Heigh-ho, heigh-ho, it's off to work we go – the Fourth Industrial Revolution and thoughts on the future of work in Australia

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Abstract

The Fourth Industrial Revolution (4IR) suggests significant transformation of the Australian economy with predictions of 'technological unemployment'. Combined with other significant economic, demographic and social shifts, it is inevitable that future of work will change. This paper applies industrial revolution scholarship to contribute new empirical insights into the transformation of Australia's economy between 2006 and 2016 and evaluate Australia's progress in the 4IR. The paper also introduces gender as a largely missing component in industrial revolution scholarship. Adapting the shift-share method of analysis to ABS Census data, the paper attributes the change in the share of employment and industry restructure over the decade to four factors: national economic growth, industry (re)structure, employment composition, and within industry employment composition. The paper finds that while job growth occurred in the decade to 2016, it was largely driven by a national growth effect associated with increasing consumption and the industry effect associated with the rise of the services sectors and the changing social organisation of care, rather than innovation and technological advancements. Job destruction, on the other hand, is evident in industry sectors associated with the 4IR; the replacement of jobs by automation and artificial intelligence to increase competitiveness and productivity. To transition to the phase of job creation in an industrial revolution, Australia needs socio-political intervention to address four key issues.

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Introduction

Current public discourse regarding the future of work and the Fourth Industrial Revolution (4IR) invites anxiety (Morgan 2019), implies determinism (Nübler 2016) and fails to acknowledge the socio-political role required in shaping the future of work (Perez 2012b). Instead, the collective framing of a future of 'technological unemployment' is at risk of becoming a self-fulfilling prophecy.

The 4IR suggests significant transformation of the Australian economy. Within that structural change some industries will decline, others will grow, and all will undergo some form of change. Combined with other significant economic, demographic and social shifts, it is inevitable that future of work will also change.

This paper reviews industrial revolution scholarship and applies Perez' three phases of shifting techno-economic paradigm (Perez 2004, 2010); the International Labour Organisation's (ILO) theories of capabilities for productive transformation (Nübler 2014b), and Nübler's framework for achieving a golden age of job creation (2016), to contribute new empirical insights into the transformation of Australia's economy between 2006 and 2016 and evaluate Australia's progress in the 4IR. The paper also introduces gender as a largely missing component in industrial revolution scholarship.

Adapting the shift-share method of analysis (Arcelus 1984) to ABS Census data, the paper attributes the change in the share of employment and industry restructure over the decade to four factors:

1. National economic growth
2. Industry (re)structure
3. Employment composition
4. Within industry employment composition

The paper finds that while the Australian economy grew and jobs were created over the decade, job destruction occurred in the industries associated with the 4IR, particularly for men, and particularly for those employed full-time in the manufacturing sector, consistent with the 'disappearing working man' phenomenon (Rozner 2017). Both the share of Gross Domestic Product (GDP) and employment increased in sectors not directly associated with the 4IR; over a quarter of the total growth in employment was in the health care and social assistance sector (27.6 per cent), followed by education and training (16.0 per cent), mostly women employed full-time or part-time. This growth is more likely to be explained by the rise of the services sector (Autor & Dorn 2013; Gallie 1991, 2017) and, more specifically, the care economy resulting from changes to the social organisation of care (Dwyer 2013).

In addition, the shift to part-time work for both men and women indicates further risk of job destruction and widening inequality. The findings also show that some industry sectors remain highly gendered, however, a positive within sector effect is evident for women in the construction, mining and utilities sectors, traditionally considered male-dominated industries.

The structure of this paper is as follows. begins with an overview of the transformational process of an industrial revolution, followed by details of the

empirical approach used to analyse Australia's progress in the 4IR and then presents the findings. The paper then discusses the findings in relation to the literature and public policy in Australia, before concluding with thoughts on the future of work in Australia should current trends continue.

The process of industrial revolution

In Australia, recent literature pertaining to the current 4IR, defined as an extension of the third (digital) revolution to the convergence of digital, biological, and physical spheres (Schwab 2016), is largely dominated by a plethora of grey literature from business consultancy groups[1] focused on the implications of digital disruption and the FIR at the micro level – jobs and skills[2] –, or the meso-level – business model innovation to increase productivity[3] –, rather than the wider, macro-level strategic process of potential socio-economic transformation that the FIR could enable (CEDA 2018; Dean & Spoehr 2018). There is however, extensive scholarship pertaining to the process of industrial revolution.

Like history, the process of an industrial revolution repeats itself; a long wave transformation which plays out over half a century, give or take a decade (Atkinson 2018; Perez 2004, 2010, 2012b; Soete 2018). The historical cycle of an industrial revolution is a three-phase process involving job destruction (Phase 1) and job creation (Phase 3) with a turning point, or adjustment phase, sandwiched between the two (Perez 2010). Perez describes an industrial revolution as 'the vast diffusion of what was once an invention into a socio-economic phenomenon' requiring a new 'techno-economic paradigm' (Perez 2010). To warrant revolutionary status, Perez and others (see for example Atkinson (2018); Hofheinz (2018); Nübler (2016); Soete (2018)) argue that new technologies in the market must have the capacity and capabilities to profoundly transform the rest of the economy and, eventually, society. This long wave transformation and ultimate diffusion consists of three phases culminating in a 'great surge of development'. Commencing with the installation period associated with the adoption of new technologies into business systems, led by finance and free markets, in the quest for increased productivity and competitiveness, this phase is also associated with job destruction. The third phase is the deployment period which is associated with job creation whereby the full benefits of the technological revolution are spread across the economy and society. Between these two phases sits an adjustment period which is accompanied by resistance to change, inertia, social dishevel, rising inequality, regional disparities and economic stagnation, eventually becoming a critical issue which requires socio-political intervention. Perez and others (listed above) argue that the adjustment period is not a passive process and cannot be left to the markets to determine. The period of this interval lasts as long as it takes to establish the institutional framework required to fully capture the potential of

1 See for example Bankwest Curtin Economics Centre (2018); Deloitte (2019); Hajkowicz et al. (2016); Reeson et al. (2016); Seet et al. (2018).

2 See Morgan (2019) pages 12 to 15 for a critique of 'consultancies, think tanks and modellers' contribution to the literature and policy making relating to the Fourth Industrial Revolution.

3 See for example Australian Industry Group (2019); CEDA (2012); McKinsey & Company (2019); Prime Minister's Industry 4.0 Taskforce (2017)

the new techno-economic realm; it needs to be shaped by government regulation and policies. The level of political consensus, conflict or confusion strongly influences the speed and the ease or difficulty with which the surge of development and growth is established. Given that changes in an economy usually happen at a much faster pace than institutional reform, according to Perez these adjustment phases have historically been long and difficult – two to three decades – and accompanied by considerable social costs.

While Schwab (2016) suggests the world is currently progressing through the Fourth Industrial Revolution (4IR), claiming 'We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before', others disagree. Perez (2010) argues that advanced nations are currently experiencing the adjustment period of the fifth industrial revolution while Atkinson (2018) argues the world is on the cusp of the sixth industrial revolution, having not fully realised the potential of the fifth given the inability to achieve the socio-political transformation required. He suggests that the next industrial revolution will 'likely be grounded in AI, robotics and perhaps nanotechnology and biotechnology' similar to Schwab's (2016) definition of the 4IR; the convergence of digital, biological, and physical spheres. Both Perez and Atkinson agree that the first industrial revolution of mechanisation in the 1770s was followed by steam and railways in the 1830s, steel, electricity and heavy engineering from 1875, oil, the automobile and mass production from 1908 and then the fifth, the age of information and telecommunications, from 1971. Each of these transformations followed the same installation, adjustment and deployment process outlined above whereby a new socio-political paradigm was required to fully realise the growth potential associated with each new techno-economic opportunity.

While technological advancements have the potential to revolutionise the economy and society, the argument that this will result in persistent 'technological unemployment' is contested (Anderson 2009; Atkinson 2018; Barany & Siegal 2015; Montresor 2018). Predictions for the future of work suggest significant transformation of the type, and content, of jobs available in the labour market resulting from economic restructuring, as has occurred in previous revolutions, however the focus on technology as the determinant of the structural change in the wider employment market leads to a narrow explanation of change over time (Fernández-Macías 2012). Atkinson (2018) argues future job creation will be based on consumption patterns, largely related to greater expenditure associated with higher incomes resulting from increased productivity and wealth generation during the deployment phase of the industrial revolution process. Additional factors include, but are not limited to, higher levels of educational attainment and labour force participation, the age structure of the respective populations, the level and type of immigration and the type of welfare state (Baum 1997; Goos & Manning 2007; Hamnett 1996; Murphy & Oesch 2018; Oesch & Rodríguez Menés 2010). Another perspective is that of the rise of the services sector (Autor & Dorn 2013; Gallie 1991, 2017) and, more specifically, the care economy resulting from changes to the social organisation of care (Dwyer 2013), closely linked to changing household consumption. Howcroft and Rubery (2018) further argue that

the changing nature of work has gender-specific impacts and that emerging forms of work reinforce gender inequalities, however, they do note that these issues are not related to technological advancement per se but to institutional frameworks and associated regulatory environments and policies. They suggest that the 4IR presents a timely opportunity to propose a rethink of both the structures of employment and the forms of work as well as the division in both paid and unpaid work between men and women.

Perez suggests that most advanced nations are on the cusp of the deployment period, the turning point of the revolutionary process which will eventually lead to job creation and wider wealth generation. However, to progress to the job creation phase, the increasing mismatch between the economy and the regulatory systems created during the installation phase needs to be resolved. The installation phase is a market driven process which involves the often rapid and intense adoption of new technologies into business models and practices with the aim of increasing productivity and remaining competitive in a global market, usually with a short term focus (Dean & Spoehr 2018; Nübler 2016; Perez 2010). This often includes new production techniques, diversification, changes in the organisation of work, cost savings and labour-saving processes and, as such, is associated with job destruction. This period is characterised by unintended consequences such as increasing job and skill mismatches, obsoletion of qualifications and training, unemployment, income and wealth polarisation, jobless economic growth and within nation economic and social divergence (Perez 2010). This period is also referred to as incremental or process innovation, or the imitation or adoption of new innovations rather than new product innovation itself which is considered to be the primary mechanism driving initial structural change and an ensuing industrial revolution (Nübler 2016). While some argue that the current revolution is data driven and that the global economic base has shifted from one dominated by the production of physical capital, to one of servicisation and intangible products (Hofheinz 2018; Soete 2018), Nübler (2016) suggests that it is product innovation which is primary mechanism for structural change and eventual job creation and further argues that product innovation is dependent on a strong manufacturing base. She provides evidence that those nations with diverse and sophisticated manufacturing bases are more dynamic and better positioned than services-based economies to revolutionise their economy and society and that this potential is underpinned by a nation's Educational Attainment Structure (EAS) (Nübler 2014a, 2016).

Despite widespread process innovation globally, productivity has not yet increased at the level expected to shift the transformation into the deployment phase whereby productivity gains are distributed more widely in society and job creation ensues (Gordon 2016; OECD 2015; Productivity Commission 2016). This is somewhat explained by the increasingly networked and expanded global market, and the speed at which new technology, largely digital rather than traditional manufacturing innovation, is applied and exploited, keeping downward pressures on costs to maintain competitiveness (Soete 2018), thus preventing product innovation.

Nübler (2016) expands on Perez' (2004, 2010) techno-economic paradigm for achieving economic and societal prosperity associated with industrial revolutions to

develop a framework for achieving a 'golden age of job creation'. This framework is underpinned by the International Labour Organisation's Theory of Capabilities for Productive Transformation (Nübler 2014b) arguing that the theory contributes to a better understanding of the link between education, training and technological learning on the one hand and economic growth on the other; facilitating the revolutionary opportunities attached to technological advancements.

Essentially, Nübler argues that revolutionary opportunities are endowed within a nation's productive capabilities. These include the physical capacities; production factors and infrastructure, and the social capabilities; the collective knowledge base and the institutional framework, which enable transformation. While some nations may share similar physical capacities, it is the intangible capabilities, which differ among nations, that facilitate the level of innovation and economic diversification possible. It is these capabilities which also shape future structural change. Nübler (2014b, 2016) argues that it is the combination of productive capabilities which are the major determinants of the job creation adjustment process. In particular, she argues that it is the competence of the labour force; the nature and knowledge base, combined with the institutional framework of the society; the rules, regulations and policies, which determine the performance and progress of an economy and society during an industrial revolution. ILO research into the difference in competence of labour forces identified that different knowledge bases, measured by the educational attainment structure (EAS), explains differences in industry structures and therefore economic performance, and that it holds for both developing and developed countries. Nübler (2014a) argues that the EAS, rather than educational levels, is the most significant determinant of the pattern of industrial development and growth. As such, the EAS represents an important carrier of capabilities to diversify, develop and achieve growth. Defined as the share of the labour force based on educational attainment, EAS, can be further defined according to its shape along a bell curve. Capabilities to innovate and develop new products are therefore influenced by the particular mix of educational, vocational and technical competencies, which increase with the diversity and complexity of the knowledge sets embodied in the labour force.

'Strong middle' EAS are those with relatively higher shares of vocational and technical education and training. This EAS provides the widest range of options for developing and diversifying industry structures associated with a technological revolution.

'Missing-middle' EAS are polarised and present with relatively lower shares of vocational and technical education but higher shares of schooling and tertiary education. According to Nübler, missing middle EASs provide limited options for advancing technological revolutions as the labour force lacks the broad supply of complementary occupations required in addition to tertiary qualified managers and professionals. Rather, the relatively higher tertiary education share provides options to develop advanced services such as research and development, finance, tourism, ICT enabled services, and administrative services.

The ILOs comparison of the strong and missing middle EAS shows that these two EAS' result in different patterns of industrial development. According to the ILO, the missing middle countries are limited in expanding their manufacturing base,

and industrialise by expanding sophistication in services, however, the ILO suggests that even the highest performing missing middle countries cannot achieve the levels of sophistication within manufacturing than can be achieved by the strong middle nations. Further, EAS tends to reflect income and wealth distribution in society, and missing middle EAS are often found in countries with high inequalities (Nübler 2014a). These findings are also consistent with the literature on over-qualification associated with the expansion of higher education (see for example Figueiredo et al. 2015; Holmes & Mayhew 2015, 2016; Lloyd & Payne 2016), skill utilisation (see for example Felstead, Gallie & Green 2017; Keep 2017; Livingstone 2017; McGuinness, Pouliakas & Redmond 2017; Quintini 2011; Smith 2017) and job polarisation (see for example, Barany & Siegal 2015; Cirillo 2018; Coelli & Borland 2016; Denny 2019; Goos & Manning 2007; Montresor 2018; Salvatori 2015) .

The other element for achieving a 'golden age of job creation' is the process of collective learning, including trust in the institutional framework (Morgan 2019; Nübler 2016; Perez 2004, 2012b). The premise of collective learning is that it incorporates not just education from schooling and higher education, but is accumulative, including tacit learning of concepts, rules, procedures and expectations in organisational, social, cultural and economic contexts, not just at an individual level but also at the collective level such as within enterprises, organisation and societal groups. This process of collective learning develops a knowledge structure within society which, according to Nübler (2014b), determines the feasible patterns of productive transformation. In the context of industrial revolution, Perez argues that this process of collective learning also requires unlearning, learning and relearning processes, new rules and regulations and undertaking new training and skill development. Morgan (2019) extends the understanding of the revolutionary process, stating that the diffusion of new technology is subject to the values, principles and mechanisms of society so much so that the extent of diffusion is subject to the response by institutions, rules, laws, behavioural responses, rights and obligations associated with new technology and how society uses it, or rejects it.

The institutional framework which governs the rules and regulations of both the economy and society, forms a critical component of the process to job creation during an industrial revolution. Nübler (2016) argues that institutions are integral in the pace of change, driving the adjustment phase and mobilising support for change whereby the institutional framework generates a sense of justice in society, that the distribution of gains and losses; the unintended consequences of technological advancements associated with the revolution, are considered fair. This has already been recognised in Australia by CEDA (2018), pointing out that 'while businesses adapt to the disruption that new technologies create, governments need to be identifying new regulations to be institutionalised to keep economies transparent and effective'. This includes maintaining trust in the institutional framework. Trust that institutions will respond accordingly in times of systemic failings provides people and society with the confidence and security they need to continue on with their lives, highlighting the importance of institutions being adaptable and flexible to achieve long-term advances in prosperity. Perez (2004) sums up the challenges of the adjustment phase as a process whereby the existing institutional framework becomes obsolete as it was designed

around a previous techno-economic paradigm, arguing that the persistent application of obsolete practices can actually aggravate society and the economy contributing to a collapse, often in the form of a recession or financial market failure.

Given the long wave creative destruction process (Schumpeter 1942) to widespread prosperity of an industrial revolution, Hofheinz (2018) suggests that the pressing issue now is how do nations prepare for and legislate for an economy where society faces a different set of challenges, problems that will need to be mitigated with a different set of policies, proclaiming "We stand on the cusp of an important decision: will we find and develop the social innovation needed to make the digital revolution a win-win for all?"

The following section outlines the empirical approach to analysing Australia's progress in industry restructuring and socio-economic transformation within the revolutionary process of the 4IR.

Method

In order to better understand the restructuring of the Australian industry base over the decade between 2006 and 2016 and how it may align with the phases of an industrial revolution, this paper adapts the shift-share analysis method first used in regional economics to study the components of regional growth and development (Dunn 1960). Shift-share analysis is an effective method used to isolate structural and compositional characteristics within aggregate change over a period of time (Danko III & Hanink 2018). It has been used extensively to identify sector-level employment change in regions which could be attributable to national, regional or industry factors while controlling for national, aggregate, effects.

This paper uses shift-share analysis to attribute changes in employment in the Australian economy to economic performance, industry structural change, employment composition (labour force participation by men and women), and, adapting Arcelus' (1984) extended shift-share analysis method to disaggregate the industry effect; compositional labour force change within an industry sector. Using ABS Census data for 2006 and 2016, changes in employment in Australia over the decade are attributable to four different effects:

1. National economic growth
2. Industry structure
3. Employment composition
4. Within industry employment composition

The change in employment between two periods is simply the difference in employment levels between period 1 E_1 and period 2; E_2 so that:

$$\Delta E = E_{2-} E_1$$

In its simplest form, the shift-share analysis method enables the statistical separation of the main national and industrial forces affecting the change in

employment; ΔE_s^e– the number of men and women employed full-time or part-time (e) for industry (s).

This change in employment can be decomposed to national, industrial and employment composition effects and expressed as follows:

$$\Delta E = NG_s^e + LM_s^e + IS_s^e$$

Whereby, NG_s^e represents the national growth component which is the expected change in employment composition (e) for industry (s) if it grew at the same rate as the total national employment rate. LM_s^e represents the employment composition component – the mix of men and women employed full-time or part-time – which is the portion of the employment change attributed to the difference in employment composition (e) of industry (s) and that of the nation. IS_s^e represents the industry share component. That is, the share of the change in employment attributed to differences in the change in employment composition at industry and national level due to the particular circumstances of the industry. In regional studies, this component is referred to as the 'competitive effect' (Danko III & Hanink 2018) as it illustrates whether a region possesses a competitive advantage in that industry over other regions on a national scale.

In this adaptation, the competitive effect can be equally applied to an industry's competitive advantage in terms of employment opportunities in times of economic restructuring, as in the case of the 4IR. That is, the competitive advantage that an industry sector may offer men or women full-time or part-time employment opportunities.

$$NG_s^e = E_s^e * e^n$$

$$LM_s^e = E_s^e * (e_e^n - e^n)$$

$$IS_s^e = E_s^e * (e_s^e - e_s^n)$$

Where E_s^e is the number employed by employment composition (e) for industry (s) and where e^n is the percentage change in the national employment level, e_s^n, is the percentage change in employment in industry (s) at the national level, e_e^n, is the percentage change in employment composition (e) at the national level and e_s^e is the percentage change in employment composition (e) for industry (s).

Arcelus argues that the competitive effect in its simplest form does not account for regional effects as it is restricted to employment change analysis based on national performance. As such he extends the simple form to disaggregate the competitive advantage effect to include *a regional growth effect* – the part of ΔE attributable to growth of the region – and *the regional industry mix effect* – the part of ΔE attributable to combined regional and industry factors, that is, a within region competitive advantage.

For this study, these regional effects are translated as industry structure effects (I_s^e) and within industry employment composition effects (IM_s^e). The industry structure

effect identifies the industry share of employment change due to the overall change in employment in the industry and the within industry employment composition effect identifies the share of employment change that is particularly due to the change in employment composition for the industry. Based on this, the industry share component can be redefined as follows:

$$IS_s^e = I_s^e + IM_s^e$$

Arcelus also argues this can be equally applied to the national growth component and the employment composition component; providing a competitive advantage sub-component and a degree of differentiation component.

Arcelus further argued that this simple form of shift-share analysis does not account for the degree of differentiation within sectors and with respect to both the national and employment composition components either. Using Arcelus' extended method each shift-share analysis component is disaggregated into an 'expected' or 'differential' effect (1984, p. 6). The expected effect is the share of employment change that would have been expected that is due to overall change in employment for industry (s) if the industry had the same employment composition as the nation. The differentiation effect is the share of employment change that is attributed to the extent of deviation from the nation for industry (s) and employment composition (e). These effects are calculated based on the concept of 'homothetic employment' (HE_s^e), that is, the employment composition (e) for industry (s) if the structure of the employment in the industry was equal to the national employment structure.

Homothetic employment is expressed as follows:

$$HE_s^e = E_s * \frac{E_e^n}{E^s}$$

Where, E^s is the total employment in the industry sector, E_e^n is the national employment composition and E^n is the total national employment, all for the first period.

Given these extensions, the three shift-share components in equation 2 are calculated as follows:

$$NG_s^e = HE_s^e * E^n + (E_s^e - HE_s^e) * e^n$$

$$LM_s^e = HE_s^e (e_e^n - e^n) + (E_s^e - HE_s^e) * (e_e^n - e^n)$$

$$IS_s^e = HE_s^e (e_s^e - e_s^n) + (E_s^e - HE_s^e) * (e_s^e - e_s^n)$$

IS_s^e is also calculated to account for the disaggregation of the industry effect and the within industry employment composition effect, so that

$$I_s^e = HE_s^e (e^s - e^n) + (E_e^s - HE_s^e) * (e^s - e^n)$$

$$LM_s^e = HE_s^e * [(e_s^e - e^s) - (e_e^n - e^n)] + (E_e^s - HE_s^e) * [(e_s^e - e^s) - (e_e^n - e^n)]$$

Thus, NG_s^e can identify the extent to which employment composition (e) in industry (s) is impacted by national economic performance and the degree of differentiation, or lack thereof, in employment composition (e). LM_s^e can identify whether an industry experienced a shift (positive or negative) ('competitive advantage' in regional studies)compared with other industries in terms of employment composition opportunities as well as the extent to which an industry may be gendered or the workforce standardised (whereby 'standardised' is full-time employment).

Data used for this analysis is drawn from the 2006 and 2016 ABS Census' of Population and Housing (Census). These collections were selected as they represent similar, relatively stronger periods of economic performance compared with 2011. The dataset includes all those Australian men and women employed full-time or part-time by the industry in which they worked[4], as defined by the Australia New Zealand Standard Industry Classification (ANZSIC), at the Division level.

Findings

Over the decade to 2016, an additional 1,385,142 Australians were employed, either full-time or part-time, a growth rate of 16.6 per cent. Part-time employment grew 28.1 per cent, while full-time employment increased by 11.3 per cent, so that the share in full-time employment reduced to 65.4 per cent of the workforce from 68.5 per cent in 2006. Over half of the increase (56.9 per cent) was experienced by women, where employed women increased by 20.4 per cent, compared to a 13.2 per cent increase for men. Part-time employment increased substantially for both men and women, 35.8 per cent and 24.6 per cent respectively. See Table 1.

Table 1. Change in employment composition, Australia, 2006 to 2016

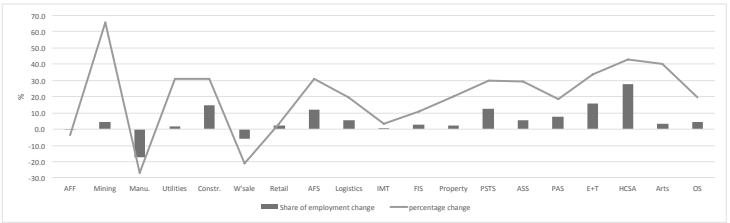
	Percentage change (%)	*Share of total employment change (%)*
Women	20.4	56.9
Men	13.2	43.1
Part-time	28.1	53.3
Full-time	11.3	46.7
Men, full-time	8.3	22.0
Women, full-time	16.7	24.6
Men, part-time	35.8	21.1
Women, part-time	24.6	32.2

Source: ABS Census of Population and Housing, 2006 and 2016, author calculations.

4 Those employed, but away from work, are excluded from the dataset as their level of attachment to the labour force (full or part-time) cannot be determined.

When employment change is considered by industry, substantial restructuring of the economy is evident. While the number of people employed increased for all but three industries (Agriculture, Forestry and Fishing, Manufacturing and Wholesale Trade) the share of employment growth by industry shifted considerably from the traditional industrial sectors to the services sectors. Over a quarter of the total growth in employment was in the Health Care and Social Assistance sector (27.6 per cent), followed by Education and Training (16.0 per cent). Construction (14.9 per cent), Professional, Scientific, Technical Services (12.5 per cent) and Accommodation and Food Services (12.0 per cent) shared the majority of the remaining employment growth, supressed by Manufacturing (-17.5 per cent) and Wholesale Trade (-5.8 per cent).

Figure 1. Percentage change in employment and in employment share', ANZSIC Division 1, Australia, 2006 to 2016



Source: ABS Census of Population and Housing, 2006 and 2016, author calculations

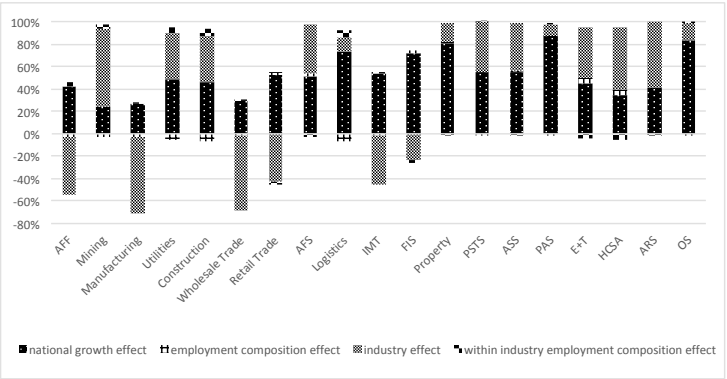
Applying the extended shift-share analysis outlined in the method section, a greater understanding of the factors associated with the changes in employment is possible.

At an industry only level, the change in the share of employment is attributable to either the national growth effect or the industry effect, with the employment composition effects offsetting the other. As expected, given a larger population, growing economy and associated increasing consumption, the national growth effect contributed positively to each industry's change in employment over the decade, however, at varying degrees. See Figure 2. The national growth effect was the greatest contributor to change in employment for Public Administration and Safety, as well as the consumption services sectors such as Other Services, Property[5], Financial and Insurance Services and Logistics[6] supporting the thesis of the rise of services associated with changing consumption patterns of the population (Atkinson 2018; Dwyer 2013; Gallie 2017). Whereas the industry effect was the greatest contributor to change in employment for those sectors with exposure to opportunities based on changing demographics (Health Care and Social Assistance), policy priorities (the

5 Rental, Hiring and Real Estate Services
6 Transport, Postal and Warehousing Services

NDIS, education and training, arts and recreation) and the resource boom (Mining). Industries such as Utilities[7], Construction, Accommodation and Food Services and Administration and Support Services shared their growth between national and industry effects. The industry effect placed downward pressure on industries exposed to automation and globalisation (Manufacturing and Agriculture, Forestry and Fishing), technological advancements (Wholesale Trade and Retail Trade) and artificial intelligence (Information, Media and Telecommunications and Financial and Insurance Services).

Figure 2. Drivers of employment change by ANZSIC Division 1, Australia, 2006 to 2016



Source: ABS Census of Population and Housing, 2006 and 2016, author calculations

Figure 3 illustrates the four shift-share analysis effects on employment change for men and women employed full-time or part-time for each industry sector. For all employment composition combinations, the national growth effect is positive, and the industry effect is consistent within the industry sector, that is either positive or negative, however, the extent of the effect differs. Where the employment composition effect is positive, the industry sector experienced a positive shift compared with other industries for that combination of sex and labour force attachment. The converse is true when the employment composition effect is negative. That is, the employment composition, and its extent, indicates whether an industry's workforce is gendered or standardised, compared with other industries. Where the within industry employment composition effect is positive, the industry sector experienced a positive shift for that employment composition combination within the sector. The converse is true if the within industry employment composition effect is negative. Also see Table 2.

For the Agriculture, Forestry and Fishing, Manufacturing and Wholesale Trade sectors, all associated with the implications of technology advancements, job

7 Electricity, Gas, Water and Waste Services

destruction is evident. Employment decline was driven by a strong, negative industry effect, slightly offset by a weaker national growth effect. For each there is also a strong shift away from full-time employment for men, with the shift for employment composition negative for full-time work, and strong and positive for part-time work for men. Within wholesale trade, men and women also experienced a strong negative effect for part-time work (-16.1 and -17.4 per cent respectively).

National growth strongly effected the utilities, Construction, Professional, Scientific and Technical Services, Administration and Support Services and Accommodation and Food Services sectors. All were also accompanied by a strong industry effect, particularly so for women in the utilities, construction and professional services sectors, traditionally considered male-dominated sectors. All sectors show a negative shift for full-time employment for men, and a shift to part-time employment, particularly for the professional services (33.1%), Administrative and Support Services (39.2%) and Construction (36.0%) sectors. Within industry competitive advantage differs for each sector, however, part-time work within the industry has a negative effect for women in all sectors except for Administration and Support Services (17.5%), and particularly for those in Construction (-39.9%). Full-time work for women shows a strong negative effect for Accommodation and Food Services (-39.3%) and Administration and Support Services (-33.0%), yet a strong positive effect for Construction (15.8%) and utilities (29.6%), while slightly negative for professional services (-13.0%).

While Retail Trade, Information, Media and Telecommunications (IMT) and Financial and Insurance Services experienced a positive national growth effect within its overall employment growth, each was also offset by a negative industry effect, more so for the Retail sector (associated with digital disruption and the 4IR). Each sector also shows a positive effect for part-time employment, particularly for men, while within industry employment composition effects favour men working full-time, particularly for the Financial and Insurance Services (36.7%) and IMT (26.3%) sectors, with a corresponding negative effect within industry effect for women working full-time in Financial and Insurance Services (-16.9%), providing evidence of gendered industries and the impact of the internet of things and artificial intelligence.

Employment growth for the Logistics, Property, Public Administration and Safety and Other Services sectors was driven by strong, positive national growth effects, particularly for women. Each sector also experienced a positive, yet weak, industry effect. Like all other sectors, the shift for men was strongly positive for part-time employment, and to a lesser degree for women employed part-time. Within sector employment composition effects differed considerably. Property favoured full-time work for men and women (19.5% and 24.2% respectively) while the converse was true for other services (-8.9% and -28.8% respectively). Administration and Support Services provided a stronger negative shift for full-time employment for women (-33.0%) while Logistics showed a strong negative shift for part-time employment for women (-26.7%).

The industry effect was stronger than the national growth effect for the Mining, Education and Training, Health Care and Social Assistance, and Arts and Recreation Services sectors, particularly the Mining sector, reflecting the resource boom over the

period of analysis. The industry effect was also relatively stronger for women than men, excepting the Arts and Recreation sector. All sectors showed a strong shift to part-time work for men. Mining showed a positive within sector employment composition shift for women employed full-time (12.2%), while the Arts and Recreation Services sector showed a strong, negative within industry employment composition effect for women employed full-time (-20.2%). Men employed full-time in the Education and Training sector shows both a negative employment composition shift (-17.4%) as well as a negative within sector shift (-12.3%), as did men employed part-time (-10.1%). Women employed in the Health Care and Social Assistance sector show a negative within sector shift, despite a positive shift for the overall employment composition effect. Conversely, men employed in the Health Care and Social Assistance sector enjoyed a positive employment composition shift within the sector.

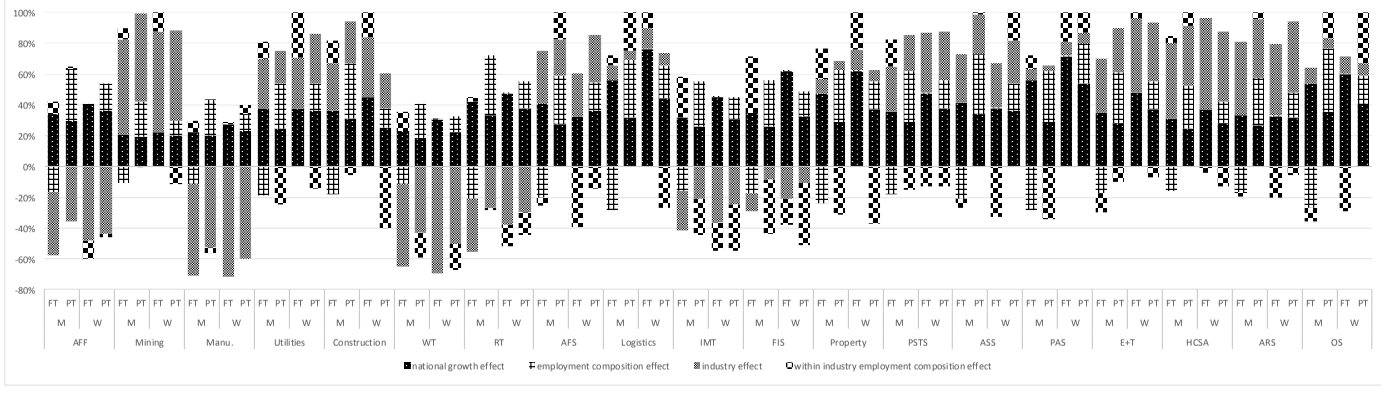
These findings largely reflect the gendered reality of the labour market. Most of the job change for men and for women depends on what is happening in male-dominated and female-dominated occupations; men are particularly vulnerable to changes in manufacturing and construction and women particularly vulnerable to changes in the public sector and private services (Howcroft & Rubery 2018; Rozner 2017). Further, women are disproportionately represented in non-standard forms of work (i.e. part-time), however this situation is also increasing for men. The findings also show that while some industry sectors remain highly gendered, a positive within sector comparative effect is evident for women in the Construction, Mining and Utilities sectors, traditionally considered male-dominated industries.

Table 2. Employment composition effect and within industry employment composition effect, men and women, full time and part time, by industry

	Employment composition				*Within industry employment composition*			
	Men		*Women*		*Men*		*Women*	
	Full time	*Part time*	*Full time*	*Part time*	*Full time*	*Part time*	*Full time*	*Part time*
Agriculture, Forestry and Fishing	-	+		+			-	
Mining	-	+					+	-
Manufacturing	-	+		+				
Utilities	-	+		+	+	-	+	+
Construction	-	+		+	+		+	-
Wholesale Trade	-	+		+	+	-		-
Retail Trade	-	+		+			-	-
Accommodation and Foods Services	-	+		+		+	-	-
Logistics	-	+		+		+		-
Information, Media and Telecommunications	-	+		+	+	-	-	-
Finance and Insurance Services	-	+		+	+	-	-	-
Property	-	+		+	+	-	+	-
Professional, Scientific and Technical Services	-	+		+	+	-	-	-
Administration and Support Services	-	+		+			-	+
Public Administration and Safety		+		+		-	+	+
Education and Training	-	+		+	-	-		
Healthcare and Social Assistance	-	+		+				-
Arts and Recreation Services	-	+		+			-	
Other Services	-	+		+	-	+	-	+

Source: ABS Census of Population and Housing, 2006 and 2016, author calculations

Figure 3. Drivers of employment change by ANZSIC Division 1, by employment composition, Australia, 2006 to 2016



Source: ABS Census of Population and Housing, 2006 and 2016, author calculations
Notes: FT = full-time employment, PF = Part-time employment, M = men, W = Women, AFF = Agriculture, Forestry and Fishing, Manu. = Manufacturing, WT = Wholesale Trade, RT = Retail Trade, AFS = Accommodation and Food Services, FIS = Financial and Insurance Services, PSTS = Professional, Scientific and Technical Services, ASS = Administrative and Support Services, PAS = Public Administration and Safety, E+T = Education and Training, HCSA = Healthcare and Social Assistance, ARS = Arts and Recreation Services, OS = Other Services

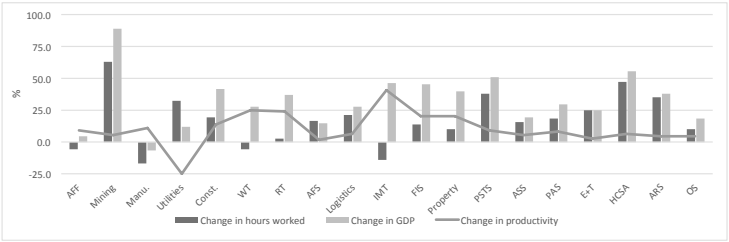
Discussion

At an aggregated data level, over the decade to 2016, the Australian economy grew, both in terms of Gross Domestic Product (GDP) and employment. However, aggregated data can mask the transformation of economies and societies impacting on the ability to identify the need to undertake regulatory reform. As this paper shows, a portion of employment growth is attributable to overall national economic growth, but within economy structural change is also evident in Australia over the decade. These changes warrant more detailed attention.

Over the period, job destruction occurred. Consistent with Perez' Phase 1 of an industrial revolution and the Routine-Biased Technological Change (RBTC) thesis of Goos, Manning and Salomons (2014), this loss occurred predominantly in sectors associated with technological advancements; Manufacturing, Agriculture, Forestry and Fishing, Wholesale Trade and IMT, evident from the negative industry effect in the shift-share analysis. While the Manufacturing sector also realised a reduction in GDP, the latter three sectors increased their economic contribution, indicating improvements in productivity (measured as the relationship between inputs (hours worked) and economic output (GDP)), which is also consistent with the process of an industrial revolution. Considerable improvements in productivity are also evident for most other sectors (except Accommodation and Food Services), with the increase in GDP greater than the increase in the number of hours worked, particularly for Retail Trade, Finance and Insurance Services and Property, again consistent with technological advancements, but less so for the Arts and Recreation Services, Education and Training and Health Care and Social Assistance sectors. See Figure 4.

Job creation also occurred. Aside from the Construction sector being driven by a national growth effect, sectors which experienced the greatest growth in jobs were in the services sectors; Health Care and Social Assistance and Education and Training, mostly women employed full-time or part-time. Driven by a positive industry effect, this growth is more likely to be explained by changing demographics, consumption patterns (Atkinson 2018; Autor & Dorn 2013; Gallie 1991, 2017) and the social organisation of care (Dwyer 2013), rather than the job creation phase of an industrial revolution. That said, relatively strong job creation in Professional, Scientific and Technical Services, is consistent with the imitation phase of an industrial revolution and Goos, Manning and Salomons (2014) Skill-Biased Technological Change (SBTC) hypothesis as well as the industrial profile of Nübler's missing middle EAS nations.

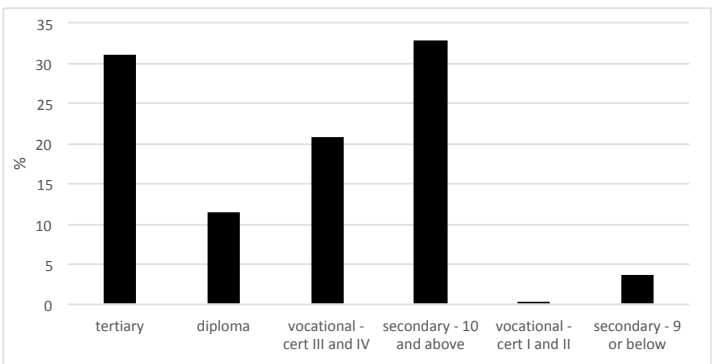
Figure 4. Economic restructuring, ANZSIC Division 1, change in hours worked, GDP and productivity, Australia, 2006 to 2016



Source: ABS, Australian National Accounts: National Income, Expenditure and Product, Jun 2019, Cat. No. 5206.0; Labour Force, Australia, Detailed, Quarterly, Aug 2019, Cat. No. 6291.0.55.003; Australian National Accounts, Jun 2016, Cat. No. 5204.0.

Australia's educational attainment structure can be defined as a 'missing middle' EAS according to Nübler's (2014a, 2016) classification. Around a third of Australia's labour force highest level of educational attainment is a tertiary qualification (30.1%) or secondary school education – year 10 or higher (32.8%), while only 20.1% have a vocational or technical qualification at the certificate III or IV level. See Figure 5. This missing middle EAS constrains Australia's ability to innovate and diversify its industry base beyond a services-based economy. As Nübler explains the EAS represents an important carrier of capabilities to expand, innovate and develop the manufacturing of inventions and other technological advancements, rather than just adopting other nation's innovations within a business model, as appears to be the case in Australia.

Figure 5. Educational Attainment Structure (EAS), Australian labour force, 2016



Source: ABS Census of Population and Housing, 2016 NB. data not available for 2006

Nübler asserts that manufacturing is a "leading sector" in the process of productive transformation with strong linkages between industries and services sectors in progressing technological advancement. While the services sectors have replaced manufacturing in nations with a missing middle EAS, Kucera and Roncolato (2013) argue that advanced services can also be a lagging or leading complement to manufacturing and therefore shouldn't be considered in isolation of each other in industrial policy.

In Australia, Dean and Spoehr (2018) assert that Australia's manufacturing policy is situated in Phase 1 of the industrial revolution being limited to short term objectives using process innovation aimed at increasing productivity. Alternative approaches to manufacturing policy should incorporate longer-term objectives of industrial transformation and the development of new markets, jobs and economic sectors based in digitally connected supply and value chains. In the absence of a longer term view, Dean and Spoehr (2018) suggest the consequences will be dire for the labour market, resulting in widespread job destruction. This is fear is affirmed in a report to the Prime Minister's Industry 4.0 Taskforce (Prime Minister's Industry 4.0 Taskforce 2017) which states the aim of adopting and deploying new technologies associated with the 4IR is to digitise the entire manufacturing process to increase competitiveness so that 'the interconnection of products, machines, networks and systems independently communicating and cooperating with each other over the entire manufacturing process results in minimal or no human intervention'. Even so, according to Grodach and Gibson (2019) while broader government agendas position the manufacturing sector in 'inevitable decline', it also attempts to rebrand manufacturing within the narrative of a high-tech, innovation-driven advanced manufacturing economy. The confused rhetoric regarding manufacturing and its future role in the economy demonstrates a false dichotomy between manufacturing and the knowledge and creative spheres, suggesting that the latter needs to replace the former in the period of economic transformation (Gibson & Warren 2013). There has been a failure to shift the understanding of manufacturing from traditional to contemporary resulting in manufacturing policy being situated between entrenched visions of deindustrialisation and emerging notions of a renewed, advanced manufacturing sector.

The Harvard University Kennedy Business School's Atlas of Economic Complexity (Hausmann 2019) confirms that Australia lacks the economic diversity and productive capabilities to enable it to grow strongly relative to other countries into the future. Similar to Nübler and Perez, Hausmann states that the ability of a country to achieve relatively strong growth is dependent on the productive knowledge that goes into making products (know-how or productive capabilities) and diversity, the number and breadth of products a country is able to make. Hausmann (2019) argues that a country's total diversity can also be expressed by the collective know-how held within that country, what Nübler would refer to as the EAS and social capabilities. Of 133 countries in the Atlas, Australia ranks as the 93rd most complex. Compared to a decade prior, Australia's economy has become less complex, worsening 22 positions in the ECI ranking[8] due to its dependence on commodities. It concludes that Australia's

8 A measure of the knowledge in a society as expressed in the products it makes. The economic complexity of a country is calculated based on the diversity of exports a country produces and their ubiquity, or the number of the countries able to produce them (and those countries' complexity).

worsening complexity has been driven by a lack of diversification of exports and that in the future Australia is positioned to take advantage of only a moderate number of opportunities to diversify its production using its existing productive capabilities.

According to (Hausmann 2019) economic growth is driven by a process of diversifying know-how (productive capabilities) to produce a broader, and increasingly more complex, set of goods and services. In Australia, export growth over the past five years has been driven by expanding its global market share of services, however, globally, long term economic growth is driven by diversification into new products that are incrementally more complex. Based on Australia's export profile, Hausmann (2019) concludes that Australia has diversified into too few products to substantially increase income growth into the future.

Conclusion

Based on Perez' (2010) three phases of techno-economic paradigm, the ILO's Theory of Productive Capabilities (Nübler 2014b) and Nübler's (2016) framework for achieving a 'golden age of job creation', this paper finds that Australia's industrial structure and knowledge sphere is well positioned to develop advanced and sophisticated professional services as well as the adoption of innovation into business models. However, the nation will be constrained in its ability to lead product innovation and transition to the job creation phase of an industrial revolution to achieve a 'great surge of development' due to its educational attainment structure (EAS) and proportionately smaller, and declining, manufacturing sector.

While job growth occurred in the decade to 2016, this was largely driven by a national growth effect associated with increasing consumption and the industry effect associated with the rise of the services sectors and the changing social organisation of care, rather than innovation and technological advancements. Job destruction, on the other hand, is evident in industry sectors associated with the 4IR; the replacement of jobs by automation and artificial intelligence to increase competitiveness and productivity.

Public discourse relating to the Fourth Industrial Revolution is currently stuck in the job destruction phase rather than job creation and widespread prosperity, the risk being a failure of public policy and institutional frameworks to prevent the former becoming a self-fulfilling prophecy.

The ability of a country to transition its economy from job destruction to job creation requires extension beyond relying on market forces to encompassing socio-political intervention. This potential socio-economic transformation is dependent upon a country's productive and social endowments whereby productive capacities are embodied in the physical sphere of production factors and infrastructure and the social capabilities are embodied in the intangible sphere; the educational attainment structure (EAS), the collective knowledge base of a society and its institutional framework (Nübler 2014a, 2014b, 2016).

In order to transition to the third phase of industrial revolution to achieve longer term growth and social prosperity, Australia needs socio-political intervention to address four issues:

1. The transformation of the institutional framework to facilitate both economic and social prosperity through increasing trust and safe-guarding;
2. The repositioning of education, skill and training policy to shift its educational attainment structure to one of 'strong middle' and enhancing collective learning and the knowledge structure;
3. The prioritisation of gender equality in rethinking both the structure of employment and the forms of work for both men and women; and
4. Redesigning economic development policy to embrace contemporary manufacturing as a growing, important industry.

Perez likens the current global economic and social challenges to the period prior to the Great Depression of the 1930s and resistance to then US President Franklin Roosevelt's New Deal for prolonged economic stagnation (Perez 2012a). However, despite declaring that he may not succeed but that he would try and try again; "The country needs and, unless I mistake its temper, the country demands, bold, persistent experimentation. It is common sense to take a method and try it. If it fails, admit it frankly and try another. But above all, try something.", through political leadership and government and industry collaboration, Roosevelt facilitated institutional reform that created the greatest 'surge of development' in history.

References

Anderson, P 2009, 'Intermediate occupations and the conceptual and empirical limitations of the hourglass economy thesis', *Work, Employment and Society*, vol. 23, no. 1, pp. 169.

Arcelus, FJ 1984, 'An extension of shift-share analysis', *Growth and change*, vol. 15, no. 1, pp. 3.

Atkinson, R 2018, 'Shaping structural change in an era of new technology', in M Neufeind, J O'Reilly & F Ranft (eds), *Work in the Digital Age: challenges of the Fourth Industrial Revolution*, Rowman & Littlefield International London, p. 103.

Australian Industry Group 2019, *The Fourth Industrial Revolution: Australian businesses in transition*, AiGroup, Sydney.

Autor, D & Dorn, D 2013, 'The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market', *American Economic Review*, vol. 103, no. 5, pp. 1553.

Bankwest Curtin Economics Centre 2018, *Future of Work in Australia: preparing for tomorrow's world*, Curtin University, WA.

Barany, Z & Siegal, C 2015, *Job Polarization and Structural Change*, SciencesPo Department of Economics, France.

Baum, S 1997, 'Sydney, Australia: A Global City? Testing the Social Polarisation Thesis', *Urban Studies*, vol. 34, no. 11, pp. 1881.

CEDA 2012, 'Australia adjusting: Productivity, innovation and the future of work', paper presented to Prime Minister's Economic Forum, Brisbane.

—— 2018, *Connecting people with progress: securing future economic development*, Committee for Economic Development of Australia,, Melbourne.

Cirillo, V 2018, 'Job polarization in European industries', *International Labour Review*, vol. 157, no. 1, pp. 39.

Coelli, M & Borland, J 2016, 'Job polarisation and earnings inequality in Australia', *Economic Record*, vol. 92, no. 296, pp. 1.

Danko III, JJ & Hanink, DM 2018, 'Beyond the obvious: A comparison of some demographic changes across selected shrinking and growing cities in the U nited S tates from 1990 to 2010', *Population, Space and Place*, vol. 24, no. 6, p. e2136.

Dean, M & Spoehr, J 2018, 'The fourth industrial revolution and the future of manufacturing work in Australia: challenges and opportunities', *Labour & Industry: a journal of the social and economic relations of work*, vol. 28, no. 3, pp. 166.

Deloitte 2019, *The path to prosperity: why the future of work is human*, Deloitte Australia, Australia.

Denny, L 2019, 'Economic restructuring and the polarisation of the workforce: a regional perspective', *Australasian Journal of Regional Studies*, vol. 25, no. 1, pp. 4.

Dunn, ES 1960, 'A statistical and analytical technique for regional analysis', *Papers in Regional Science*, vol. 6, no. 1, pp. 97.

Dwyer, RE 2013, 'The Care Economy? Gender, Economic Restructuring, and Job Polarization in the U.S. Labor Market', *American Sociological Review*, vol. 78, no. 3, pp. 390.

Felstead, A, Gallie, D & Green, F 2017, 'Measuring Skills Stock, Job Skills, and Skills Mismatch', in C Warhurst, K Mayhew, D Finegold & J Buchanan (eds), *The Oxford Handbook of Skills and Training*, Oxford University Press, UK, p. 321.

Fernández-Macías, E 2012, 'Job Polarization in Europe? Changes in the Employment Structure and Job Quality, 1995-2007', *Work and Occupations*, vol. 39, no. 2, pp. 157.

Figueiredo, H, Biscaia, R, Rocha, V & Teixeira, P 2015, 'Should we start worrying? Mass Higher Education, skill demand and the increasingly complex landscape of young graduates' employment', *Studies in Higher Education*, pp. 1.

Gallie, D 1991, 'Patterns of skill change: upskilling, deskilling or the polarization of skills?', *Work, Employment and Society*, vol. 5, no. 3, p. 319.

—— 2017, 'The quality of work in a changing labour market', *Social Policy & Administration*, vol. 51, no. 2, pp. 226.

Gibson, C & Warren, A 2013, 'A city that makes things: reconstituting manufacturing', https://apo.org.au/sites/default/files/resource-files/2013/11/apo-nid59746-1278001.pdf.

Goos, M & Manning, A 2007, 'Lousy and lovely jobs: The rising polarization of work in Britain', *The review of economics and statistics*, vol. 89, no. 1, pp. 118.

Goos, M, Manning, A & Salomons, A 2014, 'Explaining Job Polarization: Routine-Biased Technological Change and Offshoring', *American Economic Review*, vol. 104, no. 8, pp. 2509.

Gordon, J 2016, 'Australia's Productivity: Some Insights from Productivity Analysis', *Asia & the Pacific Policy Studies*, vol. 3, no. 2, pp. 173.

Grodach, C & Gibson, C 2019, 'Advancing Manufacturing?: Blinkered Visions in U.S. and Australian Urban Policy', *Urban Policy and Research*, vol. 37, no. 3, pp. 279.

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

Hamnett, C 1996, 'Social Polarisation, Economic Restructuring and Welfare State Regimes', *Urban Studies*, vol. 33, no. 8, pp. 1407.

Hausmann, R 2019, *Atlas of Economic Complexity*, Harvard's Growth Lab, Harvard Kennedy School, Harvard University, US, 4 November 2019, data visualisation tool.

Hofheinz, P 2018, 'Value creation in the data-driven economy', in M Neufeind, J O'Reilly & F Ranft (eds), *Work in the Digital Age: challenges of the Fourth Industrial Revolution*, Rowan & Littlefield, London, p. 89.

Holmes, C & Mayhew, K 2015, *Over-qualification and skills mismatch in the graduate labour market*, Chartered Institute of Personnel and Development, London.

—— 2016, 'The economics of higher education', *Oxford Review of Economic Policy*, vol. 32, no. 4, pp. 475.

Howcroft, D & Rubery, J 2018, 'Gender equality prospects and the fourth industrial revolution', in M Neufeind, J O''Reilly & F Ranft (eds), *Work in the Digital Age: challenges for the fourth industrial revolution*, Rowman & Littlefield, London, p. 63.

Keep, E 2017, 'Current Challenges: policy lessons and implications', in C Warhurst, K Mayhew, D Finegold & J buchanan (eds), *The Oxford Handbook of Skills and Training*, Oxford University Press, New York.

Kucera D., Roncolato L. (2013) Structure Matters: Sectoral Drivers of Growth and the Labour Productivity-Employment Relationship. In: Islam I., Kucera D. (eds) *Beyond Macroeconomic Stability. Advances in Labour Studies*. Palgrave Macmillan, London.

Livingstone, D 2017, 'Skill Under-Utilization', in C Warhurst, K Mayhew, D Finegold & J Buchanan (eds), *The Oxford Handbook of Skills and Training*, Oxford University Press, USA, p. 281.

Lloyd, C & Payne, J 2016, *Skills in the Age of Over-qualification: Comparing Service Sector Work in Europe*, Oxford University Press.

McGuinness, S, Pouliakas, K & Redmond, P 2017, *How Useful Is the Concept of Skills Mismatch?*, IZA Discussion Papers, No. 10786.

McKinsey & Company 2019, *Australia's automation opportunity: reigniting productivity and inclusive income growth*, McKinsey Australia, Australia.

Montresor, G 2018, 'Job polarization and labour supply changes in the UK', *Labour Economics*, vol. 58(C), pp. 187.

Morgan, J 2019, 'Will we work in twenty-first century capitalism? A critique of the fourth industrial revolution literature', *Economy and Society*, pp. 1.

Murphy, E & Oesch, D 2018, 'Is Employment Polarisation Inevitable? Occupational Change in Ireland and Switzerland, 1970–2010', *Work, Employment and Society*, vol. 32, no. 6, pp. 1099.

Nübler, I 2014a, 'Social policy and productive transformation: Linking education with industrial policy', in *UNRISD Conference, New Directions in Social Policy: Alternatives from and for the Global South*, Geneva, Switzerland.

—— 2014b, 'A theory of capabilities for productive transformation: Learning to catch up', in J Salazar-Xirinachs, I Nübler & R Kozul-Wright (eds), *Transforming Economies: Making industrial policy work for growth, jobs and development*, International Labour Office, Geneva, pp. 113-149.

—— 2016, *New technologies: A jobless future or golden age of job creation?*, International Labour Office Geneva.

OECD 2015, *The Future of Productivity*, OECD Publishing, Paris, /content/book/9789264248533-en http://dx.doi.org/10.1787/9789264248533-en.

Oesch, D & Rodríguez Menés, J 2010, 'Upgrading or polarization? Occupational change in Britain, Germany, Spain and Switzerland, 1990–2008', *Socio-Economic Review*, vol. 9, no. 3, pp. 503.

Perez, C 2004, 'Technological revolutions, paradigm shifts and socio-institutional change', in E Reinert (ed.), *Globalization, economic development and inequality: An alternative perspective*, Edward Elgar Publishing Limited, UK, pp. 217-242.

—— 2010, 'Technological revolutions and techno-economic paradigms', *Cambridge journal of economics*, vol. 34, no. 1, pp. 185.

—— 2012a, 'Technological revolutions and the role of government in unleashing golden ages', in *Kondratieff Waves: Dimensions and Prospects 2012*, vol. 1929, pp. 211-218.

—— 2012b, 'Technological Revolutions and the Role of Government in Unleashing Golden Ages', *Journal of Globalization Studies*, vol. 3, no. 2, pp. 19.

Prime Minister's Industry 4.0 Taskforce 2017, *Industry 4.0 Testlabs in Australia: preparing for the future*, Swinburn Unveristy of Technology,Australian Government, Victoria.

Productivity Commission 2016, *Increasing Australia's future prosperity*, Canberra.

Quintini, G 2011, *Over-qualified or under-skilled: a review of existing literature*, OECD.

Reeson, A, Mason, C, Sanderson, T, Bratanova, A & Hajkowicz, S 2016, *Report Report for TAFE Queensland, The VET era: Equipping Australia's workforce for the future digital economy*, CSIRO, Brisbane.

Rozner, G 2017, *The disappearing Australian working man*, Institute of Public Affairs, Melbourne.

Salvatori, A 2015, *The anatomy of job polarisation in the UK*, IZA.

Schumpeter, J 1942, 'Creative destruction. Capitalism', *Socialism and Democracy*, vol. 825, pp. 82.

Schwab, K 2016, 'The Fourth Industrial Revolution: what it means, how to respond', viewed 17 September 2019, https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/.

Seet, P-S, Jones, JT, Spoehr, J & Hordacre, A-L 2018, *The Fourth Industrial Revolution: the implications of technological disruption for Australian VET*, 1925717208, NCVER, Adelaide.

Smith, C 2017, 'Skill demands and developments in the advanced economies', in J Buchanan, D Finegold, K Mayhew & C Warhurst (eds), *The Oxford Handbook on Skills and Training*, Oxford University Press, New York.

Soete, L 2018, 'Destructive creation: explaining the productivity paradox in the digital age', in M Neufeind, J O'Reilly & F Ranft (eds), *Work in the digital age: challenges for the Fourth Industrial Revolution*, Rowman & Littlefield, London, pp. 29-46.