

Figure 6. Aggregate Capital-Labour Ratio



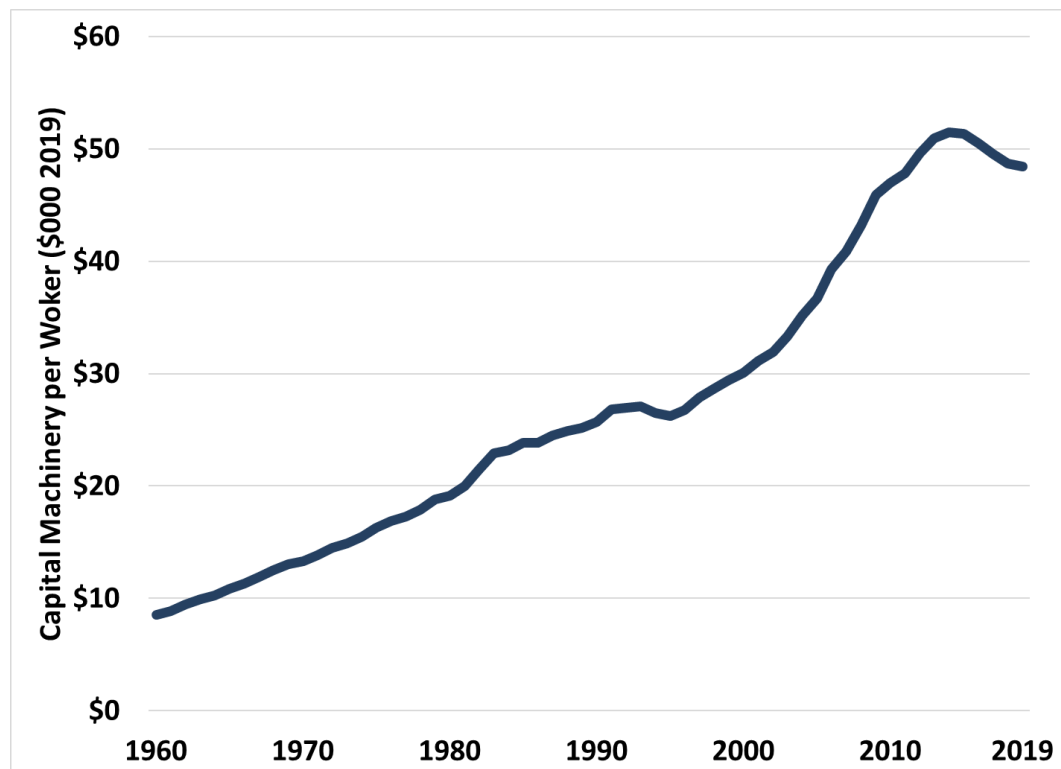
Source: Author's calculations from ABS Catalogues 5204.0, Table 63, and 6202.0, Table 2, and Reserve Bank of Australia (1996), Table 4.3.

The whole process of general economic development consists of the accumulation and use of more capital and technology in production over time: both tangible capital (like structures and machinery), intangible capital (knowledge and software), and human capital (skills and education). For a developed country to experience a sustained decline in the amount of capital used in production relative to labour is unusual and worrisome. It has never happened before in Australia's postwar history.⁹

⁹ As is visible in Figure 6, the aggregate capital-labour ratio did fall for two years following the end of the 1991-93 recession, due to a strong rebound in employment levels after that downturn. But that was clearly a temporary cyclical effect, quickly replaced by the resumption of steady increase in capital-intensity typical of the postwar era. The current downturn in the capital-labour ratio has lasted longer, was preceded by some years of very slow growth, and occurred in non-recessionary conditions. It is hence both more unusual and more concerning.

Figure 7 illustrates a similar calculation focusing on the use of machinery and equipment in production in Australia, relative to the use of human labour. This is a more focused measure of the intensity of machinery use (rather than all forms of capital). This ratio should presumably be closely associated with labour displacement: according to the standard ‘robots are coming’ narrative, if humans are being replaced by machines, this ratio should be rising rapidly.

Figure 7. Net Machinery and Equipment Capital per Worker



Source: Author's calculations from ABS Catalogues 5204.0, Table 63, and 6202.0, Table 2, and Reserve Bank of Australia (1996), Table 4.3.

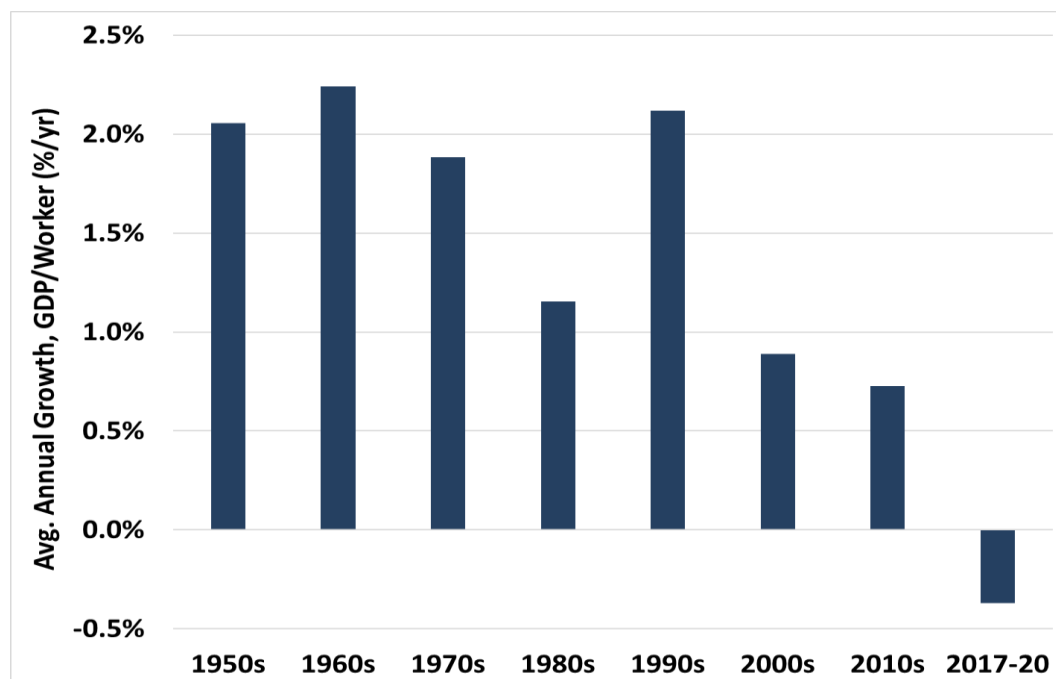
However, in the case of machinery and equipment, this historic U-turn in the long process of capital accumulation is more evident, and it started sooner. After quintupling during the half-century from 1960 through 2010, the stock of real machinery and equipment per worker peaked in 2014, and then turned down. The machinery-labour ratio has since declined by a cumulative 6%. In other words, the typical Australian worker uses 6% less machinery and equipment to do their job with today, than they did in 2014. So much for robots taking our jobs: to the contrary, it seems that brute labour is enhancing its role in the productive process. And for anyone concerned with the long-term prospects of economic development, innovation, and prosperity, this is not a good sign at all.

EXHIBIT 7: PRODUCTIVITY GROWTH HAS NEVER BEEN WORSE

One obvious implication of the slowdown in innovation, investment, and mechanisation which is confirmed by the preceding data, is an expected deceleration of productivity growth. Productivity measures the amount of real value-added which can be produced by a typical worker in a given period of time. It depends on many different factors, but one of the most important is the stock of technology which workers use to supplement their labours. Workers cannot do much with their bare hands. But if they are able to use sophisticated technology and machinery in the course of their work, productivity will increase.

If automation and mechanisation were truly having labour-displacing effects (whereby machines were replacing workers in production), labour productivity growth would unambiguously accelerate. More output with fewer workers implies rapid increases in productivity. Once again, however, the concrete empirical experience of Australia's economy confirms this is not occurring. To the contrary, labour productivity growth has notably slowed in the last decade. More startling, in recent years it seems to have shifted into reverse: since 2017 the amount of real output produced by the typical Australian worker is now *declining*.

Figure 8. Labour Productivity Growth by Decade



Source: Author's calculations from ABS Catalogues 5206.0, Table 2, and 6202.0, Table 1, and Reserve Bank of Australia (1996), Tables 4.3 and 5.2.

Through the long postwar expansion, real labour productivity in Australia grew at an average of about 2% per year. This provided a real underpinning for the sustained increases in wages and living standards that were enjoyed in the postwar era: real wages doubled in Australia between 1950 and the 1980s. Of course, higher labour productivity is no guarantee of higher real wages; whether higher output translates into higher incomes for workers depends entirely on the institutional and economic balance of forces in the economy, which shape the extent to which workers are able to win higher wages reflecting the improved efficiency of their labour. The emphasis on inclusive growth, collective bargaining, and strong labour standards that typified Australia's 'fair go' economy of the postwar era was just as important in real wage growth as was the strong pace of productivity growth. In other words, productivity growth is a necessary but not sufficient component of this virtuous process.

Productivity growth was somewhat weaker during the turbulent 1980s, but regained the 2% postwar average pace during the 1990s. Since the turn of the century, however, labour productivity growth has slowed significantly: falling below 1% per year during the 2000s (half the average pace of the postwar era), and then further still since 2010. Several factors account for the marked slowdown in real productivity growth in Australia's economy since 2000:

- The significant slowdown in the pace of business investment in innovation and machinery, described above.
- The shift of overall output in Australia's economy toward private services industries and resource extraction. Private services have relatively low levels of productivity. Resource industries have high output per worker, but productivity tends to decline over time (as more easily-extracted reserves of minerals are exhausted, and more inaccessible and expensive resources are exploited).
- The erosion of previously strong labour standards and workplace protections, which have allowed employers more freedom to profitably employ labour in relatively low-productivity, insecure, poorly-paid jobs.

Shockingly, average productivity per worker in Australia's economy has actually declined in the last three years (as indicated by the furthest right bar in Figure 8), at an average annual rate of almost 0.4% per year. This decline in productivity, which is very unusual, corresponds closely with the parallel decline (illustrated in Figure 7) in the real value of machinery and equipment used by the average Australian worker. The failure of Australian businesses to invest in new technologies and ideas, and to put those ideas into practice through investments in tangible machinery and capital, is an

important cause of the worrisome stagnation (and more recently, outright decline) of productivity in Australia.

Discussions over productivity in Australia tend to quickly become very ideological in nature, with competing stakeholders advocating long-held policies and preferences on the basis that they will purportedly improve efficiency and productivity. In particular, business lobbyists routinely demand more deregulation, deunionisation and lower taxes – claiming those changes will ultimately enhance the efficiency of their businesses, and consequently drive overall economic progress. But the evidence provided above suggests that weak productivity performance is closely correlated with the failure of Australian businesses to invest in innovation and capital equipment. Instead of blaming unions, red tape, and taxes for poor productivity, business lobbyists should look in the mirror.

From the perspective of Australian workers, the slowdown and reversal in labour productivity growth strongly refutes the notion that labour is being replaced by machines in any aggregate sense. If that were true, productivity growth would have to accelerate, by definition, and the capital-labour ratio would unequivocally grow. But the stagnation of investment and consequent slowdown of productivity growth is certainly not good news for workers – even if it does ease fears about widespread technological unemployment. The lack of productivity improvement will exacerbate distributional struggles, and will reinforce the unprecedented stagnation in real wages in Australia that has been evident since 2013.¹⁰ It undermines the international competitiveness of Australian exports, and corresponds to the continuing shift of employment toward low-tech, poorly-paid jobs, especially in private service industries. Fears about mass technological displacement of workers by robots are clearly not justified by empirical evidence of Australia's recent economic performance. But the absence of automation has likely contributed to (and at minimum is strongly associated with) the evident and painful deterioration in the quality and productivity of so many jobs.

EXHIBIT 8: MOST NEW JOBS ARE IN LOW-TECH INDUSTRIES

Across the whole economy, private business investment in R&D spending equals 1% of national GDP. As noted above, that's relatively low by international standards – and the research effort of Australian business has faltered badly over the last decade.

¹⁰ For detailed discussion of the wages slowdown, its causes, consequences, and potential policy responses, see Stewart, Stanford and Hardy (2018).

However, there are five broad sectors of the economy which do relatively better in investing in innovation, beating that national average; these five sectors are listed in Table 2. The most innovation-reliant sector of the economy is manufacturing (which invested 4.4% of sector GDP in research), followed closely by professional, scientific

Table 2 Innovation Intensity and Job-Creation			
	Business R&D Investment (\$b, 2017-18)	R&D as Share Sector Value-Added (%)	Change Employment, 2014-19 (000)
Manufacturing	\$4.6	4.4%	-27.0
Pro./Science/Technical	\$5.1	4.2%	211.6
Finance	\$2.8	1.8%	38.3
Info./Telecom.	\$0.6	1.4%	5.8
Wholesale Trade	\$0.9	1.3%	7.5
Sub-Total: Higher-Innovation Private	\$14.1	2.8%	236.1
Arts & Recreation	\$0.1	0.8%	42.1
Utilities	\$0.4	0.8%	13.1
Mining	\$1.0	0.8%	-1.2
Agriculture, Forestry & Fishing	\$0.3	0.7%	6.2
Other Services	\$0.2	0.5%	30.3
Rental	\$0.2	0.4%	-4.2
Retail Trade	\$0.2	0.3%	40.7
Administration	\$0.2	0.3%	58.9
Construction	\$0.3	0.2%	146.6
Transportation	\$0.1	0.1%	68.3
Accommodation & Food Serv.	\$0.0	0.1%	125.0
Sub-Total: Lower-Innovation Private	\$3.1	0.3%	525.8
Public Admin.	\$0.0	na ¹	102.4
Education	\$0.1	na ¹	157.5
Health Care	\$0.1	na ¹	333.6
Sub-Total: Public Sector	\$0.2	na¹	593.5
Total Economy	\$17.4	1.0%	1355.4
Source: Author's calculations from ABS Catalogues 8104.0, 5204.0, and 6291.0.55.003. 1. Most R&D investments in these primarily public sector industries are financed by government and public agencies, and hence the small ratio of private R&D spending to sector GDP is not a meaningful indicator of the innovation-intensity of these sectors.			

and technical services (4.2%). In fact, those two sectors alone account for over half of all R&D spending by Australian businesses. Other sectors which beat the national average (but by less impressive margins) include finance; information, media and telecommunications; and wholesale trade (which uses new technology in logistics and supply chain systems). The average R&D intensity of these five high performing sectors is 2.8% of GDP.

In contrast, the other industries in Australia's broader private sector make relatively weak investments in new research and technology, falling well below the national 1% average benchmark. These sectors include private service industries like retail, hospitality, and personal services. But some goods-producing sectors, such as mining and construction, also make undersized investments in new research and technology. On average, these 11 lower-innovation private sector industries invest just 0.3% of sectoral GDP in new R&D.

Conventional wisdom holds that the jobs of the future lie in technology-related industries and occupations. If that were the case, then we would assume that higher-innovation sectors of the economy would be leading the pack in job-creation. But in fact, the reverse is true. Lower-innovation private-sector industries created more than twice as many jobs over the past five years, as higher-innovation sectors. The five strong R&D performers created 236,000 net new jobs between 2014 and 2019.¹¹ Almost all of those new jobs were in the professional, scientific and technical services industry. Ironically, the manufacturing sector – the most innovation-intensive part of the whole economy – actually shed workers during this time.

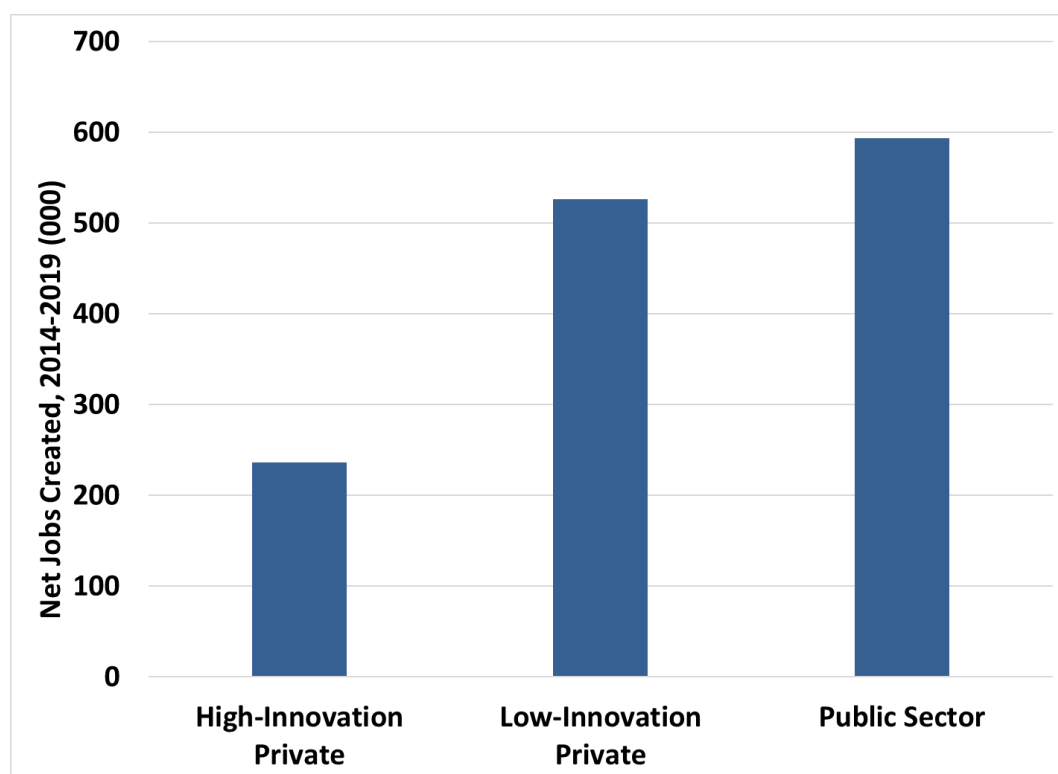
On the other hand, the industries with below-average innovation created a combined total of 525,000 new jobs in the same period. In fact, the three biggest job-creators in that group of 11 lower-innovation sectors (construction, transportation and hospitality) also demonstrated the weakest innovation investments of all 11: with R&D spending equal to just 0.1%-0.2% of sector GDP. Within the private sector of Australia's economy, therefore, overall employment is shifting toward less technology-intensive jobs and industries. A large majority of new private sector jobs are arising in low-tech industries – where average wages are low, jobs are very insecure, and innovation is not a central feature of business strategy

Perhaps surprising to some observers, by far the strongest rates of job-creation occurred in the three broad sectors of the economy that are dominated by public and

¹¹ These figures compare annual average employment for 2014 and 2019, and do not reflect the downturn in employment in 2020 associated with the COVID-19 pandemic.

non-profit services: health care and social services, education, and public administration.¹² These sectors of the economy created almost 600,000 new jobs in that same five-year period – 44% of all net new positions over that 5-year period. Some activities within these broad public sector industries demonstrate very high rates of research and innovation investment, such as higher education and health care. But most of that innovation is funded via public investments and grants; very little is financed by private firms (and hence the R&D data reported in Table 1 are not a meaningful indicator of the innovation intensity of these public sector industries).

Figure 9. Net Job Creation and Business R&D



Source: Author's calculations as described in Table 2.

Figure 9 summarises the surprising composition of job growth in Australia, during this “most exciting” era of business innovation and creativity. It is simply not true that the ‘jobs of the future’ will be found in high-tech, innovation-intensive undertakings. In reality, far more jobs are being created in more mundane, typically poorly-paid functions: waiters and baristas, retail clerks, drivers, and cleaners. The shift in aggregate employment toward those lower-innovation, lower productivity sectors is one of the factors behind Australia’s very poor aggregate performance on productivity

¹² There are some private firms operating in these sectors, but the overwhelming majority of production occurs via public, non-profit and community agencies.

and capital investment. And the source of greatest strength in Australian employment patterns has no direct relationship at all to private sector innovation activity: public services have generated the strongest job gains of any part of the national economy. While many public sector functions embody new technology and innovation, the expansion of this form of work owes more to the desire of Australians to consume high-quality public services – not to any technological imperative.

The traditional assumption that the best career prospects for young Australians in the future will be found in high-tech innovative industries must be reconsidered. In fact, the greatest source of new work will be in public, human and caring services. In the private sector, future Australian workers are much more likely to be employed in relatively low-tech (and often low-wage) jobs in industries like hospitality and personal services. This reconsideration of future employment patterns has obvious and important implications for many areas of economic and labour market policy, to which we now turn.

Implications for Policy

The preceding analysis provides a surprising counter-narrative to the stereotypical conception that the future of work will be centrally determined by the accelerating onward rush of technology. To be sure, robots can do incredible things – assembling Ikea furniture, preparing and baking pizzas, delivering packages right to your doorstep – in controlled laboratory settings. But their ultimate use in the real-world economy depends on many other factors: including management talent, ambition and capacity; capital market and financial conditions; broader macroeconomic trends; the skills and capacities of workers; regulations and infrastructure; and global economic conditions. For all these and more reasons, the sad reality is that Australian businesses are failing miserably to put the full potential of these technologies into motion. Business-friendly policy reforms (like deregulation, privatisation, deunionisation, and globalisation) have not solved this failure; more likely they have exacerbated it.

The end result is an economy that, by several important measures, has stopped advancing, and may even be going backward. And that surprising qualitative regression was visible long before the COVID-19 pandemic, which can only have exacerbated the weakness of Australian business investment and innovation. Australia is falling further behind other countries in the pace of innovation. Capital-intensity and productivity are both shrinking, rather than growing. A growing share of Australians is employed in relatively menial, low-tech, poorly-paid and often-insecure jobs: in sectors like retail, hospitality, and personal services. The dystopian vision of mass technology-induced unemployment is certainly not coming true. But what we are getting instead is equally discouraging.

The failure of business investment and innovation in Australia underpins the worrisome trends in all of the indicators identified above. Hence, a comprehensive policy response to these issues must focus on measures to boost the pace of innovation here, to apply new ideas and technologies more ambitiously in the real economy, and to equip Australian workers to fill the jobs required in those new functions – and to share equitably in the resulting economic gains. Here are several of the broad policy implications suggested by the preceding analysis:

SKILLS MATTER, BUT IN UNEXPECTED WAYS

In contrast to the common advice that acquiring more skills is the ‘magic bullet’ for success in the future high-tech labour market, it is not obvious that Australia’s economy has actually become more skills-intensive. Relatively few jobs have been created in the most technology-intensive industries and occupations. More jobs have been created in relatively low-tech sectors, where innovation has been very slow: like retail, hospitality, and personal services. Individuals with higher education certainly have better employment outcomes. But that could reflect the role of credentialisation and ‘degree inflation’ in assisting better-educated individuals to successfully land scarce jobs. This does not prove that their higher skills are actually required to perform the functions they were hired for.

Meanwhile, the idea that significant numbers of positions are going unfilled because of a lack of adequately-skilled applicants has been debunked.¹³ The notion that individuals can protect themselves by choosing higher education in specific technical skill categories (such as engineering, computer programming, or maths) is also questionable. Some evidence indicates that employers actually value a broader and more flexible array of skills (including ‘soft skills’ such as communication, problem solving, and teamwork) rather than any specific technical attribute. This is especially relevant given that technological change can render specific technical skills (like particular programming languages) obsolete very quickly.

So investing in more skills should not be seen as a panacea for improving employment outcomes in a time of technological transition. Stronger skills programs (especially in vocational education), and improving pathways for skilled graduates into jobs that use those skills, can certainly play a role in facilitating the expansion of high-tech industries. But that strategy should be seen as just one element of a broader portfolio of strategies, that must be focused on the overarching goal of stimulating the creation of higher-skill jobs (and the industries that create them). Merely possessing valuable skills means little if jobs are not available that use those skills. The evidence above indicates that Australia’s poor performance in investing in innovation, and building industries that use new knowledge and technologies intensely, is the primary constraint on applied technological progress in Australia, not a lack of skilled workers.

¹³ See, for example, Pennington and Stanford (2019), who provide empirical evidence that reported skills shortages in specific occupations have abated significantly since the global financial crisis.

CAPITAL INVESTMENT IS TOO SLOW, NOT TOO FAST

The evidence is clear that there is no wave of all-knowing machines penetrating Australia's economy, displacing human beings and creating massive adjustment and unemployment problems. To the contrary, technical progress in the real economy was faster in previous decades than more recently. Over the last decade the pace of investment in new machinery and equipment (including robots) in Australia has been positively glacial.

Underinvestment in innovation (both intangible knowledge and tangible technology) is part of a bigger problem of slowing capital investment in Australia. Since the peak of the resources boom in 2013, capital spending has declined by over one-third (relative to GDP) – and that was before the onset of the COVID-19 pandemic and resulting recession. Traditional business-friendly measures like deregulation, lower taxes, tax preferences for certain kinds of investment (such as mining and property development), restrictions on union activity, other efforts to suppress labour costs, outsourcing and privatisation of public services, and others, have not arrested the decline in investment spending. Indeed, by cheapening relative labour costs and undermining consumer incomes (and hence aggregate demand), these measures may have discouraged investments in more genuinely innovative products and processes.

Business lobbyists are once again pressing hard for significant reductions in company tax rates, arguing that will be crucial in revitalizing business capital spending of all kinds in Australia. But the evidence is weak that across-the-board tax cuts, with no conditions regarding Australian reinvestment of resulting savings, will have any noticeable impact on the investment effort of Australian businesses.¹⁴ There are many other, more promising policy options for eliciting more real investment effort from Australia's business sector, than has been forthcoming under the present business-friendly, 'trickle-down' approach.

For example, fiscal measures would have more effect on investment spending if they were tied directly to incremental investment decisions. Proposals like accelerated depreciation for capital investment or investment tax credits would be more effective in mobilising additional funds into new commitments for capital assets. Those measures can be tailoured to provide maximum incentive for investment in particular

¹⁴ For reviews of the evidence regarding the weak impact of general business tax reductions on investment spending, see Richardson (2017) and Stanford (2017).

strategic assets – such as advanced machinery and equipment, robots, and other cutting-edge technologies.

In many cases, direct participation by public financial sources can motivate and accelerate investment in desired sectors and technologies. The Clean Energy Finance Corporation, for example, has a strong record in leveraging multiplied volumes of private capital into capital investments related to innovative renewable energy developments. Similar partnerships of public and private capital could be effective in motivating more tangible capital investment in other sectors; Australia's superannuation funds could also play a more active role in supporting these investments.

More direct public participation is also potentially valuable in eliciting a stronger R&D effort by Australian business. To date, Australia has relied mostly on tax incentives for private R&D – that are among the most lucrative in the industrial world, but have had little success in eliciting a stronger innovation effort (as noted above). International evidence suggests that countries which invest more public support directly in targeted innovation projects (or 'missions,' to use the terminology of Mazzucato, 2011) ultimately succeed in eliciting more private innovation spending than do no-strings-attached market-based incentives. There are many upcoming technologies and projects for which direct public participation would be appropriate and effective in motivating more overall innovation investment (both tangible and intangible): such as major defence equipment projects, big investments in renewable energy development, and high-value public service investments (such as health care facilities).

SECTOR COMPOSITION AND TRADE PATTERNS MATTER

An important factor in the secular decline of Australian innovation activity – measured both by R&D investments and the installation of sophisticated automated technologies – has been the long decline in the domestic manufacturing sector. Relative to the size of the domestic market for manufactured products, Australia has the most undersized manufacturing sector of any OECD countries (Stanford, 2020). That dubious status is the legacy of a generation of complacency by policy-makers and the business community – convinced (wrongly) that Australia didn't need manufacturing thanks to its abundance of natural resources.

However, the erosion of domestic manufacturing has had unexpected consequences for many other economic indicators. As indicated in Table 2, manufacturing is the most innovation-intensive sector in the economy: even today, after years of contraction,

Australian manufacturers invest a larger share of their total output back into new R&D (around 4.5% of value-added in 2017-18) than any other part of the economy. That is more than 4 times the national average for business R&D, and surpasses even the high-tech professional, scientific and technical sector. A country with a larger manufacturing base will have greater capacity to conduct R&D and other innovation, and more opportunities to apply new technologies in practical, shop-floor settings. Moreover, a sophisticated and technologically adept manufacturing sector contributes to innovation and mechanisation in the rest of the economy, too: since robots and other advanced machinery are, in and of themselves, sophisticated manufactured products, having adjacent manufacturing capabilities can thus assist businesses in any sector (including resources, agriculture, and services) in successfully applying automation in their own businesses.

There has been a resurgence of economic interest in the value of pro-active industrial policy measures, aimed at nurturing the domestic presence of industries with desirable technological, economic and environmental characteristics.¹⁵ Rather than assuming that market forces alone will guide the structure of a national economy toward an optimal sectoral composition, the consensus is now that targeted policies are beneficial in attracting and expanding desirable sectors. While industrial policy was traditional focused on large-scale manufacturing facilities, modern industrial policy can be generalised beyond manufacturing to include other sectors and activities with similar desirable attributes – with similarly positive implications for national innovation and technological performance. Any sector that is innovation-intensive, oriented toward export market opportunities, generates higher-skill and well-paying jobs, demonstrates relatively rapid productivity potential, and anchors the presence of domestic supply chains should be a candidate for targeted policy support from governments. These lessons need to be learned and implemented by Australian policy-makers, who for too long have espoused the view that governments should refrain from ‘picking winners’ – and instead rely solely on market forces and private business decisions to determine our broad industrial structure.¹⁶

International experience also affirms the value of a more inclusive and collaborative approach by government to fostering economic and technological development, rather than a ‘hands-off’ strategy which leaves major decisions to private sector actors.

¹⁵ For recent examples of this research, please see Stiglitz et al. (2013) and Rodrik (2008).

¹⁶ Of course, in practice Australian governments, regardless of their political stripe, have not been nearly so *laissez faire* in their approach to the sectoral make-up of the economy, and have been willing to provide powerful assistance to favoured industries (including powerful preferences for property development, private health insurance, new mining developments, financial sector activity, and others).

Countries with more vibrant investment and innovation records, which in turn translate into greater success in international trade and lower unemployment at home, include those with a multi-partite or corporatist approach to investment, training, and exports: including Germany and other continental European countries, Scandinavian countries, and the industrial powerhouses of east Asia (led by Japan and Korea, but now including China, Taiwan, and Singapore).

If we are to develop and foster a stronger portfolio of technology-intensive industries in Australia, and thus enhance our overall innovation and investment effort accordingly, government will need to play a more active, ambitious role in supporting investment (both tangible and intangible) in targeted sectors. In addition to supporting investment through the concrete fiscal measures described above, this will also require acting to create economic and competitive conditions receptive to the success of domestic high-tech producers: including stronger public procurement targets, meaningful efforts to stimulate exports of Australian value-added products and services (rather than relying so heavily on primary exports in our trade strategies), and integrating sector development strategies with well-resourced skills and training programs.

International trade interactions will also have to be reformed as part of a broader strategy to nurture more innovation and investment in Australia. Successful advanced manufacturing requires opportunities for export to make domestic production in specialised products economically viable; traditional reliance on simply lowering tariffs and signing free trade agreements have not been successful in stimulating Australian manufactured exports, and more likely have undermined domestic high-tech industries.¹⁷ A successful innovation and investment strategy, therefore, will also require a complementary approach to trade policy: one that effectively ensures that high-tech Australian products and services will have as much opportunity for genuine export success, as their foreign-made counterparts have so obviously enjoyed in the Australian market.

¹⁷ See Stanford (2020) for details on the negative effects of Australia's free trade agreements on domestic manufacturing.

Conclusion

It would be wrong to simply dismiss the fears of many Australians about the negative effects of automation and new technology on their job security as ill-informed or irrational – even though the empirical evidence presented above overwhelmingly suggests that automation in the real Australian economy is slowing down, not speeding up. Australian workers experience pervasive insecurity in their work lives. They are already enduring historic stagnation in wages, the steady growth of insecure and precarious work in all its forms, and the erosion of their capacity to demand and win a ‘fair go’ in an increasingly unforgiving labour market. In that context, viewing the onward march of technology as a threat rather than an opportunity is quite understandable. And there are many instances in which Australian workers have indeed lost their jobs as a result of the application of new technology in certain workplaces – and were usually left without appropriate transition supports, income protection, or opportunities for retraining or redeployment.

However, while fear of technological displacement is understandable, by digging deeper we can understand that it is the shift in the economic and institutional balance of power in our economy, not an acceleration of technology, which explains the pervasive insecurity and hardship which now characterizes Australia’s labour market. Ultimately, technology itself is neither inherently useful or destructive in its impacts on work, workers and living standards. Whether technology lifts wages and working standards, or whether it leads to displacement and surveillance, depends entirely on the social and institutional context in which new technologies are conceived, developed and implemented. The experience of Australia’s long postwar boom – when applied mechanisation was much faster than it is today – is proof positive that technological change can better our lives, so long as the economy is managed with a focus on bettering the well-being of those who work in it.

The commonly-expressed claim that robots and other forms of automation are destroying the basis for prosperity among Australian workers is factually wrong. Worse yet, it diverts attention away from more immediate and damaging threats to jobs and incomes. The pace of business investment in innovation, technology, and machinery is far too slow for Australia to fulfil its promise as a global economic leader. The recent stagnation and even decline of capital intensity, productivity and real wages are damning indictments of the failure of Australia’s business sector to fulfil its assigned role as engine of qualitative and quantitative economic development. In part because of the failure of private-sector investment and innovation, Australia’s labour market is

increasingly dependent on industries and occupations which cannot offer long-run opportunity, prosperity and sustainability. This includes our growing reliance on low-productivity low-wage private service sector jobs, and our continuing and unsustainable dependence on simplistic resource extraction to pay our way in global trade.

For all these reasons, Australia (and Australian workers) needs more investment in robots, and other forms of new technology, not less. This needed renewal of investment in technology must occur in the context of economic, labour and social policies which empower workers to share in the decision-making surrounding new technology, to defend against its potential displacing effects, and to share fairly in the resulting benefits (including better and safer jobs, higher real incomes, and more leisure time). And achieving stronger innovation and mechanisation will also require a rebalancing of economic leadership and authority. We cannot continue to rely on the autonomous decisions of profit-seeking businesses to fundamentally determine the pace of investment and innovation, in their own interests. That reliance on business-led development has left Australia with our present underperforming, structurally regressing, and increasingly unequal economy and society. Achieving a more dynamic and innovative economy – one which is truly “exciting,” both technologically and socially – will require challenging and disciplining business decision-making, and giving governments, workers, and communities a bigger role (and a bigger stake) in innovation, investment and technological change.

References

Carney, Tanya, and Jim Stanford (2018). *The Dimensions of Insecure Work: A Factbook* (Canberra: Centre for Future Work), https://www.tai.org.au/sites/default/files/Insecure_Work_Factbook.pdf.

Durrant-Whyte, Hugh, et al. (2015). "The Impact of Computerisation and Automation on Future Employment," in Committee for Economic Development of Australia, ed., *Australia's Future Workforce?* (Melbourne: Committee for Economic Development of Australia), pp. 56-64

Frey, Carl Benedikt, and Michael A. Osborne (2016). "The Future of Employment: How Susceptible are Jobs to Computerisation?", *Technological Forecasting and Social Change* 114, pp. 254-280.

International Federation of Robotics (2019). *World Robotics 2019: Industrial Robots* (Frankfurt: International Federation of Robotics), <https://ifr.org/worldrobotics/>.

Koziol, Michael (2016). "How Malcolm Turnbull's innovation agenda failed to take flight," *Sydney Morning Herald*, 18 July, <https://www.smh.com.au/politics/federal/how-malcolm-turnbulls-innovation-agenda-failed-to-take-flight-20160714-gq5dwu.html>.

Mazzucato, Mariana (2011). *The Entrepreneurial State: Debunking Public vs. Private Sector Myths* (London: Anthem).

Pennington, Alison (2020). *An Investment in Productivity and Inclusion: The Economic and Social Benefits of the TAFE System* (Canberra: Centre for Future Work).

Pennington, Alison, and Jim Stanford (2019). *The Future of Work for Australian Graduates: The Changing Landscape of University-Employment Transitions in Australia* (Canberra: Centre for Future Work).

Reserve Bank of Australia (1996). "Australian Economic Statistics 1949-1950 to 1996-1997: Occasional Paper No. 8," <https://www.rba.gov.au/statistics/frequency/occ-paper-8.html>.

Richardson, David (2017). *Company Tax and Foreign Investment in Australia* (Canberra: Australia Institute), <https://www.tai.org.au/sites/default/files/P314%20Company%20tax%20and%20foreign%20investment%20in%20Australia.pdf>.

Rodrik, Dani (2008). "Normalizing Industrial Policy," Commission on Growth and Development Working Paper No. 3 (Washington: World Bank), <http://documents.worldbank.org/curated/en/524281468326684286/Normalizing-industrial-policy>.

Stanford, Jim (2017). "U.S. Private Capital Accumulation and Trump's Economic Program," *Real World Economics Review* 77 (March), pp. 74-90, <http://www.paecon.net/PAERreview/issue79/Stanford79.pdf>.

Stanford, Jim (2020). *A Fair Share for Australian Manufacturing: Manufacturing Renewal for the Post-COVID Economy* (Canberra: Centre for Future Work),

Stewart, Andrew, Jim Stanford, and Tess Hardy, eds. (2018). *The Wages Crisis in Australia: What It Is and What To Do About It* (Adelaide: University of Adelaide Press).

Stiglitz, Joseph E., Justin Y. Lin, and Celestin Monga (2013). "The Rejuvenation of Industrial Policy," World Bank Policy Research Working Paper No. 6628 (Washington: World Bank), <https://openknowledge.worldbank.org/handle/10986/16845>.