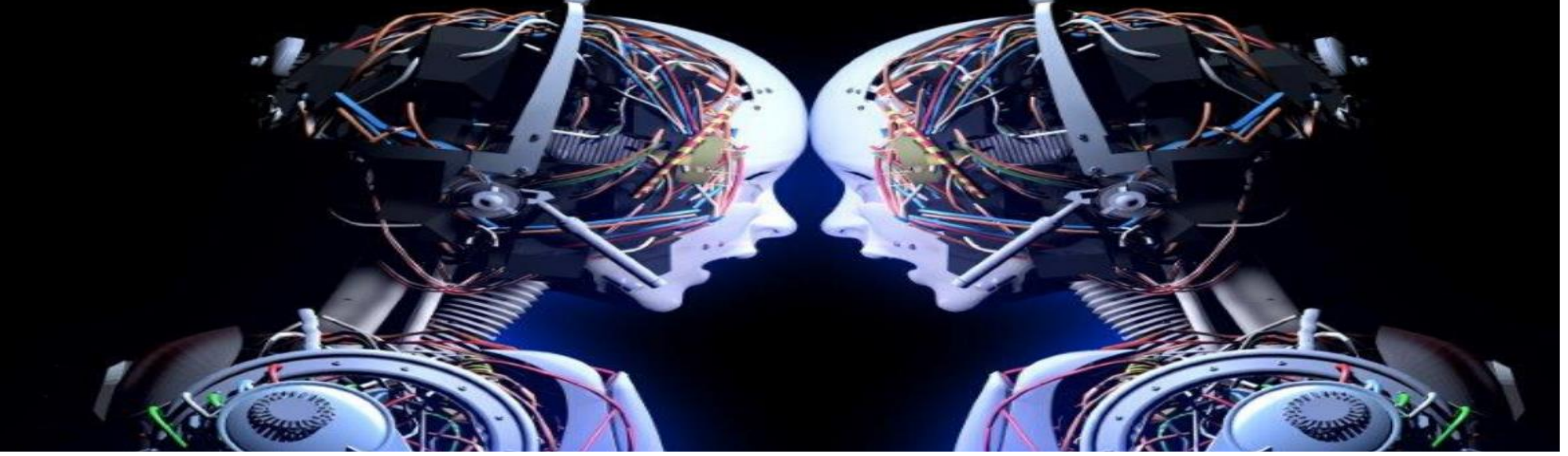

Impact Study of the 4th Industrial Revolution on the Safety and Security Sector in South Africa.

Executive summary

This report reflects the content of a study conducted by Afriwealth Graduate Institute (AGI) on behalf of (and funded by) Safety and Security Sector Education and Training Authority (SASSETA).

The brief was to; conduct qualitative and quantitative analysis to understand the impact of the 4IR on the changing nature of work; conduct research on the labour market for the identification of the skills needs implications (Labour Market analysis and skills needs implications in the 4IR) and; to identify the impact of the 4IR on the labour market (employment and unemployment

This report comprises four main sections and a chapter on recommendations.

(i)The 'context' section provides an overview of the 4IR.

(ii) In section 2, the literature review paves the way for the methodology used in the study. The section captures the evolution, current and previous thinking around the 4IR, in the world, Africa and South Africa.

(iii)The methodology section describes the data collection tool (principally the research questionnaire) and its administration in Durban, Cape Town and Johannesburg as well as focused group discussion adopted in Pretoria during the SASSEATA road shows. Opinions of experts, practitioners and key stakeholders were elicited through interviews and focus group dialogues. The study deployed a qualitative research approach as detailed in part three of this report.

(iv) After an analysis of the perception of over 200 respondents, synthetisation of focus group discussion as well extensive extraction of established thoughts from the literature the findings section (Part 4) explores 4IR-related trends shaping the future. Further, emerging technologies and innovations that could change the future of work, and opportunities as well as challenges associated with the safety and security sector in South Africa were fully teased out.

This study provides a strategic outlook on the future of work in the context of the 4IR and the emphasis is not on theory building. Its underpinning objective is the construction of possibilities that could be debated on the grounds of current trends and future perspectives.

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Part One:
The context

1. The evolution of industrial revolutions

Industrial revolutions occur when new technologies and world views introduce significant shifts in economic systems and social structures (Schwab, 2016). The current reality is that technological advancement is increasingly transforming the way we work, live, communicate, travel and socialise, which, at the rate, it is going, could fundamentally alter life, as we know it. So profound could it be that renowned futurist Ray Kurzweill predicts a future period during which the pace of technological change will be so rapid, its impact so deep, that human life will be irreversibly transformed (Frey Osborne & Holmes). In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before, and humankind now finds itself at the genesis of a revolution considers to be the Fourth Industrial Revolution (4IR) (Mason, 2015). The term 'Fourth Industrial Revolution', also known as Industry 4.0, has its roots in Germany's federal government 2011 high-tech strategy, and commentators believe that Industry 4.0 will leverage the internet, digital technologies and quantum sciences to drive further into autonomous, intelligent cyber-physical systems (Schwab, 2016).

More than sixty years ago economists Shepard Clough and Charles determined that the prerequisites for an Industrial Revolution rest on six fundamentals, namely, capital, capitalism, markets, labour, natural resources, and machines (Hwang, 2016). As far as the First Industrial Revolution is concerned, if the sudden, qualitative and fundamental transformation, which happened in or about the 1780s, was not a revolution then the word has no common sense meaning (Hwang, 2016). England and France serve as a case in point, as conditions in these two countries met the prerequisites for industrialisation more adequately; hence their prominence in the unfolding of the first industrial revolution. In terms of industrial revolutions spanning humanity's existence, Table 1.1 below provides a useful introductory snapshot (McKinsey Global Institute, 2017).

The table enlightens the trajectory of the 4IR and that humanity has experienced three industrial revolutions. The first took place in the 18th century, as people moved away from relying on the power of animals to mechanised power. The second occurred in the late 19th and early 20th centuries when a host of breakthroughs set in motion systems of mass production and communication. The third happened over the last half-century as computers unlocked the digital world. In each stage, new technologies and world views introduced significant shifts in economic systems and social structures.

Table 1.1: Industrial Revolutions over time

	Agricultural Revolution	1st Industrial Revolution	2nd Industrial Revolution	3rd Industrial Revolution
Time	5000BC – 18th Century	19th Century	20th Century	21st Century
Energy Construct	Horsepower & water	Steam	Oil & Electricity	Renewable
Communications Technology	Writing	Cheap printing (Convergence of linotype and press)	Telephony & Media	Digital Networking
Form of social organisation and settlement	City States Hydraulic Civilisation	Factory based cities	Suburban conurbation	Interconnected 'village' ecologies

Source: Schwab (2016).

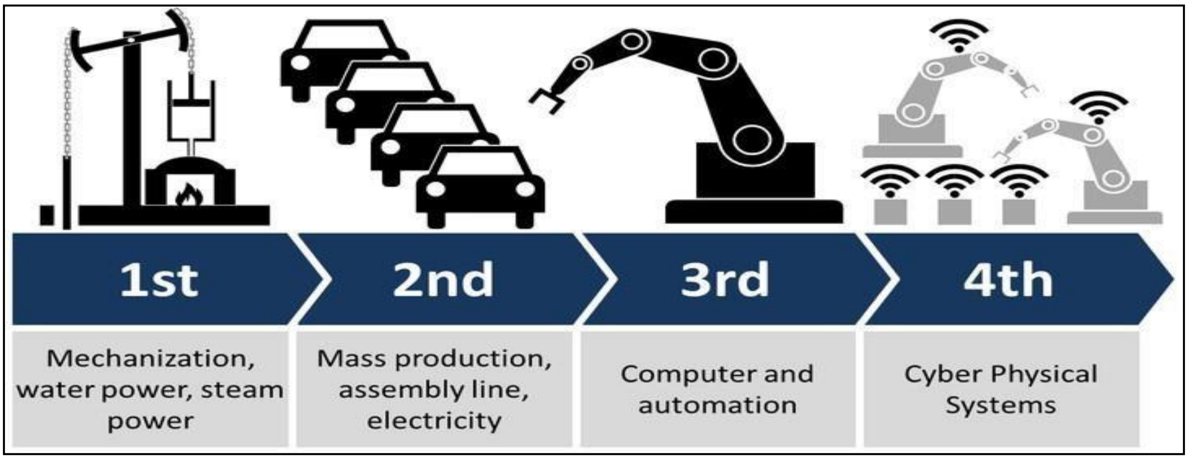
The 4IR can be understood once we unpack the concept and related aspects of this evolving revolution. This report looks briefly at the origins of 4IR and attempt to locate ourselves within this new era, before exploring how the concept translates into practice and the possible impacts and opportunities, particularly in terms of the future of 'work', in this period of rapid, disruptive and pervasive technological change with particular reference to SASSETA.

Three years ago, 4IR was the central theme at the World Economic Forum (WEF) annual meeting, Davos 2016. 4IR and Artificial Intelligence (AI) have remained prominent each year and a lot of research documentation has come from this. At Davos 2019, the theme was "Globalisation 4.0: Shaping a Global Architecture in the Age of the Fourth Industrial Revolution", based on the idea that we "are entering a fourth industrial revolution, where a new wave of technological progress will launch us into a new era of globalisation." (McKinsey Global Institute, 2017).

The 4IR, or "Industry 4.0" (manufacturing-focused), is the term popularized by the WEF for the current and developing environment in which disruptive technologies and trends are changing the way we live, work and relate to one another. Such emerging technologies include artificial intelligence (AI), the Internet of Things (IoT), cloud computing, cybersecurity, the sharing economy, robotics, autonomous robots and vehicles, additive manufacturing (3D printing), cyber-physical systems, genome editing, blockchain technologies, big data and analytics, virtual reality (VR), augmented reality (AR) and hybrid or mixed reality (MR) (Schwab, 2016).

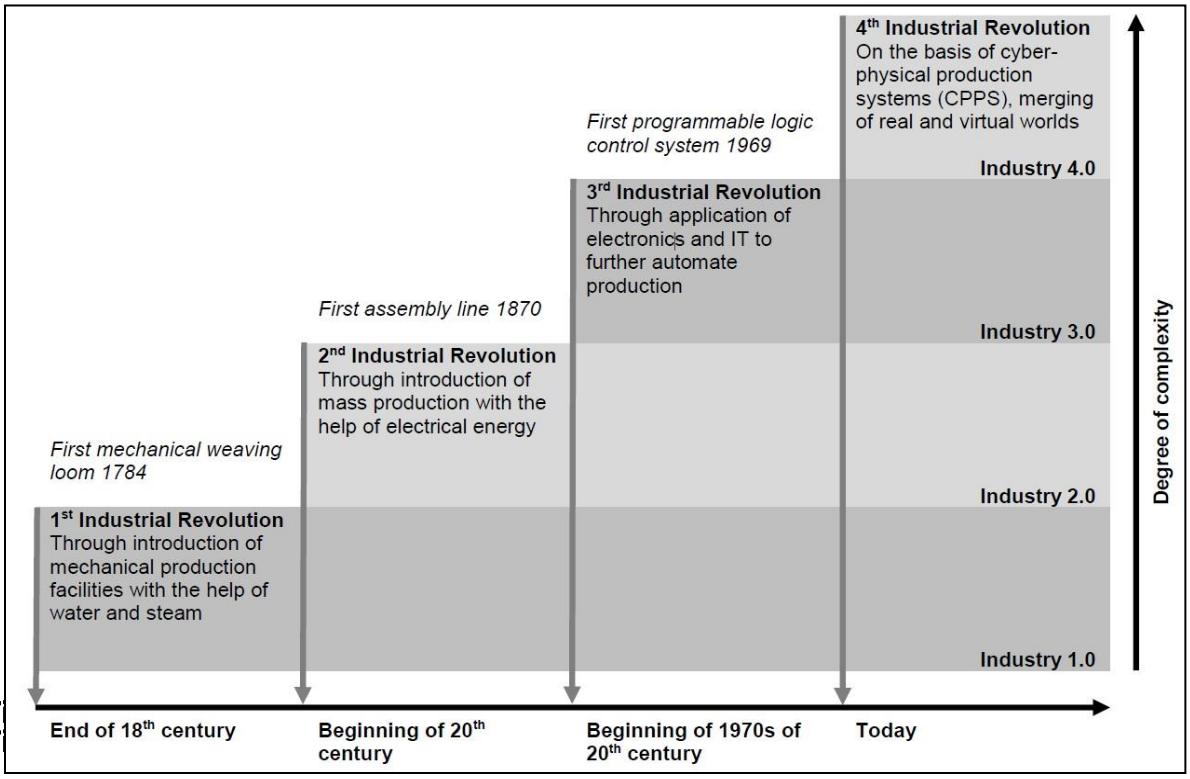
The Industrial Revolution (IR) – now termed the First IR and also regarded as the first wave of innovation (Kondratieff cycle or K-wave) – Is dated from the mid-18th century. In another important consideration when observing the evolution of industrial revolutions, is the degree of complexity. Figures 1 and 2 below illustrate the evolution from the introduction of mechanical production facilities aided by steam and water, to that of cyber-physical production systems which converge the physical and virtual worlds, with the associated increase in the degree of complexity (Schwab, 2016).

Figure 1.1: Timeline depicting the development of the industrial revolutions.



Another important consideration when observing the evolution of industrial revolutions, is the degree of complexity. Figure 2 below illustrates the evolution from the introduction of mechanical production facilities aided by steam and water, to that of cyber-physical production systems which converge the physical and virtual worlds, with the associated increase in degree of complexity.

Figure 1. 2: Industrial Revolutions over time



Therefore, the technological or Second IR – the age of science or "Age of Synergy" – dates from the end of the 19th century, with the adoption of the production line, first used on a large scale by the meat-packing industries of Chicago and Cincinnati during the 1870s (Schwab, 2016). The slaughterhouse system informed Henry Ford's design and innovations in the first permanent, moving assembly line in 1913 and the advent of electrically powered time-efficient mass production and division of labour. The period saw major breakthroughs in the form of power generation and distribution, communications (e.g. telegraph, radio, telephone), new materials and substances including alloys and chemicals, mass-produced pencils and wood-based paper, the internal combustion engine and petroleum.

The Digital Revolution or Third IR – also termed the "Information Age" – began from the late 1940s with the development of digital systems, communication and rapid advances in computing power, which enabled new ways of generating, processing and sharing information. Computerisation, electronics, automated mass production, and information and communications technology (ICT) characterise the Third IR, coinciding with the 5th wave of innovation which enabled the transformation of the world into a "global village".

While 4IR is arguably an extension of the Digital Revolution and builds on the widespread availability of digital technologies, it is considered to be a distinct era for several reasons including the complexity and sheer speed of technological breakthroughs, the pervasiveness of scope, the impact of the tremendous system of changes, the role of 'big data', and "because it will even challenge our ideas about what it means to be human" (Roser, 2017)

The 4IR sees the dawn of "cyber-physical systems" and the convergence of digital, biological, and physical innovations enabling entirely new capabilities for people and machines and entirely new ways of embedding technology within larger societies, communities, and even in the human body. 4IR has a disruptive effect on all economies and, as with any revolution, there are associated risks and benefits, and a series of social, political, cultural, and economic upheavals are expected to unfold over this century.

4IR, with associated uncharted growth in digitisation and internet connectivity, is argued to have "the potential to drive Africa forward like never before, enabling innovation, spurring new business models and improving the delivery of public services." (Roser, 2017). In South Africa, the inaugural Digital Economy Summit of 4IRSA – an initiative between several universities, government and major private-sector players – was convened in July 2019, with the theme: "Positioning SA to be Globally Competitive in the Fourth Industrial Revolution." (Hlatshwayo, 2017).

With reference to the safety and security sector, anecdotal evidence suggests that this sector may be hugely impacted by the disruptive technologies of the 4IR. The study on *Robotic Wars* by Levengrahams (2015) is a case in point. Indeed, studies are ongoing with respect to possible influences of the 4IR on public safety, cyber-security, intel activities and as well on military operations and defence doctrine.

It is in the context of the above unfolding reality that SASSETA supports the call by the Minister Dr Blade Nzimande (of Higher Education and Training) to ensure increased access to training and skills development opportunities in South Africa in preparation for the 4th industrial Revolution.

SASSETA is committed to its mission of becoming the labour market intelligent Hub for the sector. The SETA is, therefore, taking up the responsibility of developing a credible and research-based impact assessment of the Fourth Industrial0 Revolution and Artificial Intelligence regime on the safety and security sector in South Africa. This will, in turn, enable SASSETA to as a matter of urgency begin to support relevant education and training interventions in the sector, particularly in the context of the National Skills Development Strategy (NSDS) IIII and the White Paper for Post-School Education and Training.

1.2. Positioning SASSETA in the 4IR

The 4IR will have a profound impact on the nature of state relationships and international security. This particular section reflects the attention to SASSETA and the issues of important transformations linked to the fourth industrial revolution as security is a topic not sufficiently discussed in the public domain and in sectors outside governments and the defence industry.

The critical danger is that a hyperconnected world of rising inequality may lead to increasing fragmentation, segregation and social unrest, which in turn creates the conditions for violent extremism (Naude,2017). For the author, the 4IR will change the character of safety and security threats while also influencing shifts of power, which are occurring both geographically, and from state to non-state actors. Faced with the rise of armed non-state actors within what is already an increasingly complex geopolitical landscape, the prospect of establishing a common platform for collaboration around key international security challenges become a critical and more demanding challenge.

i. Connectivity, fragmentation and social unrest

As mentioned by Hlatshwayo (2017), the world lives in a hyper-connected world, where information, ideas and people are travelling faster than ever before. We also live in a world of rising inequality, a phenomenon that will be exacerbated by the massive changes in the labour market. Widening social exclusion, the challenge of finding reliable sources of meaning in the modern world, and disenchantment with established elites and structures, perceived or real, have motivated extremist movements and enabled them to recruit for a violent struggle against existing systems

Hyper-connectivity does not naturally come together with greater tolerance or -adaptability, as seen in the reactions to the tragic human disruptions in South Africa since 2015 (strikes, unrest, and xenophobia) (Hlatshwayo & Buhlungu, 2017). However, the authors emphasise that the same hyper-connectivity also contains the potential to reach common ground based on greater acceptance and understanding of differences, which could help bring communities together rather than driving them apart. If South Africa does not continue moving in this direction, however, the alternative is that it leads to increasing fragmentation.

ii. The changing nature of conflict

The 4IR will affect the scale of conflict as well as its character. The distinctions between war and peace and who is a combatant and non-combatant are becoming uncomfortably blurred. Similarly, the battlefield is increasingly both local and global. Organizations such as ISIS, operate principally in defined areas in the Middle East but they also recruit fighters from more than 100 countries, including South Africa largely through social media, while related terrorist attacks can occur anywhere on the planet. Modern conflicts are increasingly hybrid in nature, combining traditional battlefield techniques with elements that were previously mostly associated with armed non-state actors. However, with technologies fusing in increasingly unpredictable ways and with state and armed non-state actors learning from each other, the potential magnitude of change is not yet widely appreciated (Hattingh, Sheer & Du Plessis 2017).

As this process takes place and new, deadly technologies become easier to acquire and use, it is clear that the fourth industrial revolution offers individuals increasingly diverse ways to harm others on a grand scale. Realizing this leads to a greater sense of vulnerability. It is not all bleak. Access to technology also brings with it the possibility of greater precision in warfare, cutting-edge protective wear for combat, the capacity to print essential spare parts or other components right on the battlefield, and so on.

iii. Cyber Security and warfare

Cyberwarfare presents one of the most serious threats of our time. Cyberspace is becoming as much a theatre of engagement as land, sea and air were in the past. It can safely be postulated that, while any future conflict between reasonably advanced actors may or may not play out in the physical world, it will most likely include a cyber-dimension simply because no modern opponent would resist the temptation to disrupt, confuse or destroy their enemy's sensors, communications and decision-making capability.

This will not only lower the threshold of war but will also blur the distinction between war and peace, because any networks or connected devices, from military systems to civilian infrastructures such as energy sources, electricity grids, health or traffic controls, or water supplies, can be hacked and attacked (Myburgh, 2019).

> In 2019, 79% of all online phishing victims lose their money, and that South Africa was the twenty-third highest attacked country in terms of hacking and cybercrime. One out of 14 emails sent in South Africa is a scam. South Africa is becoming a target internationally and we are falling victim to these types of crimes more frequently and that 52% of global Internet users become victims of cybercrime, with a $476 loss on average per incident in South Africa. (Myburgh, 2019)

The concept of the adversary is also affected as a result. Contrary to the past, you may not be certain of who is attacking you and even whether you have been attacked at all. Defence, military and national security strategists focused on a limited number of traditionally hostile states, now they must consider a near-infinite and indistinct universe of hackers, terrorists, activists, criminals, and other possible foes. Cyberwarfare can take many different forms – from criminal acts and espionage to destructive attacks such as Stuxnet – that remain largely underestimated and misunderstood because they are so new and difficult to counter.

Since 2017, there have been many instances of cyber-attacks directed at both specific public and companies in South Africa, yet discussions about this new era of warfare are still in their infancy and the gap between those who understand the highly technical issues of cyber warfare and those who are developing cyber policy widens by the day. Whether a set of shared norms will evolve for cyber warfare, analogous to those developed for nuclear, biological and chemical weapons, remains an open question. South Africa lacks even a taxonomy to agree on what amounts to an attack and the appropriate response, with what and by whom (Myburgh, 2019). Part of the equation to manage this scenario is to define what data travels across borders. This is an indication of how far there is to go on effectively controlling cross-border cyber-based transactions without inhibiting the positive outputs from a more interconnected world.

iv. Autonomous warfare

Autonomous warfare, including the deployment of military robots and AI-powered automated weaponry, creates the prospect of "robo-war", which will play a transformative role in a future conflict. The seabed and space are also likely to become increasingly militarized, as more and more actors – state and commercial – gain the ability to send up satellites and mobilize unmanned underwater vehicles capable of disrupting fibre-optic cables and satellite traffic. Criminal gangs are already using off the- shelf quadcopter drones to spy on and attack rivals. Autonomous weapons, capable of identifying targets and deciding to open fire without human intervention, will become increasingly feasible, challenging the laws of war (Myburgh, 2019).

v. New frontiers in global security

As stressed in part two of this report, it only has a limited sense of the ultimate potential of new technologies and what lies ahead. This is no less the case in the realm of international and domestic security. For each innovation, there will be a positive application and a possible dark side. While neurotechnologies such as neuroprosthetics are already employed to solve medical problems, in future they could be applied to military purposes.

Computer systems attached to brain tissue could enable a paralysed patient to control a robotic arm or leg. The same technology could be used to direct a bionic pilot or soldier. Brain devices designed to treat the conditions of Alzheimer's disease could be implanted in soldiers to erase memories or create new ones. "It's not a question of if non-state actors will use some form of neuroscientific techniques or technologies, but when, and which ones they'll use," reckons James Giordano, a neuroethicist at Georgetown University Medical Center, "The brain is the next battlespace." (Stearns, 2017).

The availability and, at times, the unregulated nature of many of these innovations have a further important implication. Current trends suggest rapid and massive democratization of the capacity to inflict damage on a very large scale, something previously limited to governments and very sophisticated organizations. From 3D-printed weapons to genetic engineering in home laboratories, destructive tools across a range of emerging technologies are becoming more readily available. And with the fusion of technologies, a key theme of this report, unpredictable dynamics inherently surface, challenging existing legal and ethical frameworks.

vi. Towards a more secure world

Driven by the changes heralded by the fourth industrial revolution, could we discover some alternative equilibrium that analogously turns vulnerability into stability and security? Actors with very different perspectives and interests need to be able to find some kind of modus vivendi and cooperate in order to avoid negative proliferation. Concerned stakeholders must cooperate to create legally binding frameworks as well as self-imposed peer-based norms, ethical standards and mechanisms to control potentially damaging emerging technologies, preferably without impeding the capacity of research to deliver innovation and economic growth.

International treaties will surely be needed, but there will always be concerns that regulators in this field will find themselves running behind technological advances, due to their speed and multifaceted impact. Hence, conversations among educators and developers about the ethical standards that should apply to emerging technologies of the 4IR are urgently needed to establish common ethical guidelines and embed them in society and culture. With governments and government-based structures, lagging behind in the regulatory space, it may actually be up to the private sector and non-state actors to take the lead.

The development of new warfare technologies is, understandably, taking place in a relatively isolated sphere. However, is the potential retreat of other sectors, such as gene-based medicine and research, into isolated, highly-specialized spheres, thereby lowering our collective ability to discuss, understand and manage both challenges and opportunities linked to employment.

The following section is a detailed discussion of current and previous thinking and publications around the 4IR in the World, Africa and South Africa.

Part Two:
Review of the 4IR literature

2. Introduction

The use of literature is important to complement the results of an exploratory study. To collect a comprehensive set of policy, draft papers and academic contributions related to the fourth industrial revolution, the largest abstract and citation database of peer-reviewed literature, was chosen that provided a comprehensive overview of the world's research output, but particularly the World Economic Forum, The BRICS, World Bank and others. Other sources included electronic databases, including Science Direct, EBSCO host, Emerald, ProQuest and Wiley Inter-Science journals and databases. It shall also research and data from think tanks, industry leaders, research institutions and researchers, universities, and the business community.

A search string was constructed through the combination of the operator OR in between two terms: "the fourth industrial revolution" and "the 4th industrial revolution". References that met the following criteria were collected and used and a measure to use such for further processing and interpretation of information:

- They were published online before the middle of March 2017;
- They contained one of the search terms in the abstract, title and/or keywords;
- They were written in the English language;
- They were published in policy and conference proceedings, journals, book series, and books.

This enabled the team to assess the state of current research related to skills needs for 4IR. This included models of engagement with industry for employment and skills development with proven results or the potential to scale. The goal of this review was to better understand the problem, examine solutions and potential models, explore new areas of potential opportunities, and to make recommendations to drive progress and sustainable impact in skills and workforce development.

2.1. Background to the 4IR

"We stand on the brink of the 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"
(Schwab, 2019)

The world is on the crossroads of yet another industrial revolution with rules of change and transformation is continuously rewritten. The emerging 4IR is characterised by as a fusion of technologies that blur the lines between the physical, digital and biological and neuro-technological spheres (Dlamini,2016)

The Fourth Industrial Revolution (4IR)—characterized by the fusion of the digital, biological, and physical worlds, as well as the growing utilization of new technologies has ushered in a new era of economic disruption with uncertain socio-economic consequences (Cronjé,2016)

The 21st century has ushered in innovative technologies that can help governments' better serve their constituents (McKinsey & Company, 2016). At a time when public finances are under strain, there is new thinking (OFE, 2015) that governments must deliver new services and improve existing ones, while operating more efficiently, with greater transparency with a growing focus on service user and staff engagement. It is even more important to the private sectors that are driven by the demands of their stakeholders but are agile to change and adoption of practices that propel better value propositions.

According to Schwab (2019), the pioneer of the World Economic Forum (WEF), the First Industrial Revolution used water and steam power to mechanize production. The Second used electric power to create mass production. The Third used electronics and information technology to automate production. Now a 4IR is building on the Third, the digital revolution that has been occurring since the middle of the last century. The "4IR" is a new rubric referring to technological forces and innovations that portend to disrupt and transform lives in ways that were, until now, unthinkable. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres. The potential to apply autonomous or semi-autonomous machines is extremely significant. Advancements have reached the point where highly skilled jobs are as susceptible to replacement by automation as ones which do not require much education or training (White, 2016). This is a new area of interest in many private and government domains, ranging from defence and intelligence to public safety, agriculture, environmental protection, and public transportation.

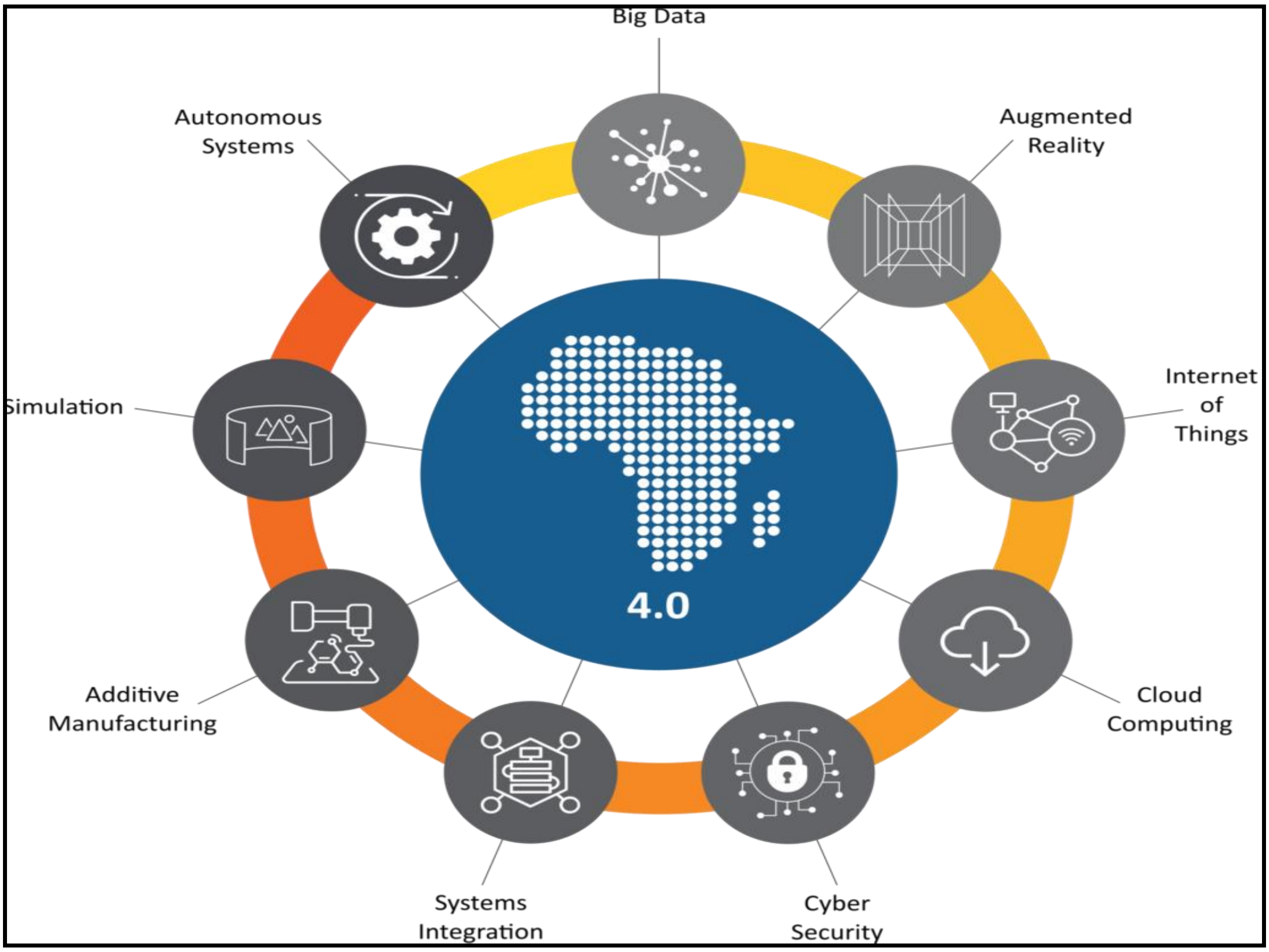
Technology sneaks into workplaces and impacts the environment in ways that most do not think about it until it's "at the front door". In order to create and shape technologies, the government must be armed with the intelligence necessary to envision and enact bold policies. Zhang (2016), Dlamini (2016) and Cronje (2016) expect new technologies, expectations, policies, stakeholders and even physical workspaces to all play into a new way of transforming the traditional public sector and these disruptive innovation accelerators could possibly have the most long-term potential to impact human culture overall.

Work is intrinsic to human development (UNDP, 2015) and in addressing societal challenges, Mazzucato (2016) and Cook (2017) advocate that the government must lead by actively directing the economy toward new "techno-economic paradigms". Previous technological revolutions occurred because governments undertook bold missions that focused, not on minimizing government failure but on maximizing innovation. Although the public sector has historically led the way on adopting Artificial Intelligence (AI) in critical areas such as defence and national intelligence, these significant changes in new and advanced technology, take decisions without direct human input.

In introducing technology means that the work conditions are changed and the environment is modified, therefore existing policies, practices, and regulations may need to be updated or even created and revisiting current policies to make certain that they are still valid and appropriate for the new environment is critical.

PWC (2017) held the view that people react in unexpected ways, therefore, no change program goes completely according to plan and not every technology will work the same way within every context - one size does not fit all. Thus, a study from Stanford University's (2016) reports that bringing technology into the workplace has far-reaching and often opposite ramifications of de-skilling of jobs. This "out with the old, in with the new" attitude, threatens to break down the traditional chain of command. In general, the relationships between individuals of any level of a company tend to suffer from the introduction of new technological methods. When technology is put into the hands of front line government professionals, no single methodology will fit every company, but there is a set of practices, tools, and techniques that can be adapted to a variety of situations and this becomes quickly apparent how and where the technology fits into their specific work (Cook, 2016). These technologies are often summarised into the following pillars:

Figure 2.1 The 9 pillars of industry 4.0



Source: (Cook, 2016).

The 4IR, also known as the 'Digital Industrial revolution' or 'Industry 4.0', or simply '4IR' is a broad term used to describe the ongoing global conversion of labour-intensive manufacturing processes toward incorporating robotics, artificial intelligence (AI), big data, customer service personalisation and other forms of digital innovation, pointing to a future where the knowledge economy and the manufacturing sector are in effect, inseparable. Like earlier industrial revolutions, those quickest to utilise these new technologies will reap the most benefit. Some estimates place the profits reaped by early-adopting firms at almost 120%, with a measly 10% for those who only adopt these new technologies later on.

2.2. The framing of the theoretical basis

Theories of industrialisation and modernisation should be more than descriptions of changes that occur in an industrialising society (Homer, 1982). Innovation requires innovation entrepreneurial attitudes, economic incentives to change technique, and previous inventions or knowledge which make possible the development of new technology. Musson (1972) points out that such an interdisciplinary, qualitative approach is necessary for a complete understanding of the industrial revolutions.

Theory of Responsibility Attribution brings the collective technological advancement by the cohort of Mayhew (2016), Slattery (2016), Walsh (2015) and Marsh (2013), countenanced by Hewstone's (1991) position that the theory of responsibility attribution of causal human behaviour contributes to an outcome. There is no obvious way that autonomous machines can be held accountable for their actions since they lack intentions (Human Rights Watch, 2015). Mohd's (2016) neutrality opines the interface between humans and machines as both complex and subtle. The trick is to match the complexity of the part you use, to the complexity of the job in hand. When greater sophistication does mean greater utility, the choice permits humans to argue that they cannot be held causally responsible, and thus cannot be blamed, for the technological outcome, a defence that McGraw (1990) terms 'diffusion of responsibility'.

The relevance of the Socio-Evolutionary Theory is based on the assumption that societies gradually change from simple beginnings into even more complex forms (Sociology Guide.Com, 2016). Workers already displaced by automation, such as those on assembly lines, could also feel the impact of the latest technology, as robots which are able to move around – so-called robots – are able to perform more intricate tasks (Treanor, 2016). Using socio-evolutionary theory as its underlying perspective, this literature links the relationships between evolved social behaviour within the private and public service due changes in the way of work and life (Pierce & Whiteand, 2006).

2.3. Drivers of Change during the industrial revolutions

It is important to point out that the most significant driver of change, across all industries, is the changing nature of work itself. Drivers of change will also have a very disparate impact within the public sector. The model changes created by these drivers will, in turn, have specific and different consequences for employment and skills needs in government. As new technologies make "anytime, anywhere" work possible, governments are breaking up tasks in new ways, leading to a fragmentation of jobs across many industries (TRALAC, 2016).

Curran (2016) mentions that institutions must actively, deliberately, and decisively pursue emerging technology to uncover the high potentials that could reposition its business for the Fourth Industrial Age. McKinsey & Company (2018) recently advance fundamental positions that such new technologies present private and public institutions with a number of important questions:

- How can it serve a population (market) that is increasingly mobile and more dependent on technology?
- How to use social and digital channels to interact with it's our clients/stakeholders?
- How can it leverage the vast amount of data generated daily to better serve the public?
- How can it use technology to deliver new services or products?
- How can it do all of these things while keeping costs down?

The response to McKinsey & Company (2018) self-introspection is that these institutions have the unique ability to marry its strategic vision with the operational and technological initiatives necessary to actualize that vision. In so doing this will impact dramatically on service providers, policy on technology best practices, usage guidelines, regional government's efforts to improve operations, collaboration across agencies by consolidating support functions into centralized shared services, centres of excellence, creating best-practice IT organization, improving existing services, launching new services and advising government on cybersecurity risks and develop a strategy for safeguarding IT operations.

2.4. Emerging and enabling technologies of the 4IR

An enabling technology is one which affects not only the area to which it is immediately directed but one which also brings about fundamental and structural changes in many other areas (Coates et al, 1994:26). Historical examples of enabling technologies include the development of electric lighting, which has had, and is still having, a significant impact on the way in which we use time and space. Similarly, the substitution of horse-drawn transport by the automobile, the ship and by aeroplane has had far-reaching effects on our social systems.
The following are the current enabling technologies, and one enabling issue:

- Information technologies: The convergence of computers and communications.
- Biotechnology: New genetics and proteomics.
- Materials technologies: New materials and applications of materials.
- Energy technologies: Efficient use of resources, including renewable resources, to produce, transfer and store energy.
- Transportation technologies: An on-going underpinning set of technologies that enable transportation of all physical items.
- Environmentalism: An enabling issue – pollution, genetically modified organisms, limited resources.

The enabling technologies (called by some writers the dominant or emerging technologies) and the enabling issues are all interrelated. They are the major drivers of global change at present, and will continue to be so for the next 20 to 30 years, if not longer in some cases.

Robotics, currently dealt with under information technology, is an important sub-enabling technology. In fact, progress in the field of robotics coupled with the fact that it does not really fit in completely under information technology could lead to it being seen as a sixth enabling technology in future. This is where the notion of the 4IR becomes salient.

However, the list of new technologies grows every day. Robots, augmented reality, algorithms, machine-to-machine communications, 3-D printing, and autonomous vehicles help people with a range of different tasks (Osborne, 2016). These technologies are broad-based in their scope and significant in their ability to transform existing businesses and personal lives. They have the potential to ease people's lives and improve their personal and business dealings (McKinsey, 2017) In his book, "Pax Technica," political scientist Philip Howard outlines an "empire of bits" that is transforming how people interact with one another. Technology is becoming much more sophisticated and this is having a substantial impact on the workforce. However, there are key emerging technologies that will determine, among other things, the development dilemmas as summarised below:

Table 2.1. The Twelve Key Emerging Technologies

Technology	Description
3D printing	Advances in additive manufacturing, using a widening range of materials and methods; innovations include 3D bioprinting of organic tissues.
Advanced materials and nanomaterials	Creation of new materials and nanostructures for the development of beneficial material properties, such as thermoelectric efficiency, shape retention and new functionality.
Artificial intelligence and robotics	Development of machines that can substitute for humans, increasingly in tasks associated with thinking, multitasking, and fine motor skills.
Biotechnologies	Innovations in genetic engineering, sequencing and therapeutics, as well as biological-computational interfaces and synthetic biology.
Energy capture, storage and transmission	Breakthroughs in battery and fuel cell efficiency; renewable energy through solar, wind, and tidal technologies; energy distribution through smart grid systems, wireless energy transfer and more.
Blockchain and distributed ledger	Distributed ledger technology based on cryptographic systems that manage, verify and publicly record transaction data; the basis of "cryptocurrencies" such as bitcoin.
Geoengineering	Technological intervention in planetary systems, typically to mitigate effects of climate change by removing carbon dioxide or managing solar radiation.
Ubiquitous linked sensors	Also known as the "Internet of Things". The use of networked sensors to remotely connect, track and manage products, systems, and grids.

Neurotechnologies	Innovations such as smart drugs, neuroimaging, and bioelectronic interfaces that allow for reading, communicating and influencing human brain activity.
New computing technologies	New architectures for computing hardware, such as quantum computing, biological computing or neural network processing, as well as the innovative expansion of current computing technologies.
Space technologies	Developments allowing for greater access to and exploration of space, including microsatellites, advanced telescopes, reusable rockets and integrated rocket-jet engines.
Virtual and augmented realities	Next-step interfaces between humans and computers, involving immersive environments, holographic readouts and digitally produced overlays for mixed-reality experiences.

Source: (World Economic Forum, 2017).

Whereas all these are relevant to the trajectory of the 4IR in the next decade, this document is specifically focused on exploring and the most apparent technologies today in several countries and how they have changed/will change the entire landscape of the way of work and life. These selected few are briefly discussed below:

- **Robots**

Robots are expanding in magnitude around the developed world. Figure 1 shows the numbers of industrial robots in operation globally and there has been a substantial increase in the past few years. In 2013, for example, there were an estimated 1.2 million robots in use. This total rose to around 1.5 million in 2014 and is projected to increase to about 1.9 million in 2017.5 Japan has the largest number with 306,700, followed by North America (237,400), China (182,300), South Korea (175,600), and Germany (175,200). Overall, robotics is expected to rise from a $15 billion sector now to $67 billion by 2025.6 (World Economic Forum, 2017).

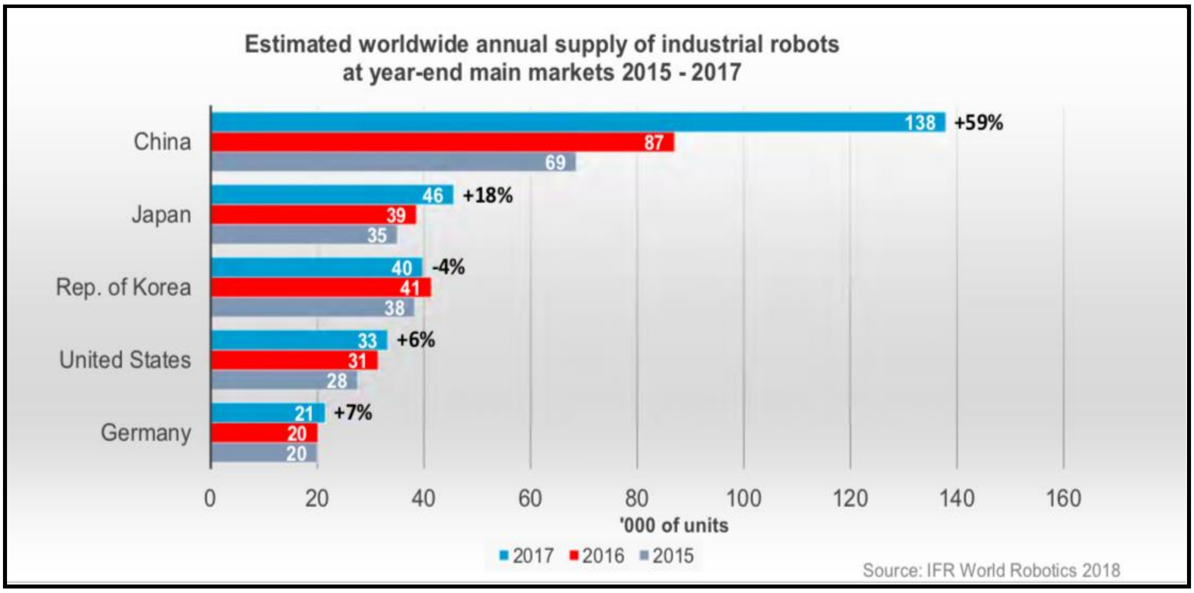
The worldwide sales of industrial robots achieved a new record number of 248,000 units in 2015. This represents a rise of 12 per cent compared to the previous year (2014: 221,000 units). This sees the continuation of the global automation boom, which commenced in the wake of the financial crisis in 2009. A record 381,000 industrial robots were shipped globally in 2017, according to the latest International Federation of Robotics (IFR) World Robotics Report. The new figure represents an increase of 30 per cent, which means the annual sales volume of industrial robots increased by 114 per cent over the last five years (2013-2017). The sales value increased by 21 per cent compared to 2016 to a new peak of US$16.2 billion in 2017 (World Economic Forum, 2017).

"Industrial robots are a crucial part of the progress of manufacturing industry," (Junji 2018) Robots evolve with many cutting-edge technologies and are vision recognition, skill learning, failure prediction utilizing AI, the new concept of man-machine-collaboration plus easy programming and so on (McKinsey, 2017). They will help improve the productivity of manufacturing and expand the field of robot application.

The IFR outlook shows that in 2021 the annual number of robots supplied to factories around the world will reach about 630,000 units.

Therefore, what is the world's leading industrial robotics markets includes five major industrial robotics markets represent 73 per cent of the total sales volume in 2017: China, Japan, South Korea, the United States and Germany.

Figure 2.2: The estimated world robot population ending 2017.



Source: Global Asset Management study (2019)

According to an RBC Global Asset Management study (2019), the costs of robots and automation have fallen substantially. It used to be that the "high costs of industrial robots restricted their use too few high-wage industries like the auto industry. However, in recent years, the average costs of robots have fallen, and in a number of key industries in Asia, the cost of robots and the unit costs of low-wage labour are converging … Robots now represent a viable alternative to labour."

In the contemporary world, there are many robots that perform complex functions. According to a presentation on robots, "the early 21st century saw the first wave of companionable social robots. They were small cute pets like AIBO, Pleo, and Paro. As robotics become more sophisticated, thanks largely to the smartphone, a new wave of social robots has started, with humanoids Pepper and Jimmy and the mirror-like Jibo, as well as Geppetto Avatars' software robot, Sophie. A key factor in a robot's ability to be social is their ability to correctly understand and respond to people's speech and the underlying context or emotion." (Kenney & Zysman, 2016)

These machines are capable of creative actions. Anthropologist Eitan Wilf of Hebrew University of Jerusalem says that sociable robots represent "a cultural resource for negotiating problems of intentionality." (Grace, Salvatier, Dafoe, hang and Evans, 2017). They describe a "jazzimprovising humanoid robot marimba player" that can interpret music context and respond creatively to improvisations on the part of other performers. Designers can put it with a jazz band, and the robot will ad-lib seamlessly with the rest of the group. If someone were listening to music, that person could not discern the human from the robot performer.

In Japan, there is a new hotel called Henn-na that uses robots to check people in and escort guests to their rooms. The robotic receptionist speaks Japanese or English, depending on the preferences of the guest. It can set up the reservations for people, take them to their rooms, and adjust the accommodation's temperature. Within the room, guests can use voice commands to alter the lighting and ask questions regarding the time or weather (Grace et. al., 2017).

Amazon has organized a "picking challenge" designed to see if robots can "autonomously grab items from a shelf and place them in a tub." The firm has around 50,000 people working in its warehouses and it wants to see if robots can perform the tasks of selecting items and moving them around the warehouse. During the competition, a Berlin robot successfully completed ten of the twelve tasks. To move goods around the facility, the company already uses 15,000 robots and it expects to purchase additional ones in the future (Frey, Osborne & Deloitte, 2018)

- **Computerized Algorithms**

There are computerized algorithms that have taken the place of human transactions. This is seen in the stock exchanges, where high-frequency trading by machines has replaced human decision-making. People submit, buy, and sell orders, and computers match them in the blink of an eye without human intervention. Machines can spot trading inefficiencies or market differentials at a very small scale and execute trades that make money for people (Kenney & Zysman, 2016). Some individuals specialize in arbitrage trading, whereby the algorithms see the same stocks having different market values. Humans are not very efficient at spotting price differentials but computers can use complex mathematical formulas to determine where there are trading opportunities. Fortunes have been made by mathematicians who excel in this type of analysis (McKinsey, 2018).

> "To make a computer do anything, you have to write a computer program. To write a computer program, you have to tell the computer, step by step, exactly what you want it to do. The computer then 'executes' the program, following each step mechanically, to accomplish the end goal. When you are telling the computer what to do, you also get to choose how it's going to do it. That's where computer algorithms come in. The algorithm is the basic technique used to get the job done." (Ford, 2018:12)

- **Artificial Intelligence**

Artificial intelligence refers to "machines that respond to stimulation consistent with traditional responses from humans, given the human capacity for contemplation, judgment and intention." (Ford, 2018). It incorporates critical reasoning and judgment into response decisions. Long considered a visionary advance, AI now is here and being incorporated in a variety of different areas. It is being used in finance, transportation, aviation, and telecommunications. Expert systems "make decisions which normally require a human level of expertise.

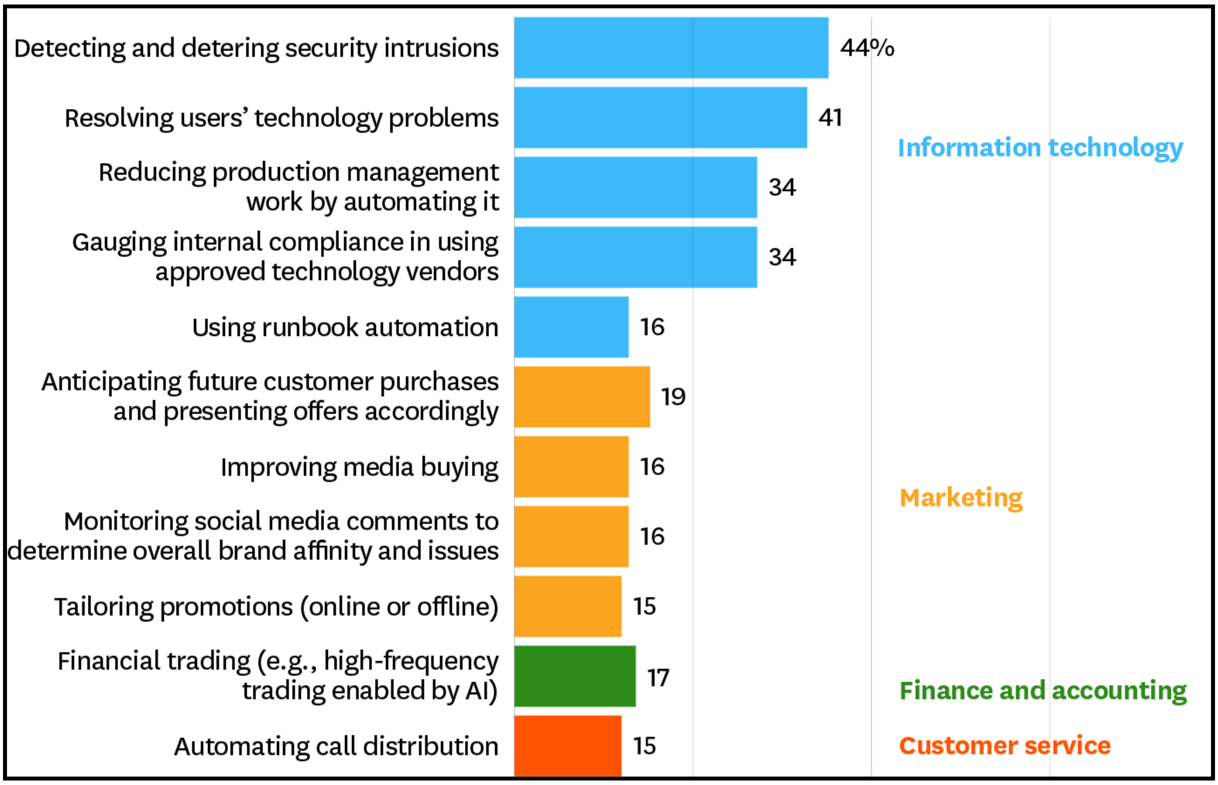
These systems help humans anticipate problems or deal with difficulties as they come up.

There is growing applicability of artificial intelligence in many industries (Elliott, 2017). It is being used to take the place of humans in a variety of areas. For example, it is being used in space exploration, advanced manufacturing, transportation, energy development, and health care. By tapping into the extraordinary processing power of computers, humans can supplement their own skills and improve productivity through artificial intelligence.

For the past few years, Ford (2018) mentions that AI has slowly been working its way into being a household topic and put into more use in businesses. Companies ranging from General Electric to Spotify use AI for predictive analytics, data insights, and even more physical tasks such as machine maintenance to better control safety. Companies like Microsoft have been slowly and quietly building intelligence into their products for a long time—anyone who uses the Office 365 product suite or Skype will recognize these features upon closer inspection.

Though many of the concerns around AI lie with the fact that workers are worried their jobs will be automated and they will be out of work, in reality, AI helps users work faster and smarter, moving from a more administrative role to be able to focus on strategy and technique. For example, incorporating AI into a contract lifecycle management platform allows contract creation to be accelerated as details can be auto-populated, as well as analysed faster, as more can be quickly extracted (Elliott, 2017). The chart below highlights how companies use AI, with the focus not being the elimination of jobs, but removing mundane tasks or time-consuming research in projects.

Figure 2.3: The use of AI around the world



Source: Tata consulting Services (2018)

- ### Augmented Reality

Augmented reality is bringing 3-D technologies and graphic displays to human existence. For example, Facebook's Oculus, Google's Magic Leap, and Microsoft's HoloLens represent consumer examples of this development. They enable people to supplement the usual senses with computer-generated graphics, video, sounds, or geo-location information. These images can be mapped to the physical world and made interactive for the user.

People can mount displays on their heads or stand in a digital lab where images are projected onto the wall. Using handheld devices or sensors, they can move through buildings, simulate battle conditions, role play disaster responses, or immerse themselves in virtual reality.

Some of the most advanced applications have come from the military. Its planners use augmented reality to train recruits for street patrols and battle conditions. Supervisors can alter virtual conditions and see how the soldiers respond. This allows them to "experience" a wide range of circumstances from the safety of the laboratory (Ford, 2018). That helps them navigate actual battlefields once they are sent abroad.

- ### 3D Printing

Three-dimensional (3D) printing is currently used across sectors such as jewellery, toys and cars. As costs come down and the technologies' sophistication increases, 3D printing's attributes of speedy delivery, customisation and responsiveness to consumer preferences have strong potential to trump traditional methods of production.

According to Bowles (2014), by driving down the fixed cost of manufacturing, 3D printing can democratise manufacturing by fragmenting the sector and allowing companies in Africa to engage in manufacturing without the heavy investment once required. However, hubs of 3D activities may emerge closer to demand in high-income countries. The need for highly-skilled, design-related labour will increase, while low-skilled labour employed in production and assembly will diminish, jeopardising the opportunities that light manufacturing once offered to low-skilled workers. Examples include US car manufacturer Ford, which uses 3D printing for auto part prototypes, and General Electric, which uses 3D printing to manufacture its turbine parts.

- ### The Current State of Play in Augmented Reality (The Present)

Bowles (2018) asserts that Augmented reality is achieved through a variety of technological innovations; these can be implemented on their own or in conjunction with each other to create augmented reality. They include:

- **General hardware components** – the processor, the display, the sensors and input devices. Typically, a smartphone contains a processor, a display, accelerometers, GPS, camera, microphone etc. and contains all the hardware required to be an AR device.

- **Displays** – while a monitor is perfectly capable of displaying AR data there are other systems such as optical projection systems, head-mounted displays, eyeglasses, contact lenses, the HUD (heads up display), virtual retinal displays, Eye Tap (a device which changes the rays of light captured from the environment and substitutes them with computer-generated ones), Spatial Augmented Reality (SAR – which uses ordinary projection techniques as a substitute for a display of any kind) and handheld displays.
- **Sensors and input devices include** – GPS, gyroscopes, accelerometers, compasses, RFID, wireless sensors, touch recognition, speech recognition, eye tracking and peripherals.
- **Software** – the majority of development for AR will be in developing further software to take advantage of the hardware capabilities. There is already an Augmented Reality Mark-up Language (ARML) which is being used to standardize XML grammar for virtual reality. There are several software developments kits (SDK) which also offer simple environments for AR development.

- **The Future of Augmented Reality**

Lowry (2018), an UX Designer, writing for the Next Web says that AR is the future of design and we tend to agree. Already mobile phones are such an integral part of our lives that they might as well be extensions of our bodies; as technology can be further integrated into our lives without being intrusive (a la Google Glass) – it is a certainty that augmented reality provides opportunities to enhance user experiences beyond measure. This will almost certainly see major advances in the much-hyped but still little seen; Internet of Things. UX designers in the AR field will need to seriously consider the questions of how traditional experiences can be improved through AR – just making your cooker capable of using computer enhancements is not enough; it needs to healthier eating or better-cooked food for users to care.

- **Smart Factories and the Internet of Things (IoT)**

Autor (2015) makes emphasis that Smart technologies that can collect, interpret and analyse data, using it to communicate functions to other technologies without the use of human-to-human or human-to-computer interactions – otherwise known as the Internet of Things (IoT) – are set to revolutionise manufacturing. A smart factory is premised on IoT and employs physical-to-digital technology in machines that sense, monitor and control, with real-time communication between different parts of the value chain to serve as the basis for self-optimisation.

According to Autor (2015), the effect of smart factories on manufacturing will be twofold. First, there will be improvements to operational performance, including efficiencies in labour. Second, physical-to-digital technologies will rely on advanced services to make optimal use of the data generated. This implies that manufacturing will probably become less reliant on low-skilled (mass) labour, and more dependent on engineers, programmers and other analytics-based professions to optimise these new technologies. Firms with smart factories include Germany's Siemens, auto parts manufacturer Hirotec America and US appliances manufacturer Whirlpool.

The future will belong to AR when it improves task efficiency or the quality of the output of an experience for the user (Lowry, 2018). This is the key challenge of the 21st century UX profession. AR or augmented reality has gone from pipe dream to reality in just over a century. There are many AR applications in use or under development today, however – the concept will only take off universally when UX designers think about how they can integrate AR with daily life to improve productivity, efficiency or quality of experiences. There is an unlimited potential for AR, the big question is - how will it be unlocked?

- **Autonomous Vehicles**

Unmanned vehicles and autonomous drones are creating new markets for machines and performing functions that used to require human intervention. Driverless cars represent one of the latest examples. Google has driven its cars almost 500,000 miles and found a remarkable level of performance. Manufacturers such as Tesla, Audi, and General Motors have found that autonomous cars experience fewer accidents and obtain better mileage than vehicles driven by people (Acemoglu & Restrepo, 2017)

Unmanned drones are being used for a variety of purposes. In India, for example, authorities are using them for crowd control. Whenever there is extensive violence or mob attacks, police deploy drones armed with pepper spray and cameras, and use them to disperse crowds and round up troublemakers (Acemoglu & Restrepo, 2017). Law enforcement officials claim these devices have been very effective at helping to restore order.

They also are being used in real estate, agriculture, entertainment, and wildlife management. People employ them to photograph the property, monitor pest infestations in crops, and manage wildlife sanctuaries. This helps officials get to hard-to-reach areas and track problems autonomously without humans having to be in particular geographic spots.

2.5. The Disruptive Impact of these Emerging Technologies

The potential of emerging technologies to disrupt established business models is large and growing. It is tempting to think of technological disruption as involving dramatic moments of transformation, but in many areas, disruption due to emerging technologies is already quietly underway, the result of gradual evolution rather than radical change. Consider autonomous vehicles: we are not yet in a world of vehicles that require little or no human intervention, but the technologies that underpin autonomy are increasingly present in our "ordinary" cars.

As the technological changes entailed by the 4IR deepen, so will the strain on many business models. The automotive sector remains a good example. It has been clear for some time that car manufacturers need to plan ahead for a world in which many of the factors that determine current levels of car ownership may no longer be present. Increasing evidence of this planning is now starting to shape commercial decision-making. For example, in December 2016, Volkswagen launched a new "mobility services" venture, MOIA, in recognition of "an ever-stronger trend away from owning a vehicle towards shared mobility as well as mobility on demand" (Berriman & Hawksworth, 2017:12)

The deep interconnectedness of global risks means that technological transitions can exert a multiplier effect on the risk landscape. This does not apply only to newly emerging technologies: arguably much of the recent social and political volatility reflects, in part at least, the lagged impact of earlier periods of technological change. One obvious channel through which technological change can lead to wider disruption in the labour market, with incomes pushed down and unemployment pushed up in affected sectors and geographical regions. This, in turn, can lead to disruptive social instability, in line with the GRPS finding this year that the most important interconnection of global risks is the pairing of unemployment and social instability.

Another prism through which to look at the interaction of risks and emerging technologies is that of liability – or, to put it another way, the question of who is left bearing which risks as a result of technological change. There are multiple potential sources of disruption here. The insurance sector is an obvious example when talking about liability; just as car manufacturers must prepare for a future of driverless vehicles, so the reduction in accidents this future would entail means insurance companies must prepare for plummeting demand for car insurance (Tata, 2017). But the idea of liability can also be understood more broadly, to include the kind of social structures and institutions on social protection. Already there are signs of strain in these institutions, such as mounting uncertainty about the rights and responsibilities of workers and employers in the "gig economy". One of the challenges of responding to accelerating technological change in the 4IR will be ensuring that the evolution of our critical social infrastructure keeps pace.

2.6. Africa and the 4IR

Automation and emerging digital technologies—what is termed the 4IR, or 4IR—are set to destroy developing countries' traditional pathways for growth. It is not a question of if, but when manufacturing-led development will no longer be the viable escalator it has always been. As advanced technologies for robotics, 3D printing, artificial intelligence (AI) and other 4IR technologies outsmart and undercut labour, the opportunity for poor countries to use abundant cheap labour to their productive advantage becomes slimmer (Arntz, Gregory & Zierahn, 2016).

On top of that, African economies already face high unemployment, underemployment and poverty. Africa's youth population is expected to double by 2050, becoming 3.5 times the size of Europe's. By 2100, it is expected to quadruple to reach almost 4.5 billion. A ballooning underemployed youth population on Europe's doorstep could become a significant challenge for the West too, blowing the current migration problem out of the water (Arntz, et al., 2016).

But 4IR does not have to be a story of peril. While some1 point to the challenges of 'premature deindustrialisation', driven in large part by 'labour-saving technological progress',2 there is some emerging literature that seeks to offer a more balanced and hopeful reading of what 4IR may hold for developing economies (Arntz, et al., 2016).

Arntz, et al., (2016) make emphasis that Africa can use technologies like AI to improve access to healthcare across the continent for the most vulnerable and needy communities. It can even help make diagnoses in rural areas, where there are precious few doctors. And we're already seeing technology changing the face of education in countries like India, where they've launched a national teacher platform that builds capacity by allowing teachers to provide richer content while giving administrators access to data about student study patterns. Digital platforms are not only transforming teaching but changing the way we think about learning.

Another relatively quick win for Africa would be to roll out digital identification systems, as India has done with its Aadhaar system, which can play a major role in driving financial inclusion and reducing corruption through reduced fraud and leakages in social benefits payment systems. Once people have digital identities, they can do anything from getting a SIM card to arranging a bank account or pension (Brown, Cheung & Lauder, 2016).

If Africa can empower people with their personal information and data, they can use this data to get better loans, get better skills and ultimately earn better salaries. On the African continent, developing a high-performing digital ecosystem will provide a unique chance to stimulate the economy and create jobs. But the real promise of 4IR is to unlock a new future for Africa's estimated 700 million young people (Brown, et al.,2016).

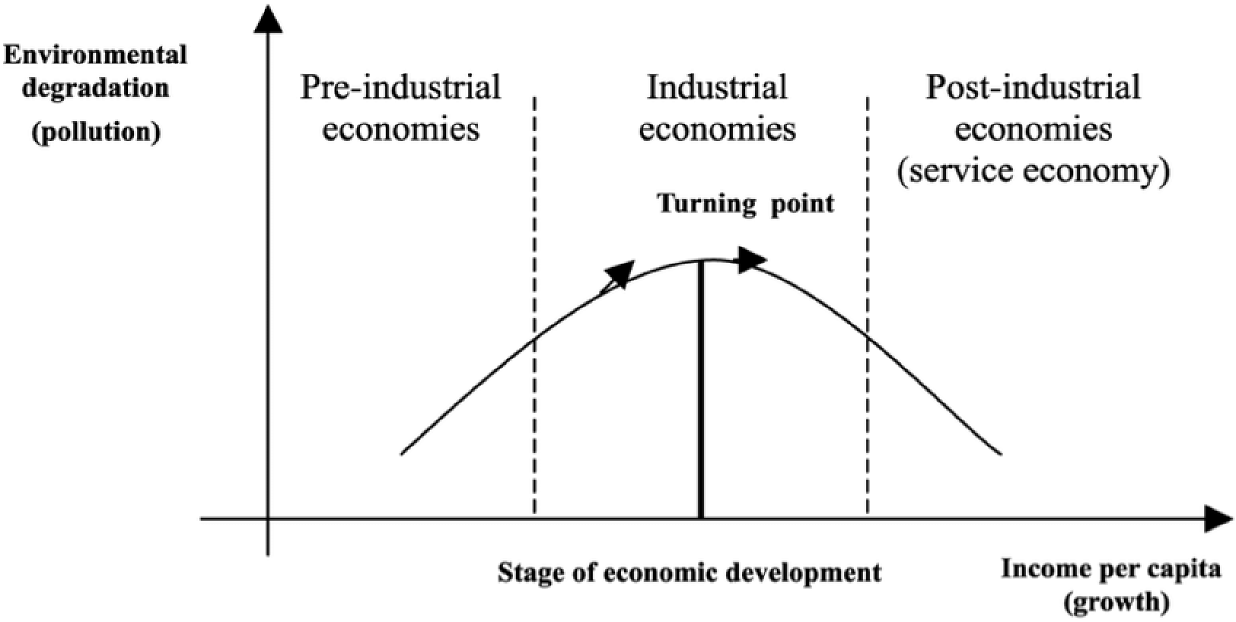
The revolution's most exciting dimension is its ability to address negative externalities – hidden environmental and social costs. As Schwab (2018), the rapid technological advances in renewable energy, fuel efficiency and energy storage not only make investments in these fields increasingly profitable, boosting GDP growth, but they also contribute to mitigating climate change, one of the major global challenges of our time.

Some African countries' growth trajectories may follow the hypothesised Environmental Kuznets Curve, where income growth generates environmental degradation. This is partly because natural capital is treated as free, and carbon emission as costless, in our global national accounting systems (Agarwal, 2019)

The Environmental Kuznets Curve is used to graph the idea that as an economy develops, market forces begin to increase and economic inequality decreases. More specifically that as the economy grows, initially the environment suffers but eventually the relationship between the environment and the society improves.

The environmental Kuznets curve is hypothesized relationship between environmental quality and economic development: various indicators of environmental degradation tend to get worse as modern economic growth occurs until average income reaches a certain point over the course of development (Agarwal, 2019)

Figure 2.4: The hypothesised Environmental Kuznets Curve.



Source: Panayotou (1993)

In Africa, Agarwal, (2019) opines that most emerging technologies will make it possible to truncate this curve. It becomes possible to transition to a "circular economy", which decouples production from natural resource constraints. Nothing that is made in a circular economy becomes waste. The "Internet of Things" for example allows tracking material and energy flows to achieve new efficiencies along product value chains. Even the way energy itself is generated and distributed will change radically, relying less and less on fossil fuels.

For Dobbs, Manyika, and Woetzel, (2018), perhaps most importantly for African countries, then, renewable energy offers the possibility of devolved, deep and broad access to electricity. Many have still not enjoyed the benefits of the second industrial revolution. The fourth may finally deliver electricity because it no longer relies on centralised grid infrastructure. A smart grid can distribute power efficiently across a number of homes in very remote locations. Children will be able to study at night. Meals can be cooked on safe stoves. Indoor air pollution can basically be eradicated.

Beyond renewable energy, the IoT and blockchain technology cast a vision for financial inclusion that has long been elusive or subject to exploitative practices.

"The circular economy is a redesign of this future, where industrial systems are restorative and regenerative by intention. Nothing that is made in a circular economy becomes waste, moving away from our current linear 'take-make-dispose' economy. The circular economy's potential for innovation, job creation and economic development is huge: estimates indicate a trillion-dollar opportunity (Dobbs, et al., 2018)

2.6.1. Selected African Countries at the centre of the 4IR

- **Kenya**

Artificial Intelligence (AI) and blockchain are attracting interest in Africa, as they have the potential to successfully address social and economic challenges there. And there are so many other areas in which 4IR technology can be transformational. Improvements in Africa's ICT sector have been largely driven by expanding mobile digital financial services: The East African region had nearly half of global mobile money accounts in 2018 and will see the fastest growth in mobile money through 2025 (McKinsey & Company, 2018).

Kenya, in particular, has been investing in a digitally savvy workforce to build robust digital economies and competitive markets. The has been increased investment in digital platforms that offer products and services through digital channels. Most platforms are developed by the private sector, but some (e.g., digital ID systems) are public sector-led. Fourth is the development of digital financial services to enhance financial inclusion; M-Pesa in Kenya is the best example of such a system. The development of digital financial systems requires reforms of monetary and financial regulations and supervision systems to allow mobile phone operators to provide financial services. Kenya has been able to create an ecosystem to encourage digital entrepreneurship and innovation. With its large numbers of imaginative and creative youth, Kenya is indeed supporting Africa to become the start-up continent (McKinsey & Company, 2018).

- **Ghana**

This is where the Google Artificial Intelligence Centre is located- Accra, Ghana. Google first announced plans to open the research centre in 2018 and it is the first of its kind in Africa as it uses research models developed by African-based scientists to help solve problems unique to the African continent. The Accra centre has now joined similar AI research centres in Paris, Tel Aviv, and San Francisco. Headed by Research Scientist Moustapha Cisse, the centre was officially launched in April this year and Cisse, along with his team of scientists, work tirelessly to develop ways to help AI find solutions to daily socio-economic problems such as health, agriculture, education and language understanding, etc (McKinsey & Company, 2018).

Ghana-based companies Farmerline and Agrocenta offer farmers mobile and web technology for agricultural advice, weather information, and financial tips. Zenvus, a Nigerian start-up, measures and analyzes soil data to help farmers apply the right fertilizer and optimally irrigate farms.16 The "Sparky Dryer," the dehydration machine invented by a Ugandan engineer, uses biofuel to dehydrate produce and reduce food waste.17 African entrepreneurs and start-ups are also using the Internet of Things to help farmers optimize productivity and reduce waste through data-driven "precision farming" techniques (McKinsey & Company, 2018).

- **Rwanda**

Mobile technology has become a platform for improving medical data and service delivery: About 27,000 public health workers in Uganda use a mobile system called mTrac to report medicine stocks. The SMS for Life program, a public-private partnership, reduces medicine shortages in primary health care facilities by using mobile phones to track and manage stocks levels of malaria treatments and other essential drugs.18 Rwanda became the first country to incorporate drones into its health care system, using autonomous air vehicles to deliver blood transfusions to remote regions. Technology has also improved disaster response: During the West African Ebola outbreak in 2014, WhatsApp became an easy method of dispersing information, checking symptoms, and communicating under quarantine (McKinsey & Company, 2018).

- **Namibia**

Currently, Namibia is experiencing increased interests in locally developed and based ICT applications that are catching the interest of the Government. Namibia is focused on creating a knowledge-based society where technology, innovation, entrepreneurship at every socio-economic level becomes the norm. Vision 2030 and the Harambee Prosperity Plan are both working towards this goal. This means to do things differently and have to do them fast. The country has fully embraced new technology, embraced cloud services and avoiding mistakes that the early adopters made. It has engaged and implement best practices and adapt them to our own needs and circumstances. It has engaged and implemented the best possible solutions, hardware and people to continue to improve our ICT rankings in the coming years as well as gaining a competitive edge in the region since we are willing to use technology and innovation to our advantage (McKinsey & Company, 2018).

It is scaling up the development of home-grown talent through internships with relevant companies and by stimulating tertiary institutions to continue focusing on ICT-skills development for the knowledge-based economy. It has built networks, acquired and developed tailor-made technology that suits a particular set of challenges and issues, using the latest technology available. Consider the West Africa Cable System (WACS) or 5G networks that have connected large but sparsely populated country (McKinsey & Company, 2018).

- **Ethiopia**

In Ethiopia, Illness detection and pharmaceutical production have most immediately benefited from digitization. AI is being slowly implemented in Ethiopia to help medical professionals correctly diagnose cervical cancer and other abnormalities. IBM Research Africa is also using AI to determine the optimal methods for eradicating malaria in specific locations and using game theory and deep learning data analytics to diagnose pathological diseases and birth asphyxia (McKinsey & Company, 2018).

2.6.2. 4IR and the assumed risks

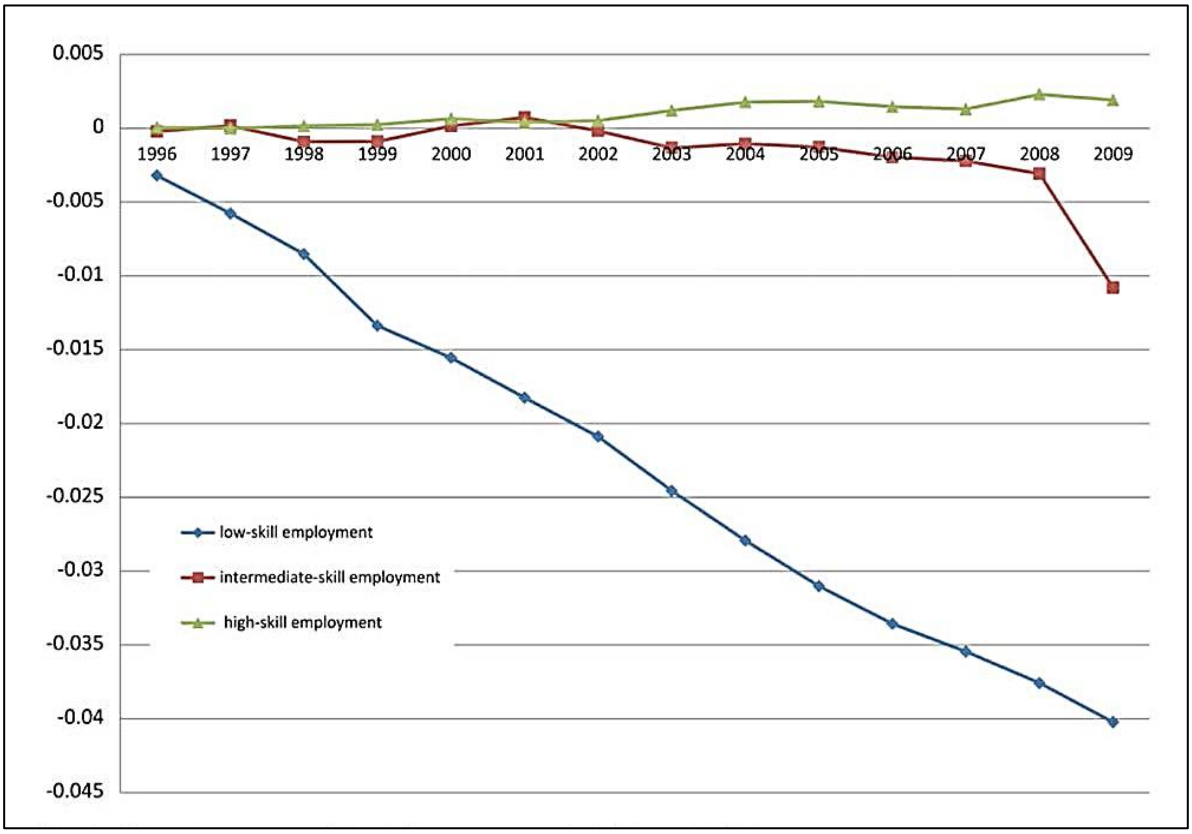
No revolution comes without risks. One, in this case, is rising joblessness. Developing countries have moved away from manufacturing into services long before their more developed counterparts did and at fractions of the income per capita. Rodrik (2016) calls this process "premature deindustrialisation".

> Developing countries are turning into service economies without having gone through a proper experience of industrialization. This is now referred to as "premature deindustrialization (Rodrik 2016).

The employment shares of manufacturing, along with its value addition to the economy, has long been declining in industrialised nations. But it's also been declining in developing countries. This is unexpected because manufacturing is still the primary channel through which to modernise, create employment (especially by absorbing unskilled labour) and alleviate poverty. Manufacturing industries that were built up under a wall of post-independence protectionism are starting to decompose.

The social effects of joblessness are devastating. Demographic modelling indicates that Africa's population is growing rapidly. For optimists, this means a "dividend" of young producers and consumers. For pessimists, it means a growing problem of youth unemployment colliding with poor governance and weak institutions.

Figure 2.5: Premature de-industrialisation



Source (Rodrik 2016:19)

Palma (2017) urges then that such premature deindustrialisation means that countries are running out of industrialization opportunities sooner and at much lower levels of income compared to the experience of early industrializers. Asian countries and manufactures exporters have been largely insulated from those trends, while Latin American countries have been especially hard hit. Advanced economies have lost considerable employment (especially of the low skill type), but they have done surprisingly well in terms of manufacturing output shares at constant prices

Therefore, from the views of Palma (2017), new technologies threaten to amplify current inequalities, both within and between countries. Mining – typically a large employer – may become more characterised by keyhole than open-heart surgery, to borrow a medical metaphor. That means driverless trucks and robots, all fully digitised, conducting non-invasive mining. A large proportion of the nearly 500 000 people employed in South African mining alone may stand to lose their jobs.

Rising inequality and income stagnation are also socially problematic. Unequal societies tend to be more violent, have higher incarceration rates, and have lower levels of life expectancy than their more equal counterparts. New technologies may further concentrate benefits and value in the hands of the already wealthy. Those who didn't benefit from earlier industrialisation risk being left even further behind.

2.6.3. The Potential of 4IR In Africa

In recent years, the ICT sector in Africa has continued to grow, a trend that is likely to continue. Of late, mobile technologies and services have generated 1.7 million direct jobs (both formal and informal), contributed to $144 billion of economic value (8.5 per cent of the GDP of sub-Saharan Africa), and contributed $15.6 billion to the public sector through taxation (World Bank, 2019) Digitization has also resolved information asymmetry problems in the financial system and labour market, thus increasing efficiency, certainty, and security in an environment where information flow is critical for economic growth and job creation.

According to the World Bank (2019) Failure to recognize and capitalize on 4IR opportunities, conversely, will impose considerable risks on African stakeholders: Without attempts to move beyond existing models of innovation, entrepreneurship, and digital growth on the continent, African businesses risk falling further behind, exacerbating the global "digital divide" and lowering their global competitiveness. Going beyond the existing models requires discipline in governance to allow an endogenous innovative environment.

At the same time, institutions must protect the market through consumer protection laws and regulations that encourage competition. Below are some of the areas that Africa may benefit from the 4IR.

- **Encouraging economic growth and structural transformation**

In recent years, the ICT sector in Africa has continued to grow, a trend that is likely to continue. Of late, mobile technologies and services have generated 1.7 million direct jobs (both formal and informal), contributed to $144 billion of economic value (8.5 per cent of the GDP of sub-Saharan Africa), and contributed $15.6 billion to the public sector through taxation (World Bank, 2019). Digitization has also resolved information asymmetry problems in the financial system and labour market, thus increasing efficiency, certainty, and security in an environment where information flow is critical for economic growth and job creation.

Failure to recognize and capitalize on 4IR opportunities, conversely, will impose considerable risks on African stakeholders: Without attempts to move beyond existing models of innovation, entrepreneurship, and digital growth on the continent, African businesses risk falling further behind, exacerbating the global "digital divide" and lowering their global competitiveness (WEF, 2018). Going beyond the existing models requires discipline in governance to allow an endogenous innovative environment. At the same time, institutions must protect the market through consumer protection laws and regulations that encourage competition.

- **Fighting poverty and inequality**

The spread of digital technologies can empower the poor with access to information, job opportunities, and services that improve their standard of living. AI, the Internet of Things (IoT), and blockchain can enhance opportunities for data gathering and analysis for more targeted and effective poverty reduction strategies. Already, we have witnessed the transformational power of formal financial services through mobile phones, such as M-Pesa, reaching the underserved, including women, who are important drivers for sustainable poverty eradication. These financial services allow households to save in secure instruments to enlarge their asset base and escape cycles of poverty (WEF, 2017).

- **Reinventing labour, skills, and production**

By 2030, Africa's potential workforce will be among the world's largest (World Bank, 2018) and so, paired with the needed infrastructure and skills for innovation and technology use, the 4IR represents a massive opportunity for growth. Indeed, the 4IR is dramatically changing global systems of labour and production, requiring that job seeker cultivate the skills and capabilities necessary for adapting rapidly to the needs of African firms and automation more broadly. Already, Africa's working population is becoming better educated and prepared to seize the opportunities provided by the 4IR: For example, the share of workers with at least a secondary education is set to increase from 36 per cent in 2010 to 52 per cent in 2030 (World Bank, 2018).

- **Increasing financial services and investment**

Digitization has impacted economic growth through inclusive finance, enabling the unbanked to enter formality through retail electronic payments platforms and virtual savings and credit supply technological platforms (World Bank, 2018). More broadly, digitization is enabling entrepreneurs and businesses to rethink business models that are more impactful, sustainable, and connected to other sectors of the economy. For example, with fintech, digitization has gone beyond the financial sector to affect the real sector and households, transforming product designs and business models across market segments (GSM, 2018). Businesses are able to design products and trade online, and individuals are able to operate financial services and payments for shopping and investments. The government is also migrating to online platforms to conveniently provide public services.

Other 4IR technologies are also having an impact. For example, in West Africa and Kenya, blockchain has enabled efficient verification of property records and transactions and expanded access to credit in some previously informal sectors of the economy (World Bank, 2018). Since blockchains are immutable, fraud—and thus the cost of risk—is reduced. There are also immense opportunities for job creation in Africa (World Bank, 2018). Given the informal sector is estimated to constitute 55 per cent of sub-Saharan Africa's GDP. (with significant heterogeneity across countries), these tools can be transformational. Their consequences can cascade: Increased financial inclusion contributes to greater capital accumulation and investment, hence the potential for employment creation (World Bank, 2018).

- **Modernizing agriculture and agro-industries**

Africa has yet to harness the full potential of its agricultural sector, and 4IR technologies provide an opportunity to do so. Farming alone accounts for 60 per cent of total employment in sub-Saharan Africa and the food system is projected to add more jobs than the rest of the economy between 2010 and 2025 (Chan, 2018). Farm labour and income are especially important in sub-Saharan Africa, where on-farm activities represent almost 50 per cent of all rural income in countries like Ethiopia, Malawi, Nigeria, and Tanzania (World Bank, 2018). Information on competitive pricing, monitored crop information, disease prevention tips, and disaster mitigation support has the potential to transform the agriculture sector to improve income, production, and demand throughout the continent. Furthermore, as incomes rise across the continent, growing consumer demand for food and beverages will coincide with business-to-business growth in agro-processing.

Ghana-based companies Farmer line and Agrocenta offer farmers mobile and web technology for agricultural advice, weather information, and financial tips. Zenvus, a Nigerian start-up, measures and analyses soil data to help farmers apply the right fertilizer and optimally irrigate farms (Ndung'u, 2018). The "Sparky Dryer," the dehydration machine invented by a Ugandan engineer, uses biofuel to dehydrate produce and reduce food waste. African entrepreneurs and start-ups are also using the Internet of Things to help farmers optimize productivity and reduce waste through data-driven "precision farming" techniques (Ndung'u, 2018).

- **Improving health care and human capital**

African countries face numerous health challenges exacerbated by climate change, limited physical infrastructure, and a lack of qualified professionals. 4IR technology can help mitigate these threats and build sustainable health care systems, especially in fragile states. Mobile technology has become a platform for improving medical data and service delivery: About 27,000 public health workers in Uganda use a mobile system called mTrac to report medicine stocks. The SMS for Life program, a public-private partnership, reduces medicine shortages in primary health care facilities by using mobile phones to track and manage stocks levels of malaria treatments and other essential drugs (Akinwande,2018). Rwanda became the first country to incorporate drones into its health care system, using autonomous air vehicles to deliver blood transfusions to remote regions. Technology has also improved disaster response: During the West African Ebola outbreak in 2014, WhatsApp became an easy method of dispersing information, checking symptoms, and communicating under quarantine (Akinwande,2018)

Illness detection and pharmaceutical production have most immediately benefited from digitization. AI is being slowly implemented in Ethiopia to help medical professionals correctly diagnose cervical cancer and other abnormalities (WEF, 2017). IBM Research Africa is also using AI to determine the optimal methods for eradicating malaria in specific locations and using game theory and deep learning data analytics to diagnose pathological diseases and birth asphyxia. (Akinwande,2018). African countries should avoid a proclivity back towards the import substitution industrialisation programmes of early independence. The answer to premature deindustrialisation is not to protect infant industries and manufacture expensively at home. Industrialisation in the 21st century has a totally different ambience. In policy terms, governments need to employ systems thinking, operating in concert rather than in silos.

Rapidly improving access to electricity should be a key policy priority. Governments should view energy security as a function of investment in renewables and the foundation for future growth. More generically, African governments should be proactive in adopting new technologies. To do so they must stand firm against potential political losers who form barriers to economic development. It pays – in the long-run – to craft inclusive institutions that promote widespread innovation.

There are serious advantages to being a first mover in technology. Governments should be building clear strategies that entail all the benefits of a 4IR. If not, they risk being left behind. The next section focuses on South Africa and the 4IR.

2.7. South Africa and the 4IR

The World Economic Forum's the Future of Jobs (January 2016) Report, which envisions how jobs in their industry will change up to the year 2020, and the new skills needed to drive them, based on a survey covering 15 of the world's largest economies, including South Africa (Spooner, 2016). A major goal of the report is to analyse the impact of key drivers of change and provide specific information on the relative magnitude of these expected changes by industry and geography, and the expected time horizon for their impact to be felt on job functions, employment levels and skills.

However, it is cardinal to note that there are indications that the global economy has entered a new era of more subdued growth at least for the foreseeable future and South Africa is indeed taking a knock. The consumer and government responses to the excesses and over-exuberance engendered by significant debt accumulation during the first 15 years prior to 2008/09 have brought about slower economic growth in the advanced economies. Many less developed economies are also experiencing more moderate growth as a result of inter alia major structural adjustments (e.g., China); significantly lower commodity prices (e.g., Russia, Nigeria, Angola); and political and economic mismanagement (e.g., Brazil, Venezuela).

Further considerations include the future impact of major demographic changes, such as ageing in the advanced economies, and rapid urbanisation in Asia and Africa. The former has potentially profound implications for the sustainability of societies where the growth in the number of elderly people is outstripping the annual increase in the number of people of working age. At the same time, the 4th Industrial Revolution is changing not only the nature and duration of work but possibly also questioning the very meaning of what it means to be human.

Mason (2016) suggests that because of new technologies, capitalism as we know it is in decline and is likely to be replaced by an entirely new socio-economic system: post-capitalism. This utopian global system will be spearheaded not by the organised working class, but by the networked class who will harness zero marginal cost production, use copious amounts of real data to understand, model and test ideas for change, promote collaborative, non-profit forms of work, and ensure that everyone is paid a basic income. In this way, it is suggested, it is possible to create from the ashes of the Great Recession, a more socially just and sustainable global recovery.

Although South Africa was fairly immune to the financial shenanigans that were the prelude to the global 'Great Recession', the country was certainly strongly hit by the after-shock in the form of the impact on the real economy. In 2009 South Africa recorded a negative economic growth rate, bringing to an end the longest ever recorded upward phase of the business cycle. Western Europe, one of the major 'victims' of the Great Recession is also South Africa's major trade and investment partner (WEF, 2017). Economic decline in Europe translated into a significant decline in exports to that region. And for an open economy like South Africa that is bound to suppress economic activity. More than 900 000 jobs were lost – the highest proportional job loss in the world. The recovery since then has been sluggish, lacklustre and uninspiring.

The slow global economic recovery, the ongoing tepid growth in Western Europe, the growth slowdown in China, the significant decline in resource prices, and a debilitating drought have undoubtedly inhibited South Africa's growth performance over the last eight years. These external factors are naturally beyond our control. What is more worrying, however, is the fact that these external constraints have highlighted a number of domestic – largely structural – obstacles to growth, development and job creation (PWC, 2017).

2.8. Major issues of concern

- **The power of Trade Union Movements**

One of the biggest problems facing South Africa is that its leaders are stuck in a protectionist mode as was by argued (Venter, 2016). This is particularly salient regarding the looming 4IR, which signals that over one-third of skills (35%) that are considered important in today's workforce will have changed in a mere five years from now. However, former President Jacob Zuma believed that the global economic crisis and major advances in technology should be tackled head-on by a cohesive African response, driven by the African Union. He questioned if constructs like the World Economic (WEF) Forum held any real quantifiable value for the continent. "We must stand alone as a continent and look at how we solve our issues. The AU has gravitated towards looking at the interests of the continent collectively, which was not the case 20 years ago, (due to) pressure from colonialists."

Hajkowicz (2016) candidly attacks the concern - Are we heading towards mass unemployment as computers and robots do all the work? His answer is equally forthright - The short answer is no! So, we're not entering into an era of job destruction but rather one of rapid transition. So, we're not entering into an era of job destruction but rather one of rapid transition. The economy can be expected to create new jobs at a commensurate rate at which it extinguishes existing jobs. There are reasons to believe that job creation will outpace job destruction.

Concerns about offering a poorer service to disadvantaged groups have held back moves towards digitisation in many public service organisations, particularly in rural areas. Effective democratic governance requires that citizens be able to identify and hold accountable those who make decisions that produce undesired outcomes (see, among many, McGraw, 1990; Peffley, 1984; Powell and Whitten, 1993; Rudolph, 2003 and Walsh (2015)). But allowing machines to make lethal decisions could create a 'responsibility gap' (Matthias, 2004), as it is not clear how such machines could be held accountable.

Whilst Cassidy (2016) is optimistic that South Africa should grasp the opportunities presented by the 4IR, he believes that the country needs also to be wary of the perils. Mahlakoana (2016) considers that South Africa would need to move fast to advance its technological might if it wanted to remain at a player in the global economy. South Africa just like all other nations should expect "key disruptions on employment levels, skills sets and recruitment patterns". Whilst Slattery (2016) cogitates that transformative shifts usually come with new challenges; Curran (2016) is struck by the unpreparedness of many institutions for the coming revolution and who are not yet fully taking advantage of today's technological disruptions. The impact of such a shake-up would however only be limited to how well the public service was prepared for the future. A key is a strategic approach to emerging technology.

- **Skills**

The challenges of the 4IR "are the convergence of technology and creativity of people. We need a young population that is skilled, knowledgeable to use telecommunication and medical technology for the betterment of the people. Our networks for telecommunications should be robust enough to support the implementation of the 4IR ". The world is a significantly under-producing technological innovation that is needed to tackle global challenges, including boosting productivity, improving health, and protecting the environment (IT-Online, 2016).

Statisticians predict the technology field will expand exponentially because of the demand for state-of-the-art technology products (Mayhew, 2016). The exponential growth of digital technology since the 1990s has brought us to the "4IR". Cronjé (2016) and Rossi (2015) accept that the exponential and unprecedented speed at which the revolution is taking place has a disruptive effect on entire systems including the production, management and governance of every industry. However, TRALAC's (2016) analyses are that skills instability, the rapid change in the skills requirements of all existing jobs, will also impact countries differently.

O'Brien (2016) maintains that in many ways, these advances are propelling our society forward, yet they are also magnifying the gap between available and needed skills, and employers face the challenge of finding talent equipped with the know-how to succeed in a world of rapid innovation. So how do we close this gap? We need to invest in human capital by not only hiring the best but also empowering our workforce, particularly women and those in local markets, to rise to senior leadership levels. Rossi (2015) ruminates that transformative and disruptive Artificial Intelligence (AI)-enabled apps are evolving to meet the future's promise, transporting us from a reliance on the old educational institutions to future-ready training programs that give us just what we need to know when we need to know it.

One of the major barriers to change identified by chief human resource officers is the lack of specificity on the types of disruptive change underway. This will entail government taking more responsibility for upskilling, reskilling and collaborating rather than competing on talent (TRALAC, 2016).

- **Corruption**

South Africa has moved from 67 to 61st place on Transparency Internationals (2018) s' ranking. Sera (2016) offers that rigged and inflated contracts, absenteeism, pension scams and unnecessary consultancy were among the most common ways in which public money was frittered away. When citizens become apathetic to gross corruption and think they can do nothing to protest it, then it will continue. The technology could become a game-changing force where trust is at a premium, and where people need protection from identity theft, including the public sector (managing public records and elections). A voting machine records votes in a frontier country known for past political corruption. Though there is no central government repository, each vote is tagged to an individual with no duplication (Plansky, O'Donnell and Richards 2016). The individual identities remain anonymous, and the results of the election are undisputed.

The issue of a more efficient regulatory compliance of a central, immutable ledger of transactions would allow auditors and regulators to rapidly monitor the flow of financial data, avoiding after-the-fact verification. Transactions are tracked and statistics are kept so that governments are aware of the movement of capital across their borders, and activity is monitored for patterns that might indicate money laundering. The system is presumed immune to tampering, fraud, or political control because every core transaction is processed just once and Swain (2014) contemplates that the only way to accelerate change was for public bodies to have a concrete and visible plan of what they intended to do, audited by an outside body, to make them accountable for any failure to achieve it.

The greatest disruption, however, could be experienced by workers who have so far felt immune to robotic competition, namely those in middle-skill professions. Treanor (2016) points to clerical work, such as customer service, being replaced by artificial intelligence and what tended to distinguish private sector organisations was their determination to put the customer first, irrespective of whether they were using face-to-face, telephone or online communication, and the public sector should learn from this.

- **Redistribute Wealth**

According to Mhango (2016), the recent Oxfam Report recommends how to bridge the gap between the poor: pay workers a living wage, protect the workers 'right to unionize; end the gender pay gap, promote equal inheritance and land rights for women; minimize the power of big business and lobbyists nongovernment's; shift the tax burden away from labour and consumption and towards wealth and capital gains, and use public spending to tackle inequality. Additionally, one may argue that bridging the gap between the poor and rich countries will never make any sense if all the obstacles Western and rich countries imposed on the poor country in trade are not pulled down. So, too, there must be efforts and plans to address the colonial legacy.

- **Education**

Over the past few years, Schwulst (2016) perceives that there has been a rise of innovation hubs aimed at supporting technological innovation and incubating bold new ideas. "To this end, we are seeing an increasing number of companies explore new ways of upskilling staff that extend beyond universities or universities of technology.

Senior public sector technology workers are leaving agencies and younger employees with new skills are taking their places. This changing landscape is forcing technology leaders to rethink their approach to talent management today and for the future. Public sector leaders who are moving forward with transformative technologies are also turning their attention to the workforce that will be expected to deliver value from these investments (White, et al., 2015).

With robots continuing to revolutionise workplaces, the Oxford Martin School study (2013) predicts that almost half of all jobs will be automated in the next two decades. Rossi (2015) reflects that the education system has proven unequal to the task of identifying individual talent and ability to require new knowledge that enables individuals to become valued and valuable assets moving forward. Professionals in the workplace will have to fill knowledge gaps created by the pace of change. Accountants will find that software has replaced them, and that software neither miscalculates nor leaves the risk of a government audit to chance. Interpreters will sit idle, because anybody in any language can communicate across the globe, in any language, and in real-time.

Kemp (2016) trusts that disruptive technology meant, for example, that quality education could be accessed by anyone if done properly. "This cannot be done now, but we are told that the 4IR moves so fast that it will be cheap (to implement). But we need to redesign our schools and change what we think of what children expect from their education."

This also requires retraining of teachers who will need to drive the use of technologies in institutions of learning. "We must show young people there is hope and we must do it through skills and jobs and show there are opportunities in entrepreneurship" (SITA, 2016). The objective is to understand the employment, skills and education concerns of stakeholders in South Africa as an emerging market. This research also examines the career and education realties of young people impacted by the economy and the importance of skills and education and focuses on the concerns, challenges and opportunities they face as they build their careers and respond to the skills demands of current or prospective employers. Further to interrogate whether young professionals feel the training and education opportunities they had were appropriate for their current work roles and career aspirations. By providing new insights and a perspective from young people, this will inform and contribute towards vital discussions that political, business and civil society will have in preparing those who will truly master the 4IR.

- **Specialised Skills**

A need was identified to ensure the provision of specialised ICT skills to government. In line with this need, a tender (Tender 38) was awarded to various companies to provide such skills, as and when required (SITA, 2016).

- **Security**

Dukes (2014) and (IT-Online, 2016) opine that technology helps to make sure that information is accessible only to the right people, and makes it nearly impossible for pertinent company information to be leaked. But there is a fine balance to be struck between strengthening security while at the same time enhancing the user experience – additional layers of security seldom lead to the speed and efficiency consumers crave. Across devices, industries and organisations, progress is being made in harnessing the power of voice biometrics and authentication and 2016 will see this become increasingly mainstream.

The public sector is also traditionally nervous about sharing information and bad at sharing good practice (Swain, 2014). Due to the lack of experience, presented a serious problem because security issues meant many government bodies were unable to look abroad to fill skills gaps.

- **Labour Challenges**

Beyond 2020, the 4IR will have brought advanced robotics and autonomous transport, artificial intelligence and machine learning, advanced materials, biotechnology and genomics that will transform the way we live, and the way we work. Cassoojee (2015) and Kemp (2016) aver that technology is about risk. Some will succeed and some will fail but the government needs to inspire young people. This would require the government to create a platform for a national discourse where these challenges could be addressed. Some jobs will disappear, others will grow and jobs that don’t even exist today will become commonplace. South Africa’s future workforce will need to align its skillset to keep pace with these developments (Venter, 2016).

Technological innovation also redefined the job market and changed the notion of empowerment. As was mentioned by Dlamini (2016), the National Union of Metalworkers of South Africa (NUMSA, 2019) says South Africa's last-place ranking in a cooperative labour employee relations survey shows that the country has the most militant working class in the world, and the relationship between workers and their bosses is ranked the worst out of all the countries surveyed. Dlamini (2016) avers that it requires a well-coordinated effort by the government, business, labour and civil society.

South Africa needs leaders and managers who are abreast of developments and who understand what the 4IR means to workers and what opportunities it holds, as well as what will be needed in terms of skills knowledge and attitude to capitalise on it. Most importantly, such leaders and managers must show the way, motivate and coach, inviting everybody along so that it’s a win-win situation (Venter, 2016). Unfortunately, as soon as discussions start about change leaders of trade unions and other stakeholders immediately move into a protectionist mode, signalling resistance to change and issuing warnings that "the government delegation to Davos is going there to kill jobs".

- **Streamlining processes**

To create opportunities to work in multiple locations Cook (2016) counsels that one should determine if the chosen technology offers the quickest and easiest way. IT-Online (2016) speculate whether technology is adding steps to work processes or is it making work more streamlined? Swain (2014) on the other hand ascertain that in many cases collaboration between different bodies to achieve economies of scale is often the only answer, however, such collaboration is not straightforward. The result is that public bodies often find themselves duplicating solutions they could have found more cheaply together. There is not much appetite for change in the public sector because of fear of getting things wrong, as the public sector comes under intense scrutiny if it messes up.

2.9. Understanding Automation, Employment and the Digital Economy

2.9.1. Automation and Technological Unemployment

A burgeoning literature highlights the impact of 'technological disruption', originally defined by John Maynard Keynes (1930) as the discovery of new techniques of economising on labour, outrunning the pace at which we can find new uses for labour. Today, this is driven by advances across several interdisciplinary fields and mutually reinforcing technologies such as machine learning and artificial intelligence (AI), Internet of Things (IoT), robotics, additive manufacturing, synthetic biology, and smart materials (Brynjolfsson and McAfee 2014). While recognizing that digital innovation is likely to disrupt established models of education, employment and job market structures, the implications for labour supply and demand are widely contested. Studies can be broadly divided into those that present a strong negative relationship between automation and employment and those that provide an alternative view.

2.9.2. The negative relationship between automation and employment

Frey and Osborne (2017) is probably the most visible example of research presenting a bleak picture of how automation may affect the future of skills and jobs. They use an occupation-based approach to analyse the relationship between automation and the future of work. They categorise 'occupations according to their susceptibility to computerisation' (meaning job automation by means of computer-controlled equipment) (Frey and Osborne 2017). They asked machine learning researchers to hand-label 70 occupations 'assigning 1 if automatable and 0 if not'.

They explain:

> 'For our subjective assessments, we draw upon a workshop held at the Oxford University Engineering Sciences Department, examining the automatability of a wide range of tasks. Our label assignments were based on eyeballing the O*NET tasks and job description of each occupation. This information is particular to each occupation, as opposed to standardised across different jobs. The hand-labelling of the occupations was made by answering the question "Can the tasks of this job be sufficiently specified, conditional on the availability of big data, to be performed by state-of-the-art computer-controlled equipment". Thus, we only assigned a 1 to fully automatable occupations, where we considered all tasks to be automatable. To the best of our knowledge, we considered the possibility of task simplification, possibly allowing some currently non-automatable tasks to be automated. Labels were assigned only to the occupations about which we were most confident' (Frey & Osborne 2017:22).

They then used O*NET variables associated with the level of perception and manipulation, creativity and social intelligence required to perform the job (believed to limit the potential of computerisation) to supplement these subjective judgments and correct potential labelling errors. Based on the 70 occupations reviewed in this way, they constructed a model with which to estimate the possibility of automation of 702 occupations. Looking at the distribution of jobs in the US economy, they conclude that 47 per cent of total employment is at risk. Frey and Osborne stress that they focus on technological capabilities, not actual job losses. Moreover, they are not specific regarding timeframes as they analyse what 'occupations are potentially automatable over some specified number of years, perhaps a decade or two' (Frey and Osborne 2017).

Frey and Osborne's occupational approach has been used in a range of other countries, with the assumption that the automation risk level for an occupation is the same across countries; as such, cross-country differences in the level of potential automation are seen to be driven by the occupational structure (Arntz et al. 2016). Pajarinen and Rouvinen (2014) estimate the share of jobs at risk in Finland at 35 per cent, and Bowles (2014) between 40 per cent and 60 per cent in Europe. Frey and Osborne, in collaboration with Deloitte (2014), estimate that 30 per cent of jobs in London and 35 per cent in the UK are at high risk of being made redundant by technology in the next 10 to 20 years – with a much higher proportion for those jobs paying less than £30,000 per year. The Bank of England, based on a similar methodology, estimated that up to 15 million jobs could be at risk of automation (Haldane 2015; Houses of Parliament 2016).

Frey and Osborne, along with these associated studies, do not take into account new jobs that may be created as a result of automation. Therefore, these studies look at the potential for existing jobs to be automated, rather than examining the net impact of automation on jobs/ employment – for which an analysis of job creation is also required. Studies limited to the potential automaticity of jobs have also been criticized for not taking economic aspects into account, such as the cost of replacing humans with machines, or as Schwarzkopf (2015) has put it: 'tasks are only automated when this is economical. On the shop floor potential, automatability has no validity, here things need to pay off'.

McKinsey (2017) based on an analysis of 2,000 work activities across 800 occupations, estimates that half of the work activities taking place today could be automated by 2055, although this could 'happen 20 years earlier or later', depending on various factors, including costs, labour market dynamics, economic benefits, along with social and regulatory acceptance. It also notes that 'less than 5 per cent of all occupations can be automated entirely using demonstrated technologies, while 60 per cent of all occupations have at least 30 per cent of constituent activities that could be automated. More occupations will change than will be automated away' McKinsey (2017)

The focus on job tasks in McKinsey's (2017) study involved disaggregating occupations into activities and assessing the extent to which 18 performance capabilities (associated with sensory perception, cognitive, social, emotional and natural language processing capabilities) were required in those activities, along with the required level of competence in those capabilities to perform the work activity 'successfully'. They then assessed the performance of existing technologies on the same criteria:

> By estimating the amount of time spent on each of these work activities, we were able to estimate the automation potential of occupations in sectors across the economy, comparing them with hourly wage levels. Drawing on industry experts, we also developed scenarios for how rapidly the performance of automation technologies could improve in each of these capabilities. The analysis we conducted for the United States provided us with a template for estimating the automation potential and creating adoption timing scenarios for 45 other economies representing about 80 per cent of the global workforce '(McKinsey 2017:14).

Grace et al. (2017) surveyed machine-learning researchers who had published in 2015 in two leading conferences on AI. They sought their views on when they believed AI would outperform humans on a range of activities. The results, based on a sample of 352 respondents (21% of the authors contacted), show that researchers predicted that AI will outperform humans in many of those activities (such as translating languages, writing school essays, driving a truck) in the next ten years, and will outperform humans in a number of others within a 40-year period (working in retail, writing a bestselling book, working as a surgeon). They further report that researchers 'believe there is a 50% chance of AI outperforming humans in all tasks in 45 years and of automating all human jobs in 120 years' (Grace et al. 2017).

Acemoglu and Restrepo (2017) 'move away beyond feasibility studies', such as those by Osborne and Frey and Grace et al., to focus on the actual use of robotics. They draw on data from the International Federation of Robotics (IFR) on the use of industrial robots (in 19 industries) between 1990 and 2007 in the US, together with data on employment shares from the US Census to show that the introduction of robots has 'large and robust' negative effects on employment. This study is based on a model 'where robots and workers compete in the production of different tasks' and takes into account that 'the share of tasks performed by robots varies across industries and there is the trade between labour markets specializing in different industries. This is argued to be important as robots are assumed to affect employment and wages negatively through displacement (of workers from tasks previously performed), but also positively through productivity effects ('as other industries and/or tasks increase their demand for labour'). Their model 'shows that the impact of robots on employment and wages in a labour market can be estimated by regressing the change in these variables on the exposure to robots, a measure defined as the sum over industries of the national penetration of robots into each industry times the baseline employment share of that industry in the labour market' (pp.2-3).

These specifications provide the starting point for their empirical strategy. They thus exploit differences in the penetration of robots by industry and the local distribution of employment across industries to estimate that 'one more robot per thousand workers reduces the employment to population ratio by about 0.18-0.34 percentage points and wages by 0.25-0.5 per cent' (Acemoglu and Restrepo 2017). This is equivalent to 'one new robot reducing employment by 5.6 workers' (p.4), taking into account increases in employment in other areas of the economy through productivity effects. Without taking this into account, the figure the authors provide is a reduction of 6.2 workers per new robot.

The OECD has started a new approach to add information on the relationship between computers and skills. Their 'computers and skills demand project' (OECD 2017) used the Programme for International Assessment of Adult Competencies (PIAAC) data (assessing competency levels in literacy, numeracy and problem solving) to compare the performance of computers and human workers. They report than less than 15 per cent of workers use those skills 'on a daily basis with a proficiency that is clearly higher than computers' (Elliott, 2017). This study focuses on only three of the skills that are used at work. The OECD notes that the approach could be extended to other skills to develop a more accurate view of computers' capabilities to substitute for human labour.

2.9.3. An alternative view

Arntz et al. (2016) argue that much of the research evidence presenting a strong negative relationship between automation and work is methodologically flawed. In particular, they take issue with occupation-based approaches, such as that used by Frey and Osborne, on the grounds that they overestimate job automatibility: 'Occupations labelled as high-risk occupations often still contain a substantial share of tasks that are hard to automate'. Automation targets tasks rather than occupations, and many occupations have tasks that are difficult to automate (Autor 2014:39). As a result, adjustments to technology often take the form of changes in tasks within occupation rather than changes in employment shares between occupations (Arntz et al. 2016).

They also use PIACC data, that gathers information about task structures across OECD countries, and estimate the relationship between work tasks and the automatibility defined by Frey and Osborne (Arntz et al. 2016:12). Using PIAAC individual-level data on actual tasks performed, they take into account the way that tasks vary by job within the same occupation.

This approach enables a better exploration of differences between countries, as it does not depend on the assumption that task structures will be constant across them.

Arntz et al. (2016) estimate that, on average for the 21 OECD countries that they include in their analysis, 9 per cent of jobs are automatable –the range goes from 6 per cent in Korea to 12 per cent in Austria. This is much lower than in Osborne and Frey's study: 'not taking account of the variation of tasks within occupations exerts a huge impact on the estimated automatability of jobs' (Arntz et al. 2016). They underline that their own figures are likely to be an overestimation given (1) economic, legal, social and ethical barriers preventing or slowing down automation, (2) possibilities of job-task reorganization and workers switching tasks to focus on those that are not automated and (3) the creation of additional jobs 'through demand for new technologies and through higher competitiveness' (Ibid. p.4).

Their main conclusion is that 'automation and digitalization are unlikely to destroy large numbers of jobs. However, low qualified workers are likely to bear the brunt of the adjustment costs as the automatability of their jobs is higher compared to highly qualified jobs' (Ibid.:4). Based on this premise, the implications of the study are that there is a 'need to focus more on the potential inequalities and requirements for (re-)training arising from technological change than the general threat of unemployment that technological progress might or might not cause '(Ibid:25). They find that high educational requirements and jobs requiring cooperation or where workers spend larger proportions of time influencing others are less subject to automatability. Routine tasks (related to the exchange of information, selling, or using fingers and hands), and jobs that have high shares of those tasks, are more exposed to automation. It should be noted that Arntz et al., (2016)'s task-based approach still relies on experts' assessment rather than the actual use of technologies in the workplace.

Autor (2014) also argues that the extent to which machines will be able to replace humans at work is often overestimated because the challenges in automating tasks requiring flexibility, judgment and common sense, 'remain immense' (Autor 2014). A central point in his argument is that machines' complementarities with certain types of human labour can increase productivity, earnings and demand for skilled workers. He notes the 'deceleration of employment growth in abstract-intensive occupations after 2000' and provides evidence suggesting that the 'locus of displacement of middle-skills employment is moving into higher-skilled territories'

Autor (2014) examines whether this may be due to technology having climbed up in the task domain so that it can now substitute for professional, technical and managerial occupations. While he notes that this possibility should not be dismissed, he uses data on computer and software investment to cast doubt over this interpretation: if technology could now substitute for highly paid work, he argues, we should be seeing a marked corporate increase in investment in technology whereas the opposite has happened. Autor interprets the reduction in investment after 2000 as the 'bursting of a bubble' (Ibid. p.29) after the 1990s craze in investment, which restricted innovation and demand for high skilled workers.

He concludes that even in this era of uncertainty, we can be fairly confident that 'the technological advances that have secularly pushed outward the demand for skilled labour over many decades will continue to do so' (Ibid. p.39). The implication is that 'human capital must be at the heart of any long-term strategy for producing skills that are complemented rather than substituted by technology' (p.39).

Graetz and Michaels (2015) use the increase in industrial robots between 1993 and 2007 (in 17 countries across the developed world) to analyse their impact on employment. Using data from the Industrial Federation of Robotics (IFR) to estimate 'robot density' across 14 industries, they examine differences in real value-added, labour productivity and hours worked.1 They find little reason for concern during that period, noting no significant effect on total hours worked, although they also observed 'some evidence that robots reduced the hours of both low-skilled and middle-skilled workers' (Graetz and Michaels 2015:1). They do not find effects on the hours worked by high-skilled workers, those with a college degree and above, which they take to confirm skill-biased technological change (SBTC) arguments. They estimate that such increases in the use of robots were responsible for 10 per cent of the GDP growth and 15 per cent of the productivity gains in those economies, and documented congestion effects as 'larger increases in robot density translated into increasingly small gains in productivity' (diminishing marginal gains).

The question is whether similar trends will stand today and in the near future. As the authors note 'there is plenty of potential for increased use of robots in new industries' and to use their increased capabilities to a greater extent in the industries where they are already in use – even though the congestion effects that they report suggest that 'robot densification is not a panacea for growth' (Ibid.:5).

2.9.4. Evaluating the Evidence

The different approaches identified above indicate that the impact of automation and digital technologies on employment are widely contested. The literature presents varied expectations regarding the potential of automation to replace workers, in part, because some studies look at what robots/ computers are able to do now, whereas others reflect on what computers will be able to do in the future (near or far). What computers will be able to do is a moving target, and expectations around it need to be continuously revised and reformulated.

The literature making prospective estimations (whether occupation or task-focused), relies overwhelmingly on the expert judgment in making evaluations on the changing relationship between automation and the future of work. However, technical experts tend to overestimate the capacity of new technologies (Arntz et al. 2016; Autor 2014). There are also some 'retrospective' studies providing estimates based on the effects of the introduction of robots on employment, but the data used is somewhat dated, and there are significant methodological problems in assuming that investment in technology determines changes in employment statistics.

Blanket claims about the impact of digital technologies overlook the way that they are applied across sectors and occupations. Typically, it is low skilled jobs that are assumed to be most in danger, consistent with long-established ideas about technological progress and the occupational structure. However, there is growing evidence of new technologies transforming professional, managerial and technical occupations. Moreover, the studies reviewed rarely take into account the potential for job creation around automation, or for the relocation of those made redundant as a result of automation. As a result, the picture of the net impact of automation on the labour market is partial.

Most studies focus on the potential for automation, without incorporating into their models economic and social factors that may stimulate or deter the replacement of workers by technology. As such, much of the literature falls back on technological determinism, with little reference to the way companies 'choose' to deploy new technologies or to the capitalist economy, which is the engine for technological innovation (Schumpeter 1943). Martin Ford, for example, suggests that the evidence already shows that, 'a race between technology and our ability to reform our political and economic systems is really no race at all… as… machines are likely to permanently take over a great deal of the work now performed by human beings.' (Ford 2009:4-5). But it is human decisions that are taken by people in power within organisations or governments that shape the introduction and use of these technologies. As Simon Head observes, although we are often talking about abstract electronic and statistical entities which are impersonal, 'all the system's rules and commands, in fact, have human origins in the superior expertise of the technical, managerial elite whose wisdom is baked into the system' (Head 2014).

Most of the research also provides little detail on the time-frames for replacing humans by technology. Almost without exception, the literature on digital disruption is replete with vague references to how long it will take for the workplace, jobs and skills to be transformed in the way that industrialism transformed agricultural employment. The failure to specify when tomorrow's world become today's world is particularly important to all stakeholders as there is a vast difference between half of existing occupations disappearing or being significantly reformed in the next 10 years as opposed to 25-30 years' time.

The next section goes beyond the focus on job numbers to look at the skills implications of the 'digital' economy. As we will show, research in this area has been much more limited.

2.9.5. Automation, Skills and the Digital Economy: Reflecting on the three Accounts

When examining the skills implications of what can loosely be described as 'digital disruption', there are three main positions, although the boundaries between them are somewhat fuzzy and some of these accounts converge on specific points. Much of this literature is not directly comparable as writers focus on different aspects of digital disruption. Some, for example, concentrate on the potential decline in employment numbers resulting from automation and advances in machine learning, while others look at new ways of working in the 'gig' or 'platform' economy. The three views can be characterised as 'labour scarcity', 'job scarcity' and 'end of work'.

i. **Labour Scarcity**

Despite an emphasis on changing skill requirements, occupational restructuring and labour market disruption, the labour scarcity (Autor 2015) approach retains a largely optimistic account of new areas of jobs growth and skills upgrading, consistent with established theories of human capital and skill-biased technological change. It claims that there will be an increasing demand for high skilled workers and a reduction in demand for lower-skilled workers as more routine jobs are automated and people retrain for more skilled jobs.

ii. **Job Scarcity**

This approach recognises that new technologies may enhance the skills of a relatively small proportion of the workforce, but the general direction of technological innovation is towards the redesign of existing jobs, where much of the knowledge content is captured in software that permits a great level of standardisation and potential to deskill or automate a wide range of occupations, including technical, professional and managerial roles. Here, job scarcity points to a significant skills mismatch between an expanding supply of educated and skilled workers, and scarcity of good quality job opportunities, primarily resulting from the routinisation and segmentation of job roles rather than 'technological unemployment'.

iii. **End of Work**

This approach views technological unemployment (Keynes 1930) as transforming the future of work, along with the labour market foundations of capitalism. In the post-capitalist era, it is claimed that we need to rethink the purpose of education, skill formation and the labour market.

These approaches are briefly discussed below:

- **Labour Scarcity**

The labour scarcity approach conforms to the longstanding view that the economy and demand for skills are defined by the stage of technological development. The more technologically advanced an economy the greater the demand for skilled people 'doing clever things for a living'. As in the past, new positions and professions are believed to emerge to replace any job losses due to technological disruption. This view is informed by theories of human capital and skill-biased technological change (SBTC). According to its mainstream version, new technologies alter the relative demand for different types of labour, leading to an increased demand for skilled workers. The education system, therefore, remains at the heart of economic and social policy, as the relationship between technology and education is not only the source of economic growth but also wage (in)equality. Autor (2015) writes 'the primary system of income distribution in market economies is rooted in labour scarcity; citizens possess (or acquire) a bundle of valuable "human capital" that, due to its scarcity, generates a flow of income over the career path'. This is to envisage a future of work characterised by a shortage (or scarcity) of people with higher-level marketable skills.

Goldin and Katz (2008) argue that there is a race between education and technology, the outcome of which explains patterns of wage inequalities in America. The race is 'between the growth in the demand for skills driven by technological advances and the growth in the supply of skills driven by demographic change, educational investment choices, and immigration' (2008). They conclude that educational wage differentials and wage inequalities since 1980 result from problems in the supply of skills that has failed to respond to an acceleration in demand due to shifts in technological change. Such accounts have helped to fuel the expansion of higher education around the world and contributed to a greater focus on STEM-related fields. Other interpretations point to the need for educational reforms to develop the skills that are seen as crucial for an advanced digital economy (Hanushek & Woessmann 2015)

Integral to this argument is the view that 'digital disruption' may lead to technological unemployment but this is likely to be short term, as economic history suggests that new jobs will emerge even if we cannot specify them in advance. Such uncertainty, if anything, adds to the importance of education and skill formation in preparing people to be adaptable rather than simply skilled. Those currently in low skilled, routine jobs, who are judged to be most at risk of automation, will, therefore, need to upgrade their skills to take advantage of emerging if unspecified, areas of higher-skilled job growth.

Schwab (2016) suggests that full implications of the 4IR are yet to be grasped. He points to the 'unlimited possibilities' of billions of people connected by mobile devices offering access to real-time data and leading-edge knowledge; unprecedented processing power and data storage; and:

> 'a confluence of emerging technology breakthroughs, covering wide-ranging fields such as artificial intelligence (AI), robotics, the internet of things (IoT), autonomous vehicles, 3D printing, nanotechnology, biotechnology, material sciences, energy storage and quantum computing, to name a few. Many of these innovations are in their infancy, but they are already reaching an inflexion point in their development as they build on and amplify each other in a fusion of technologies across the physical, digital and biological worlds.' (Schwab 2016:1).

These technologies, he argues, will result in many new positions and professions being created. While these are currently difficult to foresee, he claims, 'I am convinced that talent, more than capital, will represent the critical production factor. For this reason, scarcity of a skilled workforce rather the availability of capital is more likely to be the crippling limit to innovation, competitiveness and growth' (Schwab 2016:44-45; Autor 2015). Although perpetuating the view that developing skills and individual talents is key to the future, he suggests that what we mean by 'high skill' is likely to change as it can no longer be limited to holding a degree or having a specific set of professional capabilities: 'the 4IR will demand and place more emphasis on the ability of workers to adapt continuously and learn new skills and approaches within a variety of contexts.' (Schwab 2016:45).

Therefore, inequality in the era of digital disruption will be linked to 'ontological inequality', separating those willing to adapt and those who resist change, as he predicts, 'we may witness an increasing degree of polarization in the world, marked by those who embrace change versus those who resist it' (Schwab 2016:97). Such a view is consistent with orthodox human capital theory, where individual incomes are primarily a result of whether people are willing to invest in their education.

The literature we categorise under labour scarcity includes writers and researchers with divergent views on the impact of automation on existing and future levels of employment, but similar views on the 'supply' side solutions. David Autor, referred to above, suggests that claims of widespread technological unemployment are exaggerated, pointing to periodic warnings over the last two centuries, including the Luddite movement of the early nineteenth century: 'I expect that a significant stratum of middle-skill jobs combining specific vocational skills with foundational middle-skills levels of literacy, numeracy, adaptability, problem-solving, and common sense will persist in coming decades' (Autor 2015:27).

Autor's view stands in stark contrast to Carl Frey and Michael Osborne's (2013) claim that 47 per cent of America jobs could be at risk of computerization. They suggest jobs in transportation and logistics, office administration and production occupations are particularly at risk. But what makes these arguments consistent, is the idea that those with lower skills are at most risk and therefore there is a race between technology and education to develop more advanced skills to remain relevant in tomorrow's labour market:

> 'Our model predicts a truncation in the current trend towards labour market polarization, with computerisation being principally confined to low-skill and low-wage occupations. Our findings thus imply that as technology races ahead, low-skill workers will reallocate to tasks that are non-susceptible to computerisation – i.e., tasks requiring creative and social intelligence.' (Frey and Osborne 2017:45)

Brynjolfsson and McAfee (2014:11) also make a direct link to the second machine age, in which 'technological progress is going to leave behind some people, perhaps even a lot of people, as it races ahead' but at the same time, they argue:

> 'there's never been a better time to be a worker with special skills or the right education because these people can use technology to create and capture value. However, there's never been a worse time to be a worker with only "ordinary" skills and abilities to offer, because computers, robots, and other digital technologies are acquiring these skills and abilities at an extraordinary rate.'

Here the fundamental challenge remains the reform of education systems to prepare the future workforce to take advantage of new opportunities emerging within a technologically advanced economy. This may include offering opportunities to less privileged students (i.e. poor families, women and ethnic minorities), by dismantling barriers to occupational mobility widely recognised to confront their access to the established professions (Brown 2013; McKnight 2015).

The labour scarcity approach can also be seen in much of the literature that focuses on the 'gig' or 'sharing' economy. The restructuring of work leads people to work in multiple contexts, breaking established models of employment and career development. Many accounts of these changes highlight the need to 'reskill' the workforce as more people are given an opportunity to use their skills, knowledge and talent to earn a living, even if this no longer conforms to the conventional model of organisational success (Huws, Spender and Joyce 2016).

There has been a lot of discussion about online digital platforms with the potential to disrupt many areas of employment in a diverse range of business activities, including travel, accommodation, retail, banking, education and training, and software development (Srnicek 2017). Platforms such as Uber, Airbnb, Upwork, Profinder and Freelancer, are not only seen to offer a quick and cost-effective way of linking supply and demand but according to Schwab (2016:20) 'enables the effective use of under-utilized assets – namely those belonging to people who had previously never thought of themselves as suppliers (i.e. of a seat in their car, a spare bedroom in their home, a commercial link between a retailer and manufacturer, or the time and skill to provide a service like delivery, home repair or administrative tasks)'.

The idea of the gig economy is often presented as new, exciting and entertaining. It describes how digital technologies are being used to break with out-dated ways of working based on the amount of time you spend in the office or factory. The gig economy presents a different world of work in which people are given greater freedom, no longer contracted to sacrifice five or six days a week in exchange for a paycheck. Individuals are free to decide when, where, and for how long they want to work. It is typically represented by freelance consultants with expert knowledge and skills to sell through digital platforms such as freelancer.com, upwork.com, etc. It is also characterised as an inevitable shift in response to the changing aspirations of a younger generation of 'digital natives' who it is claimed no longer want to work 9-5, day-in-day-out for other people.

Such interpretations of the need for re-skilling has also been linked to 'bottom-up' innovation and social (as well as economic) enterprise, driven by declining marginal costs of communication and production, meaning that you do not need to own factories, offices or expensive computers to participate in new forms of economic activities. In short, the same technological trends that are enabling companies to develop sophisticated global value chains through process innovation also make available micro-level co-production. With the growth of digital platforms, such as iTunes apps, etc. it is believed that it is possible for anyone to develop new applications for sale or make them free to others. There has been a lot of interest in the Internet of Things, 3D printing, open manufacturing, and MOOCs, within a 'sharing' economy enabling people to contribute to, and benefit from, the 'collaborative commons' (Anderson 2012).

- **Job Scarcity**

While some highlight reskilling, consistent with skill-biased technological change, others point to the prospects of digital disruption, resulting in increasing standardization, routinisation, and the de-skilling of a significant proportion of the workforce. This alternative interpretation raises fundamental questions about the future demand for 'knowledge' workers, job quality and human capital assumptions about earnings matching learning. Here the focus has been less on the impact of automation on overall (un)employment, and more on the future demand for high skilled workers. While the 'knowledge' economy is associated with scientific knowledge, technologically innovative, and the creative industries, it is claimed that what is not adequately recognized is how digital innovation has also given company managers and executives new powers of control and command (Head 2014).

Job scarcity accounts reject the human capital view that higher-level skills are the route to income growth through raising productivity (Piketty 2014; Stiglitz 2012). Rather, there is a recognition that it is not only about 'technologies' but 'capitalism' (Schumpter 1943; Wajcman 2015). Technology is not destiny as its use is shaped by the forces and relations of production, that lead firms to deploy technologies in ways that sustain the proprietary rights of owners, shareholders, and senior executives. This view was consistent with Schumpeter and insights from Marx, where capitalism is in a state of 'constant commotion' drawing on new technologies and business practices (Mason, 2015).

Harry Braverman's classic study of Labour Under Monopoly Capitalism argued that firms used technologies to enhance the power and control of business owners through a process of deskilling. He expressed scepticism about terms like 'skill', 'training' and 'education', which he regarded as vague, making it difficult to assess claims of increasing skills 'upgrading' over time. He suggested that much of the work on skills upgrading is based on 'impressionistic theory' (Braverman 1974:424) and challenged the idea of an increase in the average demand for skill:

> 'Since, with the development of technology and the application to it of the fundamental sciences, the labour processes of society have come to embody a greater amount of scientific knowledge, clearly the "average" scientific, technical, and in that sense "skill" content of these labour processes is much greater now than in the past. But this is nothing but a tautology. The question is precise whether the scientific and "educated" content of labour tends towards averaging, or on the contrary, towards polarization. If the latter is the case, to then say that the "average" skill has been raised is to adopt the logic of the statistician who, with one foot in the fire and the other in ice water, will tell you that "on the average", he is perfectly comfortable. The mass of workers gains nothing from the fact that the decline in their command over the labour process is more than compensated for by the increasing command on the part of managers and engineers' (Braverman 1974:425).

This presents a different interpretation of the relationship between technological innovation and skills, in contrast to SBTC described above, as Braverman (1974:425) went on to note that 'The more science is incorporated into the labour process, the less the worker understands of the process'. Therefore, while Braverman may be accused of underestimating the development of professional, managerial and technical employment in the latter decades of the twentieth century, the idea of knowledge being embedded in the labour process itself, rather than increasing opportunities for employees to use knowledge and skills, is of major significance to understanding today's digital disruption. More recent evidence suggests that new technologies are enabling new forms of command and control by using digital software to capture knowledge and automate business processes.

Braverman (1974:424) argue that the twentieth century witnessed the widespread use of mechanical Taylorism characterised by the Fordist production line, where the knowledge of craft workers was captured by management, codified and re-engineered in the shape of the moving assembly line, resulting in a clear divide between a semi-skilled workforce and the managers and professionals who controlled all aspect of factory life. Today, the same processes of knowledge capture are being applied to intermediate and high skilled employees in the service sector. Brown, et al. argue that the twenty-first century is an age of digital Taylorism. This involves translating knowledge work into working knowledge through the extraction, codification and digitalisation of knowledge into software prescripts and templates that can be transmitted and manipulated by others regardless of location. The result is the standardisation of functions and jobs, including an increasing proportion of technical, managerial and professional roles that raise fundamental questions about the future of 'knowledge' work:

> 'Companies may continue to pay a premium for outstanding talent; however, it is defined, but they are increasingly segmenting their knowledge workers in an attempt to know more for less. Although some are given permission to think, increasing efforts are being made to translate knowledge work into working knowledge where what is in the minds of employees is captured and codified in the form of digital software, including online manuals and computer programs that can be controlled by companies and used by other often less-skilled workers.' (Brown, Lauder and Ashton 2011:66).

Whereas the distinction between conception and execution in a period of mechanical Taylorism transformed the relationship between the working and middle classes, digital Taylorism takes the form of a power struggle within the middle classes, as these processes depend on reducing the autonomy and discretion of managers and professionals. As Wilensky (1960:557) predicted, 'the men who once applied Taylor to the proletariat would themselves be Taylorized.' The re-stratification or segmentation of 'knowledge' work, Brown et al. argue, restricts permission to think to those in 'developer roles', typically including staff in executive functions, along with those identified as high potential researchers, managers, and professionals. They are highly qualified and, in corporate settings, are expected to work on international engagements and are typically recruited from global elite universities.

Those in developer roles are distinct from 'demonstrator roles' where people are employed to implement or execute existing knowledge, procedures or managerial protocols. They include knowledge used by consultants, managers, teachers, nurses, and technicians, but delivered through digital software. Although demonstrator roles include well-qualified people, there is less scope to think outside the digital box as much of the expert knowledge is captured in expert (digital) systems. However, this does not always eliminate the need for good customer-facing skills as the standardisation required to achieve mass customisation still needs customers to feel that they are receiving a personalized service. This may contribute to a continuing demand for university graduates but these are far removed from the archetypal graduate jobs of the past.

In turn, demonstrator roles are also distinct from 'drone roles' that offer little discretion to employees, although a good level of literacy, numeracy, and teamwork skills are often required. Much of the work is digitally controlled and includes back-office functions such as data entry jobs or customer contact roles in call centres, where virtually everything is prescribed or scripted in software packages. Many of these jobs are highly mobile as they can be standardized and digitalized. They are often filled by well-qualified workers either attracted by relatively high salaries in emerging economies or struggling to find a job that matches their training or expectations in developed economies. These are also roles that are most likely to be superseded by digital automation given advances in artificial intelligence, voice recognition and biorobotics (Brown, Lauder and Sung 2015).

Simon Head's (2014) account is consistent with Brown et al.'s as he sees the coming together of new technologies to perform highly complex tasks in the control and monitoring of business processes and employees as a high-tech version of Fredrick Winslow Taylor's 'scientific management'. In what he calls 'the first machine age' he suggests:

> 'the working class occupied a world apart, tethered to factories and assembly lines and bearing the full rigours of industrialism. In the new machine age, the working class can be all of us. The new industrialism has pushed out from its old heartland in manufacturing to encompass much of the service economy, and it has also pushed upward in the occupational hierarchy to include much of the professional and administrative middle class: physicians as well as call-centre agents; teachers, academics, and publishers as well as "associates" at Walmart and Amazon; bank loan officers and middle managers as well as fast-food workers.' (Head 2014:5)

Therefore, the application of new technologies to manufacturing is nothing new but the application of digital Taylorism to 'white-collar' rather than 'blue-collar' work has real revolutionary potential. Rather than sparking a new wave of 'office' employment, it has seen office work being standardized, digitalized and modularized. Susskind and Susskind (2015), view this differently as the liberation of the professions, breaking the monopoly of professional practices as expert knowledge becomes more widely accessible through new modes of digital communication, 'as our systems and machines are becoming increasingly capable.' As they note, 'when it comes to the future capabilities of our machines, the overall trajectory of technological advance is clear and of great importance for the professions – more and more tasks that once required human beings are being performed more productively, cheaply, easily, quickly, and to a higher standard by a range of systems. And there is no apparent finishing-line' (Susskind and Susskind 2015:159).

Some authors have also pointed to the ways in which digital technologies have been used to develop standard platforms resulting in 'on-demand' forms of non-standard flexible labour, in insecure or precarious jobs, with little access to basic employment rights, let alone skills training or career progression (Beck 2000; Standing 2011). Such models are associated with significant knowledge capture as customer information, billing, marketing and business development are controlled by those who operate the digital platforms.

- **End of Work**

The 'end of work' approach pushes the discussion beyond changes in the nature of skills and work to include the future of capitalism. Jeremy Rifkin argues that the transformation of the workplace is part of a more profound shift in capitalism's ability to raise productivity to the point that it approximates what economists call the 'optimum general welfare' where the cost of producing additional products and services has 'zero' marginal cost (Rifkin 2014:2-3).

To put this differently, it means that the profits typically made by those involved in delivering a college course, publishing a book or making products, are eliminated because of the declining cost of communicating, manufacturing and selling. He suggests that over a third of the world's population are already producing their own information on relatively cheap smartphones and computers which they can share via video, audio and text at near-zero marginal cost. Likewise, Paul Mason concludes that 'the real danger inherent in robotization is something bigger than mass unemployment, it is the exhaustion of capitalism's 250-year-old tendency to create new markets where old ones are worn out' (Mason 2015).

The point these authors and others are making is that the means of production are becoming cheaper because 'information' is positive-sum, it is not used up in the same way as physical products. New technologies have reduced the cost of communicating and advanced computing so that anyone with access to the internet is plugged into a world of information. As the scope increases at the same time as costs decline, there is the potential for more social activities blurring the distinction between market and non-market activities. Facebook, for example, allows you to connect with family and friends but at the same time displays tailored adverts, depending on your recent web search history.

According to Rifkin it is no longer credible to argue that productivity creates more jobs than it replaces, as 'much of the productive economic activity of society is going to be increasingly placed in the "hands" of intelligent technology, supervised by small groups of highly skilled professional and technical workers' (Rifkin 2014:129). Therefore, it is claimed that advances in machine intelligence, robotics and advanced analytics, holds the prospect of 'liberating' hundreds of millions of people from work in the market economy in the next 20 to 30 years (Ibid. 121).

Paul Mason similarly suggests that such trends mark the beginning of a post-capitalist era:

> 'the rapid change in technology is altering the nature of work, blurring the distinction between work and leisure and requiring us to participate in the creation of value across our whole lives, not just in the workplace. This gives us multiple economic personalities, which is the economic base on which a new kind of person, with multiple selves, has emerged. It is this new kind of person, the networked individual, who is the bearer of the post-capitalist society that could now emerge. The technological direction of this revolution is at odds with its

> social direction. Technologically, we are headed for zero-price goods, unmeasurable work, an exponential take-off in productivity and the extensive automation of physical processes. Socially, we are trapped in a world of monopolies, inefficiency, the ruins of a finance-dominated free market and a proliferation of "bullshit jobs". Today, the main contradiction in modern capitalism is between the possibility of free, abundant socially produced goods, and a system of monopolies, banks and governments struggling to maintain control over power and information. That is everything is pervaded by a fight between network and hierarchy.' (Mason 2015:143- 144)

Such a radical transformation of the occupational structure would render redundant the market distinction between labour supply and demand, between employers and employees, and between sellers and consumers. This would lead to a rapid growth in what Rifkin calls 'prosumers', who will 'be able to produce, consume, and share their own goods and services with one another on the Collaborative Commons at diminishing marginal costs approaching zero, bringing to the fore new ways of organizing economic life beyond the traditional capitalist market model' (Rifkin 2014:132; Frayne 2015).

In pursuing the same line of argument, Jeremy Rifkin raises the ultimate question of what is the human race going to do with itself if mass employment disappears from economic life:

> 'What if the marginal cost of human labour in the production and distribution of goods and services were to plummet to near zero as intelligent technology substitutes for workers across every industry and professional and technical field, allowing businesses to conduct much of the commercial activity of civilization more intelligently, efficiently, and cheaply than with conventional workforces? That too is occurring as tens of millions of workers have already been replaced by intelligent technologies in industries and professional bodies around the world. What would humans do, and more importantly, how would it define its future on Earth, if mass and professional labour were to disappear from economic life over the course of the next two generations? That question is now being seriously raised for the first time in intellectual circles and public policy debates.' (Rifkin 2014:70)

This approach is different from the others in highlighting the end of work rather than the transformation of work, at least in the terms we have come to think about work as waged employment. The idea of digital disruption typically plays a central role in such accounts as it implies that the fundamental economic problem of material abundance, rather than material scarcity, has been solved by a revolution in productivity, facilitated by technological innovation no longer dependent on mass employment (Gorz 1999). This transforms the nature and purpose of education and skill formation, from an emphasis on employability skills to a more holistic view of life skills beyond standard models of employment and career development.

This section has distinguished three approaches with regards to skills, work and the digital economy: labour scarcity, job scarcity and the end of work. These approaches have different policy implications which mirror the current lack of consensus revealed in current research on automation and the future of work. Given this lack of consensus, it's important to examine the policy responses to 'digital disruption' in the South African sectors.

2.10. Conclusion

The primary benefit of technology is efficiency. In the future, will it ever be possible to be offline anymore? Cassidy (2016) and Mayhew (2016) postulate that South Africa's leaders need to urgently start a conversation around the moral and ethical issues raised by the current technological advances. The world of computers and information technology has become so important that it's highly doubtful that there will be a return to traditional methods of conducting business.

If SASSETA, in particular, is not prepared to adapt to a changing environment, its workers will be left behind. Should South Africa fail to capitalise on the opportunities of the 4IR, it will lead to the familiar blame game about who should have done what to prepare its workers, but didn't. Pierce & White and (2016) offer different social structures evolved to solve these different problems. These findings support the theory that our response to social situations is determined by an endogenous component, our evolved human nature, in combination with an exogenous component. While the endogenous component is a product of the evolutionary process and largely beyond the influence of management, the ecological component, the perception of the resource context can be affected by managerial action. Implications for researchers and managers, and areas for continued investigation are explored in findings of this report.

Part Three:
Methodology and Approach

3. Introduction.

A research design serves as a framework for collecting and analysing data and the choice of research design reflects the priority given by the researcher to a range of dimensions of the research process. In this case, the following aspects are relevant: Understanding behaviour and the meaning of that behaviour in its specific social context, and having a temporal appreciation of social phenomena and their interconnections; expressing connections between variables, and generalising to larger groups of individuals than those forming part of the investigation.

A research design is also a plan or blueprint of how research is conducted, and the type of study required to provide acceptable answers to the research problem or question. This study is not in the domain of developing new theory but is more about creating an understanding of the future to construct a strategic outlook. Whereas theory construction would imply findings that can be confirmed and generalised within certain boundaries, the intent of this specific study will be focused more on the construction of possibilities that could be argued on the ground of current trends and perspectives of the future. The knowledge and insights of a range of key experts in the field under focus, as well as authoritative secondary data, are typical sources of data for this study.

In this research, it primarily focused on tapping the views from a purposively selected group of experts and stakeholders by means of interviews and dialogue, in other words, qualitative data. A structured interview guide was developed and used, but questions were designed to elicit open-ended responses, and further freedom was allowed to experts to add additional information that they may have deemed relevant and important. The term purposeful sampling (or selection) is used mostly in exploratory research where the intention is, within reason, to access the best-known data sources given the purpose and subject matter of the study, which is somewhat unknown and novel to many.

The expert interview and stakeholders dialogue, in certain circles (split between the various arms: policing, Corrections, Defence, Justice, Intelligence Activities, Legal Services, as well as Private Security and Investigation Activities) was an accepted research methodology, although often viewed with scepticism by paradigmatic purists, which mostly have an interest in explaining or understanding existing phenomena.

At least 200 stakeholders participated in the process voluntarily. Meetings had been helping the provinces of Gauteng, Durban and Cape town between January and February 2020.
In this research, two forms of interview processes were suggested: interviews with individual experts, and focus group interviews where a broader set of knowledgeable people could provide their inputs. Whereas one-on-one interviews are best for individual views and reasoning, focus groups or dialogues were better for group reasoning and stimulation of further ideas, thus adding a supplementary angle.

Based on the above background, a qualitative research approach was deemed appropriate for this study. Quantitative tools were also be developed and sent to various selected individuals within the subsectors so as capture more views regarding the 4IR in the sector.

3.1. Research Design

The research approach choice is further influenced by the purpose and required outcomes of the study. The purpose of this diagnostic, impact and design study is to investigate the trends underpinning the fundamental change [associated with the 4th Industrial Revolution] expected to disrupt economic, social and politic systems at various levels of society, evaluate the impact of the change and to provide a scientific foundation for a response plan to ameliorate the negative and maximise the positive impacts.

Specifically:

i. Conduct an analysis to understand the impact of the 4IR on the changing nature of work
ii. Conduct research on the labour market for the identification of the skills needs implications (Labour Market analysis and skills needs implications in the 4IR)
iii. To identify the impact of the 4IR on the labour market (employment and unemployment)

In light of the above purpose of the research and the key questions, the social context for the research is the potential impact of the 4th Industrial Revolution on SASSETA in South Africa. Qualitative study is described as ideal for exploring the meaning and understanding of concepts as well as identifying the pervasiveness of phenomena and patterns of association (Babbie, 2010). Qualitative research is suitable when a researcher, through an iterative approach of induction and deduction, wants to understand concepts, especially those emerging over time, based on information about context and voices of participants. In deductive qualitative research, the application of current information directs the way in which observations and findings are made, while an inductive study reverses this connection to start with observations and findings from which constructs emerge through iterative weaving back and forth between data and theory.

3.2. Information and Data Analysis

The processing of qualitative and quantitative research data obtained from the sources used in this study adopted a pragmatic approach based on early and consistent coding during content analysis, as advocated by Bryman and Bell (2011). They argue that early coding assists the researcher to understand the available data, while also alleviating feelings of being swamped by data, which may happen when analysis of data is deferred to the end of the data collection period. Depending on, the understanding and availability of respondents, quantitative tools were determined by both parties. Analysis of the primary data from the respondents' interviews and focus groups commenced after the recorded interviews and dialogues are transcribed and subjected to the content analysis of the questions posed. The coding of the qualitative data from primary sources was largely based on the codes associated with a set of the key questions that were answered in this study.

3.3. Triangulation of qualitative research information

Triangulation means examining the research issue or phenomenon from more than one perspective to answer the research question(s). Triangulation also entails using more than one method or source of data in the study of social phenomena. The use of "between methods" triangulation is proposed by Quinlan (2011) to provide a more valid view of that phenomenon by using interviews, observations and focus groups. In this study, triangulation was done between expert interviews, stakeholder focus groups inputs and targeted literature reviews.

The trustworthiness features of the results from the study were also enhanced through data-integration workshops by the core research team where arguments and assumptions were challenged and synthesised conclusions evaluated for robustness. The core team also reviewed each other's work to ensure alignment and consistency.

3.4. Limitations

One major limitation was the duration of the project as it commenced quite late but was eventually done well. Evaluating impact often starts from the baseline. For this case, may stakeholders, apart from not being notified on time had very little knowledge of what the 4IR is all about. This was managed by dialogue and forums to get to them to understand what it was. Interestingly, many lacked simply the technical knowledge but had a significant understanding (idea) of what it was, although in the same instance very shallow.

The next section shares the findings from all the stakeholders who participated in the interviews and dialogues.

Part Four:
The Findings

4. Introduction

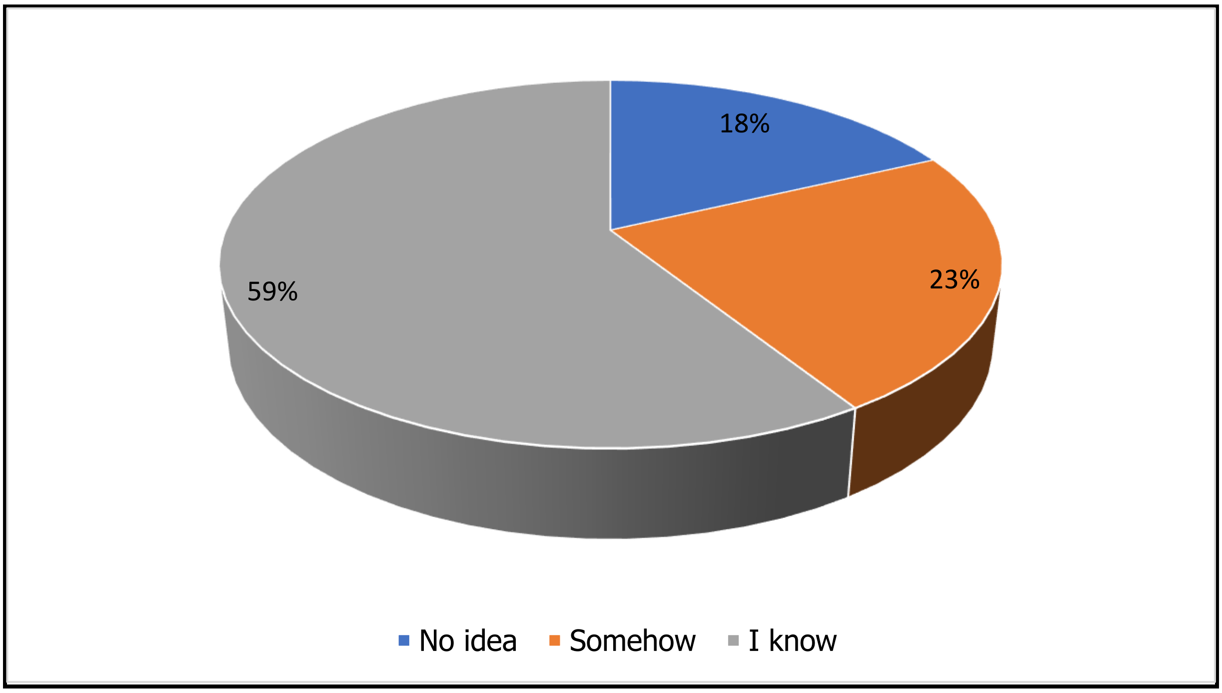
The findings of this report are presented within the framework of the scope and key research questions as specified in the research terms of reference as was classified in 3.1 of the methodology. Each of these themes is reported based on an integration of the views solicited from expert interviews and focus groups as well as the literature review.

4.1. Findings

i. Knowledge and Understanding of the Fourth Industrial Revolution (4IR)

Whereas there were very few exceptions regarding the understanding of the Fourth Industrial Revolution, 59% of responses stirs up various controversies and interpretations. There was no single-use of new concepts in language to defined by the definiteness of meaning and order. Accordingly, to the understanding of the Fourth Industrial Revolution and the order of its composition, triggers of controversies regarding the Fourth Industrial Revolution but provides some basis for estimating the definiteness of the meaning and order of the concept. Figure 4.1 is the representation of the clients' Knowledge and understanding of the 4IR.

Figure 4.1. Client Knowledge and understanding of the 4IR



According to the findings, 59% opined that the 4IR is dawned through the use of cyber-physical systems (CPSs), the Internet of Things (IoT), and services. Most responses point to the views that the 4IR cannot be understood and defined well, but it includes the following: smart factories, cyber-physical systems, self-organization, new systems in distribution and procurement, new systems in the development of products and services, adaptation to human needs, and corporate social responsibility.

Some also viewed the 4IR as the revolutionary change that occurs when IT proliferates in all industries, that is, the primary, secondary, and tertiary industries. In other words, it is a result of the horizontal expansion of IT. Therefore, the understanding of the features of 4IR is the creative connection between technology and the market in all industries based on IT, that is, the creative and open combination of technology and the market through open innovation, or growth based on the open business model.

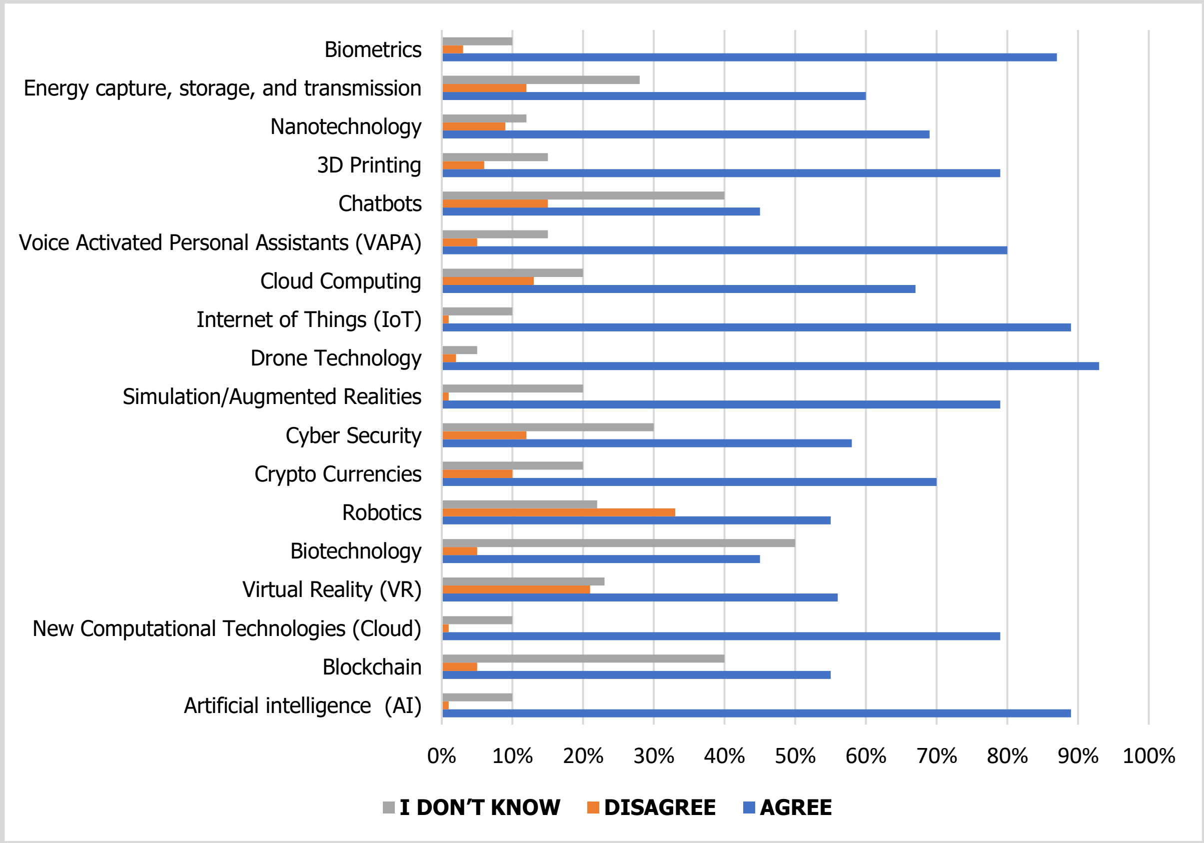
It can then be concluded that while was some shallow expressions regarding the understanding of the Fourth Industrial Revolution, it is one of the global megatrends that is shaping the industrial, academic and policy debates around the evolving new forms of industrial production that are influenced by various emerging technologies

ii. The emerging technologies that will be inactive use within the South African Safety and Security space soon

It appears from the responses that South Africa has been investing in emerging research areas such as robotics, artificial intelligence, nanotechnology, biotechnology and advanced manufacturing. Several of these emerging technologies are likely to map different strategies and technology roadmaps guide governments and any institutional investment in these multiple emerging technologies that are associated with Industry 4.0.

Figure 4 below is a summary of responses related to emerging technologies that may affect SASSETA in the nearest future.

Figure 4.2 Emerging technologies



iii. The negative/adverse effect(s) of the Fourth Industrial Revolution on the safety and security sector in South Africa.

Literature about the 4IR agrees to how it is changing how we live, work, and communicate. It's reshaping government, education, healthcare, and commerce almost every aspect of life.
In the future, it can also change the things people value and the way they value them. It can change relationships, opportunities, and identities as it changes the physical and virtual worlds that society inhabit and even lifestyles. Within this view, the respondents mention the following as key elements through which the 4IR would adversely affect the safety and security sector in South Africa;

- Increased unemployment and loss of jobs as people may not have or acquire new skills quickly enough adopt, as well as an increase in redundant skills and Retrenchment,
- Overreliance on imported cheap technology system,
- The exploitation of the working conditions as in many countries,
- Redundancy will more possibility broaden broader-based inclusive crime fuelled by technological growth,
- Obsolete jobs would enhance the mechanism for individuals to destroy the safety and security industry,
- The poor infrastructure to adapt and accommodate change due to technology,
- Cybercrime and personal information hacking,
- The high cost of production, loss of income

- The violation of access to personal information,
- More dependency on artificial intelligence, i.e. increasing security inequalities as the rich can afford private security at the expense of the poor

However, while the 4IR has the power to change the world positively, and that societies have to be aware that the technologies can have negative results if they don't think about how they can change us. It was clear that institutions have to build what they value selectively. This means for a need to remember institutional values as they're building with these new technologies. For example, if SASSETA was to value security over safety in time, it can build technologies that ensure more security at the expense of safety. In turn, these technologies can create incentives that make it harder to change that underlying value. Findings also show that people have a deep relationship with technologies as it how they create their own world and have to develop them with care. More than ever, it's important that all begins right.

iv. The impact (benefits/opportunities) of the Fourth Industrial Revolution on the safety and security sector in South Africa

Current thinking had identified that new technologies can be powerful agents for good. It revealed that education and access to information can improve the lives of billions of people. Through increasingly powerful computing devices and networks, digital services, and mobile devices, this can become a reality for people around the world, including those in underdeveloped countries.

The social media revolution embodied by Facebook, Twitter, and Tencent has given everyone a voice and a way to communicate instantly across the planet. Today, more than 30% of the people in the world use social media services to communicate and stay on top of world events. These innovations can create a truly global village, bringing billions of more people into the global economy. They can bring access to products and services to entirely new markets. They can give people opportunities to learn and earn in new ways, and they can give people new identities as they see the potential for themselves that wasn't previously available.

For the findings, respondents pointed to the following aspects that would be potential benefits of the 4IR;

- More automation means efficiency, technology enhances safety and security if used effectively and efficiently (time-saving vs cost savings)
- As current skills become irrelevant new skills will be improved,
- Empowering individuals and small companies to perform as even better and faster,
- Improve the communication in and out of the country,
- Increase the scope of SETA activities,
- It will help to detect deter and monitor crime trends leading to improve crime intelligence, simplify difficult tasks, business opportunities for technology developers,
- Improve livelihoods and communication,
- Quick and swift actioning for example using drone technologies,
- Easy control of safety devices through streamlining operations reporting and organization

structures,

- Contactless transactions, effortless clearings, and overall improvement improve management,
- A shift to information-based intelligence security would result into higher conviction rate due to improved intelligence,
- Integrated security processes and less security breaches
- Improved security by means of artificial intelligence and biometrics,
- Data security, building sustainable communities,
- It's an opportunity for security personnel to upgrade themselves through training opportunities for youth and women community safety and security organizations,
- Improve the efficiency and accuracy in workforce due to faster service, time-saving and convenience, less workload, less people needed, the potential rising incomes of people and quality of life

> *"The Fourth Industrial Revolution, finally, will change not only what we do but also who we are. It will affect our identity and all the issues associated with it: our sense of privacy, our notions of ownership, our consumption patterns, the time we devote to work and leisure, and how we develop our careers, cultivate our skills, meet people, and nurture relationships." —Klaus Schwab, The Fourth Industrial Revolution*

i. The effect of 4IR on the future of work in South Africa's safety and security sector

In terms of the future of work, respondents opined that workers with less education and fewer skills are at a disadvantage as the Fourth Industrial Revolution progresses. SASSETA and governments may need to adapt to the changing nature of work by focusing on training people for the jobs of tomorrow. Talent development, lifelong learning, and career reinvention are going to be critical to the future workforce. However, the key highlights from the data were:

- There is likely to be an improvement in productivity and processes as they become simple, quicker and safer
- It will surely replace the huge number of underemployed bodyguards through the use of technology
- Unemployment will increase as machines will be replacing human beings
- Digitalization of process would render many workers redundant
- Data will create more opportunities for safety and security
- It would influence policy in education and training
- Automation of mundane tasks will increase electronic security and backup

All these are in line with the literature where there is mention of Artificial intelligence which is unleashing a whole new level of productivity and augmenting lives in many ways. As in past industrial revolutions, it can also be a disruptive force, dislocating people from jobs and surfacing questions about the relationship between humans and machines.

It's inevitable that jobs are going to be impacted as artificial intelligence automates a variety of tasks. However, just as the Internet did 20 years ago, the artificial intelligence revolution is going to transform many jobs and spawn new kinds of jobs that drive economic growth. Workers can spend more time on creative, collaborative, and complex problem-solving tasks that machine automation isn't well suited to handle.

ii. The skills to reduce vulnerability and maximally benefit from the Fourth Industrial Revolution

While many of today's occupations will still exist in the future, the report observes form the findings that they will indefinitely transform, and in many cases, occupational categories will overlap with one another to form new roles. This is already happening and the rate at which it is occurring is expected to accelerate over time. For the SASSETA, participants mentioned that it's not to say that AI and automation will necessarily replace most jobs, but rather, will require people to adapt and learn how to use this technology to enhance existing processes. These roles will be focused on skills such as monitoring and operating automated and online processes in conjunction with their existing roles and responsibilities.

Some sentiments were that what is certain is that the new generation will become increasingly diverse and analytical in their way of thinking. They will continuously adopt new skills and be more adaptable to frequent changes in the workplace and in their roles, as new job roles start to open up and certain skills become obsolete.
In summary, the following had been identified as critical skills to adapt to the demands of the 4IR:

TECHNICAL SKILLS
- Cyber skills,
- Basic computer skills
- Information technology skills,
- Coding and programming
- Numerical skills,
- Data security skills,
- Data analysis skills

SOFT SKILLS
- Adaptability
- Communication
- Creativity
- Cross-cultural communication and conflict management
- Emotional intelligence
- Flexibility
- Innovation
- Interpersonal skills
- Leadership
- Networking skills
- Problem solving
- Resourcefulness
- Social and emotional
- Teamwork, working together more efficiently and effectively
- Willingness to learn new things

The findings are almost in line with World Economic Forum report, The Future of Jobs (2018) where the 10 skills that shall be needed for the Fourth Industrial Revolution namely: Complex Problem Solving; Critical Thinking; Creativity; People Management; Coordinating with Others; Emotional Intelligence; Judgement and Decision Making; Service Orientation; Negotiation and; Cognitive Flexibility

iii. Support systems towards understanding and adoption of new technologies in South Africa's safety and security sector?

For South Africa, one of the major driving forces for the success of the industrial revolution could be referred to the dedicated governmental organizations and responsibilities. Governmental policy is critical to facilitate an eco-innovation system and effective industrial clusters, while the following directions are the response to the adoption of new technologies in South Africa's safety and security sector from the participants:

- Upgrading industry integrations of research & development, design thinking, service, marketing, and manufacturing for higher added values
- Strengthening the linkages between academia-industry and collaborations for industrial development
- Improving the smart industrial supply chain ecosystem
- Facilitating start-up businesses through various platforms
- Enhancing the development of self-sustainable products and services
- Enhancing the professional competency of critical technologies
- Establishment of government-led standards and common infrastructure for technology development
- Technological and vocational training and talent development systems, including design and business development competency
- Public policy, funding, incubation, accelerator, and tax benefit systems
- Structural policy initiatives and incentives to ensure appropriate resources and employment can be supportive of talent development
- DHET and stakeholders to increase, collaborations, research and information dissemination regarding the 4IR
- There should be increased initiatives towards legal understanding
- Promote training on the 4IR within the sector
- Cooperate and work clauses closely with the private security sector stakeholders in order to achieve be focused on a common set of attainable goals
- SASSETA to take a leadership role as a seta
- Establish memoranda of understanding with various sectors that have technical advantage or ETQAs that are involved with industry specializing in the field
- Introduce new ways new technology that will make work for this sector better accordingly
- Avail finances for education and training throughout all the stakeholders
- Lessen bureaucracy and improve decision-making
- Improves specialized practical training at various levels of security sectors

  Efforts to benchmark to other developed countries in terms of safety and security and take lessons from them
- Strategic planning to accommodate the 4 Industrial Revolution beginning with systems

and people

- Proper IT project management and change management solutions
- Implemented the policy and for up for all providers to start working on the 4IR
- Education institutions to embrace technology especially colleges and universities so as to produce graduates with the required IT skills

Educational institutions should also create mechanisms to reinvestigate the teaching and learning objectives of courses designed in schools and highlight technological changes and their effects on industrial applications and life. Technology can help to facilitate the effectiveness of teaching and learning in many ways, such as e-learning systems, enabling the sharing of knowledge, best practices, classroom experiences, and cross-disciplinary learning between diverse geographies.

For technical and vocational training systems, the private sector could help to organize work-based learning for students and promote careers through public campaigns, vocational tracks in education, and investment in technical and vocational training systems.

Part Five:
Conclusions and Recommendations

5. Introduction

The reviewed literature, as well as responses from the stakeholders, have given rise to a stimulating and certainly relevant debate given that it addresses pressing safety and security issues that are central to the future of SASSESTA, Safety and Security, employment, economic development, income distribution, and individual wellbeing, across the Country. Some main points can be extracted from this review.

5.1. Conclusions

The findings conclude that the definition and understanding of the 4IR are as follows; Second IT revolution: Major technological disruptions with digitalization: Digital age with internet of Things or Industrial Internet: IoT revolution: Innovation based on Combinations: Emergence of Disruptive New Combination: Self-organization and Self-actualization: Super Disruptive Innovation: New industrial Revolution with IoT, Big Data, AI and BlockChain: Manufacturing Innovation 3.0: The broad Changes in Industries as well as Society.

The second observation relating to the ways to respond to the 4IR in terms of institutions are the following. The fluidity of capital must be improved, and the entrepreneurial role of the state must be significantly strengthened. Economic policy and innovation policy need an open design. Let us make organizations more creative and resilient. The continuity in change: Dedicated governmental organizations and responsibilities: Disruptive Emergence and Flexible Focusing: Transforming time, space and human in real-world: New expansion should be encouraged in human labour resources. Trust between science and the public should be secured first. Government and civil society should collaborate and design together. A strategic plan should be designed through the cooperation of universities and firms.

The other ways to respond to the Fourth Industrial Revolution in terms of Technology are the following. Cyber-physical systems (CPS): Combinational technologies: Adopting a design thinking methodology: The practical knowledge: Artificial Intelligence, and Robotics: Not losing flexibility technology: Most technologies become commodity or sharing resource: Diminishing the boundaries among technologies: The fusion of virtual space and actual space: Smart factor, autonomous machines, 3-D printing: Adopting open innovation activities as well as training people in soft skills like communication, emotional intelligence, leadership, change management to mention a few.

The success of the 4th industrial revolution will depend on SASSETA leadership and from all stakeholders working together to leverage the opportunities and address the challenges of the 4IR. Such leadership, for example, is responsible for developing and implementing an enabling environment for digital transformation and innovation. It is also responsible for leading think tanks and the much-needed innovation in the 4IR of its strategic spheres of work. Leadership also play an important role in preparing society for the changes brought by the 4IR. Political leadership in South Africa has already recognized the 4IR and its potential to address the countries triple challenges of poverty, unemployment, and inequality.

Within SASSETA structures, the development of policies and strategies addressing digital transformation should be a sign of commitment from leadership. The implementation of reforms, however, remains a challenge as witnessed by poor understanding of 4IR by its stakeholders. The commitment of some stakeholders especially the private security to work with the SASSETA appears to be questionable as witnessed by an increase in resistance to some policy reforms that the business sector perceives is not serving their interests. The process of developing policy in this area is largely seen as an issue for employers and government, as they respond to the forces of technological change. However, the introduction of technology is a social and economic process with actors playing an important role in shaping whether and how technological change takes place and with what consequences.

Collaboration between the various actors in the 4IR is critical in ensuring its success which will not only disrupt business but SASSESTA, its key partners and the society. The development of policies and strategies that are responsive to the priorities of NSDP will require that SASSETA works with business and social partners in addressing some of the challenges and leveraging the opportunities brought by the 4IR. For example, the challenges of projected job losses in unskilled job categories due to the introduction of AI or robotics in advanced security will require that SASSETA, business, workers and labour unions collaborate in coming up with strategies to mitigate the risk of massive job loses that will further deepen unemployment, poverty, and inequalities. For collaboration to happen, trusting relations and cohesion are critical. The current social, political and economic environment has created mistrust and weakened cohesion. Self-interest behaviour and corruption in the development and implementation of policy reforms have been observed in South Africa.

The 4IR requires SASSETA to rise to the challenges brought by their sociohistorical, socio-economic and economic contexts. SASSETA need to develop models or strategies that are responsive and relevant to its context instead of blindly adopting so-called "exemplary models" that have worked in contexts that are different from the other sectors adopting them. There is also a greater need to develop strategies that bring safety and security benefits instead of focusing primarily on economic prospects brought by the 4IR. Strategies should also look into innovative ways of addressing socio-economic challenges such as potential job loses, widening wage gaps and skills redundancy. In demonstrating the benefits of the 4th industrial revolution, the SASSETA should also explain how change and social innovations in industry 4.0 can address some of society's challenges and improve the quality of life and social well-being of citizens.

Literature has shown that there is little evidence that research on AI and automation, such as claims of large numbers of jobs at risk, is being used to ignite a wider agenda about the human capital bargain based on 'learning equals earning'. The job scarcity and end of work approaches both views a significant mismatch due to inadequate demand for skilled labour. They also point to the limits of the labour market to resolve distributional issues concerning who does what and gets what. Therefore, issues of (re)distribution are conspicuous in their absence, given the growing interest in basic income initiatives in recognition that the future of work will not result in shared prosperity, but depends on significant institutional reform beyond education and training systems (Haldane, 2018).

While there is always a place for predictions about future scenarios, their use is limited given the complex relationship between technology, employment and skills. The pace and shape of technological change are subject to a whole variety of factors from economic incentives to the social, ethical and regulatory aspects, as well as the different power relations within organisations among different groups (professionals, trade unions, managers), and broader societal relationships.

5.2. Key Recommendations

Clearly, the 4IR presents significant opportunities as well as challenges for SASSETA and the country at large. The key issue for SASSETA is how to position their economies to benefit from the 4IR while managing the challenges that it presents. Below are three strategies that stakeholder felt should be prioritized.

i. Fixing the labour-skills mismatch in advance

Since creating jobs for the burgeoning youth population is a priority the South African government, SASSETA should be reluctant to support technologies that threaten existing jobs. Some of the current technologies tend to replace low-skilled workers of which South Africa has an abundance with higher-skilled workers, constraining participation in the 4IR to sectors with relevant skills. South African and SASSETA must invest in education and reskilling programmes to ensure that technology supplements, instead of replaces, labour.

ii. Enhancing agile governance for secure, effective management of the 4IR and integration into national and global value chains

As innovation is at the heart of the 4IR, reinforcing state and institutional capacity to drive and support innovation and create an enabling business environment is essential for success. A major regulatory challenge involves increasing cybersecurity. SASSETA appears to lack a comprehensive legal framework and institutional capacity to address challenges of the 4IR. Just as an example, instead, efforts to prevent cybercrime are implemented by private sector actors themselves. I.e, between 2017 and 2018, there was a 73 per cent increase in Information Security Management System-certified companies, from 129 in 2015 to 324 in 2018, with a significant increase (59%) in the number of ISO/IEC 27001 certifications between 2009 and 2017.

Adopting widely accepted and appropriate norms and regulations, such as these, is the first step to increasing 4IR. At the same time, SASSETA should invest in its employees and key stakeholders to develop skills and integrate safety and security in their decision-making process.

The development of the National Integrated ICT Policy White Paper shelters an integrated policy framework that spans various government portfolios would be beneficial in bringing about policy certainty and providing the cohesion of national efforts to bring about a digital evolution. It offers a unique opportunity for SASSETA to enhance initiatives around the 4IR. With aligned policies and procedures, many role players can adapt to the rapid changes of the 4IR and leverage it to accelerate participation in national and global value chains.

iii. Developing physical and digital infrastructure

Access to advanced technology in South Africa is constrained by infrastructure parameters such as lack of electricity and low tele density, internet density, and broadband penetration. As a result, mobile phone and internet use remains low. Other technological bottlenecks include a lack of standardized application programming interfaces and common data languages for the increased integration of largely self-sufficient systems as well as exposure to the dangers of cyberattacks. Accelerating the physical connectivity of fibre-optic networks as well as the interoperability of virtual platforms is critical not only for upgrading technology but also for reaching and lowering unit costs for the underserved.

More broadly, adequate infrastructure development will drive and sustain economic transformation in South Africa. Closing the internet connectivity and access gap with advanced economies will enable more African countries to enter service markets. SASSETA may become more competitive with access to digital platforms for research, investigations, protection and convictions.

To make the most of the 4IR, SASSETA and stakeholders need to recognize new niches for industry and leverage them to achieve safety and security and take decisive steps to close the gaps in digital skills, infrastructure, and research and development.

5.3. Closing remarks

Predictions about the future development of 4IR are, however, as self-assured as they are diverse, and whether value can be extracted from the breadth and diversity of predictions is questioned. Expert judgement, in theory, and in practice, and timeline predictions prove to be mostly unreliable, generally containing little useful information.

Considering these evident challenges and opportunities inherent to 4IR, Schwab (2019) calls for the mobilisation of the collective wisdom of people's minds, hearts and souls to adapt, shape and harness the potential of disruption. It is therefore conceivable that 4IR sets an important agenda for leaders in public and private sectors, academia and civil society, and the urgency of the matter is apparent on the micro-, mezzo- and macro domains (component parts of a general evolutionary analysis of coordination and change

Appendix

Acronyms in the 4IR

The following descriptions are provided as background and are not intended to be exhaustive.

- **3D printing**. Additive manufacturing techniques used to create three-dimensional objects based on "printing" successive layers of materials.

- **Advanced Materials** (including nanomaterials). A set of nanotechnologies and other material science technologies, which can produce materials with significantly improved or completely new functionality, including lighter weight, stronger, more conductive materials, higher electrical storage (e.g. nanomaterials, biological materials or hybrids).

- **Artificial intelligence.** Computer science learning algorithms capable of performing tasks that normally require human intelligence and beyond (e.g. visual perception, speech recognition and decision-making). They also include:

  - **Automation:** Programming a system or process to function automatically, such as Robotic process automation (RPA) using software with AI and machine learning capabilities to handle high-volume, repeatable tasks that previously required humans to perform.
  - **Machine learning:** The science of getting a computer to act without programming, or "the scientific study of the algorithms and statistical models that computer systems use to effectively perform a specific task or program without using direct instructions, relying on models and inference instead." **Deep learning** is a subset of machine learning that, in very simple terms, can be thought of as the automation of predictive analytics, or "an application of AI that helps create these 'thinking machines' by providing systems with the ability to automatically learn and improve from experience without being explicitly programmed."
  - **Machine vision:** The science of allowing computers to see, where visual information is captured and analysed, using a camera, analogue-to-digital conversion and digital signal processing. Not bound by biology, machine vision can be programmed, for instance, to see through walls, and is used in a range of applications from signature identification to medical image analysis.
  - **Natural language processing (NLP):** The processing of human language by a computer programme. One of the older and best-known examples of NLP is e-mail spam detection, while current approaches to NLP are based on machine learning with tasks including text translation, sentiment analysis and speech recognition.
  - **AR –** Augmented Reality combines real and virtual worlds, real-time interaction, and accurate 3D registration of virtual and real objects, in an interactive experience that sometimes combines sensory modalities, including visual, auditory, haptic, somatosensory and olfactory.

- **Robotics.** Electro-mechanical, biological and hybrid machines enabled by AI that automate, augment or assist human activities, autonomously or according to set instructions.
- **Drones & autonomous vehicles.** Enabled by robots, autonomous vehicles can operate and navigate with little or no human control. Drones fly or move in water without a pilot and can operate autonomously or be controlled remotely.

❖ **Biotechnologies**. Encompassing bioengineering, biomedical engineering, genomics, gene editing, and proteomics, biomimicry, and synthetic biology this technology set has applications in areas like energy, material, chemical, pharmaceutical, agricultural and medical industries.

❖ **Energy capture, storage, and transmission**. New energy technologies range from advanced battery technologies through to intelligent virtual grids, organic solar cells, spray-on solar, liquid biofuels for electricity generation and transport, and nuclear fusion.

❖ **Blockchain** (and distributed ledger). Distributed electronic ledger that uses cryptographic software algorithms to record and confirm immutable transactions and/or assets with reliability and anonymity. It has no central authority and allows for automated contracts that relate to those assets and transactions (smart contracts).

❖ **Geo-engineering.** Large-scale, deliberate interventions in the Earth's natural systems to, for example, shift rainfall patterns, create artificial sunshine or alter biospheres.

❖ **Internet of things.** A network of advanced sensors and actuators in land, air, oceans and space embedded with software, network connectivity and computer capability, which can collect and exchange data over the internet and enable automated solutions to multiple problem sets.

❖ **Neurotechnologies.** Technologies that enable humans to influence consciousness and thought through decoding what they are thinking in fine levels of detail through new chemicals that influence brains for enhanced functionality and enable interaction with the world in new ways.

❖ **New computing technologies**. This includes technologies such as quantum computing, DNA-based solid-state hard drives and the combining of Third Industrial Revolution technologies (e.g. big data, cloud) with the other technologies (e.g. IoT, advanced sensor platforms). Quantum computers make direct use of quantum-mechanical phenomena such as entanglement to perform large-scale computation of a class of currently impossible tasks by traditional computing approaches.

❖ **Advanced sensor platforms** (including satellites). Advanced fixed and mobile physical, chemical and biological sensors for direct and indirect (remote sensing) of myriad environmental, natural resource and biological asset variables from fixed locations or in autonomous or semi-autonomous vehicles in land, machines, air, oceans and space.

❖ **Virtual, augmented and mixed reality.** Computer-generated simulation of a three-dimensional space overlaid to the physical world (AR) or a complete environment (VR).

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