Our Future World: Global megatrends impacting the way we live over coming decades

Naughtin, Claire and Hajkowicz, Stefan and Schleiger, Emma and Bratanova, Alexandra and Cameron, Alicia and Zamin, T and Dutta, A

CSIRO

July 2022

Australia's National
Science Agency

Our Future World

Global megatrends impacting the way we live over coming decades

July 2022

Citation

Naughtin C*, Hajkowicz S*#, Schleiger E, Bratanova A, Cameron A, Zamin T, Dutta A (2022) Our Future World: Global megatrends impacting the way we live over coming decades. Brisbane, Australia: CSIRO.

*Joint first authors
#Corresponding author

Copyright

Important disclaimer

Currency conversions

All dollar value figures denote Australian dollars unless otherwise specified. Conversions were made using the annual average exchange rate for a given currency, as specified by the Reserve Bank of Australia's historical data. Conversions for forecast values were made using the June exchange rate for the year in which the forecast was calculated.

Acknowledgements

The authors would like to thank the large number of CSIRO and external colleagues who attended focus group sessions and interviews to help identify the trends in this report. The authors would also like to acknowledge John Naisbitt, the founder of the 'megatrends' concept, who passed away on 8 April 2021 whilst we were working on this project. John Naisbitt's 1982 book, *Megatrends: Ten New Directions Transforming Our Lives*, was a New York Times bestseller that has had a significant influence on CSIRO's work using megatrends.

Images

Cover: Sea Cliff Bridge, NSW Coast Near Wollongong, shutterstock.com

Pages 2–3: Wild Brumbies roaming the High Plains of NSW. Clarke Colin, flickr.com

Pages 6, 22, 30, 34–25, 44: shutterstock.com

Page 8: NSW Rural Fire Service using the Sikorsky Erickson Air-Crane, Penrith NSW; page 17: Electric charging station, Newcastle NSW; page 20, 38–39, austockphoto.com

Pages 14, 18–19, 28–29, 40: istock.com

Pages 12, 24–25, 42: unsplash.com

Contents

Global megatrends: The 2022 revision

Trends, like horses, are easier to ride in the direction they are going.

– John Naisbitt, founder of the megatrends concept

Megatrends are trajectories of change that typically unfold over years or decades and have the potential for substantial and transformative impact. CSIRO released its seminal global megatrends in 2012 as part of the *Our Future World* report. While these megatrends helped inform long-term strategic and policy directions for Australian organisations over the past decade, a lot has changed in that time too, including the recent events of the global COVID-19 pandemic, the Ukraine crisis and the flow-on impacts to global trade. These changes have had a substantial impact on businesses, communities and governments in Australia and exposed new risks and opportunities.

This report presents an update on CSIRO's global megatrends out to 2042 with the view to guide long-term investment, strategic and policy directions across government, industry, the not-for-profit sector and the broader Australian community. Adopting a similar approach to CSIRO's previous global megatrends, this work explores how the previous megatrends have evolved over the previous decade as well as the new trends, impacts and drivers that have emerged over this period, providing a perspective around how these trends may unfold in the coming decades.

Adapting to a changing climate

The protection of livelihoods, infrastructure and people's quality of life as the climate changes

Unlocking the human dimension

The elevating importance of diversity, equity and transparency in business, policy and community decision making

Leaner, cleaner and greener

The global push to reach net zero and beyond, protect biodiversity and use resources efficiently

Increasingly autonomous

The rise of artificial intelligence and advanced autonomous systems to enhance productivity and outputs across all industries

The escalating health imperative

The promotion of health in the face of rising demand, demographic ageing, emerging diseases and unhealthy lifestyles

Diving into digital

The rapidly growing digital and data economy

Geopolitical shifts

The increase in efforts to ensure global stability, trade and economic growth

Adapting to a changing climate

Extreme and unprecedented weather events are increasing in their frequency and scale of impact. Current climate forecasts predict that we are likely to experience extreme weather conditions that exceed the bounds of historical norms and concurrent climate hazards are likely to compound the overall climate risk for sectors and regions. Adapting the healthcare system, critical infrastructure and settlement patterns to climate change and extreme weather conditions will become a growing reality for many countries in the years and decades to come. This megatrend speaks to the new ways of operating that organisations and communities will need to adapt to in the face of a changing climate.

Leaner, cleaner and greener

As the size of the global population continues to grow and as more people transition from lower to higher income brackets, there will be escalating pressures placed on finite food, water, mineral and energy resources. At the same time, these constraints are driving cutting-edge innovations that aim to do more with less, achieve carbon neutrality, reduce biodiversity loss and address the global waste challenge. This megatrend explores the opportunities pushing us towards a more sustainable horizon and the importance of science, technology and innovation in helping organisations to operate within much tighter envelopes.

The escalating health imperative

Healthcare expenditure continues to show an upwards trajectory and this trend will likely be exacerbated as global populations age and as new health challenges emerge (e.g. antimicrobial resistance, future pandemics). The COVID-19 pandemic has revealed and intensified existing health challenges around the burden of chronic illness and mental health difficulties. But it has also emphasised the importance of social and economic determinants of health. This megatrend highlights the opportunities provided by preventative health and precision health in supporting better health outcomes for all Australians.

Geopolitical shifts

Recent geopolitical developments are likely to have long-lasting impacts. The Ukraine crisis and ongoing tensions in the Asia-Pacific region pose challenges for democratic countries with advanced economies seeking to ensure peace and stability. These events have led to record-level defence spending, in Australia and globally, and increasing collaboration and cooperation across matters of security, technology and defence capability. This megatrend explores the implications of emerging geopolitical shifts relating to science, technology, trade, supply chains and defence strategy.

Diving into digital

The rapid adoption of digital and data technologies in recent times has meant that many sectors and organisations have experienced years' worth of digital transformation in the space of months. This is evident in the growth in online retail, remote working, telehealth, virtual education, digital currencies and data-driven organisations. While this progress has been significant, experts predict that this is just the tip of the iceberg, with the vast majority of digitisation yet to occur. This megatrend details the next wave of digitisation for organisations and the opportunities enabled by digital and data technologies.

Increasingly autonomous

We have seen astonishing improvements in the ability of software and machines to solve problems and perform complex tasks without explicit human guidance. This is driven by ongoing scientific breakthroughs in artificial intelligence (AI) and global investments in technology-driven research and development (R&D). Today, practically all industry sectors and policy spheres in all regions of the world are increasingly adopting AI technology and developing their AI capabilities. This megatrend unpacks how AI and related science, research and technology capabilities are helping to boost productivity and solve humanity's greatest challenges and the socio-economic considerations of these technology developments.

Unlocking the human dimension

Emerging social trends have heightened the influence of human perspectives and experiences on future community, business, technology and policy decisions. Consumers are demanding increased transparency from organisations, governments and scientists to maintain their trust, and there are concerns around the spread of misinformation. The rapid rate of change associated with technology is also driving new considerations around ethical design and deployment. This megatrend highlights the social drivers influencing future consumer, citizen and employee behaviours.

Background

The future ain't what it used to be.

– Lawrence Peter 'Yogi' Berra, American baseball catcher

In 2009, CSIRO began its strategic foresight journey with an exploration of future trends impacting the Australian science, research and technology sector – a novel project for the organisation. The aim was to inform internal long-range investment and planning decisions. However, in a serendipitous turn of events, this work was shared with the outside world. An overseas consulting firm was due to present at a major conference in Melbourne in early 2010 but the video link failed. The conference facilitator and famous Australian journalist, Kerry O'Brien, asked if there was a Plan B, which turned out to be a presentation on CSIRO's not-quite-finished global megatrends.[1]

This seminal set of global megatrends combined rigorous scientific thinking with engaging narratives about the future. This work piqued the interest of the nation, and it is an area that we have continued to grow and develop in CSIRO ever since. We have applied megatrends (see *Our methods*) to provide data-driven insights across hundreds of research projects, advisory activities, training sessions and presentations to Australian companies, governments and communities. We have published on the future of sport,[2] employment,[3] tourism,[4] agriculture,[5] innovation,[6] digital technology,[7] workplace safety[8] and many more topics.

Our megatrends work has been used by a range of Australian organisations in guiding long-term decisions. ASX-listed GPT, one of Australia's largest diversified listed property groups, used megatrends to inform $1.2 billion of new investments into logistics and warehousing from 2012 to 2015,[9] which led to a 12.7% increase in net operating income.[10,11] The Commonwealth Bank also used CSIRO's megatrends to guide the restructuring of its institutional banking and markets business.[12] But megatrends are not just used by large companies. Intract is an example of an Indigenous-owned construction firm in Darwin that has used CSIRO's megatrends to inform their business decisions in response to emerging Industry 4.0 trends.[13]

We define a megatrend as a trajectory of change likely to have a substantial and transformative impact on individuals, organisations and societies. Megatrends typically unfold over years or decades and occur at the intersection of multiple interconnected trends that are narrower in scope. The trends which comprise megatrends are often classified as geopolitical, economic, environmental, social or technological (GEEST). Our definition is based on a recent systematic review of the megatrends concept that we conducted on published research papers since the term was first used by John Naisbitt in 1982.[14] Across an analysis of 217 megatrend studies published between 1982 and 2020, we found that applications of megatrends continue to grow, with close to half of the total megatrends studies published in the most recent decade.

From 2012..	To now and beyond..
Going, going...gone? From a window of opportunity for government, companies and societies to respond to biodiversity declines and climate change...	**Adapting to a changing climate** ...To operating in a fluid future climate characterised by unprecedented weather events that push historical boundaries.
More from less From wrestling with the challenge of rising demand for food, water, energy and minerals and the promise of future solutions...	**Leaner, cleaner and greener** ...To the realisation of potential solutions through synthetic biology, alternative proteins, advanced recycling and the net-zero energy transition.
Forever young From forecasting the potential impacts of an ageing population and the growing burden of chronic illness on future health budgets...	**The escalating health imperative** ...To living in a post-pandemic world that has exacerbated existing health challenges and created a burning platform to respond to future risks.
The silk highway From a period of rapid economic growth and urbanisation across Asia and the new demands of the growing middle-class population...	**Geopolitical shifts** ...To an uncertain future, characterised by disrupted patterns of global trade, geopolitical tensions and growing investment in defence.
Virtually here From the potential of increased connectivity and adoption of digital products and services at the infancy stages of online retail and teleworking...	**Diving into digital** ...To the pandemic-fuelled boom in digitisation, with teleworking, telehealth, online shopping and digital currencies becoming more mainstream.
The innovation imperative From the promise of science, technology and innovation as a potential driver of opportunities in response to these megatrends...	**Increasingly autonomous** ...To the explosion in artificial intelligence and global investment in research and development driving discoveries and applications.
Great expectations From the emergence of the experience economy and demand for personalised services, driven by rising incomes and ethical consumerism...	**Unlocking the human dimension** ...To a strong consumer and citizen push for decision makers to consider trust, transparency, fairness and environmental and social governance.

This report presents CSIRO's latest thinking on the global megatrends that are likely to impact Australian organisations over the next 20 years. These refreshed megatrends are positioned in the current context, as Australia and countries around the world navigate their way beyond the COVID-19 pandemic. From global supply chain disruptions, to geopolitical tensions, to significant social upheaval, the pandemic has created much uncertainty for organisations, which makes it difficult for leaders to plan long term. At the same time, this disruption has opened up new opportunities to accelerate change, particularly in the realm of digital transformation.

At CSIRO, we use global megatrends to identify areas where we can solve the greatest challenges through innovative science and technology. This helps ensure that every research dollar provides the maximum benefit for current and future generations of Australians. These global megatrends are also designed to provide insights for industry, government, academia and the community to better understand and prepare for long-term futures. This report provides a snapshot of emerging global megatrends, which CSIRO will continue to iterate and refresh in the years to come as new insights, trends and data come to light.

Adapting to a changing climate

As a climate scientist, I'm not surprised by the bushfires. What I am is exhausted.

– Sarah Perkins-Kirkpatrick, Australian Climate Scientist (quoted in Vox, 24 January 2020)

Extreme and unprecedented weather events are increasing in their frequency and scale of impact. Current climate forecasts predict that we are likely to experience extreme weather conditions that exceed the bounds of historical norms and concurrent climate hazards are likely to compound the overall climate risk for sectors and regions. Adapting the healthcare system, critical infrastructure and settlement patterns to climate change and extreme weather conditions will become a growing reality for many countries in the years and decades to come.

This megatrend speaks to the new ways of operating that organisations and communities will need to adapt to in the face of a changing climate.

The cost of natural disasters

Natural disasters cost the global economy an estimated $390.5 billion in 2020.[15,16] The cost to Australia alone was $13.2 billion in 2017 and this is projected to reach $39.3 billion per year by 2050.[17] The 2019–20 Black Summer bushfires in Australia left a significant dent on the country's biodiversity, killing or displacing approximately 3 billion animals and burning between 12.6 and 19 million hectares.[18-20] The most recent World Economic Forum Risk Report identifies extreme weather, climate action failure, human environmental damage and biodiversity loss among the top 10 global risks.[21] The increasing frequency and cost of natural disasters, with the potential for multiple concurrent climate hazards compounding the overall climate risk, highlight the need for urgent climate action.[22] There is a critical role for science and technology in developing solutions to enhance disaster preparedness and manage climate change impacts.

Health impacts of climate change

CSIRO and the Bureau of Meteorology predict that Australia is likely to experience more heat extremes and fewer cold extremes, longer and more severe droughts and fire seasons, continued sea level rises and ocean warming and acidification, prolonged marine heatwaves, and fewer, but more intense, cyclones in the coming decades.[23] Healthcare professionals are increasingly advocating for the relationship between extreme weather events and public health.[24] Indeed, the Australian Medical Association, the American Medical Association, British Medical Association and the World Health Organization have all declared climate change as a health emergency.[25]

Preparing to live in a hotter world

Global extreme temperature events are reaching unprecedented levels, with temperatures exceeding previous records by over two standard deviations.[26] Temperatures observed across cities in Pakistan and the United Arab Emirates already exceed the human body's threshold for survivability in humid heat conditions.[27] Heat-related deaths are predicted to grow by 60.5% or more across major Australian capital cities from 2020–50,[28] but this is likely to be a conservative estimate. Recent research suggests that official records of deaths attributed to excessive heat in Australia are underestimated by at least 50 fold.[29,30] Heatwaves can also damage infrastructure and cause operational problems for critical services such as transportation, healthcare and energy supply. Several urgent policy actions have been suggested, including addressing heat inequities and improving heat-related health metrics and heat governance.[31]

Declining water quantity, quality and availability

Global water demand was estimated at 4,600 km^3 per year in 2018 and this is projected to grow to up to 5,500–6,000 km^3 by 2050.[32] The United Nations predicts that up to 5.7 billion people will experience water scarcity at least one month per year by 2050.[32] Although water demand is increasing, reductions in the availability of water resources and pollution are reducing the amount and quality of future water resources.[33] Annual rainfall in Australia varies due to natural conditions, but there has been a long-term shift towards lower rainfall in the southwest and above-average rainfall in the north.[23] These rainfall patterns are expected to lead to an increase in flash flooding in northern Australia and drought conditions in southern and eastern Australia.[23] Scientific advances in the treatment, management and conservation of water supplies could help to alleviate future water scarcity challenges, in conjunction with sustainable development regulation.[33]

Impact of climate change on critical infrastructure

Infrastructure, such as road pavements or railways, was built using materials and methods that are designed for stable climatic conditions.[34] Extreme high temperatures can increase the risk that road pavements will rut or railways will expand and buckle.[34] An analysis of transport networks across the European Union and the United Kingdom estimated that operational and maintenance costs could increase by 1.3% or $1.4 billion if global warming was to increase to 1.5 °C and 6.9% ($7.6 billion) under a 4 °C global warming level.[34,35] Climate change can also impact airline flights: stronger winds increase the frequency and intensity of air turbulence, high air temperatures impair aircraft take-off performance and rising sea levels pose a risk for airports built near sea level.[36-38] Pre-emptively adapting existing and forthcoming infrastructure for a changing climate will be critical in reducing future infrastructure risks and costs.[34]

Insuring against climate change

More frequent and severe weather conditions are reducing the profitability of northern Australia for insurers and more households are choosing to forego insurance (20% versus 11% across the rest of Australia in 2016).[39] Northern Australia is more disaster-prone than the rest of Australia.[39] A 2020 review by the Australian Competition and Consumer Commission found that northern Australian households pay 1.8 times more in home and contents insurance premiums than the rest of Australia and similar premium discrepancies exist for strata insurance too.[39] The Insurance Council of Australia estimates that a minimum of $30 billion will need to be invested to protect coastal properties from sea level rises and some communities will need to retreat to less hazardous regions.[40]

Climate-driven mass migration

In 2020, less than 1% of the global land surface was classified as an extremely hot zone, but by 2070, this is predicted to increase to 19%, impacting 3.5 billion people who live in these regions.[41] Moreover, the share of humanity living in areas that exceed a deadly temperature–humidity combination for at least 20 days per year is predicted to rise from 30% today to 74% by 2100.[42] Assuming a mostly stable Antarctic, 150 million people worldwide live on land that could be vulnerable to future sea-level rises by 2050 and this could increase to 300 million if the Antarctic becomes unstable.[43] Climate pressures could give rise to a significant wave of climate-driven global migration in the decades leading up to the mid-century and beyond, but this is dependent on the broader social, cultural and political context.[41]

Pressure brewing under the ocean's surface

Rising atmospheric carbon dioxide (CO_2) concentrations are increasing ocean acidity.[44,45] Phytoplankton are critical to the carbon cycle, but under acidic conditions they struggle to build strong cell walls.[46] This makes them lighter and less likely to sink to the seabed as a carbon store.[46] Similar impacts are observed for coral, mussels and oysters.[44] These pressures are compounded by the impact of recreational vessels, foreign marine species and plastic pollution.[47] Australian oceans are also warming more rapidly than the rest of the world and over 100 marine species are migrating south to cooler waters.[48] Climate changes are expected to significantly impact Australian fisheries stock over the next two decades.[48] The United Nations declared 2021–30 as the Decade of Ocean Science for Sustainable Development to drive science-driven policy to improve ocean health and reverse the current cycle of decline.[49]

Leaner, cleaner and greener

The ocean humbles you. You can go and win a world title, but you're never going to beat the ocean.

– Stephanie Gilmore, Australian professional surfer and seven-time world champion

As the size of the global population continues to grow and as more people transition from lower to higher income brackets, there will be escalating pressures placed on finite food, water, mineral and energy resources. At the same time, these constraints are driving cutting-edge innovations that aim to do more with less, achieve carbon neutrality, reduce biodiversity loss and address the global waste challenge.

This megatrend explores the opportunities pushing us towards a more sustainable horizon and the importance of science, technology and innovation in helping organisations to operate within much tighter envelopes.

Future demand for food

A recent meta-analysis estimated that global food demand will increase by 35–56% between 2010 and 2050[55] – a reduction from the Food and Agriculture Organization's 2009 prediction of a 70% increase.[56] But the amount of food consumed per capita could change by 0–20% under different future scenarios.[55] The United Nations estimate that 75 billion tonnes of fertile soil and 12 million hectares of productive farmland capable of producing 20 million tonnes of grain is lost to desertification and land degradation each year.[57] Meeting the future demand for food will be challenging, but feasible. The global risk of hunger is expected to decline under futures with improved global food security, or show a small increase under a future where economic development slows and inequities within and between nations grow.[55]

A growing appetite for (alternative) protein

Global demand for protein is increasing, particularly across Asian nations.[58] This demand will be met by conventionally farmed protein sources, as well as new protein alternatives which are more resource-efficient to produce (e.g. plant-based meats, edible insects, seaweed).[59] Alternative proteins are expected to make up 11–22% of the world's protein market by 2035,[60] and sales of plant-based meats could reach $3 billion in Australia by 2030.[61] Research conducted by the University of Melbourne identified 16 alternative protein companies in Australia as of February 2020, the majority of which were using plant-based technologies and focused on plant-based substitutes for beef, chicken and pork.[62]

Synthetically engineering new biological solutions

Synthetic biology provides tailored solutions to a range of complex challenges impacting the environment, agriculture, medicine and other industrial fields.[63-65] These technologies can be applied to produce food with less energy, water and land;[66] grow lower-emissions building materials;[67] engineer biofuel alternatives to petroleum;[68] accelerate vaccine developments;[69] and produce one of the strongest biomaterials, spider silk.[70] The market for synthetic biology technologies and products is expected to grow by 24% from 2018 to 2025 and be worth $74 billion by 2025.[71] As synthetic biology applications expand, it will be important to manage any potential concerns around the ethics or safety of these technologies. Most Australians have limited knowledge around synthetic biology (85%) and they are more likely to support applications that have clear public health or environmental benefits.[64]

Increasing demand for minerals

The 2030 outlook for Australian commodities suggests that demand for steel, zinc, copper, aluminium, rare earth elements, lithium, uranium and nickel will continue to grow.[72] This demand is fuelled by rising population and income levels, urbanisation and the consumption of electronics, as well as the transition to zero-emissions technologies.[72] Ore grades in Australia have been declining over the past decades, but this has been coupled with improvements in extractive technologies, enabling metals to be sourced from lower-quality ores.[73] However, declining ore grades can increase the cost, energy, emissions and environmental footprint associated with mining activities.[73] Future innovations will likely focus on improving the precision of exploration and extractive technologies, and the sustainability of mining operations.

Biodiversity decline and investing in conservation

The world's natural ecosystems have declined by 47% relative to their natural baselines and 25% of living species are at risk of extinction.[74] Coral reefs are one of the ecosystem types under greatest pressure. The worldwide area of live coral has halved since the year 1950[75]. In terrestrial habitats the intensification of agriculture has led to biodiversity losses and reduced biodiversity-based ecological services (e.g. pollination, pest management, water retention).[76-78] It has traditionally been difficult to quantify the return on investment in conservation, but a recent analysis found conservation spending across 109 countries from 1996 to 2008 reduced the rate of biodiversity loss by 29%.[79] Demonstrating the return on investment in conservation could encourage decision makers to boost investment to a level that is required to mitigate future biodiversity declines.[79]

Turning today's goods into tomorrow's resources

Australia generates more waste per day per capita (1.5 kg) than the East Asia and Pacific region (0.6 kg) and the world (0.7 kg).[80] Almost 85% of plastics in Australia were sent to landfill in 2019,[81] and if nothing changes, RMIT University estimates that Australia's landfill space will reach capacity by 2025.[82] In 2017, China announced bans on solid waste imports,[83] which prompted many countries to reassess their waste management strategies. The Australian Government has banned exports of waste plastics, paper, glass and tyres and set a target to reduce waste to landfill by 30% by 2030.[84] Advanced recycling technologies can convert end-of-life plastics into their original building blocks to create other valuable commodities and could be used to improve the recovery of plastics in Australia.[84] Australia has the necessary infrastructure, manufacturing skills and supply chains needed to develop advanced recycling and leverage these opportunities.[84]

Towards net zero and beyond

The world is moving towards net zero. At the time of writing at least 129 countries (including Australia) have committed to achieving net-zero emissions by 2050.[85] The United Nations COP26 climate change conference members have also agreed to phase down coal in 2021.[86] Leading global investors plan to only finance companies with net-zero carbon emissions by 2050.[87] The European Union plans to introduce a carbon border tax by 2023.[88] Citizens are increasingly concerned about climate change. In Australia, 75% of people reported concerns about climate change in 2021 – a record-level response since the Australia Institute began tracking this sentiment – and 69% are supportive of domestic action to achieve net-zero emissions.[89] However, following record-level declines during the pandemic due to restrictions global greenhouse gas emissions rebounded 4.8% in 2021.[90] Global emissions have risen sharply over the past few decades and timeseries data do not yet show indication of decline.

More (renewable) energy demand

Global energy demand declined by 5.3% in 2020,[91] but this is expected to rebound to pre-COVID levels by early 2023.[91] Renewable energy sources are expected to account for 80% of the growth in global electricity demand by 2030, surpassing coal as the primary source by 2025.[91] The International Energy Agency forecasts that global electricity demand will grow at twice the rate of primary energy demand out to the year 2040.[92] The majority of demand is expected to come from China and India. The Australian Energy Market Operator is preparing Australia's grids to manage 100% renewable energy by 2025.[93] The global centre of renewable energy generation has shifted east over the past decade, with China having the highest installed solar generation capacity in 2020 (a position that was previously held by Germany in 2010).[94] With the highest wind and solar capacity per capita across developed nations, Australia has a natural advantage in renewable energy generation,[95] and the development and deployment of low-emission technologies.[96]

The environmental footprint of clean energy

Renewable energy presents opportunities to reduce global emissions, but there are emerging concerns around waste, mining and land use associated with these systems. Namely, lithium-ion battery waste in Australia is projected to grow from 3,300 tonnes in 2016 to up to 187,984 tonnes by 2036 and less than 2% of batteries are currently recovered.[97,98] Investing in domestic battery recycling could help Australia better manage this waste stream and generate up to $3 billion in potential recoverable value by 2036.[99] Moreover, the growing demand for clean energy technologies could put environmental pressures on critical energy metal mining locations, such as Indonesia for nickel mining.[100,101] Solar farm developments in Australia can also create land use challenges if such infrastructure is built on productive agricultural land.[102]

The electrification of transport

The cost of electric vehicles is declining faster than expected, enabled by steep reductions in the cost of lithium-ion batteries.[103] Electric and internal combustion engine vehicles are expected to reach price parity by 2025.[104] Various car manufacturers have committed to discontinuing the production of internal combustion engine cars within the next two decades, including Volvo, Ford, Honda and General Motors.[105] Norway is leading the charge, with electric vehicles making up 56% of its market share.[106] Electric vehicle uptake has been slower in Australia, where only 1.1% of the market share is electric.[106] To accelerate the transition to e-mobility, Australia's Future Fuels Strategy is focused on developing the grid infrastructure and charging stations needed to support more electric vehicles on Australian roads.[107]

Clean energy industries on the rise

The global energy transition opens up new industry and job creation opportunities. It is estimated that the United States energy sector will need an additional 4.6 million workers by 2035 to meet the federal government's decarbonisation goals.[108] Australia's abundant access to raw commodities and renewable energy, advanced manufacturing capabilities and concentration of relevant skilled workers yield a strong competitive advantage in emerging clean energy industries, such as green metal manufacturing.[109,110] International steelmakers are actively looking to eliminate emissions from their supply chains.[111-113] Other value-adding manufacturing opportunities could exist in the development of clean energy technologies or their inputs (e.g. nickel) – areas that are attracting significant investment and global demand.[72,114]

The dawn of the hydrogen era

The global hydrogen industry is growing rapidly given the potential role it could play in decarbonisation.[115] Over 30 countries have developed hydrogen roadmaps or have zero-carbon emissions targets that involve hydrogen strategies.[116] Australia is well placed to become a leading producer and exporter of green hydrogen, enabled by its abundant access to renewable energy resources and a skilled workforce.[115] Demand for clean energy is growing rapidly across Asian nations, particularly in Japan and Singapore which cannot generate sufficient clean energy to meet demand.[115] Significant infrastructure investment and efficiency gains, however, will be required to realise Australia's hydrogen potential, given that green hydrogen is currently three times more expensive than blue (natural-gas-powered) hydrogen.[115,117]

The escalating health imperative

Today, I always take the stairs anywhere I go; I reckon if you've got legs you should use them

– Turia Pitt, Australian mining engineer, author, speaker and ultra-marathon athlete

Healthcare expenditure continues to show an upwards trajectory and this trend will likely be exacerbated as global populations age and as new health challenges emerge (e.g. antimicrobial resistance, future pandemics). The COVID-19 pandemic has revealed and intensified existing health challenges around the burden of chronic illness and mental health difficulties. But it has also emphasised the importance of social and economic determinants of health.

This megatrend highlights the opportunities provided by preventative health and precision health in supporting better health outcomes for all Australians.

Rising healthcare costs

A greater share of GDP is spent on healthcare in Australia (10%) than the OECD average (8.8%).[118,119] The average annual health spending per capita in Australia has increased from $5,328 to $7,772 in the two decades prior to 2018–19 and healthcare makes up a leading share of government expenditure (24.3% in 2018–19).[118] The catch-22 of modern medicine is that as people are diagnosed earlier and live with conditions for longer, healthcare utilisation increases.[120] In the year 2001 total health spending in Australia was $93.3 billion. In the year 2018 we spent $185.4 billion.[121] These amounts are in constant prices (adjusted for inflation) and represent a doubling of healthcare expenditure in real terms. In 2018 per capita spending on health by Australians reached $7,485. Over the past two decades per capita spending on health in Australia has risen at an average annual rate of 2.7% reaching $7,485 per person per year by 2018.[121] Before COVID-19, the ratio of health spending to GDP in Australia was expected to rise to 13% by 2030,[118] and this could be even greater once the long-term impacts of the pandemic are factored in. Increased spending on healthcare could place pressure on funding for other portfolio areas.

Heightened risk of infectious diseases

Infectious disease outbreaks have increased in line with global population growth, air travel, urbanisation, livestock handling and wildlife harvesting.[122-124] Infectious disease events are driven by factors such as rising population density and global environmental change,[122-124] as intact ecosystems reduce the probability of pathogen transmission among humans, livestock and wildlife.[124] The COVID-19 pandemic was preceded by several significant zoonotic (transferred from animals to humans) disease outbreaks including SARS (2003), Influenza A (H5N1 in 2005 and H1N1 in 2009), Ebola (2012) and MERS (2015).[125-128] Over the past 6 months (January- June 2022) we've seen concerns about Japanese encephalitis,[129] Monkey Pox,[130] and a surge of influenza cases[131] in Australia. Next-generation DNA sequencing is rapidly accelerating responses to emerging infectious diseases and the identification of virus variants.[132,133] Ongoing investment in early detection and prevention is associated with lower economic and mortality costs and these measures are needed to improve our future resilience to infectious disease risks.[134,135]

The emerging antimicrobial resistance risk

The World Health Organization identified antimicrobial resistance (AMR) as one of the top global health issues to track in 2021,[136] and the Australian Government considers AMR as one of the most significant threats to human and animal health.[137] It is associated with the emergence of bacteria, parasites, viruses and fungi that are resistant to medicines such as antibiotics.[138] The global burden of deaths attributable to bacterial AMR was 1.27 million in 2019, with 4.95 million deaths associated with bacterial AMR. This statistic places AMR as a more significant cause of death globally than malaria or HIV.[139] A high-AMR future could lead to up to a 3.5–3.8% decline in global domestic product.[140,141] The world's governments are responding. By March 2018, governments of 100 countries worldwide had prepared a national action plan (NAP) for AMR and another 67 plans were in progress.[142] Australia's AMR strategy was published in the year 2020.[137] The World Health Organisation's Interagency Coordination Group on Antimicrobial Resistance observes that "in most countries, the greatest challenge is not writing a NAP but implementing it and demonstrating sustained action".[142]

Changes in health insurance patterns

In recent years, the share of Australians that hold private health insurance for hospital treatment dropped from 47.4% in 2015 to 44.7% in 2020.[143] The greatest declines were observed in younger cohorts, who might be less likely to utilise the healthcare system as frequently as older cohorts.[143] In 2020, 35.3% of persons aged 25–39 years held private health insurance, compared with 40.7% in 2015, while coverage among persons aged 85 years or over increased from 43.3% to 45.3% over the same period.[143,144] Private health insurance premiums have been growing faster than wages, which could reduce the perceived value of coverage for consumers.[145] This trend could pose future risks to the viability of the private health system and place additional strain on the public healthcare resources.

Our ageing population

The proportion of the Australian population that is aged 65 years or over is expected to increase from 16% in 2019–20 to 23% by 2060–61.[120] These forecasts take into account the impact that COVID-19 has had on population growth through reduced migration and existing trends around longer life expectancies and lower fertility rates.[120] Pre-COVID, it was estimated that 20.3% of the population would be aged 65 years or over by 2060–61.[53] Consequentially, the ratio of working-age people to non-working-age people is predicted to decline over the next 40 years, decreasing from 4.0 to 2.7 over this period.[120] Real GDP is also expected to grow at a slower rate over the next 40 years (2.6%) than the past 40 years (3.0%).[120] This challenge will be even more pronounced in other countries such as Japan, where the share of its population aged 65 years or over is projected to increase from 28.4% in 2020 to 38.4% by 2065.[146]

A growing chronic health burden

The burden of chronic disease is rising across the globe,[147] and 47.3% of Australian adults reported having one or more chronic illnesses in 2017–18.[148] Most Australian adults do not meet the recommended guidelines for exercise or healthy eating and the share that are overweight or obese has grown from 61.1% to 66.4% from 2007–08 to 2017–18.[148] The financial burden of lost productive life years due to chronic illness in Australia is expected to rise from $12.6 billion in 2015 to $20.5 billion by 2030.[149] COVID-19 has drawn resources away from chronic-disease detection and management,[150] and consumers have been delaying routine medical appointments and tests.[151-153] People with disabilities also had an increased risk of contracting the virus, reduced access to routine care and were adversely socially impacted by mitigation measures.[154] Delays in the detection, monitoring or treatment of chronic conditions could have long-term impacts on the health of Australians.[151]

Sleeping more, but less well

The latest survey by the Sleep Health Foundation found that 59.4% of Australians frequently experienced at least one symptom commonly associated with insomnia in 2019 and the prevalence of chronic insomnia varied from 7.5% to 14.8%, depending on the diagnostic criteria used.[155] Consistent national data on sleep patterns and disorders is lacking in Australia, making it difficult to assess changes in prevalence.[155] COVID-19 lockdown restrictions in Europe and South America were associated with increased sleep duration but reduced sleep quality.[156,157] Experts are also reporting increased presentations of insomnia due to heightened anxiety around the pandemic.[158] Poor sleep can have a negative impact on health, including a higher risk of premature death, heart disease and cancer.[159] Promisingly, recent research has shown that physical activity can both improve sleep patterns[159] and buffer the harmful impacts of inadequate sleep.[159]

A strong case for preventative health

An analysis across high-income countries found health protection and promotion interventions return an average of $14.30 in benefits for every $1 invested.[160] Health protection (e.g. vaccinations) and legislative interventions (e.g. taxing sugar-sweetened beverages) were associated with a higher return on investment than mass health promotion.[160] However, health protection and promotion makes up a minor share of healthcare expenditure in Australia and this has declined from 2.1% in 2008–09 to 1.5% in 2018–19.[118] COVID-19 provides a unique window of opportunity to accelerate progress on the socio-economic determinants of health, with previously unforeseen policy actions in housing, social support and education rapidly implemented in response to the pandemic.[161] Given that the benefits of preventative health typically unfold over longer timespans, future investments will require broad-based support.

The burden of mental health

Before COVID-19, 13% of Australian adults reported high or very high levels of psychological distress and this increased to 20.5% in November 2020 and has remained high since (20.2% in June 2021).[148,162,163] Promisingly, there has been minimal change in rates of suicide,[164] but there has been an increase in risk factors for suicidal behaviour.[164] During the lockdown in late May to October 2020, 16.9% of Victorians reported suicidal ideation and 9.5% seriously considered suicide in the past 30 days.[165] More Australians are also reporting stress (62% in 2021 versus 47% in 2020), anxiety (57% versus 48%) and depression (45% versus 33%).[166] Research from the United States found that depressive symptoms and suicidal thoughts and behaviours increased from April to September 2020, suggesting a need for mental health support during both the acute and recovery phases of the pandemic.[167] Social connection is a key protective factor that can promote more positive wellbeing outcomes during periods of high uncertainty and distress.[168] The extent to which mental health stressors present during COVID-19 have long-lasting impacts is not known.

The promise of precision health

At least $5.7 billion has been invested in advanced precision medicine capabilities by 14 national governments since 2013.[169] This figure excludes China, which announced its 15-year Precision Medicine Initiative valued at around $12 billion in 2016.[170] The Australian Government's Genomics Health Futures Mission will invest $500 million in precision medicine from 2018–28.[171] Precision health technologies could transform clinical care. For example, analyses of community-wide health data can be used to detect and tailor interventions for chronic disease.[172] While precision health can be costly, emerging evidence suggests that these interventions are as cost-effective as usual care,[173] and this will likely improve as technologies, such as genome sequencing, continue to drop in price.[174]

Geopolitical shifts

If the human race wishes to have a prolonged and indefinite period of material prosperity, they have only got to behave in a peaceful and helpful way toward one another.

– Winston Churchill

Recent geopolitical developments are likely to have long-lasting impacts. The Ukraine crisis and ongoing tensions in the Asia-Pacific region, pose challenges for democratic countries with advanced economies seeking to ensure peace and stability. These events have led to record-level defence spending, in Australia and globally, and increasing collaboration and cooperation across matters of security, technology and defence capability.

This megatrend explores the implications of emerging geopolitical risks relating to science, technology, trade, supply chains and defence strategy.

Rising investments in defence capability

In 2020, a year when global GDP shrunk by 3.2%,[175] global military spending continued to rise, reaching $2,886 billion or 2.4% of global GDP.[176] This is the highest level of world military expenditure on record since 1988 and the greatest spenders were the United States (38%) and China (14%).[176] Australia's defence spending is following a similar trajectory and the Australian Strategic Policy Institute predicts that this could grow from 2% of GDP in 2020–21 to 2.4% of GDP by 2029–30.[177] In September 2021, the Australian Government announced its new trilateral security pact, AUKUS, in which it will use American and British nuclear-powered technologies to configure its next fleet of submarines.[178]

Emerging technologies are tilting the strategic defence arena

Defence strategy and planning are being impacted by scientific and technological advances in (a) high-speed, variable-trajectory and precise-targeting missiles;[180] (b) artificial intelligence (AI) and advanced autonomous systems;[181] and (c) cyber/information warfare.[182,183] These technologies give armed forces increased/new capability to attack and defend. The number of countries with strong or leading capabilities in these areas of technology may increase and/or diversify into the future. These technologies are already being used in current warfare and grey-zone conflict.[184] It is possible these technologies may decrease the usefulness of certain defence equipment and strategies and heighten the effectiveness of others.[185] There is also likely to be considerable R&D effort and innovation in finding ways to defend against attacks using these technologies and to ensure defence forces have access to cutting-edge and world-leading capability.

Increased collaboration between democratic countries

The Ukraine crisis has revealed the extent of cooperation, commitment and shared purpose amongst the world's democratic countries and advanced economies. There has been an unambiguous willingness-to-act at the national level to uphold international law, respect country borders/sovereignty and protect human rights. The response has been immediate and wide-ranging with a large number of countries implementing trade sanctions[186-188] and providing military[189-191] and humanitarian[192] support to Ukraine in a coordinated manner. At the time of writing, both Sweden and Finland are well advanced on the pathway to become full members of the North Atlantic Treaty Organization (NATO).[193] This would see NATO membership grow from 30 to 32 countries. The trilateral security pact, AUKUS, is another example of collaboration between the United States, United Kingdom and Australia.[179] The coming decade is likely to see increased collaboration and cooperation between democratic countries seeking to ensure peace and stability.

Changing trade dynamics

The pandemic has seen a contraction in Australia's two-way trade with major partners. From 2019 to 2020 we saw our two-way trade with our top five partners decline: China (-2%); the United States (-10%); Japan (-23.6%); South Korea (-15.5%) and the United Kingdom (-17.7%).[194] This was connected to a global contraction in trade associated with the pandemic and restrictions on the movement of people, goods and services. Furthermore, in late 2020 and early 2021, China introduced tariffs and sanctions on Australian exports of coal, seafood, beef, wine, timber logs and barley.[195,196] These trade barriers, combined with other shifts in the global trade landscape, have caused some Australian exporters to pivot into alternative markets or change to an alternative domestic or international supplier.[197,198] For example, Australia's trade with India has grown 5.5% over the past 5-years.[194] The extent to which the current post/late pandemic situation prompts longer-lasting changes to Australian trade patterns is not known. It's likely that both exporters and importers will be looking for ways to reduce risks and diversify over the coming years.

Reducing the risk of supply chain disruption

The COVID-19 pandemic and geopolitical shocks have revealed Australia's vulnerability to global supply chain disruptions.[199] A recent study estimated that 90% of pharmaceutical and medical products used by Australians are imported, with the majority coming from India and China.[200] The Productivity Commission estimates that 5% of Australian imports might be vulnerable to future supply chain disruptions.[199] In February 2022, 37% of Australian business experienced supply chain disruptions, 50% of which were unable to find alternative suppliers.[201] Supplier diversification, onshoring and contingent contracting have been proposed as potential risk mitigation strategies for firms and governments.[199] Enhancing the uptake of agile manufacturing approaches, leveraging artificial intelligence (AI), robotics and other technologies, could enable Australian manufacturers to dynamically respond to market changes in a cost-effective manner.[202]

Future supply chain risks associated with seaborne trade

Recent supply chain issues have been associated with the pandemic and trade disputes. As we look to the future, there is further risk that geopolitical events could impact trade. For example, the Australian Strategic Policy Institute estimates that 80% of global trade is via sea and that between 20% and 33% of that trade moves through the contested waters of the South China Sea.[203] In the future, it is plausible that we will see Australian households, industries and governments place greater emphasis on sovereign capability and local supply chains (especially for critical goods and services), along with efforts to build more resilient supply chains that are capable of handling a broader range of disruptive events.

A foreseeable return to global connectivity

Before COVID, passenger travel was rising, the size of aircraft fleets were growing and international trade was expanding.[204,205] Although COVID-19 has had significant impacts on global interconnectedness, these declines have been less than predicted. For example, as of April 2020, the World Trade Organization expected global trade to decline by 32%,[206] but it revised its prediction to a 9.2% decline in October 2020.[206]

Forecasts from the International Air Transport Association predict that air passenger travel will surpass 2019 levels by 2023, with the quickest recovery in regions with large domestic markets.[207] But air travel by 2030 will still be 7% less than it would have been in a future without COVID-19.[207] Although COVID-19 drove many countries to shut their borders, current predictions suggest an almost full recovery of global flows in the long term.

Cybersecurity threats and resilience

The threat of cybercrime, cyberterrorism and cyberwarfare continues to escalate. There was a 13% increase in the number of cybercrime reports made to the Australian Cyber Security Centre in 2020–21 compared to the previous year, with one reported cyberattack every 8 minutes.[208] Cybercrime is estimated to cost the Australian economy $29 billion annually and these costs are expected to rise as cyberattacks increase in their frequency, scale and sophistication.[209,210] Australia's vulnerability to attacks has increased during the COVID-19 pandemic as more people work, study and access services online. A significant and growing number of attacks are targeting our critical infrastructure. There is an imperative for governments, organisations and individuals to adopt good cybersecurity practices and systems to protect themselves against future cyber threats.

Uncertainty around future flows of scientific knowledge

The global share of published papers with authors from more than one country has been on the rise, up from 18.6% in 2011 to 23.5% in 2019,[211,212] but it is unclear how the pandemic will impact international collaborations in the long term. Despite the initial boost in multi-country papers in 2020, particularly for COVID-19-related papers, emerging geopolitical tensions and travel restrictions have subsequently hindered international collaborations.[212] The number of Chinese publications with American co-authors has also been declining since 2017 and the number of American publications with Chinese co-authors declined for the first time in 2020.[212] Siloed scientific endeavours in the future could lead to duplicated research efforts and wasted resources, both of which present potential risks.

Diving into digital

We went from being the Flintstones to the Jetsons in nine months.

– Dan Schulman, PayPal

The rapid adoption of digital and data technologies in recent times has meant that many sectors and organisations have experienced years' worth of digital transformation in the space of months. This is evident in the growth in online retail, remote working, telehealth, virtual education, digital currencies and data-driven organisations. While this progress has been significant, experts predict that this is just the tip of the iceberg, with the vast majority of digitisation yet to occur.

This megatrend details the next wave of digitisation for organisations and the opportunities enabled by digital and data technologies.

Mass adoption of Industry 4.0 technologies

The adoption of high-performance computing, AI, machine learning, sensors and the Internet of Things (IoT), robotics and other Industry 4.0 technologies is growing globally. The next wave of digital innovation is expected to generate $10–15 trillion globally,[213] and currently available technologies could contribute $140–250 billion to Australia's GDP by 2025.[214] The Australian Government has invested $6 million to establish six Industry 4.0 'testlabs' to support the adoption of Industry 4.0 technologies.[215] Compared to other advanced economies, Australia has captured less value from digital innovation (11.2% versus 7.4% of GDP, respectively), particularly in regards to developing new digital industries.[213] There are untapped opportunities for Australia to accelerate digital adoption and its associated productivity gains.

Pandemic-fuelled growth in e-commerce

Amid COVID-19 restrictions and health directives, there has been a rapid growth in e-commerce. According to Australia Post, online shopping in Australia grew by 26.8% in the 12 months leading up to 31 July 2021, with online retail making up 16.3% of total retail spend in 2020–21.[216] The Queensland Investment Corporation estimates that over 18% of retail sales will be online by 2030.[217] Companies listed in the S&P/ASX All Technology Index are also outperforming ASX 200 listed companies.[218] There is a drive to increase the technical capabilities of transport and logistics using IoT, data analytics and automation to boost efficiencies and productivity.[219] Indeed, Australia Post had to suspend operations in New South Wales, Victoria and the Australian Capital Territory (all of which were under lockdown directives) for three days in September 2021 to reduce the stress on the system after 500 staff were required to self-isolate.[220]

The emergence of data-driven organisations

According to the International Data Corporation, 64.2 zettabytes of data (or 64.2 billion terabytes) were created or replicated in 2020 and this is predicted to grow at a compounding annual rate of 23% over the next five years.[221] Many organisations are increasingly realising the value of big data. A 2021 study of 85 Fortune 1000 businesses found that 96% benefited from using big data and data-driven decision making,[222] and a separate study found companies that use customer analytics are twice as likely to generate above-average profits than those who do not.[223] But, we are only at the early stages of the data-driven transformation. Only 24% of the Fortune 1000 businesses surveyed in 2021 identified as a data-driven organisation,[222] and 27% of Australian firms rated themselves as highly data-driven in 2016 (versus 39% of global firms).[224]

An office-less workforce?

The onset of COVID-19 has triggered a rapid and widespread uptake of teleworking. Before COVID-19, around 25% of employees worked from home at least once per week, compared to the start of 2021, where over 40% of workers regularly work remotely.[225] The majority of Australians prefer a hybrid working model (72%) rather than working exclusively from home or in the office.[226] Research has shown that teleworking is associated with greater worker satisfaction and lower firm costs, but it can also decrease effective communication, knowledge flows among employees and managerial oversight.[227] As such, there is an inverted U-shaped relationship between worker efficiency and teleworking, where the 'sweet spot' is in the middle.[227] Organisations will increasingly need to adapt their ways of working to maximise the benefits of teleworking, whilst minimising the potential downsides for workers and employers.

The rise of the regions enabled by teleworking and online services

The COVID-19 pandemic has triggered a reversal of historical regional internal migration patterns. Somewhat counter to *The ongoing pull of big city life* trend (see next page), the number of people living in Australian capital cities declined by 26,000 (–0.1%) in the year leading up until April 2021, whilst regional Australia grew by 70,900 people (0.9%).[228] According to CoreLogic, housing values in regional locations across Australia have grown faster in the 12 months leading up to April 2022 (28.5%) than in capital cities (17.4%).[229] This shift in settlement patterns is likely driven by the preference to live in the outer fringes of capital cities during a global pandemic and the increased uptake of flexible, remote working practices.[230] It remains to be seen whether current trends lead to a longer-term shift in settlement patterns. Future settlement and re-settlement strategies could explore opportunities to accelerate the adoption of Industry 4.0 technologies and transition to low-emission activities to build more resilient regional futures and to attract people and investment to the regions.[231]

A new era for the central business district

The recent boom in teleworking and growth in regional internal migration has had a negative impact on capital cities' central business districts (CBDs). Office occupancy rates are down across all Australian capital cities,[232] and 60% of Australian consumers have reduced or stopped their visits to the city.[233] Demand for commercial property in CBD locations has also declined, with investors increasingly opting for office spaces in the outer urban fringes.[234] The Victorian and New South Wales governments have developed local living strategies, which focus on providing access to essential shops, services, employment and education within a 20–30 minute active or public transport trip.[235,236] This decentralised approach could reduce the need for private vehicle trips and encourage investment in outer suburban and regional areas.[172,235,236] This approach could also open up opportunities to repurpose commercial properties in CBDs for residential accommodation.

The ongoing pull of big city life

In 2018, 55.3% of the global population lived in urban areas and this is forecast to grow to 60.4% by 2030 and 68.4% by 2050, with the majority of the global urban population concentrated in Africa and Asia.[237] The number of megacities with 10 million or more inhabitants will also increase from 33 in 2018 to 43 by 2030.[238] Brisbane and Perth experienced the fastest capital city growth in Australia from 2019–20,[239] but long-range forecasts suggest that future urban growth will be concentrated in Melbourne, Brisbane and Sydney (average annual growth of 2.1%, 2.0% and 1.8% from 2022–42, respectively).[53] While COVID-19 has impacted urban activities, historical projections of urban growth over the past 60 years have been remarkedly robust to shocks.[240] Long-range forecasts are likely to hold unless COVID-19 leads to a sustained preference for online communication and business activities over face-to-face interactions.[240]

Digital health is becoming mainstream

COVID-19 has fast-tracked the integration of digital health initiatives into routine healthcare management and delivery. In March 2020, subsidised telehealth services were temporarily expanded to all Australians,[241,242] resulting in a rapid uptake, with 56 million telehealth consultations conducted in Australia from 13 March 2020 to 21 April 2021.[242] Telehealth services can reduce travel time and productivity losses and improve the timeliness of care.[243] But, telehealth can lead to overutilisation of services, widen healthcare disparities in populations with limited digital access and may not reduce healthcare costs under current activity-based funding models.[243,244] The benefits of telehealth and other digital health initiatives need to be managed with the potential challenges to support a sustainable future healthcare system.

Distributed ledger technology and cryptocurrency

At the time of writing, one in six Australians owned cryptocurrency.[245,246] During the time taken to prepare this report the price of Bitcoin (the most popular digital currency) has sky-rocketed and plummeted.[16,247] Despite the growing popularity of digital currencies, less than 20% of financial advisers feel confident advising clients on these investments.[248] A lack of regulation around cryptocurrency in Australia is also deterring larger investors.[248] Singapore, Canada, the United Kingdom, El Salvador and the state of Wyoming in the United States are strong global proponents of cryptocurrency adoption and regulation,[245,249] and the Biden Administration may look to enhance its regulation around cryptocurrencies in the United States.[250] We note that during the final stages of drafting this report cryptocurrency prices experienced sharp declines. Cryptocurrency prices are volatile with numerous bear-markets and bull-markets over the past decade. The future of cryptocurrency prices is unknown; but Australians and the world have certainly become much more familiar with these digital technologies.

Enhancing the transparency of exports

Food fraud costs the Australian food and wine sector around $1.7 billion in 2017 and this is a growing issue.[251] Emerging technologies are being applied to track the movement of products across global supply chains and can be used to protect Australia's reputation for safe, high-quality products.[252,253] Examples include blockchain technologies, radiofrequency chips, nanotechnologies and laser technologies which can track products across the supply chain and verify their authenticity.[252,253] Biological identification techniques such as DNA fingerprinting technologies and spectroscopic analysis can also be used to verify ingredients and detect contaminants to prevent food fraud, substitution and adulteration.[251,253] These technologies could help build trust with international regulators and customers around Australian exports and minimise trade disruptions for producers.

Towards increased digital inclusivity

Digital inclusion in Australia has been improving since records began, with scores on the Australian Digital Inclusion Index up from 54 in 2014 to 71 in 2021.[254,255] This is a 100-point measure that defines digital inclusion by measures of access, affordability and digital ability. Higher scores reflect greater levels of digital inclusion. Lower-income groups have persistently recorded lower digital inclusion scores than higher-income groups and the digital gap between employed and unemployed Australians has widened over the past seven years.[254,255] The increased reliance on digital services as a result of COVID-19 put digitally excluded groups at risk of social isolation and limited access to online learning and online services.[254] The science and technology sector could play a role in improving digital accessibility and affordability and building the community's digital confidence.

Future demand for digital workers

To keep pace with technological change, Australia will need around an additional 6.5 million digital workers by 2025 – an increase of 79% from 2020.[256] The average Australian worker will need to gain an average of seven new digital skills and 103 million digital skill trainings will need to be conducted between 2020 and 2025 to meet this future demand.[256] The majority of this training will be undertaken by digitally skilled workers (48% of digital skill trainings), but disenfranchised workers (individuals who are unemployed or involuntarily excluded from the workforce) and non-digital workers will also have sizeable digital skill training needs (28% and 12%, respectively).[256] The future digital skill requirements will be even greater beyond Australia, with 69% of the digital skill trainings by 2025 in the Asia-Pacific region required in India.[256]

The risk of spending too much time online

The average Australian aged 16 to 64 years spent 6.2 hours online daily in 2021.[257] Although the internet provided ways to stay connected virtually during the pandemic, there are challenges with spending more time online. Research into social media use has found those who actively use social media to connect and communicate with others experience positive wellbeing benefits, but passive users experience poorer wellbeing outcomes.[258] Social media addiction is associated with poorer job performance at work given its negative impacts on work–family balance and work–family conflict.[259] Kids Helpline has also observed an increase in the number of page views for teen-specific articles on 'sexting' (up by 55.1% from 2019–20) and cyberbullying (39.3%),[260,261] suggesting an increased need for support around these online difficulties.

Increasingly autonomous

I propose to consider the question, ‘Can machines think?’

– Alan Turing, English mathematician

We have seen astonishing improvements in the ability of software and machines to solve problems and perform complex tasks without explicit human guidance. This is driven by ongoing scientific breakthroughs in artificial intelligence (AI) and global investments in technology-driven research and development (R&D). Today, practically all industry sectors and policy spheres in all regions of the world are increasingly adopting AI technology and developing their AI capabilities.

This megatrend unpacks how AI and related science, research and technology capabilities are helping to boost productivity and solve humanity's greatest challenges and the socio-economic considerations of these technology developments.

Increased research in artificial intelligence

Research into AI is increasing rapidly, with the number of peer-reviewed AI publications increasing nearly 12 times from 2000 to 2019.[262] AI represented 3.8% of all publications in 2019 versus 0.8% in 2000.[262] The AI share of patents has also grown from 2% in 2000 to 2.9% in 2019.[262] While there is limited data on R&D expenditure on AI, the size of the global AI market more generally is increasing. The International Data Corporation estimates that this market will grow from $455 billion in 2021 to $665 billion by 2024;[263] this equates to over one-third of Australia's current GDP ($1.8 trillion).[264] The geography of AI R&D is also shifting east, with China accounting for 22.4% of peer-reviewed AI publications in 2019, overtaking the European Union (16.4%) and the United States (14.6%).[262] The global growth in AI research and investment is likely to continue and transform how all industries operate in the coming decades.

New possibilities provided by artificial intelligence advances

AI systems have improved rapidly over the past five years, with AI performance exceeding human benchmarks in areas such as image recognition and natural language processing.[262] Recent advances in generative models mean that AI systems can now generate synthetic text, audio and images to a level that is indistinguishable from non-synthetic outputs.[262] These techniques are increasingly being applied to generate synthetic datasets, which can be used to train new algorithms without the need for real data.[265,266] Generative approaches can provide researchers and developers with access to large, representative datasets that can be difficult or unethical to collect.[266] While these advances open up opportunities to improve the speed and cost-effectiveness of new AI systems, they have also been used for malicious purposes, such as the creation of fake impersonation videos, known as 'deepfakes'.[266,267]

Enabling new discoveries

AI is transforming the speed, quality and breadth of practically every field of physical, natural and social science and creating new paradigms for knowledge discovery.[268,269] For example, Google's DeepMind AlphaFold uses deep learning to predict the three-dimensional structure of proteins[270,271] – a complex task that scientists have spent decades trying to solve.[272] By understanding a protein's shape, scientists can identify the protein's function and accelerate the development of new treatments.[269,271] The next frontier of autonomous experimentation is to develop an AI system that can conduct scientific discoveries that are indistinguishable from the best human scientists (the Nobel Turing Challenge).[273] AI will augment, not replace, human scientists and research institutions will likely need to adopt AI to remain competitive.[273]

Improving computational power and quantum computing

Software and hardware advances are driving future developments in AI capability. In recent times, purpose-built computer processors that are designed to handle matrix algebra and improve the efficiency of machine-learning algorithms have emerged.[274] On the horizon, quantum computing has the potential to substantially increase the computational speed and efficiency of AI and machine-learning systems.[275,276] Quantum technology is an area that is attracting significant investment, with an analysis of 52 global quantum-technology companies showing an increase in private funding ($595 million in 2017 and 2018 combined), compared with the two proceeding years ($130 million in 2015 and 2016).[277] There are many unknowns around the future of quantum computing, but one potential scenario points to a future where these technologies transform the field of AI, resulting in a significant capability uplift and paradigm change.

A growing portfolio of useful artificial intelligence applications

AI is proving useful in a broad range of domains. Examples include the use of machine learning to simulate wildfire movement and support effective and efficient fire suppression activities, as evident in CSIRO's Spark system.[278] Australian airline Qantas is also using the world's most advanced flight-planning system called Constellation (developed by the Australian Centre for Field Robotics), which applies machine learning to achieve faster, smoother and more fuel-efficient flights.[279] A Canberra-based company, Seeing Machines, is also using computer vision to detect and alert fatigued truck drivers.[280] Finally, Brisbane-based Ripper Corp, in collaboration with the University of Technology Sydney, has developed airborne drones that can spot sharks in the surf better than a human observer (93% versus 16% accuracy).[281] These examples only scratch the surface around what is possible for AI applications in the future.

Global investments in research and development

OECD countries spent $2.1 trillion (2.5% of GDP) on R&D in 2019 – an increase from $1.4 trillion (2.1%) in 2000.[282] Global research spending is growing faster than GDP, but the majority of this growth is driven by a minority of countries (e.g. Israel, Japan, Germany and South Korea), with 80% of countries spending less than 1% of GDP.[211] Countries such as the United Kingdom plan to increase R&D spending post-pandemic, up from 1.7% of GDP in 2019 to 2.4% by 2027.[283] Global private-sector investment in R&D has also risen from $523.8 billion in 2005 to $1.1 trillion in 2018.[284] According to the NASDAQ, the top companies by R&D expenditure in 2020 were Amazon ($62.3 billion), Alphabet ($40.2 billion), Huawei ($32.1 billion), Microsoft ($28.1 billion) and Apple ($27.3 billion).[285] High levels of investment in R&D will help fuel future scientific discoveries, innovations and applications.

The shifting centre of research and development investment

The past two decades of strong economic growth across Asia is driving increased investment in R&D in the region.[286] Two standout performers include China and Korea. China's R&D spending grew from 0.7% of GDP in 1998 to 2.2% in 2020, overtaking the European Union in 2015.[286] Korea spent 2.1% of GDP on R&D in 2000 and this has grown to 4.6% by 2019, placing Korea second to Israel as one of the highest R&D-spending nations globally.[286] This growth in R&D expenditure is likely to continue with emerging market and developing economies predicted to grow more strongly in 2022 (5%) than advanced economies (3.6%), driven by India, China and the ASEAN-5 nations.[175] As part of the next phase of economic growth, it is likely that emergent Asian economies will increasingly drive global R&D intensity.

Declining research and development spending intensity in Australia

Counter to global trends, R&D expenditure as a share of GDP in Australia has declined from 2.1% in 2011–12 to 1.8% in 2019–20.[287] R&D expenditure across all Australian organisations in 2019–20 ($35.6 billion) was less than what Amazon and Alphabet individually spent.[285] The higher-education sector has been a strong driver of growth in R&D expenditure in Australia,[287] but recent declines in international enrolments and university revenue could hinder future research funding.[288]

However, the digital technology sector in Australia is investing heavily in R&D. Examples include Wisetech, a logistics technology platform company, which spent $159.1 million (37% of revenue) on R&D in 2019–20;[289] Technology One, an enterprise software company, which spent $68.1 million (22% of revenue);[290] and Atlassian, an enterprise software company, which spent $1.1 billion (47% of revenue).[291] Keeping pace with global trends in R&D expenditure will be critical for Australia's global competitiveness, particularly around AI and other technology developments.

Artificial intelligence summers and winters

Whilst there's been a spotlight on AI in recent times by industry and academia, it is not new. AI has been around for over 50 years and interest in the technology has gone through several peaks and troughs over that time period.[292] Researchers have studied the history of AI and have identified two 'winters' in the early 1960s and the early 1980s; these were periods where investment, discovery and activity in AI slowed considerably.[293] These researchers put forward three potential future scenarios for AI in the 2020s: the current growth could continue, it could level off or we could experience another winter in the first part of this decade.[293] Regardless of which scenario plays out, there is likely to be a lag in how quickly recent AI breakthroughs can be translated into business and policy applications.

The ethics of artificial intelligence

In 2019, the Australian Government released a set of eight voluntary ethics principles to ensure AI is safe, secure and reliable.[294] This follows on from over 80 global responses to emerging ethical issues surrounding AI, including the establishment of the United Kingdom's Centre for Data Ethics and Innovation and the Canadian Government's AI and Society program.[295] The European Union has proposed the most stringent and advanced regulation of AI which includes a blanket ban on any AI systems that are considered an unacceptable risk to the safety, livelihoods and rights of people.[296] Currently, 68% of Australians do not trust AI systems yet 72–81% would be willing to use an AI system if assurance mechanisms were in place (e.g. independent AI ethics reviews, an AI ethics code of conduct).[297] To realise the full potential of AI, these technologies need to be accepted by the public,[298] and this will require consideration of the socio-economic implications of future technology developments to ensure they maximise the benefits to everyone.

Unlocking the human dimension

Beware the two edged sword of trust. You can do amazing things with it, but nothing without it.

– Larry Marshall, CSIRO Chief Executive Officer

Emerging social trends have heightened the influence of human perspectives and experiences on future community, business, technology and policy decisions. Consumers are demanding increased transparency from organisations, governments and scientists to maintain their trust, and there are concerns around the spread of misinformation. The rapid rate of change associated with technology is also driving new considerations around ethical design and deployment.

This megatrend highlights the social drivers influencing future consumer, citizen and employee behaviours.

Trust in Australian institutions

According to the Edelman Trust Barometer, trust in Australian institutions has remained stubbornly low since 2013.[299-307] It showed a boost from 2020 to 2021, with Australia experiencing the greatest increase across 27 nations to score 59 out of 100 (the global average was 56).[299] However, the latest Edelman Trust Barometer suggests that "Australia's trust bubble has burst" with societal trust declining for business (63% in 2021 to 58% to 2022), government (61% to 52%), media (61% to 43%) and non-government organisations 62% to 58%). Science typically attracts high levels of trust; 76% of people globally report that they trust scientists, with trust ratings among the highest in Australasia.[308] Obtaining and maintaining trust will be a challenging task for many public and private sector organisations over the coming decade. The science and research sector is likely to play a key role in building trust and communicating trusted information.

Patterns of social cohesion in Australia

While the pandemic negatively impacted social cohesion in Japan, South Korea, France, Russia and Brazil,[309] the reverse trend appears to be true for Australia. Major crises can band societies together, in response to a common threat, or fragment societies, fuelled by heightened pessimism and opposition.[310] The most recent Scanlon-Monash Index report shows an increase in measures of social cohesion in Australia from 83.7 in 2019 (out of 100) to 89.4 in July 2020 and 92.3 in November 2020.[310] The index fell to 88 points in July 2021 which is still 4.3 points above the pre-pandemic level.[310] The Scanlon-Monash Index report says that for Australia there's "evidence of a strong, cohesive and resilient society, although not without qualification".[310] The qualifications relate to widening socio-economic gaps within certain demographics, barriers to social inclusion and the impacts of the pandemic on children and young people which may be revealed over coming decades. Whether or not Australia is heading towards a more cohesive and less polarised world is not known. There is some recent evidence of an increase in cohesiveness during the pandemic which may contradict commonly held beliefs.

An 'infodemic' within the pandemic and beyond

The proliferation of false or misleading information during a disease outbreak can confuse and degrade trust in public health authorities and responses.[311] This issue is not unique to the COVID-19 pandemic, but social media platforms have amplified the problem and accelerated the spread of misinformation.[312] Research has shown that public support for science is lower when the uncertainty around scientific findings is communicated than if the finding is presented in absolute terms, even if the former is more factually correct.[313] Absolute predictions that are later disproven can also have a negative long-term impact on public support for science.[313] Enhancing public literacy around the scientific method and the complex and evolving nature of science may help maintain public support for science-based policies and decisions. There is also evidence of increased polarisation and "echo-chambers" (*i.e.* when people's pre-existing views are reinforced via biased or scope-limited information streams) due to social media use and algorithms which show information selectively.[314,315]

Communicating the complexities of science

As of October 2021 – a time at which over 64% of Australians have received two COVID-19 vaccination doses[316] – most Australians were willing to receive a booster when recommended (71.9%).[317] Early in the vaccine rollout, there were reports of rare cases of a blood clotting disorder (thrombosis and thrombocytopenia syndrome) arising from the AstraZeneca COVID-19 vaccine in adults aged under 50 years but the risk was very low;[318] however, concerns around the possible side effects of the COVID-19 vaccine remain as the predominant reason for people not getting vaccinated.[317] People struggle to weigh up the risks around vaccines due to cognitive biases that prioritise the most accessible or emotionally compelling information in decision making.[319] These mental shortcuts should be considered in communicating scientific evidence to the public in relation to the current pandemic and other areas of public concern (e.g. climate change).

A prolonged timeline for global poverty mitigation

COVID-19 and its associated economic crisis has disproportionately impacted lower-income populations and pushed 98 million people into extreme poverty.[320] The pandemic, combined with climate change and armed conflict, has delayed progress towards poverty mitigation. Under the best-case scenario, 6.7% of the world will live under the international poverty line by 2030, exceeding the Sustainable Development Goal of 3%.[320] Global divides are also emerging through access to medical supplies and vaccines.[321] The United Nations and the African Union are leading international efforts to ensure that African nations and other low-income countries have access to critical medical supplies and testing kits.[320,321] Without a unified global response to the crisis, there is a risk of inequitable growth and ongoing disease outbreaks.[320,321]

Patterns of wealth distribution and income inequality

The Gini coefficient is an internationally accepted measure of inequality based on household incomes (ranging from 0 to 1), where higher values reflect a greater concentration of incomes to fewer households.[322] In Australia, the Gini coefficient has grown from 0.31 in 2000–01 to 0.33 in 2017–18, indicating a slight increase in inequality.[322] Income inequality in Australia is close to the OECD average, with the lowest inequality in Slovenia (Gini coefficient of 0.24) and the highest in Costa Rica (0.50).[322,323] Lower Gini coefficients are associated with longer lifespans, reduced crime, improved health and overall better quality of life for citizens.[324-327] Reducing income inequality will remain an important policy objective for governments, not-for-profit organisations and businesses around the world over the coming decades.

The rising bar for the great Australian dream

The latest data from the Australian Institute for Health and Welfare shows that 17% of Australians are under financial housing stress and households spent 30–50% of their income on housing costs in 2017–18 (up from 14% in 1994–95).[328] The median cost of housing is also growing faster than household incomes.[329] From June 2019 to 2021, the median house price in Sydney rose by $291,000, with large increases similarly observed across Canberra (up $205,000), Melbourne ($195,000) and Hobart ($145,000).[330] It is becoming increasingly challenging for younger Australians to break into the property market, with the proportion of homeowners between 1981 and 2016 declining by 15% for 25–29 year-olds, by 19% for 30–34 year-olds and by 15% for 35–39 year-olds.[331] By 2041, the Australian Housing and Urban Research Institute estimates that 52.5% of Australians aged 25–54 years old will own a home, compared with 60% in 2016.[331]

Putting environmental, social and corporate governance on the agenda

Environmental, social and corporate governance (ESG) metrics are increasingly being used alongside traditional economic measures to assess organisational performance.[332] The adoption of ESG is driven by government legislation and pressure from consumers.[333] The World Business Council for Sustainable Development (a collective of leading global private organisations) identified the climate emergency, loss of nature and growing inequality as the top issues on their radar.[334] The council has committed to closing coal-fired power plants, adopting electric transportation and sharing data to foster research into sustainable practices.[334] While ESG has a long history, its significance has been magnified by COVID-19 and ESG is now a key consideration for global investors.[335] As more organisations look to improve their ESG performance, demand for R&D into solutions to ESG challenges will likely follow.

Socially aware and empowered consumers

The convergence of mobile, social, cloud and big data technologies has expanded consumers' access to information and shifted the balance of power from sellers to consumers.[336] A survey of over a thousand Australians found that 85% want to see greater transparency around sustainability and ethical practices.[337] Increasing consumer awareness around social and environmental issues is also fuelling ESG initiatives.[338] These trends are evident in healthcare too, with 49% of patients across two Melbourne hospitals reporting that they regularly search for online health information and 34.8% had done so before coming to the emergency department.[339] Empowered consumers will likely stimulate greater transparency from organisations and play a greater role as partners in future business, policy and community decision making.

Reinstating the value of indigenous knowledge

Since the late 1960s, 33% of Australia's total landmass has been returned to Indigenous Australians,[340] and Indigenous peoples now manage or have tenure rights over a quarter of the world's land surface.[341] There is increasing recognition of the need to protect the cultural integrity and economic potential of Indigenous Australians' knowledge and IP Australia is currently exploring how it can adapt Australia's intellectual property system for this purpose.[342] However, indigenous peoples are under-represented in research. For example, Maori researchers make up less than 5% of full-time academic employees in New Zealand[343] and similar trends exist across American universities.[344] Addressing barriers to cultural diversity in science will open up future opportunities to bring together indigenous knowledge and western science to unlock new discoveries.[345]

Evolving labour markets and workforce cultures

COVID-19 has encouraged people to rethink the role of work in their lives and the value they place on flexibility and activities outside of work.[346] Microsoft predicts that 41% of the global workforce is considering leaving their current employer in 2021, 46% of whom have decided to move because they have the option to work remotely.[347] In the third quarter of 2021, 23.4% of Australian employees reported that they are actively seeking other employment, compared with 19.6% globally.[348] These changes are occurring in the broader context of a multi-generational workforce. Different generations of workers can hold different expectations around work–life balance, technology, job security and stability, among other factors.[349] Employers will need to be mindful of adapting their future ways of working to these diverse and evolving employee preferences.

Gender diversity in the workplace

Female participation in the Australian labour force has grown from 58.9% in June 2011 to 61.6% in June 2021,[350] and women are increasingly represented in leadership roles (33.7% of directorships on ASX 200 boards in August 2021 versus 21.7% in 2015).[351] But the pandemic has had a disproportionately negative impact on women in the workforce. Labour participation rates showed a greater decline amongst women than men around the first peak of COVID-19 in Australia (6% versus 3.8% decline from March–May 2020, respectively).[350] The gender pay gap, which was declining up until the end of 2020, increased in May 2021, with females earning 14.2% less than males (13.4% difference in November 2020).[352] With concerns that the pandemic has delayed progress for women in the workforce by up to two decades,[353] future ways of working will need to consider ways to enhance equitable conditions for women.

Our methods

Difficult to see.
Always in motion is the future.

– Yoda, Jedi master in Star Wars

Thinking about the future is an innate human capability that is essential to survive and prosper, and it is an ability that starts to emerge in children between the ages of 3 and 5 years.[354] To envisage the future, we must have an appreciation of the past. Indeed, brain imaging studies have shown that similar parts of the human brain are engaged when people are thinking about the future versus when they are thinking about the past.[355] But the future is riddled with uncertainty and complexity and is difficult to plan for as an individual, let alone an organisation.

Strategic foresight is a long-standing field of research and application that formalises our innate and intuitive ability to think about the future, drawing upon a wide-ranging toolkit of structured methods, frameworks and processes. Unlike traditional forecasting which aims to predict a single future, foresight studies draw upon a range of quantitative and qualitative tools to tap into several different futures that vary in their level of uncertainty. These futures are denoted by the 'futures cone', where the diameter of the circle is inversely proportional to the level of certainty (Figure 1). Strategic foresight aims to help people understand alternative plausible futures so they can make wise choices and get better outcomes.

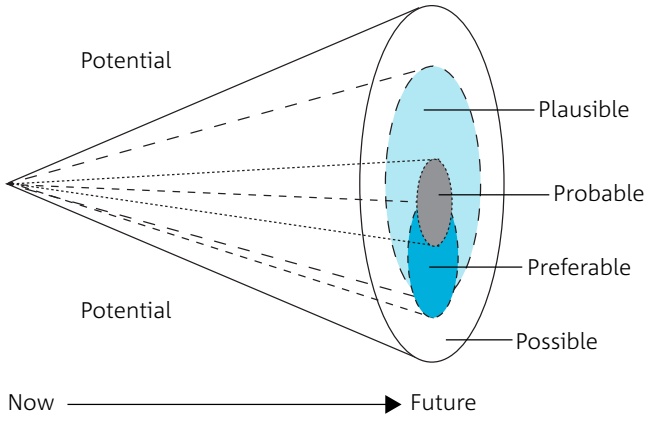

Figure 1. The futures cone
Source: Adapted from Voros[356] and Hancock and Bezold[357]

CSIRO has been researching and developing new and improved techniques for strategic foresight for over 10 years. We have pioneered a data-driven approach that can also be used to identify megatrends in a broad range of strategic and policy domains (Figure 2). This report uses the concept of a megatrend to understand probable changes that are likely to impact organisations across Australia in the coming decades. A megatrend is defined as a trajectory of change that is likely to have a substantial and transformative impact on individuals, organisations and societies.[14] Megatrends typically unfold over years or decades and occur at the intersection of multiple interconnected trends that are narrower in scope.[14]

The global megatrends presented in this report drew upon a diverse range of data sources, including academic papers, government and industry reports, organisational databases, newspaper articles and media articles. This evidence was complemented by consultations with subject-matter experts, organisational leaders, thought leaders and other key stakeholders internal and external to CSIRO. These insights were screened, classified, validated and prioritised into trends, ensuring they were relevant and well supported by robust evidence, and then synthesised into a set of megatrends by clustering trends that had common drivers and/or impacts.

These megatrends were designed to illustrate the emerging patterns of change that are likely to influence future investment, strategy and policy decisions in the years and decades to come. These megatrends reflect the next evolution of the 2012 *Our Future World* global megatrends, including deep-set trends over the past decade that are likely to continue over the next 20 years; previously nascent trends that have been dramatically accelerated; and entirely new trends that were not on the horizon 10 years ago. Strategic foresight is not a static process, and these megatrends need to be monitored, tracked and updated regularly as new information and data come to light to maintain their relevance and accuracy.

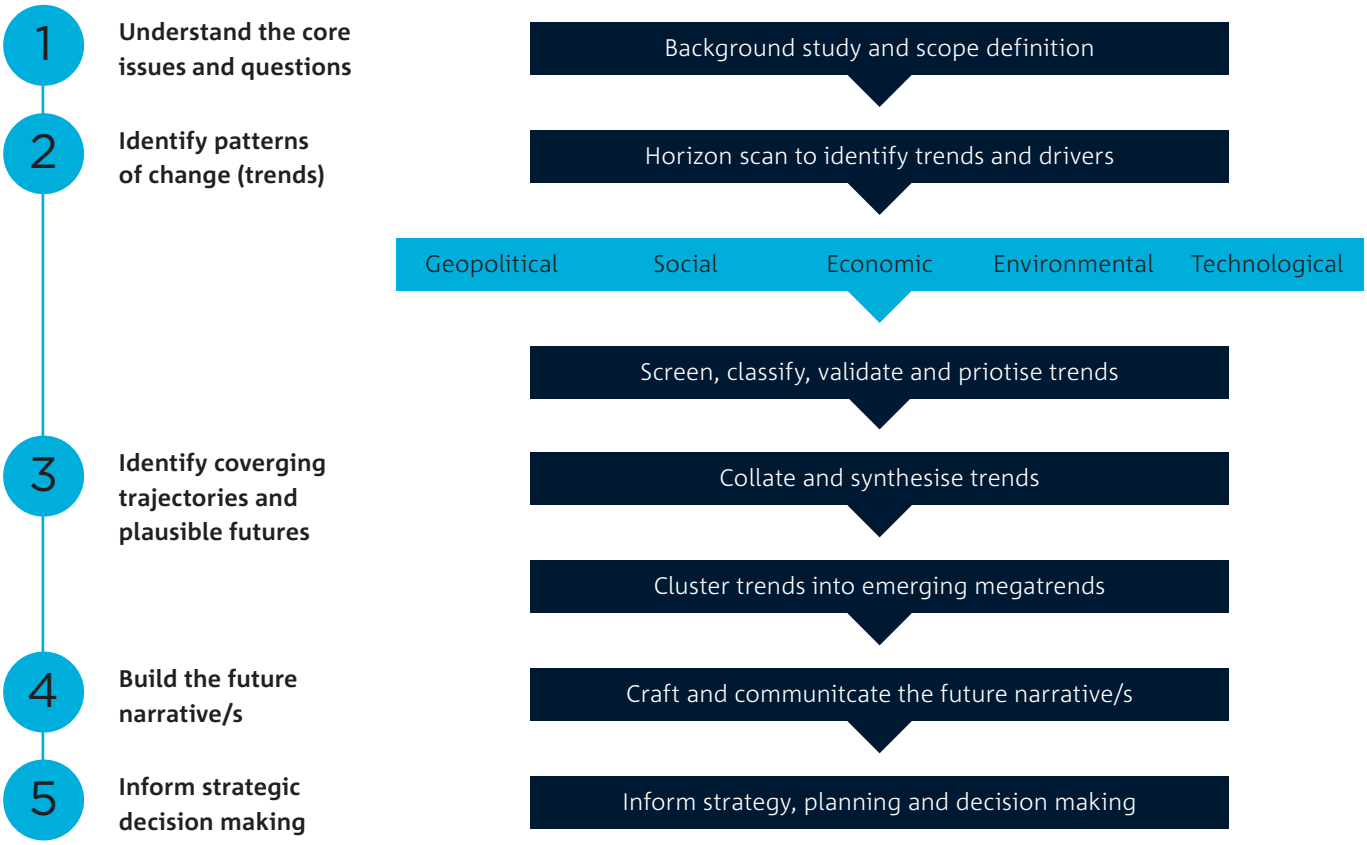

Figure 2. CSIRO's generic strategic foresight framework for identifying megatrends

References

1 Hajkowicz S (2015) Global megatrends: Seven patterns of change shaping our future. Australia: CSIRO.

2 Hajkowicz S, Cook H, Wilhelmseder L, Boughen N (2013) The future of Australian sport: Megatrends shaping the sports sector over coming decades. Australia: CSIRO.

3 Hajkowicz S, Reeson A, Rudd L, Bratanova A, Hodgers L, Mason C (2016) Tomorrow's digitally enabled workforce: Megatrends and scenarios for jobs and employment in Australia over the coming twenty years. Australia: CSIRO.

4 Hajkowicz S, Cook H, Boughen N (2013) The future of tourism in Queensland. Australia: CSIRO.

5 Hajkowicz S, Eady S (2015) Rural industry futures: Megatrends impacting Australian agriculture over the coming twenty years. Brisbane, Australia: CSIRO and the Rural Industries Research and Development Corporation.

6 Hajkowicz S, Neale N, Cameron L, Horton J, Naughtin C, Bratanova A, Sauer K (2018) The innovation imperative: Risks and opportunities for Queensland over the coming decades of economic and technological transformation. Brisbane: CSIRO.

7 Hajkowicz S, Dawson D (2018) Digital megatrends - A perspective on the coming decade of digital disruption. Australia: CSIRO.

8 Horton J, Cameron L, Devaraj D, Hanson R, Hajkowicz S (2018) Workplace Safety Futures: The impact of emerging technologies and platforms on work health and safety and workers' compensation over the next 20 years. Canberra, Australia: CSIRO.

9 GPT (2013) Future shaping at GPT. Australia: The Green Building Council of Australia.

10 Harley R (2015) GPT exploits logistics 'mega trend'. Melbourne: The Australian Financial Review (24 February 2015).

11 Carter B (2012) GPT chief looks to stay ahead of the curve. Canberra: The Australian Newspaper (13 December 2012).

12 Eggleton M (2019) The megatrends shaping our future. Sydney: Australian Financial Review (28 May 2019).

13 Intract (2019). Dream Times Newsletter: Issue 5. Darwin, Australia: Intract.

14 Naughtin C K, Schleiger E, Bratanova A, Hajkowicz S (under review) Forty years in the making: A systematic review of the megatrends literature. Australia: CSIRO.

15 Aon (2020). Weather, climate & catastrophe insight: 2020 Annual report. London, United Kingdom: Aon.

16 Reserve Bank of Australia (2021) Exchange rates. Sydney, Australia: Reserve Bank of Australia.

17 Deloitte (2017) Building resilience to natural disasters in our states and territories. Sydney, Australia: Australian Business Roundtable for Disaster Resilience & Safer Communities.

18 WWF (2020) Australia's 2019-20 bushfires: The wildlife toll. Sydney, Australia: World Wide Fund for Nature.

19 Wintle B A, Legge S, Woinarski J C Z (2020) After the Megafires: What Next for Australian Wildlife? Trends in Ecology & Evolution, 35(9): 753-757.

20 Filkov A I, Ngo T, Matthews S, Telfer S, Penman T D (2020) Impact of Australia's catastrophic 2019/20 bushfire season on communities and environment. Retrospective analysis and current trends. Journal of Safety Science and Resilience, 1(1): 44-56.

21 WEF (2021) The global risks report 2021: 16th edition. Geneva, Switzerland: World Economic Forum.

22 IPCC (2022). Climate change 2022: Impacts, adaptation and vulnerability. Geneva, Switzerland: Intergovernmental Panel on Climate Change.

23 CSIRO, BoM (2020) State of the climate 2020. Australia: CSIRO and the Bureau of Meteorology.

24 Watts N, Amann M, Arnell N, Ayeb-Karlsson S, Beagley J, Belesova K, Boykoff M, Byass P, Cai W, Campbell-Lendrum D, Capstick S, Chambers J, Coleman S, Dalin C, Daly M, Dasandi N, Dasgupta S, Davies M, Di Napoli C, Dominguez-Salas P et al. (2021) The 2020 report of The Lancet Countdown on health and climate change: responding to converging crises. The Lancet, 397(10269): 129-170.

25 Australian Medical Association (2019). Climate change is a health emergency [Media Release]. Barton, Australia: Australian Medical Association, 3 September 2019.

26 Fischer E M, Sippel S, Knutti R (2021) Increasing probability of record-shattering climate extremes. Nature Climate Change, 11(8): 689-695.

27 Raymond C, Matthews T, Horton R M (2020) The emergence of heat and humidity too severe for human tolerance. Science Advances, 6(19): DOI: 10.1126/sciadv.aaw1838.

28 Jackson W, Argent R, Bax N, Bui E, Clark G, Coleman S, Cresswell I, Emmerson K, Evans K, Hibberd M, Johnston E, Keywood M, Klekociuk A, Mackay R, Metcalfe D, Murphy H, Rankin A, Smith D, Wienecke B (2016) Australia state of the environment 2016. Canberra, Australia: Australian Government.

29 Longden T, Quilty S, Haywood P, Hunter A, Gruen R (2020) Heat-related mortality: an urgent need to recognise and record. The Lancet Planetary Health, 4(5): e171.

30 Longden T (2019) The impact of temperature on mortality across different climate zones. Climatic Change, 157(2): 221-242.

31 Keith L, Meerow S, Hondula D M, Turner V K, Arnott J C (2021). Deploy heat officers, policies and metrics. 5 October 2021, Nature.

32 UNESCO (2018) The United Nations world water development report 2018: Nature-based solutions for water. Paris, France: United Nations Educational Scientific and Cultural Organisation.

33 Boretti A, Rosa L (2019) Reassessing the projections of the World Water Development Report. npj Clean Water, 2(15).

34 Mulholland E, Feyen L (2021) Increased risk of extreme heat to European roads and railways with global warming. Climate Risk Management, 34: 100365.

35 Reserve Bank of Australia. Historical Data, Exchange Rates (cited 7 July 2021). Available from: https://www.rba.gov.au/statistics/historical-data.html.

36 Burbidge R (2016) Adapting European Airports to a Changing Climate. Transportation Research Procedia, 14: 14-23.

37 Williams P D, Joshi M M (2013) Intensification of winter transatlantic aviation turbulence in response to climate change. Nature Climate Change, 3(7): 644-648.

38 Coffel E, Horton R (2015) Climate Change and the Impact of Extreme Temperatures on Aviation. Weather, Climate, and Society, 7(1): 94-102.

39 ACCC (2020). Northern Australia insurance inquiry. Canberra, Australia: Australian Competition and Consumer Commission.

40 Insurance Council of Australia (2021). Climate Change Impact Series: Actions of the Sea and Future Risks. Sydney, Australia: Insurance Council of Australia.

41 Xu C, Kohler T A, Lenton T M, Svenning J-C, Scheffer M (2020) Future of the human climate niche. Proceedings of the National Academy of Sciences, 117(21): 11350.

42 Mora C, Dousset B, Caldwell I R, Powell F E, Geronimo R C, Bielecki Coral R, Counsell C W W, Dietrich B S, Johnston E T, Louis L V, Lucas M P, McKenzie M M, Shea A G, Tseng H, Giambelluca T W, Leon L R, Hawkins E, Trauernicht C (2017) Global risk of deadly heat. Nature Climate Change, 7(7): 501-506.

43 Kulp S A, Strauss B H (2019) New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding. Nature Communications, 10(1): 4844.

44 Smithsonian (2018) Ocean acidification. Washington DC, USA: Smithsonian Museum.

45 NOAA (2020) Ocean acidification. Washington DC, USA: National Oceanic and Atmospheric Administration.

46 Petrou K, Nielsen D (2019). Acid oceans are shrinking plankton, fuelling faster climate change. 27 August 2019, The Conversation.

47 Evans K, Bax N, Smith D (2016). Australia state of the environment: Marine environment, key findings. Canberra, Australia:

48 CSIRO (2018) Australian fisheries stocks under climate change. Hobart, Australia: CSIRO.

49 United Nations Decade of Ocean Science for Sustainable Development. Home page (cited 19 July 2021). Available from: https://www.oceandecade.org/.

50 World Bank (2020) Population estimates and projections. Washington DC, United States: World Bank.

51 United Nations Department of Economic and Social Affairs (2019). World population prospects. New York, USA:

52 ABS (2021) Population clock. Canberra, Australia: Australian Bureau of Statistics.

53 ABS (2018) Population projections, Australia, 2017 (base) - 2066. Canberra, Australia: Australian Bureau of Statistics.

54 OECD (2021) Real GDP long-term forecast. Paris, France: Organisation for Economic Co-operation and Development.

55 van Dijk M, Morley T, Rau M L, Saghai Y (2021) A meta-analysis of projected global food demand and population at risk of hunger for the period 2010–2050. Nature Food, 2(7): 494-501.

56 FAO (2009) How to feed the world in 2050. Rome, Italy: Food and Agriculture Organisation of the United Nations.

57 UN (2010) The United Nations decade for deserts (2010-2020) and the fight against desertification. New York, USA: United Nations.

58 FAO (2017) Food and agriculture data: Food balance sheets. Rome, Italy: Food and Agriculture Organisation of the United Nations.

59 Ponce-Reyes R, Lessard B (2021). Edible insects: A roadmap for the strategic growth of an emerging Australian industry. Canberra, Australia: CSIRO.

60 Witte B, Obloj P, Koktenturk S, Morach B, Brigl M, Rogg J, Schulze U, Walker D, Koeller E V, Dehnert N, Grosse-Holz F (2021) Food for thought: The protein transformation. Boston, USA: Boston Consulting Group (24 March 2021).

61 King T, Lawrence S (2019) Meat the alternative - Australia's $3 billion opportunity. Melbourne, Australia: Food Frontier and Deloitte Access Economics.

62 Lacy-Nichols J, Scrinis G, Moodie R (2020). The Australian Alternative Protein Industry. Melbourne, Australia: The University of Melbourne.

63 Fraser C, Gray P (2020) Synthetic biology in Australia. Canberra, Australia: Australian Government Office of the Chief Scientist.

64 CSIRO (2021) Public attitudes towards synthetic biology. Australia: CSIRO Media Release (8 February 2021).

65 Gray P, Meek S, Griffiths P, Trapani J, Small I, Vickers C, Waldby C, Wood R (2018) Synthetic biology in Australia: An outlook to 2030. Melbourne, Australia: Australian Council of Learned Academies.

66 Voigt C A (2020) Synthetic biology 2020–2030: six commercially-available products that are changing our world. Nature Communications, 11(1): 6379.

67 Heveran C M, Williams S L, Qiu J, Artier J, Hubler M H, Cook S M, Cameron J C, Srubar W V (2020) Biomineralization and successive regeneration of engineered living building materials. Matter, 2(2): 481-494.

68 Jagadevan S, Banerjee A, Banerjee C, Guria C, Tiwari R, Baweja M, Shukla P (2018) Recent developments in synthetic biology and metabolic engineering in microalgae towards biofuel production. Biotechnology for Biofuels, 11(1): 185.

69 Dolgin E (2020) Synthetic biology speeds vaccine development. London:

70 Whittall D R, Baker K V, Breitling R, Takano E (2021) Host systems for the production of recombinant spider silk. Trends in Biotechnology, 39(6): 560-573.

71 Ahuja K, Rawat A (2019) Global synthetic biology market, 2019 – 2025. Delaware, USA: The Insight Partners.

72 MCA (2020) Commodity demand outlook 2030. Canberra, Australia: Minerals Council of Australia.

73 Rötzer N, Schmidt M (2018) Decreasing metal ore grades—is the fear of resource depletion justified? Resources, 7(4): 88.

74 IPBES (2019) Global assessment report of the intergovernmental science-policy platform on biodiversity and ecosystem services. Bonn, Germany: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

75 Eddy T D, Lam V W Y, Reygondeau G, Cisneros-Montemayor A M, Greer K, Palomares M L D, Bruno J F, Ota Y, Cheung W W L (2021) Global decline in capacity of coral reefs to provide ecosystem services. One Earth, 4(9): 1278-1285.

76 Landis D A (2017) Designing agricultural landscapes for biodiversity-based ecosystem services. Basic and Applied Ecology, 18: 1-12.

77 Nelson K S, Burchfield E K (2021) Landscape complexity and US crop production. Nature Food, 2(5): 330-338.

78 Klein A-M, Vaissière B E, Cane J H, Steffan-Dewenter I, Cunningham S A, Kremen C, Tscharntke T (2006) Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B: Biological Sciences, 247: 303-313.

79 Waldron A, Miller D C, Redding D, Mooers A, Kuhn T S, Nibbelink N, Roberts J T, Tobias J A, Gittleman J L (2017) Reductions in global biodiversity loss predicted from conservation spending. Nature, 551(7680): 364-367.

80 Kaza S, Yao L, Bhada-Tata P, Woerden F V (2018). What a waste 2.0: A global snapshot of solid waste management to 2050. Washington, D.C., United States: World Bank Group.

81 Pickin J, Wardle C, O'Farrell K, Nyunt P, Donovan S (2020) National Waste Report 2020. Canberra, Australia: Department of Agriculture, Water and the Environment and Blue Environment.

82 RMIT University (2020). New research hub to tackle global waste crisis. 2 July 2020, RMIT News.

83 Wen Z, Xie Y, Chen M, Dinga C D (2021) China's plastic import ban increases prospects of environmental impact mitigation of plastic waste trade flow worldwide. Nature Communications, 12(1): 425.

84 Schandl H, King S, Walton A, Kaksonen A H, Tapsuwan S, Baynes T M (2021) National circular economy roadmap for plastics, glass, paper and tyres: Pathways for unlocking future growth opportunities for Australia. Australia: CSIRO.

85 Mallapaty S (2020) How China could be carbon neutral by mid-century. London: Nature News (19 October 2020).

86 Hawke J (2021) Nations reach climate deal at COP26 after compromise on coal. Sydney: ABC News (14 November 2021).

87 Jolly J (2020) Investor group makes net-zero carbon pledge to tackle climate crisis. Sydney: The Guardian Newspaper (11 December 2020).

88 van Leeuwen H (2021) EU cops international fire over carbon border tax plan. Sydney: Australian Financial Review (2 May 2021).

89 Quicke A (2021). Climate of the nation 2021: Tracking Australia's attitudes towards climate change and energy. Canberra, Australia: The Australia Institute.

90 Liu Z, Deng Z, Davis S J, Giron C, Ciais P (2022) Monitoring global carbon emissions in 2021. Nature Reviews Earth & Environment, 3(4): 217-219.

91 International Energy Agency (2020). World energy outlook 2020. Paris, France: International Energy Agency.

92 IEA (2019) World energy outlook - Report extract electricity. Paris: International Energy Agency.

93 AEMO (2021) Daniel Westerman's CEDA keynote address: A view from the control room. Australia: Australian Energy Market Operator (14 July 2021).

94 IREA (2020) Capacity and generation: Country rankings. Abu Dhabi, UAE: International Renewable Energy Agency.

95 Clean Energy Regulator (2021) Quarterly carbon market report: March quarter 2021. Canberra, Australia: Australian Government.

96 Department of Industry, Science, Energy and Resources, (2020). Australia's emissions projections 2020. Canberra, Australia: Australian Government.

97 Randell P (2016) Waste lithium-ion battery projections: Lithium-ion forums - Recycling, transport and warehousing. Melbourne, Australia: Department of the Environment and Blue Environment.

98 O'Farrell K, Veit R, A'Vard D (2014). Study into market share and stocks and flows of handheld batteries in Australia. Melbourne, Australia: Sustainable Resource Use.

99 King S, Boxall N J, Bhatt A I (2018). Lithium battery recycling in Australia: Current status and opportunities for developing a new industry. Canberra, Australia: CSIRO.

100 Katwala A (2018) The spiralling environmental cost of our lithium battery addiction. United States: Wired Magazine (5 August 2018).

101 Morse I (2021) Indonesia has a long way to go to produce nickel sustainably. London: China Dialogue (28 May 2021).

102 Murray G (2019). Food or energy? The battle over the future of Australia's prime agricultural land. 23 May 2019, Australian Broadcasting Corporation News.

103 Accenture (2021) Future charge: Building Australia's battery industries. Sydney, Australia: Accenture.

104 Soulopoulos N (2017) When will electric vehicles be cheaper than conventional vehicles? London, UK: Bloomberg New Energy Finance (12 April 2017).

105 Nicholson T (2021) Ten car brands going all electric. Melbourne, Australia: Royal Automobile Club of Victoria (Media Release 16 June 2021).

106 IEA (2020) Global EV outlook 2020. Paris, France: International Energy Agency.

107 DISER (2021) Future fuels strategy: Discussion paper. Canberra, Australia: Australian Government Department of Industry, Science, Energy and Resources.

108 Deloitte (2021) The decarbonized power workforce. Tampa, USA: Deloitte.

109 Wood T, Dundas G (2020) Start with steel: A practical plan to support carbon workers and cut emissions. Melbourne, Australia: Grattan Institute.

110 BZE (2020) The million jobs plan: A unique opportunity to demonstrate the growth and employment potential of investing in a low-carbon economy. Melbourne, Australia: Beyond Zero Emissions.

111 Lord M (2019). From mining to making: Australia's future in zero-emissions metal. Melbourne, Australia: Energy Transition Hub.

112 SSAB (2019) SSAB to be first to market with fossil-free steel. Stockholm, Sweden: SSAB Steel Production Company (Media Release 14 November 2019).

113 Ker P (2020) China's biggest steel maker explores hydrogen substitute. Australia: Australian Financial Review (5 March 2020).

114 DISER (2021) Clean energy and the electricity market. Canberra, Australia: Department of Industry, Innovation and Science.

115 Bruce S, Temminghoff M, Hayward J, Schmidt E, Munnings C, Palfreyman D, Hartley P (2018) National hydrogen roadmap. Australia: CSIRO.

116 McKinsey & Company (2021) Hydrogen Insights: A perspective on hydrogen investment, market development and cost competitiveness. New York, USA: McKinsey & Company.

117 IREA (2020) Green hydrogen cost reduction: Scaling up electrolysers to meet the 1.5^{0}C climate goal. Abu Dhabi, UAE: International Renewable Energy Agency.

118 AIHW (2020) Health expenditure Australia 2018–19. Canberra, Australia: Australian Institute for Health and Welfare.

119 OECD (2019) Health at a glance 2019. Paris, France: Organisation for Economic Cooperation and Development.

120 The Treasury (2021) Intergenerational report: Australia over the next 40 years. Canberra, Australia: Australian Government.

121 AIHW (2020) Health expenditure snapshot (release data 23 July 2020). Canberra: Australian Institute of Health and Welfare.

122 Allen T, Murray K A, Zambrana-Torrelio C, Morse S S, Rondinini C, Di Marco M, Breit N, Olival K J, Daszak P (2017) Global hotspots and correlates of emerging zoonotic diseases. Nature Communications, 8(1): 1-10.

123 Jones K E, Patel N G, Levy M A, Storeygard A, Balk D, Gittleman J L, Daszak P (2008) Global trends in emerging infectious diseases. Nature, 451(7181): 990-993.

124 Keesing F, Belden L K, Daszak P, Dobson A, Harvell C D, Holt R D, Hudson P, Jolles A, Jones K E, Mitchell C E, Myers S S, Bogich T, Ostfeld R S (2010) Impacts of biodiversity on the emergence and transmission of infectious diseases. Nature, 468(7324): 647-652.

125 Mohd H A, Al-Tawfiq J A, Memish Z A (2016) Middle East respiratory syndrome coronavirus (MERS-CoV) origin and animal reservoir. Virology journal, 13(1): 87.

126 Claas E C, Osterhaus A D, Van Beek R, De Jong J C, Rimmelzwaan G F, Senne D A, Krauss S, Shortridge K F, Webster R G (1998) Human influenza A H5N1 virus related to a highly pathogenic avian influenza virus. The Lancet, 351(9101): 472-477.

127 Guan Y, Zheng B, He Y, Liu X, Zhuang Z, Cheung C, Luo S, Li P, Zhang L, Guan Y (2003) Isolation and characterization of viruses related to the SARS coronavirus from animals in southern China. Science, 302(5643): 276-278.

128 Saéz A M, Weiss S, Nowak K, Lapeyre V, Zimmermann F, Düx A, Kühl H S, Kaba M, Regnaut S, Merkel K (2015) Investigating the zoonotic origin of the West African Ebola epidemic. EMBO molecular medicine, 7(1): 17-23.

129 DOH (2022) Japanese encephalitis - We are monitoring the unfolding situation in Australia concerning the Japanese encephalitis virus (JEV). Canberra: Australian Government Department of Health (7 March 2022).

130 WHO (2022) Multi-country monkeypox outbreak in non-endemic countries. Geneva: World Health Organisation (News Item 21 May 2022).

131 DOH (2022) Australian Influenza Surveillance Report No 04 - fortnight ending 22 May 2022. Canberra: Australian Government Department of Health (27 May 2022).

132 Chen X, Kang Y, Luo J, Pang K, Xu X, Wu J, Li X, Jin S (2021) Next-generation sequencing reveals the progression of COVID-19. Frontiers in Cellular and Infection Microbiology, 11(142).

133 Considine M-L (2020) How sewage testing helps contain COVID-19. Australia: ECOS CSIRO Magazine (4 September 2020).

134 Dobson A P, Pimm S L, Hannah L, Kaufman L, Ahumada J A, Ando A W, Bernstein A, Busch J, Daszak P, Engelmann J, Kinnaird M F, Li B V, Loch-Temzelides T, Lovejoy T, Nowak K, Roehrdanz P R, Vale M M (2020) Ecology and economics for pandemic prevention. Science, 369(6502): 379.

135 Mackenzie D (2020) The COVID-19 pandemic was predicted – here's how to stop the next one. United States: New Scientist (16 September 2020).

136 WHO (2021) Ten global health issues to track in 2021. Geneva: World Health Organisation Spotlight (24 December 2020).

137 Australian Government. Antimicrobial resistance (cited 23 September 2021). Available from: https://www.amr.gov.au/.

138 Prestinaci F, Pezzotti P, Pantosti A (2015) Antimicrobial resistance: a global multifaceted phenomenon. Pathogens and global health, 109(7): 309-318.

139 Murray C J L, Ikuta K S, Sharara F, Swetschinski L, Robles Aguilar G, Gray A, Han C, Bisignano C, Rao P, Wool E, Johnson S C, Browne A J, Chipeta M G, Fell F, Hackett S, Haines-Woodhouse G, Kashef Hamadani B H, Kumaran E A P, McManigal B, Agarwal R et al. (2022) Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. The Lancet, 399(10325): 629-655.

140 O'Neill J (2014) Antimicrobial resistance: Tackling a crisis for the health and wealth of nations. London: United Kingdom Government.

141 World Bank (2017) Drug-resistant infections: A threat to our economic future. Washington DC: World Bank.

142 IACG (2018) Antimicrobial resistance: national action plans - discussion paper. Geneva: Interagency Coordination Group on Antimicrobial Resistance, World Health Organisation.

143 APRA (2020) Private health insurance annual coverage survey December 2019. Sydney, Australia: Australian Prudential Regulation Authority.

144 ABS (2021) National, state and territory population. Canberra, Australia: Australian Bureau of Statistics.

145 Duckett S, Nemet K (2019). The history and purposes of private health insurance (Grattan Institute Working Paper No. 2019-01). Melbourne, Australia: Grattan Institute.

146 Cabinet Office (2020). Annual report on the ageing society FY2020. Tokyo, Japan: Government of Japan.

147 Vos T, Lim S S, Abbafati C, Abbas K M, Abbasi M, Abbasifard M, Abbasi-Kangevari M, Abbastabar H, Abd-Allah F, Abdelalim A, Abdollahi M, Abdollahpour I, Abolhassani H, Aboyans V, Abrams E M, Abreu L G, Abrigo M R M, Abu-Raddad L J, Abushouk A I, Acebedo A et al. (2020) Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: A systematic analysis for the global burden of disease study 2019. The Lancet, 396(10258): 1204-1222.

148 ABS (2019) National health survey: First results, 2017–18. Canberra, Australia: Australian Bureau of Statistics.

149 Schofield D, Shrestha R N, Cunich M M, Tanton R, Veerman L, Kelly S J, Passey M E (2016) Economic costs of chronic disease through lost productive life years (PLYs) among Australians aged 45–64 years from 2015 to 2030: results from a microsimulation model. BMJ Open, 6(9): e011151.

150 Domeyer P, Katsari V, Mariolis A (2020) Chronic non-communicable diseases: a sacrifice on the altar of COVID-19? British Journal of General Practice, 70(695): 281.

151 Scott S (2020) Experts worried people delaying medical tests due to coronavirus will create 'tidal wave' of diagnoses. Sydney: ABC News (14 May 2020).

152 Continuity of Care Collaboration (2020) Australians are delaying healthcare appointments and tests during COVID-19. Melbourne, Australia: Allied Health Professionals Australia.

153 Tsirtsakis A (2020). Fears of post-pandemic 'tsunami of health problems'. 14 May 2020, Royal Australian College of General Practitioners.

154 Shakespeare T, Ndagire F, Seketi Q E (2021) Triple jeopardy: disabled people and the COVID-19 pandemic. The Lancet, 397(10282): 1331-1333.

155 Reynolds A C, Appleton S L, Gill T K, Adams R J (2019). Chronic insomnia disorder in Australia. Adelaide, Australia: Sleep Health Foundation.

156 Blume C, Schmidt M H, Cajochen C (2020) Effects of the COVID-19 lockdown on human sleep and rest-activity rhythms. Current biology : CB, 30(14): R795-R797.

157 Leone M J, Sigman M, Golombek D A (2020) Effects of lockdown on human sleep and chronotype during the COVID-19 pandemic. Current biology : CB, 30(16): R930-R931.

158 Centeno-Calixto C (2021) With 'coronasomnia' on the rise, here are ways to sleep better. Melbourne: SBS News (27 August 2021).

159 Huang B-H, Duncan M J, Cistulli P A, Nassar N, Hamer M, Stamatakis E (2021) Sleep and physical activity in relation to all-cause, cardiovascular disease and cancer mortality risk. British Journal of Sports Medicine: bjsports-2021-104046.

160 Masters R, Anwar E, Collins B, Cookson R, Capewell S (2017) Return on investment of public health interventions: a systematic review. Journal of Epidemiology and Community Health, 71(8): 827-834.

161 Friel S, Baum F, Goldfeld S, Townsend B, Büsst C, Keane L (2021) How Australia improved health equity through action on the social determinants of health The Medical Journal of Australia, 214(8 Supplementary): S7-S11.

162 ABS (2020) Household Impacts of COVID-19 Survey, November 2020. Canberra, Australia: Australian Bureau of Statistics.

163 ABS (2021) Household Impacts of COVID-19 Survey, May 2021. Canberra, Australia: Australian Bureau of Statistics.

164 John A, Eyles E, Webb R T, Okolie C, Schmidt L, Arensman E, Hawton K, O'Connor R C, Kapur N, Moran P, O'Neill S, McGuiness L A, Olorisade B K, Dekel D, Macleod-Hall C, Cheng H-Y, Higgins J P T, Gunnell D (2020) The impact of the COVID-19 pandemic on self-harm and suicidal behaviour: update of living systematic review. F1000Research, 9: 1097-1097.

165 Czeisler M É, Wiley J F, Facer-Childs E R, Robbins R, Weaver M D, Barger L K, Czeisler C A, Howard M E, Rajaratnam S M W (2021) Mental health, substance use, and suicidal ideation during a prolonged COVID-19-related lockdown in a region with low SARS-CoV-2 prevalence. Journal of Psychiatric Research, 140: 533-544.

166 Dib J, Comer J, Wootten A, Buhagiar K (2021). State of mind 2021 report. Melbourne, Australia: Smiling Mind.

167 Veldhuis C B, Nesoff E D, McKowen A L W, Rice D R, Ghoneima H, Wootton A R, Papautsky E L, Arigo D, Goldberg S, Anderson J C (2021) Addressing the critical need for long-term mental health data during the COVID-19 pandemic: Changes in mental health from April to September 2020. Prev Med, 146: 106465.

168 Nitschke J P, Forbes P A G, Ali N, Cutler J, Apps M A J, Lockwood P L, Lamm C (2021) Resilience during uncertainty? Greater social connectedness during COVID-19 lockdown is associated with reduced distress and fatigue. British Journal of Health Psychology, 26(2): 553-569.

169 Stark Z, Dolman L, Manolio T A, Ozenberger B, Hill S L, Caulfied M J, Levy Y, Glazer D, Wilson J, Lawler M, Boughtwood T, Braithwaite J, Goodhand P, Birney E, North K N (2019) Integrating genomics into healthcare: A global responsibility. The American Journal of Human Genetics, 104(1): 13-20.

170 Dana G (2017) Three ways China is leading the way in precision medicine. Geneva, Switzerland: World Economic Forum.

171 Department of Health (2021) MRFF genomics health futures mission roadmap and implementation plan: National consultation report. Canberra, Australia: Australian Government.

172 Backholer K, Baum F, Finlay S M, Friel S, Giles-Corti B, Jones A, Patrick R, Shill J, Townsend B, Armstrong F, Baker P, Bowen K, Browne J, Büsst C, Butt A, Canuto K, Canuto K, Capon A, Corben K, Daube M et al. (2021) Australia in 2030: What is our path to health for all? The Medical Journal of Australia, 214(8): S5-S40.

173 Kasztura M, Richard A, Bempong N-E, Loncar D, Flahault A (2019) Cost-effectiveness of precision medicine: a scoping review. International Journal of Public Health, 64(9): 1261-1271.

174 National Human Genome Research Institute (2020). DNA sequencing costs: Data. Bethesda, USA: National Institute of Health.

175 IMF (2021) World economic outlook update: Fault lines widen in the global recovery. Washington, DC, USA: International Monetary Fund.

176 Silva D L D, Tian N, Marksteiner A (2021) Trends in world military expenditure, 2020. Stockholm, Sweden: Stockholm International Peace Research Institute.

177 ASPI (2021) The cost of defence public database (updated 21 June 2021). Canberra, Australia: Australian Strategic Policy Institute.

178 Greene A, Probyn A, Dziedzic S (2021) Australia to get nuclear-powered submarines, will scrap $90b program to build French-designed subs. ABC News 15 Sep 2021, Sydney.

179 Davis M (2021) AUKUS should prompt a shake-up of Australia's strategic mindset. Canberra, Australia: The Strategist (23 September 2021).

180 Wilkening D (2019) Hypersonic Weapons and Strategic Stability. Survival, 61(5): 129-148.

181 Moy G, Shekh S, Oxenham M, Ellis-Steinborner S (2020) Recent Advances in Artificial Intelligence and their Impact on Defence (DST-Group-TR-3716). Canberra: Australian Government Department of Defence Science and Technology.

182 Iasiello E (2021) What is the Role of Cyber Operations in Information Warfare? Journal of Strategic Security, 14(4): 72-86.

183 Robinson M, Jones K, Janicke H (2015) Cyber warfare: Issues and challenges. Computers & Security, 49: 70-94.

184 Liebetrau T (2022) Cyber conflict short of war: a European strategic vacuum. European Security: 1-20.

185 Boyd I (2022) How hypersonic missiles work and the unique threats they pose – an aerospace engineer explains. Australia: The Conversation (15 April 2022).

186 EC (2022) Sanctions adopted following Russia's military aggression against Ukraine. London: European Commission Website Accessed 3 June 2022 (https://ec.europa.eu/info/business-economy-euro/banking-and-finance/international-relations/restrictive-measures-sanctions/sanctions-adopted-following-russias-military-aggression-against-ukraine_en).

187 DFAT (2022) Russia sanctions regime. Canberra Australian Government Department of Foreign Affairs and Trade (Website: https://www.dfat.gov.au/international-relations/security/sanctions/sanctions-regimes/russia-sanctions-regime accessed 3 June 2022).

188 The White House (2022) Fact Sheet: United States Takes Further Actions to Counter Sanctions Evasion by Russia (2 June 2022). Washington DC: United States Government Website Accessed 3 June 2022 (https://www.whitehouse.gov/briefing-room/statements-releases/2022/06/02/fact-sheet-united-states-takes-further-actions-to-counter-sanctions-evasion-by-russia/).

189 DoS (2022) United States Security Cooperation with Ukraine. Washington DC: United States Department of State, Bureau of Political-Military Affairs.

190 NATO (2022) NATO's response to Russia's invasion of Ukraine (8 April 2022). Brussels: North Atlantic Treaty Organisation.

191 UK.GOV (2022) Russian invasion of Ukraine: UK government response - The UK and our allies condemn the Russian government's unprovoked and premeditated war against Ukraine. London: United Kingdom Government Website Accessed 3 June 2022 (https://www.gov.uk/government/topical-events/russian-invasion-of-ukraine-uk-government-response).

192 OECD (2022) Rights and Support for Ukrainian Refugees in Receiving Countries. Paris: Organisation for Economic Cooperation and Development (9 May 2022).

193 NATO (2022) NATO Foreign Ministers discuss Sweden, Finland membership application, reaffirm Ukraine support. Brussels: North Atlantic Treaty Organisation (Media Release 15 May 2022).

194 DFAT (2020) Australia's trade in goods and services by top 15 partners. Canberra: Australian Government Department of Foreign Affairs and Trade.

195 Smith M (2021) Australian wine stopped at Chinese ports in latest trade spat. Sydney: The Australian Financial Review (25 February 2021).

196 Smith M, Grigg A, Thompson B, Tillett A (2020) Australian exporters brace for new wave of China tariffs. Sydney: Australian Financial Review (2 November 2020).

197 Smyth J (2021). Australia shrugs off China trade dispute and opens new markets. 26 May 2021, Financial Times.

198 Dziedzic S (2021) India-Australia free trade talks to resume following Tony Abbott's visit to New Delhi. Sydney: ABC News (12 August 2021).

199 PC (2021) Vulnerable supply chains: Interim report. Canberra, Australia: Australian Government Productivity Commission.

200 IIER (2020) Australia's medicine supply: Is our health a national security / resilience issue? Australia: Institute for Integrated Economic Research.

201 ABS (2022) Business Conditions and Sentiments - Insights into Australian business conditions and sentiments (April 2022). Canberra: Australian Bureau of Statistics.

202 Australian Government (2020). Make it happen: The Australian Goverment's modern manufacturing strategy. Canberra, Australia: Australian Government.

203 Uren D (2020) Southeast Asia will take a major economic hit if shipping is blocked in the South China Sea. Canberra: Australian Strategic Policy Institute.

204 BITRE (2019) Aviation: International airline activity 2018-19 Canberra, Australia: Australian Government Bureau of Infrastructure Transport and Regional Economics.

205 WTO (2019) World trade statistical review 2019. Geneva, Switzerland: World Trade Organisation.

206 WTO (2020) Trade set to plunge as COVID-19 pandemic upends global economy. Geneva, Switzerland: World Trade Organization (Press Release 8 April 2020).

207 Pearce B (2021) COVID-19: An almost full recovery of air travel in prospect. Montreal, Canada: International Air Transport Association.

208 Australian Cyber Security Centre (2021). Annual cyber threat report: July 2020 to June 2021. Canberra, Australia: Australian Government.

209 ACSC (2020) Annual cyber threat report July 2019 to June 2020. Canberra, Australia: Australian Government, Australian Cyber Security Centre.

210 Das S (2018) Direct costs associated with cybersecurity incidents costs Australian businesses $29 billion per annum. Sydney, Australia: Microsoft (Media Release on 28 June 2018).

211 UNESCO (2021) Science report: The race against time for smarter development. Paris, France: United Nations Educational, Scientific and Cultural Organization.

212 Maher B, Van Noorden R (2021) How the COVID pandemic is changing global science collaborations. London: Nature News (16 June 2021).

213 AlphaBeta (2018) Digital innovation: Australia's $315b opportunity. Sydney: Commonwealth Scientific and Industrial Research Organisation and AlphaBeta.

214 McKinsey & Company (2017). Digital Australia: Siezing the opportunity from the Fourth Industrial Revolution. Sydney, Australia: McKinsey & Company.

215 DISER (2019) Factsheet: Industry 4.0 testlabs for Australia. Canberra, Australia: Australian Government Department of Industry, Science, Energy and Resources.

216 Australia Post (2021) Inside Australian online shopping: eCommerce update. Melbourne, Australia: Australia Post.

217 QIC (2021) Implications of online retail on the Australian shopping centre industry. Brisbane, Australia: Queensland Investment Corporation.

218 S&P Dow Jones Indices (2021). S&P/ASX all technology index. Sydney Australia: Australian Securities Exchange.

219 Twinn I, Qureshi N, Conde M L, Guinea C G, Rojas D P, Luo J, Gupta H (2020) The impact of COVID-19 on logistics. Washington DC, USA: International Finance Corporation.

220 ABC (2021) Australia Post, with 500 staff in COVID isolation, will pause parcel pick-up from e-commerce retailers in locked down states for three days. Sydney, Australia: Australian Broadcasting Corporation (1 September 2021).

221 Rydning J, Shirer M (2021) Data creation and replication will grow at a faster rate than installed storage capacity, according to IDC global datasphere and storagesphere forecasts. Needham, USA: International Data Corporation.

222 Bean R, Davenport T (2020) Big data and AI executive survey 2021. Boston, USA: New Vantage Partners LLC.

223 Bokman A, Fiedler L, Perrey J, Pickersgill A (2014) Five facts: How customer analytics boosts corporate performance. New York, USA: McKinsey & Company.

224 PwC (2016) Big decisions: Let the data do the talking. London, UK: PwC.

225 ABS (2021) A year of COVID-19 and Australians work from home more. Canberra, Australia: Australian Bureau of Statistics (17 March 2021).

226 Gash C (2020). Moving beyond remote: Workplace transformation in the wake of COVID-19. 7 October 2020, Slack.

227 OECD (2020) Productivity gains from teleworking in the post COVID-19 era: How can public policies make it happen? Paris, France: Organisation for Economic Cooperation and Development.

228 ABS (2022) Regional population - Statistics about the population and components of change (births, deaths, migration) for Australia's capital cities and regions (April 2022). Canberra, Australia: Australian Bureau of Statistics.

229 CoreLogic (2022). CoreLogic's Home Value Index continues to lose steam as the case for higher interest rates mount (1 May 2022). Sydney, Australia: CoreLogic.

230 Brinsden C (2021). House price boom slows slightly in April. 3 May 2021, The Canberra Times.

231 Lazarow N, Measham T, Fleming D. Regional Australia could hold the answers to living well in 2050 (cited 7 March 2022). Available from: https://ecos.csiro.au/regional-australia-could-hold-the-answers-to-living-well-in-2050/.

232 Ernest & Young, Property Council of Australia (2021) Reimagining our economic powerhouses: How to turn CBDs into central experience districts. Sydney, Australia: Ernest & Young.

233 NAB (2021) NAB consumer insight report: Impact of COVID-19 on Australia's CBD's & what would encourage us to visit more often? Melbourne, Australia: National Australia Bank Behavioural and Industry Economics.

234 Cummins C (2021) Investors ditch the CBD for improved value and yields. Australia: The Sydney Morning Herald (19 June 2021).

235 DELWP (2017) Plan Melbourne: A global city of opportunity and choice. Melbourne, Australia: Department of Environment, Land, Water and Planning, Government of Victoria.

236 GCS (2020) The pulse of Greater Sydney 2020: Measuring what matters in the metropolis. Sydney, Australia: Greater Sydney Commission.

237 UNDP (2018) World urbanization prospects 2018. Paris, France: United Nations Department of Economic and Social Affairs Population Division.

238 UNDP (2018) The world's cities in 2018. New York, USA: United Nations Population Division.

239 ABS (2021) Regional population. Canberra, Australia: Australian Bureau of Statistics.

240 Kii M (2021) Projecting future populations of urban agglomerations around the world and through the 21st century. NPJ Urban Sustainability, 1(10): DOI 10.1038/s42949-42020-00007-42945.

241 DoH (2020) COVID-19: Whole of population telehealth for patients, general practice, primary care and other medical services. Canberra Australia: Australian Government Department of Health.

242 Minister for Health and Aged Care (2021) Universal Telehealth extended through 2021 (media release 26 April 2021). Canberra, Australia: Australian Government.

243 Mahtta D, Daher M, Lee M T, Sayani S, Shishehbor M, Virani S S (2021) Promise and perils of telehealth in the current era. Current Cardiology Reports, 23(9): 115.

244 Snoswell C L, Taylor M L, Comans T A, Smith A C, Gray L C, Caffery L J (2020) Determining if telehealth can reduce health system costs: Scoping review. Journal of Medical Internet Research, 22(10): e17298.

245 Whitson R (2021) Lack of regulation means some cryptocurrency start-ups are being 'debanked', with investors also at risk. Sydney, Australia: ABC News (21 September 2021).

246 Finder (2021). Finder's cryptocurrency report. Sydney, Australia: Finder.

247 CoinMarketCap. Bitcoin (cited 13 October 2021). Available from: https://coinmarketcap.com/currencies/bitcoin/.

248 Powell D (2021) Floodgates about to break: Aussie super funds could tip billions into crypto. Sydney: The Sydney Morning Herald (11 October 2021).

249 ABC News (2021) El Salvador becomes first country in the world to accept cryptocurrency bitcoin as legal tender. Sydney, Australia: ABC News (7 September 2021).

250 Tokar D (2021). Biden administration embarking on 'aggressive' tack for cryptocurrency, White House official says. 12 October 2021, The Wall Street Journal.

251 McLeod R (2017) Counting the cost: Lost Australian Food and Wine Export Sales Due to Fraud. Australia: Food Innovation Australia Limited.

252 IBM (2020) Focus on food fraud. New York, USA: IBM.

253 RIRDC (2016) Agricultural product validation: Needs analysis and technology evaluation (RIRDC Publication No. 16/02). Woolongong, Australia: Rural Industries Research and Development Corporation.

254 Thomas J, Barraket J, Wilson C, Holcombe-James I, Kennedy J, Rennie E, Ewing S, MacDonald T (2020) Measuring Australia's digital divide: The Australian digital inclusion index. Melbourne, Australia: RMIT, Swinburne University of Technology, Telstra.

255 Thomas J, Barraket J, Parkinson S, Wilson C, Holcombe-James I, Kennedy J, Mannell K, Brydon A (2021) Australian Digital Inclusion Index 2021. Melbourne, Australia: RMIT, Swinburne University of Technology and Telstra.

256 AlphaBeta (2021) Unlocking APAC's digital potential: Changing digital skill needs and policy approaches. Singapore: AlphaBeta commissioned by Amazon Web Services.

257 WAS (2021) Digital 2021: Australia. Sydney, Australia: We Are Social.

258 Kross E, Verduyn P, Sheppes G, Costello C K, Jonides J, Ybarra O (2021) Social media and well-being: Pitfalls, progress, and next steps. Trends in Cognitive Sciences, 25(1): 55-66.

259 Zivnuska S, Carlson J R, Carlson D S, Harris R B, Harris K J (2019) Social media addiction and social media reactions: The implications for job performance. The Journal of Social Psychology, 159(6): 746-760.

260 Kids Help Line (2020) Insights 2020: Insights into young people in Australia. Brisbane, Australia: Yourtown.

261 Kids Help Line (2019) Insights 2019: Insights into young people in Australia. Brisbane, Australia: Yourtown.

262 Zhang D, Mishra S, Brynjolfsson E, Etchemendy J, Ganguli D, Grosz B, Lyons T, Manyika J, Niebles J C, Sellitto M, Yoav Shoham, Clark J, Perrault R (2021) The AI index 2021 annual report. Stanford, USA: Human-Centered AI Institute and Stanford University.

263 Shirer M (2021). IDC forecasts companies to spend almost $342 billion on AI solutions in 2021 [Media Release]. Boston, USA: International Data Corporation Worldwide Semiannual Artificial Intelligence Tracker, 4 August 2021.

264 World Bank (2020). GDP (current US$) - Australia. Washington, D.C., USA: World Bank.

265 Tucker A, Wang Z, Rotalinti Y, Myles P (2020) Generating high-fidelity synthetic patient data for assessing machine learning healthcare software. npj Digital Medicine, 3(1).

266 Chen R J, Lu M Y, Chen T Y, Williamson D F K, Mahmood F (2021) Synthetic data in machine learning for medicine and healthcare. Nature Biomedical Engineering, 5(6): 493-497.

267 Citron D K, Chesney R (2019) Deep fakes: A looming challenge for privacy, democracy, and national security California Law Review, 107: 1753-1820.

268 Stevens R, Taylor V, Nichols J, Maccabe A B, Yelick K, Brown D (2019) AI for science. Lemont, USA: Argonne National Laboratory.

269 The Alan Turing Institute (2019) The AI revolution in scientific research. London, UK: The Royal Society.

270 Senior A W, Evans R, Jumper J, Kirkpatrick J, Sifre L, Green T, Qin C, Žídek A, Nelson A W, Bridgland A (2020) Improved protein structure prediction using potentials from deep learning. Nature, 577(7792): 706-710.

271 DeepMind. AlphaFold: Using AI for scientific discovery (cited 29 September 2021). Available from: https://www.deepmind.com/blog/alphafold-using-ai-for-scientific-discovery-2020.

272 Dill K A, MacCallum J L (2012) The protein-folding problem, 50 years on. Science, 338(6110): 1042-1046.

273 Kitano H (2021) Nobel Turing Challenge: creating the engine for scientific discovery. npj Systems Biology and Applications, 7(1): 29.

274 Reuther A, Michaleas P, Jones M, Gadepally V, Samsi S, Kepner J (2020). Survey of Machine Learning Accelerators. 2020 IEEE High Performance Extreme Computing Conference (HPEC); p1-12.

275 Ying M (2010) Quantum computation, quantum theory and AI. Artificial Intelligence, 174(2): 162-176.

276 Biamonte J, Wittek P, Pancotti N, Rebentrost P, Wiebe N, Lloyd S (2017) Quantum machine learning. Nature, 549(7671): 195-202.

277 Gibney E (2019) Quantum gold rush: the private funding pouring into quantum start-ups. London: Nature News (2 October).

278 Miller C, Hilton J, Sullivan A, Prakash M (2015) 'SPARK – A Bushfire Spread Prediction Tool' In: Environmental Software Systems, Denzer Ralf *et al.* London: Springer International Publishing.

279 Simpson S, Sukkarieh S (2021) Partnering with Qantas to rise above the competition - Our partnership with airline Qantas looks beyond disciplinary boundaries, to take flying to the next level. Sydney: The University of Sydney (website accessed 16 November 2021).

280 DISER (2021) Australia's Artificial Intelligence Action Plan. Canberra: Australian Government Department of Industry Science Energy and Resources.

281 RipperCorp (2021) Ripper Tech Lab Empowering Intelligence Search - Major Tech Projects. Brisbane: Ripper Corp Website (accessed on 16 November 2021).

282 OECD (2021) Gross domestic spending on R&D. Paris, France: Organisation for Economic Development and Cooperation.

283 Hutton G (2021) Research & development spending. London, UK: House of Commons Library and United Kingdom Government.

284 PwC (2019) The 2018 global innovation 1000 study. London, UK: PwC.

285 Bajpai P (2021). Which companies spend the most in research and development? 21 June 2021, NASDAQ News.

286 OECD (2021) Main science and technology indicators. Paris, France: Organisation for Economic Cooperation and Development.

287 ABS (2021) Research and experimental development, businesses, Australia. Canberra, Australia: Australian Bureau of Statistics.

288 Hurley P, Hildebrandt M, Hoang S (2021). Universities lost 6% of their revenue in 2020 — and the next 2 years are looking worse. 30 August 2021, The Conversation.

289 WiseTech Global (2020) Empowering and enabling the world's supply chains: Annual report 2020. Sydney, Australia: WiseTech Global,.

290 Technology One (2021) Annual report 2020. Brisbane, Australia: Technology One.

291 Atlassian (2020) Annual report 2020. Sydney, Australia: Atlassian.

292 Haenlein M, Kaplan A (2019) A Brief History of Artificial Intelligence: On the Past, Present, and Future of Artificial Intelligence. California Management Review, 61(4): 5-14.

293 Yasnitsky L N (2020). Whether Be New "Winter" of Artificial Intelligence? Integrated Science in Digital Age; Cham: Springer International Publishing p13-17.

294 DISER (2019) Australia's AI ethics principles. Canberra, Australia: Australian Government, Department of Industry, Science, Energy and Resources.

295 Jobin A, Ienca M, Vayena E (2019) The global landscape of AI ethics guidelines. Nature Machine Intelligence, 1(9): 389-399.

296 EC (2021) Europe fit for the digital age: Commission proposes new rules and actions for excellence and trust in artificial intelligence. Brussels, Belgium: European Commission.

297 Gillespie N, Lockey S, Curtis C (2021) Trust in artificial intelligence: A five country study. Brisbane, Australia: The University of Queensland and KPMG Australia.

298 EC (2018) Ethical guidelines for trustworthy AI. Brussels, Belgium: European Commission, High-Level Expert Group on Artificial Intelligence.

299 Edelman (2021) Edelman trust barometer 2021. New York, United States: Edelman.

300 Edelman (2020) Edelman trust barometer 2020. New York, United States: Edelman.

301 Edelman (2019) Edelman trust barometer 2019. New York, United States: Edelman.

302 Edelman (2018) Edelman trust barometer 2018. New York, United States: Edelman.

303 Edelman (2017) Edelman trust barometer 2017. New York, United States: Edelman.

304 Edelman (2016) Edelman trust barometer 2016. New York, United States: Edelman.

305 Edelman (2015) Edelman trust barometer 2015. New York, United States: Edelman.

306 Edelman (2014) Edelman trust barometer 2014. New York, United States: Edelman.

307 Edelman (2013) Edelman trust barometer 2013. New York, United States: Edelman.

308 Sturgis P, Brunton-Smith I, Jackson J (2021) Trust in science, social consensus and vaccine confidence. Nature Human Behaviour, (5): 1528–1534.

309 Ipsos (2020) Social cohesion in the pandemic age - A global perspective. Australia: Ipsos Market Research (October 2020, website accessed 8 June 2022 https://www.ipsos.com/en/social-cohesion-pandemic-age-global-perspective).

310 Markus A (2021) Mapping social cohesion - Launching the Australian Cohesion Index, Incorporating the Scanlon-Monash Index. Melbourne: Monash University.

311 WHO (2021) Infodemic. Geneva, Switzerland: World Health Organisation.

312 Zarocostas J (2020) How to fight an infodemic. The Lancet, 395(10225): 676.

313 Kreps S E, Kriner D L (2020) Model uncertainty, political contestation, and public trust in science: Evidence from the COVID-19 pandemic. Science Advances, 6(43).

314 Cinelli M, Morales G D F, Galeazzi A, Quattrociocchi W, Starnini M (2021) The echo chamber effect on social media. 118(9): e2023301118.

315 Baumann F, Lorenz-Spreen P, Sokolov I M, Starnini M (2020) Modeling Echo Chambers and Polarization Dynamics in Social Networks. Physical Review Letters, 124(4): 048301.

316 Our World in Data (2022) Share of people who completed the initial COVID-19 vaccination protocol. Oxford, United Kingdom: Global Change Data Lab.

317 Biddle N, Steinhauser R (2021). Describing Australia's COVID-19 vaccine success, and ongoing challenges: October 2021. Canberra, Australia: Australian National University.

318 Department of Health. Australian technical advisory group on immunisation: Weekly COVID-19 meeting on 4 August 2021 update (cited 6 August 2021). Available from: https://www.health.gov.au.

319 Mannix L (2021). Worried about AstraZeneca? Me too. The way we think about risk might be the problem. 20 July 2021, The Sydney Morning Herald.

320 World Bank (2020) Poverty and shared prosperity 2020: Reversals of fortune. Washington DC, United States: World Bank.

321 Nkengasong J (2020). Let Africa into the market for COVID-19 diagnostics. 28 April 2020, Nature.

322 Davidson P, Bradbury B, Wong M, Hill T (2020). Inequality in Australia, Part 1: Overview. Sydney, Australia: Australian Council of Social Service and University of New South Wales.

323 OECD (2020) Income inequality. Paris, France: Organisation for Economic Cooperation and Development.

324 De Vogli R, Mistry R, Gnesotto R, Cornia G A (2005) Has the relation between income inequality and life expectancy disappeared? Evidence from Italy and top industrialised countries. Journal of Epidemiology and Community Health, 59(2): 158.

325 Hu Y, van Lenthe F J, Mackenbach J P (2015) Income inequality, life expectancy and cause-specific mortality in 43 European countries, 1987–2008: A fixed effects study. European Journal of Epidemiology, 30(8): 615-625.

326 Choe J (2008) Income inequality and crime in the United States. Economics Letters, 101(1): 31-33.

327 Pickett K E, Wilkinson R G (2015) Income inequality and health: A causal review. Social Science & Medicine, 128: 316-326.

328 AIHW (2021) Housing affordability. Canberra, Australia: Australian Institute of Health and Welfare, Australian Government.

329 Cox W (2021) Demographia international housing affordability. Los Angeles, USA: Demographia.

330 Australian Bureau of Statistics (2021) Residential property price indexes: Eight capital cities. Canberra, Australia: Australian Bureau of Statistics.

331 AHURI (2020) Australian home ownership: Past reflections, future directions. Melbourne, Australia: Australian Housing and Urban Research Institute.

332 Nie P-y, Wang C, Meng Y (2019) An analysis of environmental corporate social responsibility. Managerial and Decision Economics, 40(4): 384-393.

333 Dummett K (2006) Drivers for corporate environmental responsibility. Environment, Development and Sustainability, 8(3): 375-389.

334 WBCSD (2021) Vision 2050 time to transform. Geneva, Switzerland: The World Business Council for Sustainable Development.

335 Eggleton M (2021). ESG is a game changer for investors. 31 May 2021, Australian Financial Review.

336 Venkatachalam S (2014). Five things that make you an empowered consumer. 9 November 2014, World Economic Forum.

337 CouriersPlease (2021). New research reveals 9 in 10 Aussie consumers more likely to purchase ethical and sustainable products [Media Release]. Australia: CouriersPlease, 31 August 2021.

338 Halkos G, Nomikos S (2021) Corporate social responsibility: Trends in global reporting initiative standards. Economic Analysis and Policy, 69: 106-117.

339 Cocco A M, Zordan R, Taylor D M, Weiland T J, Dilley S J, Kant J, Dombagolla M, Hendarto A, Lai F, Hutton J (2018) Dr Google in the ED: searching for online health information by adult emergency department patients. Medical Journal of Australia, 209(8): 342-347.

340 Altman J, Markham F (2015) 'Burgeoning Indigenous land ownership: Diverse values and strategic potentialities' In: Native title from Mabo to Akiba: A vehicle for change and empowerment? Sydney, Australia: The Federation Press.

341 Garnett S T, Burgess N D, Fa J E, Fernández-Llamazares Á, Molnár Z, Robinson C J, Watson J E M, Zander K K, Austin B, Brondizio E S, Collier N F, Duncan T, Ellis E, Geyle H, Jackson M V, Jonas H, Malmer P, McGowan B, Sivongxay A, Leiper I (2018) A spatial overview of the global importance of Indigenous lands for conservation. Nature Sustainability, 1(7): 369-374.

342 IP Australia (2020) Protection of Indigenous Knowledge in the intellectual property system. Canberra, Australia: IP Australia.

343 McAllister T G, Naepi S, Wilson E, Hikuroa D, Walker L A (2020) Under-represented and overlooked: Māori and Pasifika scientists in Aotearoa New Zealand's universities and crown-research institutes. Journal of the Royal Society of New Zealand, 52: 1-16.

344 Nelson D J, Madsen L D (2018) Representation of Native Americans in US science and engineering faculty. MRS Bulletin, 43(5): 379-383.

345 Gewin V (2021) How to include indigenous researchers and their knowledge. London: Nature News (12 January 2021).

346 Leong L, Ross M, Tickle M (2021) Here comes the great resignation. Why millions of employees could quit their jobs post-pandemic. Sydney: ABC News (24 September 2021).

347 Microsoft (2021) The next great disruption is hybrid work: Are we ready? Redmond, USA: Microsoft.

348 Gartner. Gartner HR Survey Finds Australian Employees Less Willing to Go 'Above and Beyond' at Work (cited 22 February 2022). Available from: https://www.gartner.com/en/newsroom/press-releases/2021-12-09-gartner-hr-survey-finds-australian-employees-less-wil.

349 Hamer B. Why attracting and retaining the top Millennial talent is key to future success (cited 12 November 2021). Available from: https://www.pwc.com.au/digitalpulse/millennials-five-generations-workplace.html.

350 ABS (2021) Labour force, Australia (October 2021). Canberra, Australia: Australian Bureau of Statistics.

351 Australian Institute of Company Directors. Board diversity statistics (cited 7 October 2021). Available from: http://aicd.companydirectors.com.au.

352 ABS (2021) Average weekly earnings, Australia (May 2021). Canberra, Australia: Austalian Bureau of Statistics.

353 Huang G C, Silver J K (2021) Women sidelined in pandemic research. BMJ, 375: n2381.

354 Suddendorf T, Busby J (2005) Making decisions with the future in mind: Developmental and comparative identification of mental time travel. Learning and Motivation, 36(2): 110-125.

355 Addis D R, Pan L, Vu M-A, Laiser N, Schacter D L (2009) Constructive episodic simulation of the future and the past: Distinct subsystems of a core brain network mediate imagining and remembering. Neuropsychologia, 47(11): 2222-2238.

356 Voros J (2003) A generic foresight process framework. Foresight, 5(3): 10-21.

357 Hancock T, Bezold C (1994) Possible futures, preferable futures. The Healthcare Forum journal, 37(2): 23-29.

As Australia's national science agency and innovation catalyst, CSIRO is solving the greatest challenges through innovative science and technology.

CSIRO. Unlocking a better future for everyone.

Contact us
1300 363 400
+61 3 9545 2176
csiro.au/contact
csiro.au

For further information
Data61
Dr Stefan Hajkowicz
+61 7 3833 5540
stefan.hajkowicz@data61.csiro.au
csiro.au/Data61

B&M | 22-00281