Responding to the challenges and opportunities in the 4th Industrial revolution in developing countries

Conference Paper · April 2019

DOI: 10.1145/3326365.3326398

CITATIONS
53

READS
1,109

2 authors:

More Ickson Manda
University of the Witwatersrand
9 PUBLICATIONS **125** CITATIONS

SEE PROFILE

Soumaya Ben Dhaou, PhD
United Nations University (UNU)
23 PUBLICATIONS **119** CITATIONS

SEE PROFILE

Responding to the challenges and opportunities in the 4th Industrial revolution in developing countries

More Ickson Manda
University of the Witwatersrand and
Manufacturing, Engineering and Related Services Sector
Education and Training Authority
South Africa
moreikson@gmail.com

Soumaya Ben Dhaou
United Nations University (UNU-EGOV)
Rua de Vila Flor 166
4810-445 Guimaraes,
Portugal
bendhaou@unu.edu

ABSTRACT

The advent of the 4th industrial revolution promises significant social and economic opportunities and challenges which demand that governments respond appropriately in supporting the transformation of the society. The purpose of this study is to understand the challenges confronting developing countries in the adoption of digital transformation agendas to leverage the social and economic benefits of the digital-driven industrial revolution 4.0. The research is based on an interpretive case study that uses documents evidence and a review of the literature as its primary method of collecting data. South Africa is used as a single case study of a developing country that has embraced digital transformation as a critical strategy in inclusive growth.

CCS CONCEPTS

• **Applied computing** → **Computers in other domains** → Computing in government → *E-government*

KEYWORDS

Socio-technical, 4th industrial revolution, smart society, digital transformation

ACM Reference format:

M. Ickson Manda, S. Ben Dhaou. 2019. Responding to the challenges and opportunities in the 4th Industrial revolution in developing countries. In *Proceedings of the 12th International Conference on Theory and Practice of Electronic Governance (ICEGOV2019), Melbourne, VIC, Australia, April 3-5, 2019*, 10 pages. https://doi.org/10.1145/3326365.3326398

1. INTRODUCTION AND BACKGROUND

The advent of the 4th industrial revolution also known as Industry 4.0 has brought with it significant social and economic opportunities and challenges which require that governments respond appropriately (Manda & Backhouse, 2017). This industrial revolution is characterized by a fusion of technologies that is "blurring the lines between the physical, digital, and biological spheres" (Schwab, 2016:1). It is set to disrupt society, business, and government through its innovations. This revolution creates new opportunities; developing countries can leapfrog stages of development and align with developed markets by embracing the use of emerging technologies such as Artificial Intelligence (AI), big data analytics and blockchain. Various governments are taking advantage of this digital-driven industrial revolution to improve their social and economic inclusion through a transformation towards a smart society. The failure of the developing country governments to embrace the digital-driven 4th industrial revolution may result in being left behind. The United Nations has also acknowledged the power of technology, and the 4th industrial revolution recognizes technology in achieving the Sustainable Development Goals adopted in 2015 by member states.

The purpose of this study is to understand the opportunities and challenges confronting developing countries in the adoption of digital transformation agendas for leveraging the social and economic benefits of the digital-driven 4th industrial revolution. For this purpose, the following question is raised:

What challenges are developing countries such as South Africa likely to face in promoting the adoption of a digital transformation agenda in support of inclusive growth?

To address this question, a secondary data based case study on South Africa is realized. The case study illustrates the opportunities and challenges of the 4th Industrial Revolution in the South and explains what strategies has the South African government put in place to promote digital transformation?

The rest of the text is organized as follow: The first section reports a literature review and the theoretical framework, the second section describes the methodology, the third section

ICEGOV2019, April 3–5, 2019, Melbourne, VIC, Australia
© 2019 Association for Computing Machinery.
ACM ISBN 978-1-4503-6644-1/19/04…$15.00
https://doi.org/10.1145/3326365.3326398

presents South African case study, and this paper terminates with a discussion and conclusion.

2. LITTERATURE REVIEW AND THEORETICAL FRAMING

The 4th industrial revolution is characterized by future industry development trends to achieve more intelligent manufacturing processes, including reliance and construction of Cyber-Physical Systems, and the implementation and operation of smart industries that use advanced techniques and technologies (Schwab, 2016; Zhou, Liu & Zhou, 2016). The rapid adoption of new and emerging technologies such as the Internet of Things (IoT) and the Internet of Services (IOS) has given rise to the 4th industrial revolution. The 4th industrial revolution has been adopted in many countries who have labeled it "smart industry", "advanced manufacturing" or the "Industrial Internet of Things" or "Industrie 4.0" (European Parliament, 2015). Most of the literature is focusing on the technological aspect. However, the adoption and the implementation of most of the emerging technology in the society and its promotion revealed a more important complexity including different elements beyond the technology such as social, legal, institutional. This multidimensional complexity requires an adequate theoretical framework.

2.1. The theoretical framework

The socio-technical perspective gained popularity in organizational studies during the labor movements in the 1960 s and 70s (Trist, 1981) and more recently in information systems research due to the realization of the role of social and behavioral influence in information systems success (Saywer & Jarrahi, 2014). The adoption of the socio-technical perspective in information systems research is also based on the fact that the failure of technology is as a result of overlooking the importance of the behavioral and social elements in the design or implementation of new technologies (Bostrom & Heinen, 1977). Moreover, "research in the information systems field examines more than just the technological system, or just the social system, or even the two side by side. It investigates the phenomena that emerge when the two interact" (Lee, 2001: iii). The focus is on heterogeneous networks of institutions, people and technological artifacts that, together play roles in the design, development, deployment, take-up, and uses of any particular information system (Kling, McKim & King 2003).

In e-government field, the socio-technical perspective increased as well, due to the realization that, the adoption of technology in government is affected by complexity of social, organizational, technical, policy, political and other factors (Pardo, Nam & Burke, 2012). An understanding of the social, technical and organizational issues in the conceptualization, design, deployment of technology solutions in government is thus critical in the success of e-government initiatives.

The socio-technical perspective assumes that an organization can be described as a socio-technical system comprising of a working system which is made up of two jointly independent, but correlative interacting systems, the social and the technical that work in synergy (Kast & Rosenzweig, 1972; Bostrom & Heinen, 1977). The technical system is concerned with "the processes, tasks, and technology needed to transform inputs into outputs. The social system is concerned with the attributes of people (e.g., attitudes, skills, and values), the relationships among people, reward systems, and authority structures" (Bostrom & Heinen, 1977:17). It is assumed that the outputs of the work system are the result of mutual interactions between these two systems. Technical, organizational and social aspects of the system thus need to be configured in building successful information systems (Bostrom & Heinen 1977).

This study adopts the socio-technical perspective as its primary focus to understand how successful adoption of digital transformation agendas can be affected by the socio-economic, socio-political and socio-historic context. In the 4th industrial revolution, the human (social) and technology (technical) dimensions are being brought together which has resulted in the increased interaction and interconnectedness of man and machines. The successful transformation, therefore, requires an understanding of social and technical systems and the environment in which they operate in the smart society. Implications of the digital-driven revolution could be reasonably understood by assessing the implications of digital transformation on skills, jobs, work systems, and broader society. Moreover, the influence of the environment, e.g., prevailing economic condition, labor market, and the regulatory framework need to be understood to better prepare governments and their citizenry for digital transformation.

Figure 1 is an illustration of the socio-technical perspective by Bostrom and Heinen (1977). The illustration highlights the relationship between technical and social sub-system and how they interact.

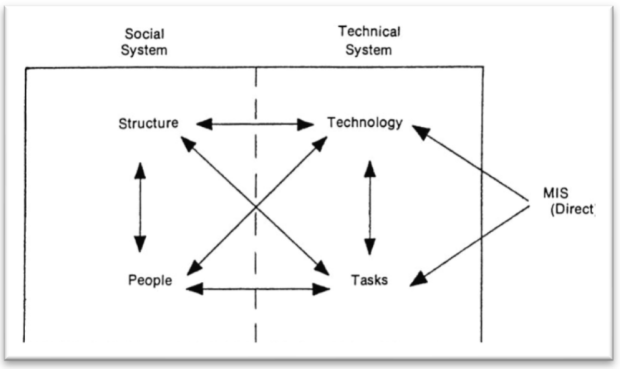

Figure 1: Socio-technical perspective, Bostrom and Heinen (1977: 25)

In this study, the focus is on how changes in the technical subsystem (mainly technology) influence structural changes in the social sub-system as well as its impact on the broader society. I also explore how the external environment plays a role in shaping the successful transformation of social subsystems in response to technology changes. The purpose of the social system

in influencing the transformation of the technical system is also examined. This is reviewed in the context of institutional transformation influenced by the changes in the social and technical sub-systems.

2.2. Drivers of the 4th industrial revolution

The successful adoption of the 4th industrial revolution will rely on the ability of governments, business and citizens to commit in supporting the transformation of society into a modern and smart society driven by advanced technology, skills, innovation and responsive policy. Below are some of the key drivers of the 4th industrial revolution identified from a review of literature.

2.2.1. Information and Communication infrastructure and emerging technologies

Technology is one of the critical drivers of the 4th industrial revolution. Technologies such as cloud computing, the internet of things (development of smart products), the internet of services (smart mobility and smart logistics) and internet of energy (efficient use of natural resources) has assumed an important role (Lom, Pribyl & Svitek, 2016). Telecommunication technologies and infrastructure such as broadband and other internet technologies provide digital connectivity for effective communication, collaboration and integration of people, systems and machines (European Commission, 2016). Reiterating the importance of reliable telecommunications infrastructure, Zhou and Zhou (2015:2148) wrote "industry 4.0 requires the establishment of a comprehensive and reliable industrial broadband infrastructure. Industry 4.0 enforces strict criteria on communication networks, and its communication networks must meet these criteria and be reliable, comprehensive and of high quality".

The integration and interoperability of cyber-physical systems are critical for enhancing communication and collaboration between man and machines in the 4th industrial revolution (Lom, Pribyl & Svitek, 2016). The integration and interoperability of systems internally (vertical integration) and across (horizontal) is a complex process that requires the standardization of systems and building a reference architecture (Zhou & Zhou, 2015).

At the heart of the 4th industrial revolution are cyber-physical systems that control and monitoring systems, processes, use advanced ICTs such as robotics, sensors and advanced manufacturing techniques such as additive manufacturing (European Parliament, 2015). Cyber-Physical Systems also play an important role in integrating the real physical world with the virtual world for future development (Zhou & Zhou, 2015).

The use of big data for increasing efficiency and decision making is a key feature of the 4th industrial revolution. Data analytics are an important technology for gaining more insights from the data so as better understand customer preferences, changing market conditions, trends and for enhancing production efficiency (World Economic Forum, 2016).

2.2.2. Education and training

The 4th industrial revolution is projected to bring disruptive changes to the labor market. Demand for highly skilled labor is projected to increase. The digital transformation and innovations in the 4th industrial revolution demand a new breed of worker, one that is skilled, innovative and technological savvy (Manda & Backhouse, 2017). This has led to a call for the need to focus on developing the so-called "future skills," some which don't exist. According to the World Economic Forum (20016:3), the " ability to anticipate and prepare for future skills requirements, job content and the aggregate effect on employment is increasingly critical for businesses, governments and individuals in order to fully seize the opportunities presented by these trends and to mitigate undesirable outcomes".

There are fears that technology will displace humans through automation in the 4th industrial revolution (Dregger, Niehaus, Ittermann, Hirsch-Kreinsen & ten Hompel, 2016). The 4th industrial revolution, however, brings new challenges and opportunities that require human intelligence and skills. Schwab (2016) asserts that "the 4th industrial revolution may indeed have the potential to 'robotise' humanity and thus deprive us of our heart and soul. But as a complement to the best of human nature, creativity, empathy and stewardship-it can also lift humanity into a collective and moral consciousness based on a shared sense of destiny". In the 4th industrial revolution, "only one type of organization will thrive a human one" (World Economic Forum, 2016:1). Creative working processes such as strategic planning, research, and development, for example, will have heightened demand for the skills needed to identify, conceptualize and implement new and innovative business opportunities presented by industry 4.0 (Deloitte, 2016).

2.2.3. Innovation

The 4th industrial revolution will demand the production of innovative products, business models and production techniques driven by technology. This calls for the need to invest more in research and development. Research and development would thus become increasingly important as a driver of innovation in the 4th industrial revolution. In Switzerland, a survey of the impact of the 4th industrial revolution in manufacturing companies by Deloitte (2016), found that an estimated 78% of the surveyed companies ranked research and development as a critical component of the 4th industrial revolution. A study by Mckinsey global institute also concluded that South Africa's growth into a globally competitive hub required the sector to increase its innovation capability (Mckinsey, 2015).

With an increasing emphasis on sustainability and inclusive growth, strategies should ensure that the returns from digital transformation should benefit society or address human and developmental challenges (Buhr, 2016). This is especially important in developing countries that are confronted by a myriad of human and social challenges that require governments to come up with innovative ways of addressing them.

2.2.4. *Policy innovation*

Innovative policy and legislative reforms are important for supporting digital transformation. They allow governments to put in place measures and resources in response to the challenges and opportunities brought by the digital ear (Dawes, Cresswell & Pardo, 2009; Cordella & Lannacci, 2010; Lips, O'Neil& Eppel, 2011; Fan, Zheng & Yen, 2014; Scholl & Scholl, 2014;). Innovations in the 4th industrial revolution bring new challenges such as trade restrictions, security of enterprise data, liability issues and personal data privacy which demand strict regulation through standards, legislation, and policies (Zhou & Zhou, 2015).

Policy plays an important role in governing the largely complex smart environment (Scholl & Scholl, 2014). The European Commission, for example, has developed an industrial policy that speaks to the 4th industrial revolution, to guide Europe in the transformation. The policy is expected to deal with issues of skills, infrastructure, funding, and regulation, etc. (European Commission, 2015). The policy creates an attractive environment for "smart industries" to thrive. Governments need to develop economic, industrial and labor market policies that are responsive and can better prepare industry, citizens, and government for the opportunities brought by the 4th industrial revolution.

2.2.5. *Responsive and context-specific strategies*

Strategies should provide clear guidelines on how governments should respond appropriately to the demands of the digital, connected and smart environment. The need for context-specific strategies especially in developing countries cannot be overemphasized. The challenge is not the absence of strategies, rather the failure of strategies to respond to the local context (Ndou, 2004; Irani, 2005; Chen, Chen, Huang, & Ching, 2006; Majdalawi, Talmarabeh, Mohammad & Quteshate, 2015). The failure to adapt the so-called "best practices" to the local context often results in poorly conceptualized strategies (Manda & Backhouse, 2016b).

2.3. Challenges in the 4th industrial revolution

The 4th industrial revolution is not without its challenges. In Europe for example, the need for investment, changing business models, data issues, legal questions of liability and intellectual property, standards, and skills mismatches were identified as some of the significant challenges identified (European Parliament, 2016). In Germany, societal challenges such as job loss, disqualification, new kinds of stress and increased social insecurity have also taken center stage in their industry 4.0 strategies (Dredger, Niehaus, Ittermann, Hirsch- Kreinsen & ten Hompel, 2016). Some of these challenges are discussed below.

2.3.1. *Potential job loses*

The increased use of technology in the 4th industrial revolution has renewed fears of massive job loses. According to the World Economic Forum (2016), "many of the major drivers of transformation currently affecting global industries are expected to have a significant impact on jobs, ranging from significant job creation to job displacement, and from heightened labor productivity to widening skills gaps." In developing countries like South Africa, these fears are exacerbated by the fact that governments are already struggling to curb a high unemployment rate. In South Africa, this is a severe blow considering the country is struggling with a high unemployment rate of 26 % according to the national accounts data (Statistics South Africa, 2018).

2.3.2. *Skills challenges*

Skills, innovation systems, and knowledge communities provide the much needed intellectual guidance in the development and implementation of smart and digital initiatives (Abdoullaev, 2011; Scholl & Scholl, 2014). E-readiness (e-skills and e-literacy) have also been identified as fundamental in the success of the so-called smart society (Manda & Backhouse, 2016b). Skills challenges identified include skills mismatches and skills redundancy due to the changing nature of jobs as a result of advances in technology and manufacturing techniques (World Economic Forum, 2016). Moreover, the e-readiness (e-literacy and e-skills) influence the citizens' ability to fully participate in social and economic activities in the smart society (Manda & Backhouse, 2016b). Low e-readiness levels in developing countries like South Africa have been cited as a hindrance in the transformation towards smart societies (Ngulube, 2007; Manda & Backhouse, 2016b).

2.3.3. *Infrastructure challenges*

Developing countries are not only confronted by societal challenges but technological and infrastructure challenges. In China, a developing country with advanced infrastructure Zhou, Liu & Zhou (2016) identified challenges surrounding the introduction of new technologies such as analytics, development of networks and smart devices. Poor ICT infrastructure in developing countries is thus one of the major challenges likely to confront governments in their bid to implement industry 4.0. Broadband penetration, for example, is still low in developing countries compared to developed economies that are considered leaders in broadband and other ICT infrastructure (United Nations, 2014; International Telecommunication Union, 2015). In South Africa, poor broadband penetration was found to be one of the barriers hindering transformation to the so-called smart society driven by digital connectivity, advanced technology, skills, knowledge, and innovation to institute economic and social development (Manda & Backhouse, 2016b).

2.3.4. *Security and privacy*

Security and data privacy issues have arguably become one of the most significant concerns in the 4th industrial revolution where technology has become a driver (Waidner & Kasper, 2016). Integration of systems in the 4th industrial revolution requires the development of new security and protection mechanisms for the faster and more flexible collaborative value networks and smart production systems (Waidner & Kasper, 2016). The increased use of data analytics is also likely going to bring new challenges when it comes to issues of data privacy and protection (Waidner & Kasper, 2016). Moreover, privacy and security concerns in technology bring with it trust issues in the "smart" era (Manda & Backhouse, 2016a).

3. RESEARCH METHODOLOGY

This study is an interpretive case study of South Africa's digital transformation journey. Documentary evidence published in the last ten years (2008-2018) such as policies, government strategies, international organization reports, government reports, consultant and industry reports are used as the primary sources of data. This period coincides with the adoption of the digital transformation agenda in South Africa. Documents such as government policies, reports, and strategies often contain rich information about government priorities, strategies and important social and economic data such as labor market information, government expenditure, economic challenges, and government interventions, etc. Collecting such information using other methods such as interviews and questionnaires could have been time consuming and expensive, not to mention the risk of collecting distorted information. These documents were then analyzed using thematic content analysis. Themes from literature and theory (closed coding) informed the coding process. Examples of themes used include infrastructure, inclusion, access, technology, labor market, skills, regulation, and leadership. Figure 2 highlights the main documents used in this study.

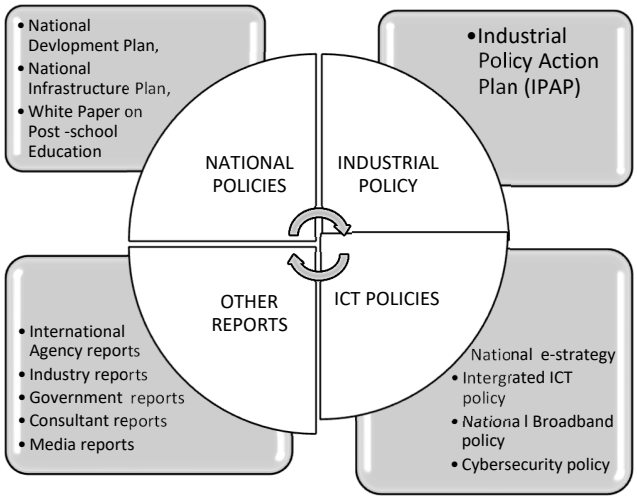

Figure 2: Document sources

4. THE 4TH INDUSTRIAL REVOLUTION IN SOUTH AFRICA

The successful adoption of new and emerging technologies brought by the 4th industrial revolution requires the implementation policies and other mechanisms that are responsive to the challenges and opportunities brought by digital transformation. To address some of the challenges brought by the advent of the 4th industrial revolution, leading countries have developed strategies and set up institutional mechanisms to deal with complex issues such as training and education, ICT infrastructure, privacy and security, and regulation.

To assess South Africa's readiness for the 4th industrial revolution, we use the indicators of the Global Competitiveness Index which measure criteria that are directly linked to the 4th industrial revolution such as quality of education, infrastructure, and innovation capacity. The Word Economic Forum Global Competitiveness Index assesses the competitiveness landscape of 137 economies, by providing insight into the drivers of their productivity and prosperity (World Economic Forum, 2018). South Africa compares well in global competitiveness to its counterparts in the BRICS, ranking 61 above Brazil (80) and below China, Russia and India ranked 27th, 38th and 40 respectively. South Africa's performance is benchmarked against other upper-middle-income economies in the BRICS (Brazil, Russia, India, and Brazil) that have embraced the 4h industrial revolution.

4.1. Information and communication infrastructure

Developing South Africa's social and economic infrastructure has been one of the government's priorities since the attainment of democracy. Investment in social and economic infrastructure is one of government strategy in creating employment and addressing the inequalities that were rife before democracy. According to a study by Mckinsey Global Institute, South Africa's spending in infrastructure between 1992 and 2012 exceeded that of most developed economies. South Africa spent an average of 4.9 % of its GDP exceeding developed economies like Canada 3.0%, Australia 4.7% and Russia 4.1% (Mckinsey, 2015). What is however worrying is that despite significant spending on infrastructure, the quality of information and communication infrastructure in South Africa remains poor. South Africa's overall e-government development index score has been weakened by poor infrastructure according to data from the 2016 UN e-government development index. This when coupled with the high cost of broadband internet, puts South Africa at a competitive disadvantage? Leading economies have thrived due to high quality and affordable ICT infrastructure that has contributed to lowering production costs and increased e-commerce due to the increased online presence and access by business, government, and citizens.

Increasing inequalities in most developing countries like South Africa is a concern in the 4th industrial revolution where digital access and inclusion have become critical. South Africa remains one of the unequal society in the word. The digital driven 4th industrial is likely to increase those inequalities if governments don't address the inequalities. The economic and other opportunities brought by the 4th industrial revolution are most likely going to benefit those with access.

Internet penetration in the BRICS (except Russia remains) low. According to World Bank Data, China and India, the two largest countries by population have the lowest percentage of its citizens using the internet at 53% and 30% respectively. South Africa the percentage of internet users is slightly above China at 54%. Brazil which is also confronted by high levels of inequalities like South Africa has 61% of its population using the internet. Russia has the highest internet users at 73%. Russia also has the lowest disparities compared to its counterparts in the BRICS.

In 2012 the South African Government adopted a National Infrastructure Plan whose aim is to transform the economic landscape while simultaneously creating significant numbers of new jobs and to strengthen the delivery of essential services through infrastructure development. To implement the plan, the government developed 18 Strategic Integrated Projects (SIPS) to cover infrastructure development in various economic sectors including ICT. Knowledge SIP 15: Expanding Access to Information and Communication Technology), aims to enhance connectivity and access to information by providing for 100% broadband coverage by 2020. Poor connectivity and infrastructure capability has slowed South Africa's digital transformation, including e-government (Manda & Backhouse, 2016b).

National information and communication infrastructure forms the backbone for digital transformation. Governments globally have invested in ICT infrastructure as a strategy of transforming to "smart societies." In building information and communications infrastructure, broadband technology, for example, is an enabling technology for connecting governments, business, and people in smart societies (International Telecommunications Union, 2015). Broadband is also an important technology for "modernizing economies and societies and stimulating the use of the internet and enabling the use of feature-rich applications and services" (Trkman, Blazic, Turk, 2008).

In 2013, South Africa implemented its National Broadband Policy and Strategy to ensure affordable broadband access by addressing both supply side and demand side issues such as infrastructure, regulation, skills, and affordability. The broadband strategy termed "SA connect" is part of government's vision of a ensuring that "a seamless information infrastructure will be universally available and accessible and will meet the needs of citizens, business and the public sector, providing access to the creation and consumption of a wide range of converged services required for effective economic and social participation" (South Africa, 2012:190).

Despite these efforts, South Africa's information and communication infrastructure remain poor. The South African government has spent significantly on social infrastructures such as schools, housing, and health facilities as and other key economic infrastructures such as transport networks and energy infrastructure. Spending on ICT infrastructure remains low as evident by budget cuts on projects linked to the development of information and communication infrastructure. The non-prioritisation of programmes related to the digital transformation agenda will have an impact on the ability of the government to meet its goal of an inclusive digital society by 2030.

4.2. Education and Training

South Africa's failing education system has impacted its global competitiveness. According to the World Economic Forum Global Information Technology Index Report (2016), South Africa was ranked last in Maths and Science education and the bottom 3 in the quality of education systems at foundation levels. Its counterparts in the BRICS have performed well in Maths and Science education and the quality of Education. Russia, for example, improved its global competitiveness due to its high-quality education system among other things. India has also been considered a leader in the quality of math and science education, including ICT skills.

Despite a failing primary education system, South Africa has arguably one of the best higher education systems in Africa. South Africa, however, continues to face a shortage of skills critical in the 4th industrial revolution due to inefficiencies in the post-schooling education and training system. Science, Engineering, and Technology (SET) for example, only constitute 29% of the total enrolments in the majority of Higher Education Institutions. This is still relatively lower compared to some of the countries in the BRICS such as India (42.6%) and Brazil (33.9%). South Africa's poor performance in mathematics and physical science education is a contributing factor in the failure to increase SET enrolments (Department of Science and Technology, 2015). The government is transforming the post-school system which is an integral part of the government's policies to improve the socio-economic status of its citizens. It has committed to developing a skilled and capable workforce to enable it to meet its goals of eradicating poverty, reducing inequality and growing the economy by an average of 5.4 percent (South Africa, 2014).

The skills challenge in South Africa is as a result of a complexity of socio-economic and socio-historic factors. The 4th industrial revolution requires a highly skilled workforce which unfortunately South Africa has been struggling to produce. An estimated 30% of workers in South Africa are unskilled with semi-skilled workers constituting 46% and skilled workers being the least at 24% (Statistics South Africa, 2018). The skilling and re-skilling of workers is an immediate priority in preparing for the 4th industrial revolution. The majority of unskilled and semi-skilled workers come from historically disadvantaged groups (Statistics South Africa, 2018). These groups have for decades, been denied socio-economic opportunities such as access to quality education. The effects of the social injustices perpetrated by the apartheid government are still being experienced two decades after South Africa became a democracy.

Transformation in higher education remains slow due to low access for previously disadvantaged groups. The poor socio-economic background of the majority of tertiary learners who come from the previously disadvantaged group has been a barrier for accessing tertiary education. "Without appropriate and adequate financial funding students who come from financially challenged households in South Africa might never be able to achieve academic success, change the negative cycle of poverty or contribute towards changing the race and gender profile of South African academe" (Machika & Johnson, 2014). Evidence shows that on average, 70% of the families of the higher education drop-outs in South Africa were in the category "low economic status," the majority who come from previously disadvantaged groups (Letseka & Maile, 2008:5). The recent "Fees must fall" movement (2015/16), a student protest for free education, resulted in massive disruptions in universities, with students vowing to shut down universities until the government hid their call. Despite commitments by the government to fund disadvantaged students, there is concern that free education is not sustainable in the current economic environment (South Africa, 2017).

4.3. The Labour market

Transformation is high on the South African government agenda, and an untransformed labor force stands in the way for the 4th industrial revolution. The projected job loses in the lower skills categories in the 4th industrial revolution is likely to affect the already disadvantaged low skilled workers more. Transformation is, however, happening at a slow pace despite mechanisms that have been put in place by the government. If the labor force remains untransformed, the adoption of new and emerging technologies likely going to face resistance from workers organized labor and other social partners due to its potential to increase social inequalities. The government also has a social and moral obligation to reduce poverty and is unlikely going to welcome further job losses due to fear of losing its legitimacy due to its failure to meet its social obligations and its promises of prosperity made when South Africa attained freedom.

There is no doubt that the 4th industrial revolution will render certain types of jobs especially the unskilled and manual jobs obsolete. The question is whether governments in developing countries like South Africa are willing to take that risk, given the already high unemployment rate now standing at 26%. In South Africa, employment creation is one of the strategies government is using to fight poverty, unemployment, and inequality. Initiatives that threaten the massive loss of jobs is likely to be met with resistance. Due to the socio-historic factors discussed above, the 4th industrial revolution is likely going to thrive if it brings with it socio-economic benefits to the historically disadvantaged and working class population, the majority who are still living in poverty. In a developing country context, socio-economic inclusion should be therefore an important feature of the "digital transformation" agenda in government, society, and industry. International best practices, innovations and new economic agenda, therefore, need to be adapted to fit the socio-economic context.

4.4. Innovation capacity

Innovation research, and development capacity is critical in achieving the government's vision of stimulating growth in the economy through advanced manufacturing and beneficiation of mineral resources (Department of Trade & Industry, 2016). South Africa has built robust national systems to support innovation, research, and development as a critical strategy for industry 4.0. The South African economy has been labeled the "most innovative" in Africa (World Economic Forum, 2016). This is important in improving South Africa's state of readiness for the 4th industrial revolution.

The government has established national institutional mechanisms for advancing innovation, research, and development for industrial innovation and development. The Council for Scientific and Industrial Research (CSIR) and Technology Innovation Agency (TIA) are two notable public institutions set up by the government for such as purpose. The CSIR is arguably one of the leading science and technology research, development and implementation organizations in Africa. It has spearhead groundbreaking research in mechatronics and micro manufacturing, energy, transport systems, high-performance computing, and cyber defense systems. The Technology Innovation Agency also serves as a key institutional intervention for promoting innovation in critical areas of the economy such as manufacturing. These public institutions are supported by South Africa's well developed Higher Education institutions. The majority are leading research institutions in Africa.

Despite efforts by the government, South Africa's innovation, research, and development capacity remains low compared to other middle-income countries such as China, India, and Brazil due to a complexity of factors. Among the BRICS group of countries, South Africa has the lowest GDP Research and Development expenditure, having been overtaken by India in 2010. South Africa only spends 0.73 % of its GDP in research and development compared to 1.15% in Brazil and 2.01 % in China. The target for the country is 1.5% GDP research and development expenditure by 2019 (Department of Science & Technology, 2016).

4.5. Context-specific strategies and innovative policies

In South Africa, government policy since the advent of democracy has focused on addressing social inequalities, equity and social justice through providing socio-economic opportunities such as quality education, employment, and entrepreneurship to all its citizens. The 4th industrial revolution should be positioned as a strategy that responds to the government's priorities that addresses some of the societal challenges through social innovation. Demonstrating how the 4th industrial revolution can address some of the socio-economic and developmental challenges, and assist developing countries in meeting the Sustainable Development Goals (SDGs) can have a profound impact on its success. South Africa's counterparts in the BRICS block have already developed specific strategies for the 4th industrial revolution highlighted in table 1.

Table 1: BRICS Industrial revolution 4.0

Country	Strategy	Focus
Brazil	New national strategy on industry 4.0	Comprise a new framework for competitiveness, innovation and entrepreneurship.
Russia	National Technology Initiative	NTI is a long-term program of the public-private partnership in development of promising new markets based on high-tech solutions that will determine development of the global and Russian economy in the next 15-20 years.

India	Make in India	Aims to transform India into a global design and manufacturing hub
China	Made in China 2025	Aims to transform China into a leading manufacturing hub by taking advantage of technology advances in manufacturing.
South Africa	National E-strategy	Aims to position South Africa as a significant player in the development of ICTs throughout the value chain of the sector as well as accelerate the uptake and usage of ICTs in other social and economic sectors

4.5.1. The National E-strategy

The National E-strategy aims to position South Africa as a significant player in the development of ICTs throughout the value chain of the sector as well as accelerate the uptake and usage of ICTs in other social and economic sectors. Within this overall strategic construct, instead of being an omnibus of all ICT initiatives, the e-strategy focuses on initiatives that have a significant, catalytic potential on growth and development with a long-term view to transition the economy to the Digital Industrial Revolution. The 3rd Pillar of the National E-strategy, for example, speaks to the "Digital Industrial Revolution." According to the National E-strategy, "in line with the 4th Industrial Revolution, there is a need for South Africa as a country to develop a comprehensive framework and action plans to deal with the opportunities while mitigating the risks of the transition to the SA Digital Industrial Revolution" (South Africa, 2017:17). South Africa's approach to transitioning to a Digital Industrial Revolution shall be underpinned by amongst others the following:

- The development of technologies and digital platforms that are relevant to the majority of South Africans and Africa.
- Technologies that can be used to improve productivity and efficiencies in the delivery of services in the local industry
- Disruptive technologies with the potential to create new markets and industries.

Digital inclusion, access, and socio-economic transformation remain a key focus of the strategy. Infrastructure development, access for previously marginalized communities, affordability and digital entrepreneurship, are some of the priority areas identified in the strategy. This is important given South Africa's socio-historic and socio-economic context. Policy has become key in transforming the structure of the economy regarding management, ownership, and control of the means of production. This has also been reflected in other policies and strategies supporting the 4th industrial revolution such as the Industrial Policy Action Plan, South Africa's strategy to address the key challenges of economic and industrial growth and race-based poverty, inequality, and unemployment.

Other countries in the BRICS have also developed context-specific strategies to position themselves for the 4th industrial revolution. In India, the 'Make in India' programme and policy, India's plan of action to promote the manufacturing of products for the world market is credited for India's progress in embracing the digital revolution. In China, "The Made in China 2025" is a ten year strategic plan that aims to transform China into a global technology and manufacturing giant by taking advantage of the 4th industrial revolution. The government of Brazil has also joined other leading economies such as Denmark and the United Arab Emirates to close the growing gap between emerging technology and policy. According to the World Economic Forum (2016), each government is expected to partner with leading businesses, start-ups, civil society, academia, and international organizations to co-design and pilot new approaches to policy to help shape the trajectory of emerging technology and will be piloted by governments and businesses around the world. Russia through its National Technology Initiative is also positioning itself to become a leader in technology markets that have been created as a result of the 4th industrial revolution.

The BRICS countries have also recognized the importance of collaboration as a strategy to leapfrog some of the leading developed countries. Several initiatives have been developed to stimulate economic cooperation including in sectors critical for the 4th industrial revolution. This will likely benefit South Africa, who unlike its counterparts in Asia, for example, have developed capability in the technology sector. The success of these initiatives will, however, depend on the complexity of factors such as committed leadership, trust, transparency and political will.

5. DISCUSSION AND CONCLUSION

The success of the 4th industrial revolution will depend on leadership from all sectors working together to leverage the opportunities and address the challenges of the 4th industrial revolution. Political leadership, for example, is responsible for developing and implementing an enabling environment for digital transformation and innovation. Business leadership is responsible for leading think tanks and the much-needed innovation in the 4th industrial revolution. Social leadership also play an important role in preparing society for the changes brought by the 4th industrial revolution. Political leadership in South Africa has recognized the 4th industrial revolution and its potential to address the countries triple challenges of poverty, unemployment, and inequality. The development of policies and strategies addressing digital transformation is a sign of commitment from leadership. The implementation of reforms, however, remains a challenge as witnessed by poor policy implementation. In the past five years, the government has developed regulative mechanisms that address some of the challenges of the 4th industrial revolution such as security and privacy, but few of these have been implemented as a law to give them legitimacy. The

commitment of business leaders to work with the government also remains questionable as witnessed by an increase in resistance to some policy reforms that the business sector perceives is not serving their interests.

Collaboration is critical during transformation or change. Collaboration between the various actors in the 4th industrial revolution is critical in ensuring the success of the 4th industrial revolution which will not only disrupt business but government and society. The development of policies and strategies that are responsive to the priorities of South Africa will require that government works with business and social partners in addressing some of the challenges and leveraging the opportunities brought by the 4th industrial revolution. For example, the challenges of projected job losses in unskilled job categories due to the introduction of robotics in advanced manufacturing will require that government, business, workers and labor 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 behavior and corruption in the development and implementation of policy reforms have been observed in South Africa.

The 4th industrial revolution requires developing countries like South Africa to rise to the challenges brought by their socio-historic, socio-economic and economic contexts. Developing countries need to develop models or strategies that are responsive and relevant to their context instead of blindly adopting so-called "exemplary models" that have worked in contexts that are different to the developing country adopting them. There is also a greater need to develop strategies that bring social benefits instead of focusing primarily on economic prospects brought by the 4th industrial revolution. 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 government should also explain how 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.

ACKNOWLEDGMENTS

This paper is a result of the project "SmartEGOV: Harnessing EGOV for Smart Governance (Foundations, methods, Tools) / NORTE-01-0145-FEDER-000037", supported by Norte Portugal Regional Operational Programme (NORTE 2020), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund (EFDR). The 1st Author is also supported by the Manufacturing, Engineering and Related Services Sector Education and Training Authority of South Africa.

REFERENCES

[1] Abdoullaev, A. (2011). Keynote:" A Smart World: A Development Model for Intelligent Cities". In The 11th IEEE International Conference on Computer and Information Technology (CIT). IEEE

[2] Bostrom, R. P., & Heinen, J. S. (1977). MIS problems and failures: a socio-technical perspective, part II: the application of socio-technical theory. MIS quarterly, 11-28.

[3] Buhr, D.(2015). Industry 4.0 – New Tasks for Innovation Policy. [Online] Available from: http://library.fes.de/pdf-files/wiso/11480.pdf (Accessed: 10/09/2016)

[4] Chen, Y. N., Chen, H. M., Huang, W., & Ching, R. K. (2006). E-government strategies in developed and developing countries: An implementation framework and case study. Journal of Global Information Management, 14(1), 23-46.

[5] Cordella, A. & Lannacci, F. (2010). Information systems in the public sector: The e-Government enactment framework. The Journal of Strategic Information Systems, 19(1), 52-66.

[6] Dawes, S. S., Cresswell, A. M., & Pardo, T. A. (2009). From ''need to know'' to ''need to share:'' Tangled problems, information boundaries, and the building of public sector knowledge networks. Public Administration Review, 69(1), 392–402.

[7] Deloitte. (2016) .Industry 4.0: Is Africa ready for digital transformation. [Online] Available from: http://www2.deloitte.com/za/africaindustry4-0?id=za:2el:3or:awa_AI40:ai40_vs (Accessed:10/09/2016)

[8] Department of Higher Education and Training.(2012). Address by minister of higher education and training, Dr. Blade Ndzimande at the launch of the labour market intelligence research project HSRC conference centre, Pretoria, 4 September 2012. [Online] Available from: http://www.hsrc.ac.za/uploads/pageContent/2770/MinisterLMIPspeechsep2012.pdf (Accessed: 12/10/2013).

[9] Department of Science and Technology (2015) South African Science, Technology and Innovation indicators. [Online] Available from: www.dst.gov.za (accessed) 06/07/2016)

[10] Department of Trade and Industry. (2016). Industrial policy action plan. [Online] available from: www.dti.gov.za (Accessed: 01/06/2015)

[11] Dregger, J., Niehaus, J., Ittermann, P., Hirsch-Kreinsen, H., & ten Hompel, M. (2016, May). The digitization of manufacturing and its societal challenges: a framework for the future of industrial labor. In Ethics in Engineering, Science and Technology (ETHICS), 2016 IEEE International Symposium on (pp. 1-3). IEEE.

[12] European Parliament (2016).Industry 4.0: digitalization for productivity and growth [Online] Available from: www.europarl.europa.eu/RegData/etudes/BRIE/.../EPRS_BRI(2015)568337_EN.pdf (Accessed:10/09/2016)

[13] European. Commission (2015) .The Factories of the Future. [Online] Available from: http://www.effra.eu/attachments/article/129/Factories%20of%20the%20Future%202020%20Roadmap.pdf (Accessed:10/07/2016)

[14] Fan, J., Zhang, P. & Yen, D. (2014).G2G information sharing among government agencies. Information & Management, 51 (1), 120–128.

[15] International Telecommunications Union (2015) The state of broadband report.[Online] Available from: www.broadbandcommission.org/documents/reports/bb-annualreport2015.pdf (Accessed: 01/06/2015)

[16] Kast, F. E., & Rosenzweig, J. E. (1972). General systems theory: Applications for organization and management. Academy of management journal, 15(4), 447-465.

[17] Kling, R., McKim, G., & King, A. (2003). A bit more to it: scholarly communication forums as socio-technical interaction networks. Journal of the American society for Information Science and Technology, 54(1), 47-67.

[18] Lee, A. 2001. Editorial. MIS Quarterly 25 (1): iii-vii.

[19] Letseka, M & Maile, S. (2008). High university drop-out rates: a threat to South Africa's future. HSRC Policy brief: Pretoria: HSRC.

[20] Lips, A.M., O'Neill, R. &. Eppel, E.A. (2011). Cross-agency collaboration in New Zealand: An empirical study of information sharing practices, enablers and barriers in managing for shared social outcomes. International Journal of Public Administration, 34(4), 255-266.

[21] Lom, M., Pribyl, O., & Svitek, M. (2016, May). Industry 4.0 as a part of smart cities. In Smart Cities Symposium Prague (SCSP), 2016 (pp. 1-6). IEEE.

[22] Machika, P. & Johnson, B. (2014).Poor students face massive financial stress. Mail and Guardian. [Online] Available from: http://mg.co.za/article/2014-04-08-poor-students-face-massive-financial-stress. Retrieved (12/06/2015).

[23] Majdalawi, Y.Kh.,Almarabeh, T., Mohammad, H. & Quteshate, W. (2015) E-Government Strategy and Plans in Jordan. Journal of Software Engineering and Applications, 8 (1), 211-223

[24] Manda, M.I & Backhouse, J. (2016a) Addressing trust, security and privacy concerns in e-government integration, interoperability and information sharing through policy: a case of South Africa" (2016). Proceedings of the 2016 International Conference on Information Resources Management (CONF-IRM). Paper 67. [Online] Available from: http://aisel.aisnet.org/confirm2016/67 (Accessed: 10/08/2016)

[25] Manda, M. I. & Backhouse, J. (2016b). Towards a "Smart Society" Through a Connected and Smart Citizenry in South Africa: A Review of the National Broadband Strategy and Policy. In International Conference on Electronic Government and the Information Systems Perspective (pp. 228-240). Springer International Publishing

[26] Manda, M.I. & Backhouse, J.(2017).Digital transformation for inclusive growth in South Africa. Challenges and opportunities in the 4th industrial revolution. 2nd African Conference on Information Science and Technology, Cape Town, South Africa

[27] Mckinsey Global Institute.(2015). South Africa's big five: bold priorities for inclusive growth.[Online] available from: http://www.mckinsey.com/global-themes/middle-east-and-africa/south-africas-bold-priorities-for-inclusive-growth

[28] Ndou, V. (2004). E-government for developing countries: opportunities and challenges. The electronic Journal of Information Systems in Developing Countries, 18(1) 1 – 24

[29] Pardo, T., Nam. & Burke.(2012). E-Government interoperability interaction of policy, management, and technology dimensions. Social Science Computer Review, 30(1), 7-23.

[30] Sawyer, S., & Jarrahi, M. H. (2014). Socio-technical Approaches to the Study of Information Systems. In H. Topi, & A. Tucker (Eds.), Computing Handbook, Third Edition: Information Systems and Information Technology (pp. 5-1).Chapman and Hall/CRC.

[31] Scholl, H. J., & Scholl, M. C. (2014). Smart governance: A roadmap for research and practice. iConference 2014 Proceedings.

[32] Scholl, H. J., & AlAwadhi, S. (2016). Creating Smart Governance: The key to radical ICT overhaul at the City of Munich. Information Polity, 21(1), 21-42.

[33] Scholl, H.J. &Klischewski, R. (2007) .Government integration and interoperability: Framing the research agenda. International Journal of Public Administration, 30(8), 889-920

[34] Schwab, K. (2016). The fourth industrial revolution. Geneva: World Economic Forum.

[35] South Africa. (2012). National Development Plan. Pretori

[36] South Africa.(2014). White Paper on Post-School Education and Training. Available from www.dhet.gov.za

[37] South Africa.(2017). National E-strategy. Available from www.dtps.gov.za

[38] Trist, E. (1981). The evolution of socio-technical systems. Occasional paper, 2, 1981

[39] Trkman, P., Blazic, B. J., & Turk, T. (2008). Factors of broadband development and the design of a strategic policy framework. Telecommunications Policy, 32(2), 101-115.

[40] United Nations (2014).United Nations e-government global survey. Online [Available from:http://unpan3.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2014 .[Accessed : 01/05/2015

[41] World Economic Forum (2016b). The global competiveness report. World Economic Forum, Geneva, Switzerland.

[42] World Economic Forum. (2016). The future of jobs: employment, skills and workforce strategy for the fourth industrial revolution. World Economic Forum, Geneva, Switzerland.

[43] World Economic Forum. (2016). The global Information Technology Report. World Economic Forum, Geneva, Switzerland

[44] Zhou, K., Liu, T.& Zhou, L. (2015, August). Industry 4.0: Towards future industrial opportunities and challenges. In Fuzzy Systems and Knowledge Discovery (FSKD), 2015 12th International Conference on (pp. 2147-2152). IEEE