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The Fourth Industrial Revolution

What does it mean for Australian Industry?

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Preface

This book explores the core themes of the Fourth Industrial Revolution (4IR), highlighting the digital transformation that has been occurring in society and business. Although an extensive literature has recently emerged that examines the impact of technological change, this has not to date included a focus on the impact of Fourth Industrial Revolution (4IR) technologies on industry sectors in Australia. This book sets out to fill that gap by exploring a broad range of Australian industry sectors in relation to the new technologies associated with the 4IR. Representing an interface between technologies in the physical, digital and biological disciplines, the chapters investigate emerging technologies such as: artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3D printing, nanotechnology; biotechnology, materials science, energy storage and quantum computing. In particular, the book focuses on new technologies being implemented across eight industry sectors (categorised by the Australian and New Zealand Industrial Classification of Industries – ANZSIC) and multiple stakeholders' predictions concerning the associated changes to labour markets, jobs and skills. The eight industry sectors featured in the book are: agriculture and mining; manufacturing and logistics; health, medical and nursing; education; retail; financial services; government services; and tourism and hospitality.

Industry-specific chapters report on the findings of collaborative research studies where the potential impact of the 4IR on labour markets, occupations, future workforce competencies and skills is explored. The catalytic effect of the COVID-19 pandemic is also considered in relation to its impetus for transitions towards more automated functions in many of the industries discussed in the book. The authors

stress the urgency of addressing the key implications identified for Australia's governments and industry so that Australia can make a positive impact in an era where technological advances are having, and will continue to have, an unprecedented impact.

Adelaide, SA, Australia — Alan Nankervis

Newcastle, NSW, Australia — Julia Connell

Melbourne, VIC, Australia — Alan Montague

Adelaide, SA, Australia — John Burgess

Quote

Automation, Artificial Intelligence (AI), and the Internet of Things (IoT) are having an impact almost everywhere, in all industries, jobs and everyday life. Given this pace of change, it is important to understand and anticipate what this means for the future: jobs, youth, government and society more broadly, so that everyone has an opportunity to participate in the digital economy.

(Cisco and Oxford Economics, 2019: 3)

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Chapter 1
Introduction

John Burgess, Julia Connell, Alan Nankervis, and Alan Montague

Abstract Although an extensive literature has been developed that examines the impact of technological change, to date this has not included a focus on the impacts of the Fourth Industrial Revolution (4IR) technologies on industry sectors in Australia. This book sets out to fill that gap by exploring a broad range of Australian industry sectors categorised by the Australian and New Zealand Standard Industrial Classification of Industries (ANZSIC). It explores the types of new technologies associated with the 4IR being implemented across eight sectors; and multiple stakeholders' predictions about the potential changes to the associated labour markets, jobs, and skills.

Keywords 4IR · Covid-19 · Structural change · Technological change

Introduction

The nature and technical capabilities of industry sectors differ, as do their labour requirements in terms of jobs, tasks, and skills. Within the context of the range of technologies linked to the 4IR, the purpose of this book is to examine the actual and projected changes that are taking place across Australian industry sectors by addressing the following questions in each chapter:

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(a) What are the characteristics of each industry sector, and its current strengths and weaknesses?
(b) What key technologies are currently impacting on the sector and what technologies are likely to have a future impact on the sector?
(c) What is the impact of technological change on the size and composition of the sector's workforce?
(d) What is the impact of technological change on the skill requirements of the sector?
(e) Are there active programs in place to support organisations and workers to accommodate the predicted technological changes? And
(f) What programs and policies are required to address the predicted changes within the sector?

In addition to outlining the topics and key questions explored in this book in relation to 4IR technologies in the selected industry sectors in Australia, this chapter incorporates a range of definitions and concepts. It begins with the nature and challenges of the 4IR before briefly considering changes in jobs, work, skills and potential new occupations and their associated new skills that have emerged. The chapter outlines structural changes in Australia, the global context of the 4IR, the framework used to structure each chapter, and the research methods used to guide authors' investigations, before providing a summary of each chapter.

What Is the Fourth Industrial Revolution (4IR)?

There has been considerable debate about the nature of what has been referred to as the Fourth Industrial Revolution (4IR) or Industry 4.0. The term 4IR was coined by Klaus Schwab, the founder of the World Economic Forum (WEF 2016), who suggested that the 'velocity, scope, and systems impact (of the 4IR) is evolving at an exponential rather than a linear pace' (Schwab 2016), with new and emerging technologies distinguishing it from previous industrial revolutions. Schwab's (2016) conceptualisation and rationale have been promoted by many authors (see Brynjolfsson and McAfee 2017; Cedefop 2019; EIU 2018; Finextra and Intel 2017; Fluss 2017; Scarpetta 2017), and the term 4IR has since acquired common parlance status. The four industrial revolutions referred to in Schwab's framework are:

> The First Industrial Revolution used water and steam power to mechanize production. The Second used electric power to create mass production. The Third used electronics and information technology to automate production. Now a Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres (Schwab 2016: webpage).

These four stages of technological development cover a period of around two hundred years. However, the 4th revolution has evolved only the past two decades. The short duration between stages 3 and 4 are symptomatic of the speed and extent

of technological change, with the 4th stage being built upon the technological developments of the 3rd stage, leading Schwab to comment:

> There are three reasons why today's transformations represent not merely a prolongation of the Third Industrial Revolution but rather the arrival of a Fourth and distinct one: velocity, scope, and systems impact. The speed of current breakthroughs has no historical precedent. When compared with previous industrial revolutions, the Fourth is evolving at an exponential rather than a linear pace. Moreover, it is disrupting almost every industry in every country. And the breadth and depth of these changes herald the transformation of entire systems of production, management, and governance (Schwab 2016: webpage).

The 4IR is not country or industry specific. It permeates the globe and has the potential to impact on all communities at different stages of development, and in various industry sectors. However, it is unlikely to have a significant impact on countries that have poor infrastructure to support ICT; large labour surpluses; large populations in rural areas or an extensive subsistence and informal economy (Ayentimi and Burgess 2018). The developing world is simultaneously experiencing forces other than technological change which are poised to impact labour markets (Bandura and Hammond 2018). First, it is 'rapidly urbanizing, creating challenges for cities in terms of infrastructure, job creation, and basic social services. Second, different regions are following varied demographic transition paths that will affect the number of potential workers, the composition of the workforce, and the types of jobs created' (Bandura and Hammond 2018: 3). It can also be argued that the emergence of the COVID-19 pandemic may have accelerated the implementation of these innovative technologies in some countries and sectors. This is evident as employers strive to reduce their staffing costs by replacing them with artificial intelligence or machine learning technologies, whilst in others economic factors may constrain such imperatives. As outlined in the chapters in this book there are already significant differences between the various Australian industry sectors in relation to their recovery from the pandemic and their subsequent intentions and capacity to utilise these new technologies.

On the positive side, the 4IR has been promoted as providing significant benefits to organisations and their managers through creating opportunities to deliver increased and higher quality products and services at a considerably cheaper cost, with enhanced speed and improved reliability (Acemoglu and Restrepo 2017; Arnold et al. 2018; Dilsizian and Siegel 2014). Conversely, the anticipated negative consequences of the 4IR have primarily focused on its threats to labour markets, workplaces, jobs (both quantity and quality), skills and employees more generally through the expectation that these new technologies will lead to massive job disruption, significant job losses and employee de-skilling (Bandura and Hammond 2018; Brynjolfsson and McAfee 2017; Finextra and Intel 2017; Fluss 2017, Marrengo 2019). That said, it has been pointed out that computerisation automates tasks, rather than jobs, and consequently the nature of most jobs is likely to change rather than disappear due to automation (Arntz et al. 2016; Susskind 2020).

Nations and industries can potentially encompass all four 'revolutions' through the processes of international trade and investment and the global spread of digital technology and the internet. However, the 4IR concept is not without its critics. The

problems are linked to technological determinism, under which, there are no points of resistance to the changes and the underlying conditions supporting technological change are constant. For example, Rainnie and Dean (2019) state that the literature on Industry 4.0 deals with technology, and the problem-solving of digital transformation issues and embedding firms within production systems. It canvasses issues of standardisation and communication and making the business and consumer case for the digitalisation of manufacturing production. Attention to the impact of (the 4IR) on more pressing human dimensions of digitally-driven industrial change is significantly lacking (p. 17).

What Are the 4IR Transforming Technologies?

In a survey of 371 leading global companies, the World Economic Forum (WEF 2016) identified the main technologies that are driving changes to work, working, jobs, skills, and the future of work (FOW). These technological changes are listed below in order of those regarded by survey respondents as being the most significant changes for their organisation and industry:

1. Mobile internet and cloud technology
2. Advances in computing power and Big Data
3. New energy supplies and technologies.
4. The Internet of Things through remote sensors, communications, and processing power in industrial and household equipment
5. Crowdsourcing, the sharing economy, and peer-to-peer platforms
6. Advanced robotics and autonomous transport
7. Artificial intelligence and machine learning
8. Advanced manufacturing and 3D printing
9. Advanced materials, biotechnology, and genomics

These technologies have potential applications across all industries supporting new production processes, new industries, new ways of working or providing entertainment and consumption. They also support efficiency improvements and productivity increases while changing the skill mix required for many industry sectors. The technological possibilities are extensive. Many of the technologies are transformative and disruptive to existing production employment and distribution arrangements within industry sectors, raising questions linked to the impact of the technologies on jobs and living standards, and how the benefits of these technologies will be supported and distributed. Schwab (2016) discusses the potential inequities that could arise as follows:

> …inequality represents the greatest societal concern associated with the Fourth Industrial Revolution. The largest beneficiaries of innovation tend to be the providers of intellectual and physical capital—the innovators, shareholders, and investors—which explains the rising gap in wealth between those dependent on capital versus labor. Technology is therefore

one of the main reasons why incomes have stagnated, or even decreased, for a majority of the population in high-income countries.

Are All Jobs and Sectors Equally Affected by Technological Change?

The displacement effects of technology will depend on the type of technological applications; the skill composition of jobs; and the extent to which the technologies can be supported and implemented. In Australia, a report produced by Cisco and Oxford Economics (2019: p. 3) suggested that the greatest displacement effects, that is the substitution of technology for jobs over the period 2018–2028, will occur in the following sectors: transport (12.4%); construction (11.2%); mining (10.7%); agriculture (10.4%); utilities (9.5%) and manufacturing (9.4%). Specifically, based on the modelling, 12.4% of equivalent full-time jobs in the transport sector will be displaced by technology over the coming decade with the aggregate displacement effect resulting in 630,000 full-time jobs across the economy. In terms of the most vulnerable sectors due to technological job displacement the report commented that:

> …the relative vulnerability of these sectors to technology-driven displacement is a result of the nature of their work. Workers spend more time operating vehicles, handling objects and controlling machines, all of which have the potential to be completed more efficiently with the application of new and existing technologies, such as advanced robotics and machine learning' (Cisco and Oxford Economics 2019: 9).

In general terms this refers to craft, trades, and transport jobs that are mainly performed by male workers in positions such as drivers, machine operators, mechanics, carpenters, technicians, and warehouse workers.

The Intersection of Structural Changes and the 4IR

One of the challenges in assessing the impact of the 4IR is that, in addition to technological changes there are structural changes that will impact on the level and growth of demand for output and jobs, and the composition of production and employment. Returning to the WEF (2016) discussion of the 4IR, their survey asked respondents from leading global companies to identify what they regarded as the primary demographic and socio-economic factors driving change in their organisations. The most significant factors identified were as follows, with the percentage referring to the proportion of respondents who identified the factor as the most important change:

- Changing work environments and flexible working arrangements (44%): remote working, co-working; teleconferencing; increased sub-contracting.

- Rise of the middle class in emerging markets (23%); rising living standards, especially in Asia, to drive and change the composition of global demand.
- Climate change, natural resource constraints and the transition to a greener economy (23%): innovation in energy development and storage; controls over carbon emissions.
- Rising geopolitical volatility (21%): implications for global trade and investment; increased expenditure on defence and policing.
- Consumer concerns about ethical and privacy issues (16%): ethical investment funds; NGO monitoring of human rights; fair trade and supply chain assessments; on-line privacy.
- Longevity and ageing (14%): especially in advanced economies. Implications for health, labour force participation, education, savings, and international migration.
- Young demographics in emerging markets (13%): population growth in emerging economies with pressures on education, youth labour markets; and implications for international migration.
- Women's rising aspirations and economic power (12%): increased labour force participation; increased household incomes; breaking down gender barriers to participation and
- Rapid urbanisation (8%): pressures on infrastructure and the environment; congestion and commuting.

Aggregating structural changes alongside technological changes will indicate the combined impact on jobs and skill requirements in the coming years. The job displacement effects of technological change are offset by increasing demand due to population and income growth. Automated check-out machines and online shopping will reduce the demand for sales staff in supermarkets and department stores, but as the population and income expands, there will likely be requirements for additional supermarkets and department stores.

The (2019) Cisco and Oxford Economics report forecast the net changes in jobs for the period 2018–2028 by sector in Australia, adding together the technological and income effects. The income effects represent the projected growth in the economy and its impact on sector output and jobs. Combining the two effects (the positive income effects and the adverse displacement effects from technological change) the three sectors that will have contributed the most jobs over the decade were forecast to be (presented in thousands of full-time equivalent jobs): healthcare (79.5); hotels and restaurants (21.6) and wholesale and retail trade (20.5). The three sectors with the most significant net job loss were: construction (73.2); manufacturing (33.3) and transport (26.1).

However, the forecasts were undertaken prior to the COVID-19 pandemic and are therefore unlikely to accurately reflect post-2020 workforce conditions. Such steady-state growth forecasts are of course eroded by unexpected changes and crises (such as bushfires, wars, earthquakes and flooding) which impact on growth, trade, investment, and the uptake of new technologies.

Impact of the 4IR on Work, Skills and Occupations

The WEF (2016) report found that changes in both where and how work is conducted will be one of the major developments from technological change. COVID-19 has forced organisations and workers to embrace mobile technologies and working away from central workplaces as options. Prior to the COVID-19 pandemic, approximately 24% of Australian workers reported working some hours from home. However, between March and April 2020, that number almost doubled, with 48% of workers transitioning to remote work (ABS 2020). In their analysis of future jobs, Ross et al. highlighted new ways of working, including technological versus geographical proximity in work and workplace identity; web intermediated work; coworking and offshoring. They argued that technological developments not only affect job and skill profiles, but also potentially how work is carried out, where and when it is conducted and for whom the work is performed. Internet technologies reconstruct the nature of the workplace, the employer, and the employment relationship. The 4IR promises to fundamentally transform the ways in which we interact with machines, and in addition, the way that machines learn, improve, and build on their own performance. The benefits of these new digital technologies may be considerable (Lu and Burton 2017). However, their impact on future work processes, training needs and workforce structures, as well as the ethical frameworks for their implementation, demand equal consideration by all stakeholders likely to be involved in decisions about their usage in various industry sectors and organisations.

The WEF (2016, 22) analysis on the future of work concluded that:

> …in the face of rapidly rising computing power, an ability to work with data and make data-based decisions will become an increasingly vital skill across many job families as employers scramble to build a workforce with solid skills in data analysis and presentation (e.g. through visualization) and the amount of potentially useful digital information generated and stored keeps increasing exponentially.

This analysis of global firms indicates that skillsets will need to change, and as a result, the potential for skills mismatches will increase as educational and training programs lag behind the skill changes required for the new technologies. Across the industries surveyed, the three primary skills identified were complex problem-solving skills, social skills, and process skills with the largest increase in future skills being cognitive abilities.

Ongoing Structural Change in Australia

Technological change is continuous and disruptive. However, it is not only technology that is changing; the underlying conditions that influence production, investment, and employment are also changing. While technology and automation have the potential to displace labour, other factors increase production and jobs. For

example, underlying wealth and income growth lead to increased trade, and demographic change. As communities become wealthier, they demand products and services that are supported by higher incomes – for example, hospitality and travel. Technology also drives down the cost of products, such as consumer electronics that become more affordable with increased demand. Demographic change alters the composition of production. Australia is ageing, and with it, the ageing community requires additional leisure and health services (Devasahayam et al. 2018; Federal Treasury 2010). The proportion of total participation in the labour market by mature-aged persons (aged 55 years and over) 'increased from 9.1%in May 1989 to 19.3% in May 2019 (Department of Employment, Skills, Small and Family Business 2019: 5). This upward trend reflects the ageing population as life expectancy steadily increases over time (Department of Employment, Skills, Small and Family Business 2019). An important demographic factor in Australia is also net immigration as it offsets ageing since the migrant cohort is, on average, younger than the general population and migrants also provide a source of skilled labour (Devasahayam et al. 2018). Moreover, the younger immigrant cohort increases the demand for such services as housing and schooling (Devasahayam et al. 2018). However, a significant decrease in migration during and following the COVID-19 pandemic will undoubtedly affect this demographic trend in Australia.

In the last thirty years, Australia's labour market has undergone a structural change with a significant shift from production industries to labour-intensive service industries and higher-skilled occupations. Technological advances over the last three decades have resulted in a changing labour market, with amplified automation supporting jobs that 'are non-routine in nature and require people to have skills that are not easily replicated by a machine (such as social skills, emotional intelligence, creativity and advanced reasoning)' (Department of Employment, Skills, Small and Family Business 2019:1). The shift to services and automation, as discussed earlier, has been prominent since 1989–2019.

In 1989, manufacturing was the largest Australian industry sector in terms of employment, accounting for 15.2% of total persons employed (Department of Employment, Skills, Small and Family Business 2019). In 2019 – three decades later, employment in manufacturing has fallen by 316,600 (or 27.2%) and is the seventh-largest employing industry, accounting for 6.6% of the total workforce. In the face of the long-term decline recorded in this industry sector, manufacturing does however remain a substantial employing industry, as 848,700 workers were employed in May 2019 (Department of Employment, Skills, Small and Family Business 2019). Occupations commensurate with the highest skill level (usually requiring a bachelor's degree or higher) accounted for 45.1% of total employment growth over the past three decades. By contrast, occupations commensurate with the lowest skill level (usually requiring Certificate I or secondary education) accounted for only 9.4% of total employment growth (Department of Employment, Skills, Small and Family Business 2019: 3).

The extent and complexity of structural change in Australia and its impact on the labour market have been captured by several studies (Adeney 2018; Connolly and Lewis 2010; Heath 2016). Adeney (2018) indicated that there are internal sectoral