Understanding and Preparing for the Societal Impacts of Process Automation

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Paper Abstract
Process automation methods and technologies are advancing and penetrating society and organisations at an exponential speed. Through a literature review, this paper aims to consolidate currently scattered discussions on the very important aspect on how process automation impacts society. It identifies themes of critical importance and highlights those that have been acknowledged but are under-addressed. It is intended for processionals who are essentially leading these digital transformations and process innovations; to be more aware of the societal implications and to provide some guidelines on what can be done to minimise negative and maximise positive societal implications of process automation.

Keywords: Future of work, Process automation, Sustainability, work design

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Process automation methods and technologies are advancing and penetrating society and organisations at an exponential speed. Through a literature review, this paper aims to consolidate currently scattered discussions on the very important aspect on how process automation impacts society. It identifies themes of critical importance and highlights those that have been acknowledged but are under-addressed. It is intended for processionals who are essentially leading these digital transformations and process innovations; to be more aware of the societal implications and to provide some guidelines on what can be done to minimise negative and maximise positive societal implications of process automation.

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1. INTRODUCTION

Digital technologies have the potential to replicate ideas, processes and innovations at extremely low cost (Brynjolfsson & McAfee, 2015). While this aspect of digitalisation brings many positive benefits for society it also carries the potential of reduced demand for various types of labour (Brynjolfsson & McAfee, 2015). Within an organisational context, the introduction of new, digital cognitive technologies such as Artificial Intelligence (AI), Natural Language Processing (NLP) and Machine Learning (ML) enable new, previously unimaginable business processes. It is now possible for smart robots to act as full-fledged members of a business process, automating both routine and non-routine activities and collaborating with humans in a variety of ways (Zarkadakis, et al., 2016). Cognitive technologies are beginning to explore unstructured and non-process context data (e.g. policies, regulations or emails), bringing new levels of process flexibility to organisations through the ability to automate unpredictable, fragmented and knowledge-intensive business processes (Hull & Nezhad, 2016; Kerpedzhiev, König & Rosemann, 2017).

Some suggest that society is now firmly engaged in a ‘race against the machine’ (Brynjolfsson & McAfee, 2011). In a widely cited paper, Oxford University researchers Frey and Osborne (2013), estimate that 47% of total US employment is at risk of automation in the next decade or two. The World Bank estimates that 77% of jobs in China are at high risk of automation, with similar numbers for India, South Africa and Brazil (World Bank Group, 2016). On a global level, research from McKinsey finds that approximately half of the activities performed by the world’s workforce could be automated using *currently available technologie*s and almost every occupation having at least partial automation potential (Manyika et al., 2017). The impacts of automation cut across many sectors and employment across all levels. MIT economist Erik Brynjolfsson states that the changing nature of the future of work is "*the biggest challenge of our society for the next decade*" (as quoted in Miller, 2014, p. 2).

Despite the high attention on how business processes could adapt to the emerging digital and cognitive technologies, there has been a lack of understanding on current societal impacts[1] of process automation. This paper explores "*What are the societal impacts of process automation?"* It aims to synthesize existing discussions, build awareness and trigger discussions, to form a springboard for future, deeper pieces of research into the societal impacts of process automation.

2. STUDY APPROACH

The review adheres to the grounded-theory-based guidelines of Wolfswinkel, et al. (2013). A Grounded Theory methodology was selected for this paper as it enables a more thorough and transparent review. The literature search commenced using the key words of; "Business Process Management", "automation", and "impacts" and synonyms thereof, focusing on Business Process Management, Business, Information Systems and Computer Science domains (given the study context). Association of IS e-Library (AISeL), ABI/Inform, Scopus and Emerald were targeted as the main data bases. After having analysed the collected papers (with further forward and backward searching), which resulted in only very limited number of papers, the search strategy was expanded to other domains such as Economics, Labour markets, Operations management, Government policy; to identify papers that referred broadly to processes and the societal impacts of process automation; which were carefully screened for relevance. Given the volume of material retrieved from this extended search and in recognition of the rapid pace of digital developments, a temporal frame of 5 years was set to limit the results and to make the analysed content more contemporary. The search took place in the second half of 2017, hence only papers from 2012 onwards were included. The only

[1] Societal impacts can be defined *"as the net effect of an activity on a community and the well-being of individuals and families"* (Centre for Social Impact, 2017, p. 1). Examples of societal impacts on a community are; those relating to employment, training & education, labour/management relations, the health & safety of workers, and diversity & equal opportunity

exception to this was the inclusion of Erik Brynjolfsson & Andrew McAffee's (2011) seminal and widely cited book "*Race Against The Machine".* Paper inclusion and exclusion guidelines were developed and adhered to. An explicit decision was made to exclude papers that focused only on the organisational impacts such as change management, cost, value and training of employees given that these are already well understood. This allowed to better focus on broader societal impacts; to consider impacts in terms of individuals, groups and governments etc.

All the extracted resources together with their bibliographic information were entered into ENDNOTE (a reference management tool). Microsoft EXCEL sheets were set up with corresponding coding rules (Saldaña, 2009), as the coding and synthesis support tools/ mechanism. The papers were read and relevant information captured as themes and recorded within the set Excel sheets (against the paper references). After having performed a first pass of all the papers key themes were aggregated into higher level groups for better sense making and reporting.

A second coder was engaged in the quality assurance of the paper selection, coding and synthesis of the papers (which was iterative in nature) with multiple coder corroboration sessions taking place at the different phases.

3. FINDINGS

We commence the presentation of the findings with an overview (derived from literature) which summarises the different eras of automation, and automation technologies applied for process automation (Section 3.1). Then the results of the thematic analysis is presented; summarising the main societal impacts (3.2), and actions been taken and/or recommended to date (3.3) to address some challenges.

3.1 Background: Eras of automation and automation technologies

Davenport and Kirby (2015, 2016) define three major eras of automation based on the types of work challenged by machines. *Table 1* is a summary of these three eras, their impacts and the reaction from society toward each wave.

<Insert *Table 1 - The Three Eras of Automation*>

Three major categories of knowledge-worker automation tools are driving the most recent era of automation: Robotic Process Automation (basic & advanced), Cognitive Automation and Social Robotics. In *Figure 1*, we have integrated research from Zarkadakis, et al. (2016) on the three most common categories of process automation technology with research from McGuire (2017) on the specific process & data input characteristics that each automation technology is best suited to.

<Insert *Figure 1 - Automation technologies and their process characteristics*>

3.2 Impacts

With the maturing of cognitive technologies, a much greater proportion of the tasks performed by knowledge workers will either be able to be replaced or augmented by machines. This future has significant impacts for society. The most popular and significant impact mentioned in the literature is on employment changes (see Section 3.2.1), and the other anticipated societal impacts (3.2.2-3.2.6) that closely relate to employment[2].

3.2.1 Employment implications of process automation

When widely cited Oxford University researchers Frey and Osborne (2013) released their findings into the susceptibility of jobs to computerisation, significant debate commenced into the increasing threat of unemployment and has continued (Pulkka, 2017). *Table 2,* summarises the key impacts to employment with jobs requiring minimal qualifications, repetitive activities and standardised environments being most impacted and jobs with creative intelligence, social intelligence or perceptual tasks in non-standard environments being least impacted.

<Insert *Table 2 – Employment Implications of process automation*>

[2] During the inductive data coding and analysis phase, the Global Reporting Initiative (2011) guidelines for Social Sustainability was used a reference framework to support with sense making and final grouping of the themes.

There is large debate within the literature about the impacts to employment of automation technologies. The debate has largely bifurcated into two groups with each presenting their own version of the future impact of automation. *Table 3* summarises the pessimist 'this time is different' scenario and the techno-optimist, 'this time is no different' scenario. It also presents a third 'middle-ground' perspective of 'this time is *a bit* different', which started to emerge in more recent times.

<*Insert Table 3 – The future impacts of automation*>

The pessimists, for example Davidow and Malone (2014), believe that *"this time is different"* (Pulkka, 2017, p. 3; Schwab, 2016, p. 9) because the exponential development of intelligent machines and robots will drive down the value of human labour, resulting in permanent high levels of unemployment (Brynjolfsson & McAfee, 2011; Davidow & Malone, 2014).

The second group, the techno-optimists, for example Autor (2015); Davenport and Kirby (2016), believe that "*this time is no different"* (Pulkka, 2017, p. 4; Schwab, 2016) and that new jobs will spring up to replace the ones that disappear. David Autor's "O-ring model" (2015, p. 4), argues that any improvements in the reliability in one of the links, will lead to an overall increase in the value of the improvements in all of the others (Autor, 2015). By incorporating cognitive automation technologies into a process to support, for example, human doctors in generating accurate medical diagnoses, the overall effectiveness and accuracy of the diagnosis process is improved. Even as certain jobs will likely be replaced through automation, Autor (2016) argues that due to humans' endless desire and inventiveness, new 'needs' will require new jobs that are almost impossible for us to conceive at the present time.

We also found a third likely scenario predicting the impacts of automation on employment that we describe as 'this time is *a bit* different.' This scenario describes a future where automation will fail to completely destroy the large numbers of jobs as predicted by Frey and Osborne (2013), but also one in which the quality and composition of jobs will change (Autor, 2015) and that middle- and low-skilled workers will be mostly and unfairly affected (Manyika, et al., 2017) leading a rise in inequality (Arntz, et al., 2016).

While there are various perspectives at either extreme of the spectrum on whether automation will be beneficial or detrimental for society, more nuanced analysis would suggest that even if automation does not affect the overall quantity of jobs available, it will still affect both the quality and task composition of jobs (Autor, 2015; Chui, et al., 2016; Pulkka, 2017). This view effectively calls for a re-examination of what a job actually is—how it's defined and structured in the context of automation technologies (Jesuthasan, Malcolm, & Zarkadakis, 2016).

3.2.2 Training and education implications of process automation

The rapid increase in the use of automation technologies in the workplace has significant implications *(see Table 4)* for training current and future workers across the different skills spectrums and at different education levels; including secondary, tertiary, vocational and professional. The literature indicates that there are some investigations by governments (The Economist, 2017) around developing new education policy that responds to the predicted impacts of automation. However, little has been written about the preparedness of organisations to invest in training and in preparing employees to deal with the rapid rate of technological change. At the same time, attitudinal readiness, being the readiness of employees to embrace working with and collaborating directly with machines, has not been discussed in the literature.

<Insert *Table 4 – Training and education implications of process automation*>

3.2.3 Implications to Labour/management relations from process automation

Decreased membership of unions, due in part to increasing levels of automation, diminishes the capability of unions to negotiate better contracts, attract more members and penetrate new establishments (Autor, 2014). A weakening in trade unions makes them less able to engage in bargaining or organising against any widespread displacement of workers (Pulkka, 2017). This means fewer strong voices to advocate on behalf of employees about the impacts of automation including fewer jobs, the needs for retraining and the health and wellbeing of workers. If the trend of decreased union membership continues, workers will need to find other mechanisms such as digital communities to collectively organise and negotiate.

3.2.4 Implications to health and safety of workers from process automation

Discussions of the health and safety impacts of process automation is minimal in the current literature, with only a few pockets of discussions. *Table 5,* presents some discussed effects of process automation techniques such as Lean Manufacturing and Just-in-Time scheduling. The literature concludes that if Lean Manufacturing methods are implemented properly, they can have a positive impact to employees. If implemented badly, the effects can be extremely harmful (Resta, et al., 2017). Just-in-time Scheduling relies on software algorithms and predictive analytics to ensure that precisely the ‘right’ amount of staffing is deployed when and where it is needed—often at short notice (Degryse, 2016). This ‘flexibility’ of working hours can lead to the combination of work and family life being severely disrupted and an increase in employee stress levels and work hours (Degryse, 2016). Given the limitations in the literature, further investigation is warranted into this much broader set of secondary societal implications for the health and safety of workers. These secondary impacts could include mental health conditions such as depression, which can lead to other societal disruptions such as an increase in drug and opioid addition rates (Gillespie, 2017).

<Insert *Table 5 –Implications to the health and safety of workers from process automation*>

3.2.5 Implications to diversity & equal opportunity from process automation

As intelligent technology is embedded into an increasing number of processes, there is greater potential for unintended discrimination against specific groups of people. In one example, Google had to apologise after an intelligent automatic photo tagging system labelled people of colour as “Gorillas” (Frankenstein’s paperclips, 2016, p. 8). In another separate perspective on the implications for male workers, Autor, Dorn, and Hanson (2017) find that as a result of local declines in employment caused by increased levels of manufacturing automation and a rise in trade with China, a fall in employment & earnings, an increase in the rate of male mortality from drug and alcohol abuse, a reduction in the proportion of young adults entering marriage and a weak rise in the proportion of births to teen and unmarried mothers. (Autor, et al., 2017, p. 37). The authors conclude that declining employment and earnings opportunities faced by young men are plausible contributors to a reduction in the marriage market value of men and ultimately to a change in structure of marriage and childbirth in the US (Autor, et al., 2017).

3.3 Recommended actions to be considered

In this section, we present a range of recommendations (synthesised from current discourses and enhanced with our interpretations) for individual workers and governments on how to prepare and respond with the present and future-potential impacts of process automation technologies.

3.3.1 Individual workers/ employees in general

By understanding how automation puts certain activities more at risk, workers can rethink how they can best engage with their jobs and plan their careers (Chui, et al., 2016). Automation strategies typically involve starting with an existing process and then subtracting activities away from it to reduce costs and improve efficiency. Davenport and Kirby (2015) argue that this approach limits our thinking to within the parameters of the work that is currently being performed today. Augmentation, by contrast, means starting with the work or process that people currently perform today and finding ways that work could be *enhanced* rather than diminished by smart machines (Davenport & Kirby, 2015). For example, while workers employed in film processing were ultimately displaced, augmentation through digital technologies unleashed many photographers, allowing them to do more and at a lower cost than before (Hajkowicz, et al., 2016).

For individual workers and those that are providers of work, Davenport and Kirby (2016) propose a change in mindset—a reframing of the threat of automation as an opportunity for *augmentation*. In a future of work where software performs the bulk of the cognitive 'heavy-lifting', Davenport and Kirby (2015; 2016, pp. 76-77) propose five paths toward employability for individual workers: 1) *Stepping up* – You invest in completing an MBA or PhD to move above the automated systems to develop big-picture insights that are too 'vast' or 'fuzzy' for machines to make. 2) *Stepping aside* – You build on your abilities to work with people and your non-codifiable strengths (e.g. creativity, humour, empathy) to move to a new type of work such as counselling, motivating people, acting, dancing or writing. 3) *Stepping in* – You pursue some STEM[3] education and build your business knowledge to become more engaged with computer systems' automated decisions to monitor and modify their function. This could include learning a programming language and being able to implement the automation technologies that power organisations. 4) *Stepping narrowly* – You look for and, master a niche that is so narrow that no one is attempting to automate yet. An example we suggest of a niche role could be that of the Ecosystems Architect—an emerging role responsible for the planning and design the digital marketplaces of the future. 5) *Stepping forward* – You stay at cutting edge of developments in computer science and analytics to develop the next generation of smart machines.

3.3.2 Governments

In this third era of automation, governments do not have the luxury of time to study the impacts of a particular technology and create a necessary policy response or regulatory framework (Schwab, 2016). New structures are required to rapidly develop policies that can prevent a backlash against the increasing levels of labour market dislocation caused by widespread automation (Burkhardt & Bradford, 2017). Borrowing from agile software development practices, Burkhardt and Bradford (2017) propose a new policy development approach—agile governance. Adapting this, governments should be constantly reviewing and responding to: 'which jobs are being automated under which economic circumstances?', 'which jobs can be elevated in skill (and wages) through cognitive software augmentation?', 'which skills are required for the new jobs and what retraining is required for existing jobs?', and 'what are the factors that prevent workers from retraining?'. Literature discusses how governments should prepare for changes in a range of areas including Education, Investment & Job Creation, and Welfare & Taxation.

<u>Education:</u> Lifelong learning programs are government policy solutions that allow workers to update their skills and training as required throughout their careers based on the needs of the worker, the industry and the impacts of new technologies (Burkhardt & Bradford, 2017). *The Economist's*

[3] STEM= Science, Technology, Engineering and Maths

(2017) report into lifetime learning highlights several initiatives being trialled (see *Table 6)* by various governments as a way of continually supporting their citizens in responding to the impacts of automation and to prepare for new technological developments as they occur:

<Insert *Table 6 – Examples of government education programs, in response to automation*>

Investment & Job Creation: If education policy is a long-term strategy for minimising automation's threat of a much smaller workforce, government job creation policy could be thought of as a more near-term response that deals with the immediate employment impacts of automation (Davenport & Kirby, 2016). Within the literature, various examples of job creation policies exist to address the immediate threat of automation:

- Government investment in projects that support peoples' desires to engage in artistic production and for the government to pay for many volunteer services that are currently performed for the good of communities (Davenport & Kirby, 2016).
- Government investment through the creation of new jobs in areas such as taking care of children and the elderly, health & environment, cities & community development (Hajkowicz, et al., 2016).
- Upgrades to infrastructure to absorb slack in the labour market and improving productivity by facilitating mixing of ideas, people and technologies (Brynjolfsson & McAfee, 2011).

In response to the impacts of automation, we find that the literature contains only general policy recommendations around investment and job creation with little detail on the feasibility of their implementation or their practical effectiveness.

Welfare & Taxation: If the pessimists as described in Section 3.2.1, are correct in their dismal prophesies of machine-human substitution, our chief economic problem will not be one of lack of wealth but one of distribution (Autor, 2015). In *Table 7*, we summarise the leading policies found in the literature that aim to address the lack of a fair wealth distribution exacerbated by automation.

<Insert Table 7 – Welfare and taxation policy responses to automation>

A popular policy response to the impact of job losses and distribution conflicts caused by automation is the Universal Basic Income (UBI) or guaranteed minimum wage (Hendrickson & Galston, 2017; Pulkka, 2017). The UBI is designed as a practical measure to make work pay and diminish economic disincentives in social security such as low-paid work (Pulkka, 2017). Opponents of the UBI argue that employment itself has value beyond generating an income in being able to provide meaning in life (Davenport & Kirby, 2016) with guaranteed jobs beating guaranteed incomes. With so much of one's identity placed around their job and the contribution that they are able to make being in that job, it would seem extremely unlikely that society would function effectively with an army of machines and software generating all the value, leaving humans without a purpose and reliant on the government for their existence.

4 DISCUSSION AND CONCLUSION

This review aimed to collate and synthesize existing discourses on the societal impact of process automation, to gain a deeper understanding of the impacts process automation brings to society as a whole, to see where the gaps were and to also see what specific actions professionals leading process-centric reforms should consider.

Prior to our work, a synthesised discussion of the societal impacts of process automation was very limited. Our analysis presents a broad range of findings on the societal impacts of process automation. On the potential long-term question of whether process automation will be beneficial for employment, we did not find the pessimist 'this time is different' scenario or the techno-optimist 'this time is no different' to be more plausible than the other. This led us to propose our own third future scenario that we summarised as 'this time is *a bit* different' (see Section 3.2.1 and *Table 3*). In this scenario, we found it possible that automation will not have the effect of causing mass unemployment but one in which certain components of workers' jobs are either replaced or augmented by machines and one in which many new, currently inconceivable jobs are created to provide people with income, but more importantly, with meaning in their lives.

Some authors acknowledge the impacts of this topic but rarely give specific guidelines on what needs to be done. Our work consolidates the diverse ‘remedial-actions’ taken and recommendations made to date and presents them in two groups. Actions/recommendations for both individual workers and governments. However, we recognise that further work must be performed as part of a much larger program of investigation into the societal impacts of process automation.

This review pointed to a range of gaps in the current literature where important areas are under researched. These include:

- The impacts of process automation to developing nations—a very large proportion of the research appears to be biased around a US-centric view with a lack of investigation into the direct and indirect societal impacts within other country contexts; especially developing nations;
- the impacts to human identity and purpose as a result of job loss;
- implications of automation technology for education and training at all levels;
- the secondary health and safety impacts to workers including mental health and possible opioid addiction (due to changes of mental conditions);
- impacts to women in organisations/society; and
- a lack of details on the implementation and effectiveness of government policy solutions to the impacts of automation.

Our work is intended to act as a springboard into much larger programs of investigation into the societal impacts of process automation. This paper is timely because we cannot delay any further our discussions on the broader impacts that people will feel only as an after-effect of the decisions that we make now around how we use process automation technology.

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TABLES

Table 1 – The Three Eras of Automation

AUTOMATION ERA	TECHNOLOGIES	IMPACTS TO JOBS & INDUSTRY	SOCIETAL ANXIETY & RESPONSE
ONE – 19th CENTURY	Steam engines, Spinning frames, stocking frames and power looms (Davenport & Kirby, 2016).	Machines relieve humans of manually exhausting, dirty and dangerous work – factories, looms and steam engines (Davenport & Kirby, 2015).	A machine-trashing rebellion in response to the rapid automation of textile production. (Autor, 2014; Frey & Osborne, 2017).
TWO – 20th CENTURY	Semiconductors, mainframe computing, personal computing and the internet (Schwab, 2016)	Machines replace dull, routine service transactions and clerical chores – airline kiosks, self-service call centres and automated teller machines (Davenport & Kirby, 2015).	Ford motor company workers rise up against unprecedented automation of assembly lines in Brook Park, Ohio (Davenport & Kirby, 2016).
THREE – 21st CENTURY	Machine Learning, Artificial Intelligence and Natural Language processing (Davenport & Kirby, 2015).	Intelligent machines take away decisions from humans & learn to automate judgement-intensive processes – autonomous drivers, medical diagnosticians, paralegals and other "knowledge workers" (Davenport & Kirby, 2015).	Strong support for Donald Trump in the 2016 Presidential election in middle-income electoral districts most exposed to automation. (Frey, Berger & Chen, 2017).

Table 2 – Employment Implications of process automation

IMPACTS	KEY FINDINGS	REFERENCES
Implications for the USA	*Perspective 1*: Within the next decade or two, 47% of total US Employment is at risk of being automated. **Jobs most at risk:** Workers whose jobs are most at risk include transportation, logistics, office administrative & support workers and service occupations. **Jobs most at risk:** Occupations that involve performing activities or operating machinery in a predictable environment (e.g. packaging products, welding & maintaining equipment, data collection/processing and interacting with customers).	(Frey & Osborne, 2013, 2017) (Chui, et al., 2016)

	Perspective 2: Automation and digitalisation are less likely to destroy large numbers of jobs. **Jobs most at risk:** Low qualified workers are most likely to be impacted as the automatability of their jobs is higher compared to highly qualified workers.	(Arntz, Gregory, & Zierahn, 2016)
Implications for Europe	Between 45% and 60% of jobs over the coming decades are at risk of being significantly impacted by technology. **Jobs most at risk:** Those involving little creative intelligence, social intelligence or perceptual tasks.	Bowles (2014a) (Bowles, 2014b)

Table 3 – The future impacts of automation

KEY FINDINGS	REFERENCES
The techno-optimists view of 'this time is no different'	
• This time is different and we're heading for permanent high levels of unemployment. • Moore's law continues to dictate the doubling of computing power every 12-18 months, this rate of progress is embedded into the development of intelligent machines and robots that will dominate the economy and drive down the value of human labour. Faced with the exponential gains in technology, it becomes more difficult to see how workers can update their skills and education quick enough in what may become a "nowhere left to run" situation.	(Davidow & Malone, 2014; Pulkka, 2017; & Schwab, 2016) (Brynjolfsson & McAfee, 2011; Davidow & Malone, 2014). (Pulkka, 2017, p. 3).
The techno-optimists view of 'this time is no different'	
• This time is no different and new jobs will spring up to replace the ones that disappear. • Tasks that cannot be substituted by automation are generally complimented by it. • Autor's (2015) "**O-Ring model**" describes a situation whereby a failure in any one link in the (process) chain leads to the entire production process to fail. Conversely, any improvements in the reliability in one of the links, leads to an overall increase in the value of the improvements in all of the others. For example, augmenting human doctors with cognitive automation technologies to generate more accurate medical diagnoses. • Autor's (2016) **"never-get-enough"** principle argues that due to humans' endless desire and inventiveness, new 'needs' will require new jobs that are almost impossible for us to conceive at the present time. For example, no one during the first industrial revolution would have predicted the need for mobile application developers in 100 years' time.	(Pulkka, 2017; Schwab, 2016) (Autor, 2015). (Autor, 2016)
A new view that 'this time is a bit different'	
• A future where automation will fail to completely destroy the large numbers of jobs as predicted by Frey and Osborne (2013). However, the quality and composition of jobs will change (Autor, 2015) and that middle- and low-skilled workers will be unfairly affected (Manyika, et al., 2017) leading a rise in inequality (Arntz, et al., 2016).	(Autor, 2015); (Manyika, et al., 2017); (Arntz, et al., 2016).
• Even if automation does not affect the overall quantity of jobs available, it will still affect both the quality and task composition of jobs. • 50% of the tasks performed by the world's workforce could be automated using currently available technologies, but that only 5% of jobs could be automated • The **easiest activities to automate** include tasks involved predictable physical work, processing data and data collection. Middle-income sectors such as manufacturing, food service, accommodations and retailing, based on technical considerations alone, these are the industries that are most susceptible to automation.	(Autor, 2015; Chui, et al., 2016; Pulkka, 2017). (Manyika, et al., 2017). (Chui, et al., 2016) (Autor & Dorn, 2013; Chui, et al., 2016).

• The **hardest activities to automate** include many that are typically found in low-income jobs that require greater flexibility in unpredictable environments, visual and language recognition and in-person interaction Examples include, preparing a meal, driving a truck through city traffic, collecting rubbish, and cleaning hotel rooms (Autor & Dorn, 2013). • The **"barbell effect,"** otherwise known as employment polarisation, is a phenomenon that results in the concentration of jobs at both the low- and high-end of the labour market and the 'hollowing-out' of middle-income jobs.	(Autor, 2014; The Economist, 2016).

Table 4 – Training and education implications of process automation

KEY FINDINGS	REFERENCES
• A decreasing proportion of 'routine work' due to automation will require effective collaboration models to support ad-hoc and unstructured processes. • As cognitive technologies begin to make more of the 'routine' decisions for humans, work will require greater cognitive, creative and entrepreneurial capabilities. • Workers will be increasingly connected and, due to the rapid advancements in automation technology, will be required to learn constantly on the job. • The work not replaced by machines will be both communication- and knowledge-intensive.	(Kerpedzhiev, Lehnert & Röglinger, 2016)
High-school educators focus on teaching students three sets of soft skills: 1. Human–machine partnerships – collaborating with machines; 2. Wise decision-making – knowing which decisions can be made by machines and those best left to humans; and 3. How to become entrepreneurial learners – being constantly on the lookout for new methods, resources and mentors to help learn new things.	(Davenport & Kirby, 2016)
Emphasise and expand the focus of collaboration by recognising that the teams students will join in the workplace will include machines. From primary school age, educators should teach what is required to form an effective human-machine partnership, with each partner effectively complimenting the strengths and weakness of the other.	(Davenport & Kirby, 2016)
University and high-school students should be taught earlier how to make wise decisions under uncertain conditions and how to determine which decisions are best made by machines and those that require human intervention.	(Schwab, 2016); (Davenport & Kirby, 2016).

Table 5 – Some observed implications to the health and safety of workers from process automation

KEY FINDINGS	REFERENCES
Example 1: Lean Manufacturing	
Lean Manufacturing can have a positive effect on workplace health & safety thanks to methodologies such as 5S, Jidoka, TPM and the idea suggestion system.	(Longoni & Cagliano, 2015; Resta, Dotti, Gaiardelli, & Boffelli, 2017)
Lean Manufacturing techniques such as Total Quality Management, Total Preventative Maintenance and Human Resource Management contributed to reduced risks for employees, lower stress levels and higher engagement.	(Resta, et al., 2017).
Example 2: Just-in-Time Scheduling	
Just-In-Time also contributed to higher workplace safety and lower accidents but *higher* stress levels for employees.	(Resta, et al., 2017).
The 'flexibility' of working hours created by just-in-time scheduling can lead to the combination of work and family life being severely disrupted and an increase in employee stress levels and work.	(Degryse, 2016)

Table 6 – Examples of government education programs, in response to automation (The Economist, 2017)

Country/ Initiative	**Description**
Singapore: Skills Future initiative	This initiative engages employers to map out the required industry changes over three-to-five years and identify the skills that they require. The government then provides vouchers to citizens that can be used at a range of training providers and generous education subsidies of up to 90% for citizens 40 and over.
Denmark: 'flexicurity' system	This system offers unemployed workers a list of up to 258 vocational training programs as a way of re-training into a different career that may have more employment opportunities.
UK: UnionLearn initiative	This initiative supports workers through union workers informing them of training options available and liaising with employers on workers' requests for training.

Table 7 – Welfare and taxation policy responses to automation

KEY FINDINGS	REFERENCES
Universal Basic Income (UBI) – A practical measure to make work pay and diminish economic disincentives in social security such as low-paid work that does not increase one's disposable income.	(Hendrickson & Galston, 2017; Pulkka, 2017).
Guaranteed Jobs – Unemployed people are less happy and that compensating them through a UBI or other welfare mechanism, doesn't make them as happy as putting them back to work.	(Davenport & Kirby, 2016)

Negative Income Tax (NIT) and a variation on the UBI called a Universal Basic Adjustment Benefit – Specifically target workers moving back into the labour market	(Hendrickson & Galston, 2017; Pulkka, 2017).
Functional Finance—central banks funding infrastructure and social welfare; and **Robot taxes**—taxes paid by employers that use robots instead of people for generating value.	(Hendrickson & Galston, 2017)

FIGURES

Figure 1 – Automation technologies and their process characteristics (adapted from McGuire (2017) and Zarkadakis, Jesuthasan, and Malcolm (2016))**.**