



The Fourth Industrial Revolution: Discourse and Contexts Shaping Nigeria's Participation

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Abstract: This paper explores the diffusion and spread of the fourth industrial revolution (4IR) otherwise known as industry 4.0 in relations to Nigeria. Technology that was once science fiction is now a reality. The real world and the virtual world are merging to create a new reality-actual reality. The core feature of the 4IR is the marriage of physical and digital technologies such as analytics, artificial intelligence, cognitive technologies and the internet of things (IoT). While the 4IR connects the world together, this connectivity is however, hierarchical and asymmetric. The 4IR still follows the social, economic and political patterns of previous industrialization, where countries and individuals at the centre of its invention and application maintain the market leader status. If the threats and opportunities of the 4IR are to be taken adequately into account in industrial policies in Africa, then a thorough understanding of the implications of the 4IR for the continent is required. This paper explores the social impact of 4IR and its implications to Nigeria and in deed Africa, the strategy going forward, the implications on talents, workforce and skills as well as the technological implications of 4IR for Nigeria. This paper concludes that digital and advanced technologies in the 4IR have become essential tools for social and economic development as well as the material well-being of individuals in the emerging digital economy. The benefit of adopting industry 4.0 technologies will be evident in its continuous diffusion and spread, leading to enhanced productivity in the economy. However, the indifference of government has both immediate and long-term negative impacts and accounts for the widening technological gap. The policy recommendation for this study is that Government should as a matter of national security, should focus on research and development and identify key areas of focus in research for product development.

Keywords: Industry 4.0, Digital Economy, Diffusion and Spread of 4IR, Technological Gap

1. Introduction

The world is grappling with the diffusion and spread of a technological revolution that is fundamentally altering not just the nature of work and occupations, but social relations as well. The fourth industrial revolution (4IR) is multidimensional-technological, economic, social, cultural, political and geopolitical. Disruptive in nature, dynamic in unfolding, the fourth industrial revolution, 4IR or industry 4.0, is ushering the world into an exciting unknown. Technology that was once confined to science fiction is now an integral part of everyday life. The 4IR is characterized by a range of new technologies that are blending the physical, digital and biological worlds. The environment, things

(objects, including cars, papers and almost everything), people, places, processes, services and data are increasingly connected and networked. This connectivity is facilitated by advancements in digital technologies. The actual (real) and virtual worlds are beginning to merge, creating a new reality. Objects and products are now automated turning them into smart objects. Smart objects, that is products equipped with actuators and sensors, QR codes and electronic chips, are steering themselves through smart factories (automated factories) and even along the entire value chain from product development to service. Production has become more distributed, more flexible and faster [4] (Daniel, 2017). The 4IR is impacting all disciplines, economies and industries and even challenging ideas about what it means to be human [12].

The Fourth Industrial Revolution is characterized by the convergence of breakthrough technologies such as advanced robotics, artificial intelligence, the internet of things, virtual and augmented reality, biotechnology and genomics as well as advanced manufacturing. These are transforming productions processes and business models across different industries [12].

The Inclusive Growth Forum [7] defines the 4IR ‘as the advent of “cyber-physical systems” involving entirely new capabilities for people and machines’, and goes on to posit that, ‘while these capabilities are reliant on the technologies and infrastructure of the Third Industrial Revolution, the 4IR represents entirely new ways in which technology becomes embedded within societies and even in human bodies’ (talk of chips in human bodies). The core feature of the 4IR is the marriage of physical and digital technologies such as analytics, artificial intelligence, cognitive technologies and the internet of things (IoT). This marriage of the physical with the digital allows for the creation of a digital enterprise that is not only interconnected, but also capable of more holistic and informed decision making. In analyzing the 4IR, automation and robotics are perceived as key components and features, representing the arms and legs of Industry 4.0; actuators and sensors in the form of cameras and detectors are taken as the senses, while data and connectivity are compared to the nervous system and artificial intelligence (AI) is the brain behind its functional capacity. Digital and advanced technological innovations have heralded the Fourth Industrial Revolution (4IR).

The First Industrial Revolution was driven by mechanization and steam engines, the second rode on the use of electricity energy and mass production and the third on electronics and information technologies (ICT) [12]. Beyond the significant role of the internet in 4IR, other applications of innovative technology are also fuelling its growth. These include advanced manufacturing and 3D printing, advanced materials, biotechnology and genomics, automation and new energy supplies and technologies. In summary, Industry 4.0 is the process of increasing digitization of production. The 4IR has ushered in the transition to the digital economy.

The digitization of the economy and society promises to spur innovation, generate efficiencies and improve services in a wide range of areas (from health to agriculture, public governance, tax, transport, international trade and investment, the financial system, education and the environment). Indeed, digital technologies contribute not only to innovation in products, but also to innovation in processes and organizational arrangements [10].

The dynamic nature of the 4IR has birthed the digital economy, one that even governments are struggling to control. The Internet has become not just a global marketplace, but a platform for innovation. Fluid by design, the internet by creating an enabling environment where creativity, free flow and exchange of ideas, entrepreneurship and experimentation can flourish, it is birthing innovative products and dynamic models of service delivery. The digital economy is growing quickly. It permeates the world

economy, from retail (e-commerce) to transportation (automated vehicles), health (electronic records and personalized medicine), social interactions and personal relationships (social networks) and also education [9]. The 4IR is overarching. This is redefining the boundaries between economic and industrial sectors, the relationship between buyers and sellers as well as the role of the public and private sectors. Production systems and global value chains will become more dynamic, flexible, efficient and sustainable, with high possibilities for customization and personalization [13]. Industry 4.0 is contributing to increased resource efficiency and helping to achieve circular economic models.

These changes are not without challenges though. The United Nations Industrial Development Organization [13]. Report, in assessing the impact of 4IR, submitted that rapid technological advancements will influence future patterns of productivity, competitiveness and employment. As occupations and industries evolve, they will exert a strong influence on education and skill requirements as well as income distribution. Their impact on global value chains will influence greatly the evolving international economic division of labour, thus, the future position of developing countries in the global economy.

The 4IR still follows the social, economic and political patterns of previous industrialization, where countries and individuals at the centre of its invention and application maintain the market leader status. The 4IR might be disruptive in nature as it creates entirely new technology and market paradigms, it is also integrative. It pulls the world together in some ways, bringing down barriers of trade by creating new products, channels of supply and delivery. It essentially connects the world together. However, this connectivity is both hierarchical and asymmetric. Individuals, societies as well as nations are connected either as producers, consumers or both. Yet, being connected as a producer and consumer does not necessarily mean that an individual, society and nations are drawing the same benefit from the system. Take for instance, the petroleum industry, Nigeria connects as a producer of crude oil but a consumer of petroleum products. So also does America. However, through advanced technology, America is able to produce oil in very difficult terrains. While Nigeria produces crude oil and consumes petroleum products, America produces oil and still consumes oil from Nigeria, enabling her to create more value from crude oil than Nigeria. This is the same scenario for most African countries with raw materials. The difference in value is the processing power of information and application of advanced technologies to leverage the opportunities offered by the 4IR. If the threats and opportunities of the 4IR are to be taken adequately into account in industrial policies in Africa, then a thorough understanding of the implications of the 4IR for the continent is required. This paper explores the social impact of 4IR and its implications to Nigeria and in deed Africa, the strategy going forward, the implications on talents, workforce and skills as well as the technological implications of 4IR for Nigeria.

2. Social Impact of Industry 4.0: The Nigerian Context

The 4IR while primarily being explored from a technical point of view has strong social implications. Increasing digitization, however, will not only have an enormous impact on machines, factories and business models, it will fundamentally redefine societies and its relations. Social development has come to involve the goal of improving peoples' livelihood. The concept of social innovation signifies a novel solution to societal challenges that is more effective, sustainable and more equitable than existing practices [11]. The good of society is in focus rather than the benefits to a single innovator. A feature of social innovation is that these solutions are a function of a common evolution, developed directly by the beneficiaries in society. A social innovation can take many forms, a principle, law, organisation, behavioural change, business model, product, process or technology. Usually, social innovations result from a combination of these components. Thus from today's perspective, many innovations can be classified as social innovations – the Internet, globalization, energy efficiency, fair trade. They are all innovative solutions that have brought major societal benefits. Social innovations have the greatest impact on a system-wide level. It is no surprise then, that successful business ideas, thus, offer both economic benefits as well as social progress. With Industry 4.0, this becomes the goal, the diffusion and spread of the 4IR is expected to be distributed amongst as many people across societies as possible.

The Nigerian society has benefited a lot from the innovations brought about by 4IR. From drop shipping, new business models, social networking to social mobilization through technology enabled social media platforms. Citizens are well represented and their voices well heard. Even when governments fight protest through court orders, it has not stopped mass protests through social media. While the society has used digital technology as a means to an end, digital technologies has also influenced societies- from increasing interconnectivity, digital skills development to lifestyle and career choices. The assertion by [3] on social development on the wings of information and technology is still valid today. The only change being that technology has gone digital and information has become more like the air we breathe. Social development across nations today is a function of the capacity of societies to establish a synergistic interaction between technological innovation and human values. The entire realm of human activity depends on the processing power of information and advanced technology. The diffusion, spread and manipulation of information through societies is leading to a new set of organizations and institutions that create positive feedback loops between productivity, flexibility, solidarity, safety, participation and accountability technology [3]. Societies will also continue to evolve based on the extent of embrace of digital technologies. The challenge then is not what digital technologies can do, but what nations, societies and individuals can harness from the potentials offered by the 4IR. If the goal of the Nigerian

society is to evolve into an advanced society, the processing of information and application of knowledge would be essential for harnessing the opportunities offered by 4IR.

As society and education evolve following the 4IR, information and knowledge are no more a great currency; it is now very abundant, readily and easily assessed. The focus now is on creativity, on designing systems and approaches that can transform information and knowledge into products. Education has moved farther from just transmitting knowledge and skills acquisition to product development. All learning today is designed to produce a concept, a model or a product. The 4IR heralds the era of creativity. Creativity is now needed to explore the physical environment and seek the application of technology to transform human interaction with the physical world. It is creativity that is fuelling innovation in product development, more simplified and far reaching models of service delivery. It takes creativity to develop social innovations, new systems and harness the power of technology. As [3] rightly pointed out, information and technology does not change societies per se, but the availability and manipulation of information and communication technology through knowledge and practice does. Societies benefiting the most from the 4IR are those not only focused on skills acquisition and training, but product development through advanced technology.

3. Industry 4.0 and the Technological Gap in Nigeria

Technological gap conjures up a picture of one country or company holding an edge over others as a result of superior technology and performance. Technological gap is also viewed as the consequences of differences across countries in factor endowments, whether innate, or as developed through past investments. However, further analysis reveals salient notions behind technological gap. Mere increases or differences in productivity between countries or among different players in the same industry are not an indication of a technological gap. Even when countries and individual companies have the same factors of production and taste, continuous process of innovation and inventions can give rise to trade and differentiation. Thus, differences in output and productivity across countries are not direct evidence that a technological gap exists between the high and lower productivity countries. The observed productivity could be the result of differences in the amounts of resources invested over time, in machinery and equipment, education, training, and other intangibles. In essence, increased productivity is not an excellent way of measuring technological gap, but might help in the diffusion and spread of technology as seen across Africa.

Technological gaps arise because some countries are more innovative than others, at least in some industries. A technological gap between countries, in most cases, should show up in three ways. The first is differences in total productivity, which probably will be reflected in output, in

terms of quality and turnover. Secondly, it is also apparent that the leading country in technology, that is, countries where the technology is coming from or developed, is a major exporter in technically progressive industries like industry 4.0 and its associated technologies. Finally, the lagging countries are often the adopters and importers of technology rather than innovators. Thus, when a country imports more technology than it produces, or relies on imports for productivity and economic transformation, there is a technological gap. The country is lagging behind in technology. A technological gap in Africa is a reflection of lack of innovation and low investments in education, research and development in product development.

Developing countries like Nigeria must keep up with technological changes if they are to harness the opportunities offered by 4IR and manage its potential disruption. The cost of implementing economic and technological reforms for social benefits is just too high for most African States including Nigeria. This is because most of the technology required to transform society are coming from outside Africa. As governments try to control the digital economy, an emerging trend from national governments has been the move away from multilateralism towards nationalism. This is influencing not just who gains access to technology, but the cost as well. A critical determinant for developing countries' ability to catch up will be the diffusion of frontier technologies associated with Industry 4.0 in their productive sectors. However, there is considerable uncertainty regarding this issue for Nigeria and indeed, Africa in relations to production and manufacturing in Africa.

Technological advances in the 4IR create specific opportunities for Africa, particularly in manufacturing and services. Manufacturing is the most productive sector, not minding the fact that it is largely becoming a service (products-as-services) in the digital economy. Countries according to [8] create wealth and become prosperous through the structural transformation of their economies. This is achieved by moving capital, labour and technology from lower to higher-productivity sectors in industry 4.0. The development and application of new technologies by countries and the acquisition of higher order skills has

become the springboard for effective participation in 4IR. In advanced economies the contribution of manufacturing has shifted to promoting innovation, productivity and trade. In the developing world, manufacturing remains critically important as a pathway from subsistence agriculture to rising incomes and living standards. Manufacturing is set to change even more rapidly as part of the fourth industrial revolution, which may offer Africa opportunities to accelerate economic transformation into higher rates of productivity and growth. However, capitalizing on these opportunities will require huge investments in technology for enhanced productivity as well as research and development [8].

Research evidence as shown by [2] indicates that agriculture has been effective in reducing poverty and impacting positively on growth in Africa. Manufacturing on the other hand, is found to be six times more productive than agriculture in Africa. Growth in manufacturing propels more rapid general economic productivity improvements. Low-end services such as retail and trade were, by 2010, only two times more productive than agriculture, with the result that growth in services (both in formal and informal sectors) in Africa has contributed to no or slow growth in aggregate per capita income [5]. Rather than improving productivity, Africa's structural transformation from low-productivity agriculture to low productivity urban-based retail services has therefore been 'growth reducing'. This is because the share of workers employed in high-productivity sectors such as manufacturing is declining [8]. THE focus on wholesale, retail and trade by most African countries, Nigeria inclusive is short-circuiting the production process. Volumes of goods that would have been produced locally are imported mostly from less than five countries into Africa. The technology and higher order skills needed to start the production process from design through manufacturing is just not available in the continent.

African countries need to move into production and production is beyond manufacturing. There are fundamental changes to production in industry 4.0. Production accounts for 36% of global GDP, over 850 million jobs and 70% of worldwide global innovation and Patents [1]. The production process is presented in figure 1.

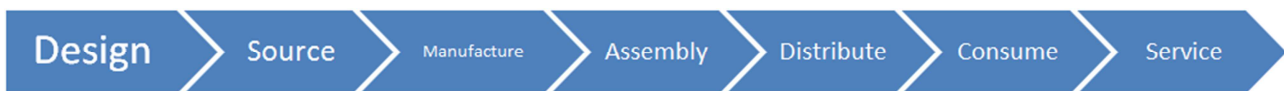


Figure 1. Production cycle by Aikman 2017.

The production process begins at the design stage, this is followed by sourcing, then manufacture, assembly, distribution and consumption in that order. The experience of sub-Saharan Africa according to [2] has not followed this trajectory. Rather, a shift has occurred from low productivity agriculture to slightly more productive employment in services, generally consisting of wholesale and retail trade in the formal and informal sector. The production system for most African countries begins at either assembly or distribution. This essentially cuts off the continent from the

early stages of production in industry 4.0, a very important component in terms of technology development and catch up.

The main engine of production and manufacturing development in industry 4.0 is the creation of new technologies, knowledge and its application. A country, in creating and introducing new products and processes attributes its success to past and sustained investment in science, technology, engineering and mathematics (STEM). The education of scientists and engineers, research and development efforts and in other activities that feed

technological advancement is significant for catching up and bridging the technological gap in the 4IR.

4. The 4IR and the Crisis of Confidence in Nigerian Higher Education System

Educational systems still wholly devoted to transmission of information and knowledge in the 4IR is not even playing catch-up, but becoming obsolete and soon to be bumped out. The implication of the short cycle of technology means that curriculum will have to be reviewed more often than previously planned. On the other hand, educational systems at the frontiers of the 4IR are those actively involved in research and development in emerging fields of technology and social systems while still transmitting new knowledge and skills to its students. The relevance of any training institution is the cutting edge education it offers.

For Nigeria, responding to the industry 4.0 will require a two-fold approach to education and training. Firstly, the process will require training in new technologies. The digital economy created by the 4IR requires highly skilled workers. The industries of the future will be smart and more cognitive. This is already evident, as manufacturers and industries automate assembly and production lines. The consequence is that while lower skilled jobs will be lost, or rather, vanish on the work floor, more jobs requiring higher order skills will be created in the same industry. Low skilled workers are mostly likely to be bumped out of the labour market of the digital economy. The International Labour Office [6] report stated that efforts of governments should be geared towards building the capacity of workers to adapt to changing occupational and skills demands and to benefit from innovation and investments in emerging technologies. This enables countries to be more competitive in the digital economy. This also positions nations to better respond to rising challenges in the labour market. Yet, as the report states, stepping up investments in education and skills training to meet current needs and to better respond to global trends in industry 4.0, will require reforms on training policies, institutions and methods for all countries. This, however, is a daunting task for most developing countries like Nigeria. Poor skills as a result of weak training systems, low technology adoption and government indifference is shutting Nigeria out of the industry 4.0. The waves of disruption occasioned by 4IR and its associated technologies are already pounding on the nation- weak manufacturing sector, low productivity, lowering academic standards and ever increasing reliance on china for technology and commodities.

One way industry 4.0 can benefit Nigerians is through enhanced productivity. A cursory look at our economy as a nation will show that the Nigerian economy has plateaued as a result of low productivity. For companies, the adoption of industry 4.0 technologies helps to enhance productivity. The introduction of new technologies mostly leads to skills training and up-skilling of existing workforce. It also

guarantees that new occupations are created even in the same industry. This, in effect, leads to enhanced business activity, what the Nigerian economy could use right now. However, such an effort will require government proactive response to technology adoption and a corresponding policy commitment to education and training. Policies guarantee what will be available in terms of digital technologies adopted from outside of Nigeria, while education and training guarantees what is accessible. Both availability and accessibility in this respect are a function of government's intervention policies.

The second aspect of education that will guarantee making the most of 4IR is research and development in higher education institutions in Nigeria. Nigeria will need a paradigm shift in educational objectives and policies to harness the opportunity offered by 4IR and ward off its challenges. Education for skills development is not enough, the country must move to education for product development.

There is need for a policy and paradigm shift to leverage education for national development. A new national policy on education that identifies priority areas for growth, research and development is urgently needed. For instance, India prides itself in pharmaceuticals and Information Technology (InfoTech). They developed human and product capacity in those areas. Targeted investment in education in these areas has helped India become a force when it comes to InfoTech and pharmaceuticals. In fact, an Indian is the head of Google, an American company. Besides, there are several InfoTech companies in India and Nigerian pharmaceutical companies are today, marketing companies for Indian drug companies at most. Not that research and development in other disciplines in education were made to suffer in India, on the contrary, they did develop as well. Tricycles used in Nigeria are manufactured in India. Indian cars are driven on the streets of London. Today, India supplies mechanical parts to the world. The essence of prioritizing key areas is to help shape focus and measure outcomes realistically. Promoting certain sectors for intervention helps a nation focus on research and development with tangible results. The Nigerian government can learn a thing or two from this and focus on key areas for growth such as pharmaceuticals, mechanical technology, ICT and electronics. Priority should be given to promoting studies in these areas, not just for human capacity development, but product development as well.

As a matter of national interest, Nigeria cannot be this big and blessed without inventions to its name. Brazil too has oil, but is also a leader in biotechnology. We need an injection of innovation from within and this has always been championed by researchers in tertiary institutions. The Nigerian economy has plateaued and needs an injection of innovation from within, not the flooding of our markets by more commodities from China by our traders parading themselves as companies. The next wave of growth in Nigeria will be from developing indigenous technology and the government needs to shift its attention to developing a functional research and robust educational system. An effective science and technology innovation system in any country depends on research in higher education. Innovation has always been championed by

research in tertiary institutions. Given the extent of rot in the system and the urgent need for transformation, stakeholders are advising the government to focus on key areas of intervention as a pilot programme. Government could prioritize certain disciplines and fund training in these areas, human capacity development as well as product development. They could focus on pharmaceuticals, mechanical, electrical and electronics technology, biotechnology, the list is endless. However, the best approach is to look inwards and based on national interests, determine which areas the country might need the most intervention. This forms the springboard for the policy, bearing in mind that the focus is not to train individuals, but product development. As such, human capacity development is just as important as investment in research for product development. This is very vital because research for skills development is quite different from research for product development.

For this policy to be effective, University lecturers will need up-skilling with respect to research skills and continued specialization. Some with PhDs may need to go for post-doctoral positions to develop much needed research skills; others may need new Master's degree as refresher courses. If the new policy would work, volunteer staff will have to train on new specialized areas to develop skills for research and product development. One or more universities may pilot one programme, while others may run another pilot programme following any agreed framework proposed by the government. Of course, this programme has to be government led using any of its relevant agencies. Universities may not own the programme right now before it goes the way of other initiatives- good on paper, bungled at implementation.

At a time when higher education is more essential than ever, there is a linkage between education and economic security. The emerging global knowledge economy rewards nations with an educated workforce. Inadequate academic preparation, lowering academic standards and loss of goodwill in public universities is undermining Nigeria's long term economic future. The country needs a functional educational system, an educated and skilled workforce to confront new economic and social threats.

5. Conclusion

In conclusion, digital and advanced technologies in the 4IR have become essential tools for social and economic development as well as the material well-being of individuals in the emerging digital economy. The benefit of adopting industry 4.0 technologies will be evident in its continuous diffusion and spread, leading to enhanced productivity in the economy. The ultimate is for Nigeria and indeed all African nations to begin the production process from design and advance to manufacturing, a corner stone effort for developing technology and enriching the value chain. This is essential to move the continent away from just trade and services. However, this requires a focus on a swift adoption of industry 4.0 associated technologies, education and

training as well as research and development. The effect of the 4IR is already being felt by Africans, but poor education and training systems as well as inadequate government preparations is impeding on Africa's response to the revolution. As nationalism tendencies rise among developed countries and the cost of technology adoption (financial and political) swirls exponentially for Africans, the effect of the indifference towards the 4IR by some national governments will be both immediate (short-term) and in the future (long-term impact). This, in addition to widening the technological gap, will have social, economic and political implications. Some nations might slip further into poverty, while others will battle social exclusion and in some cases, civil wars. The countries that rise to the challenge of the 4IR will not only grow economically and socially, but rise in relevance.

6. Recommendations

The discussion has highlighted some policy directions for governments and stakeholders. These includes:

- 1) Government should prioritize research in product development as a matter of national interest. This is beyond just training for skills development, but research for product development.
- 2) Government should refocus on training and retraining in science, technology, engineering and mathematics (STEM).
- 3) Government should as a matter of national security, identify key areas of focus in research and development for product development.
- 4) As the pace of adoption of disruptive technologies increases, so too will the need to adjust training requirements including the curriculum. It is recommended that a review of the implications of the Industry 4.0 agenda for the demand for skills and qualifications in Nigeria be initiated. This will help the government apprise themselves of the scale and impact of 4IR on the nation's training systems.

References

- [1] Aikman, D. (2017). *The Fourth Industrial Revolution*. World economic forum, Davos.
- [2] Borat, H., Ravi, K., Christopher, R. & François, S. (2017). *Sub-Saharan Africa's Manufacturing Sector: Building Complexity*. African Development Bank Group, Working Paper no. 256. Retrieved from www.afdb.org/en/documents/publications/workingpaper-series/ on 8/8/2019.
- [3] Castels, M. (1999). *Information Technology, Globalization and Social Development*. United Nations Research Institute for Social Development. UNRISD Discussion Paper No. 114, September 1999. Geneva, Switzerland.
- [4] Daniel, B. (2017). *Social Innovation Policy for Industry 4.0*. Division for Social and Economic Policies, Friedrich-Ebert-Stiftung, Bonn, Germany.

- [5] Newman, C. Jonh, P. John, R., Abebe, S., Mans, S. & Finn, T. (2016). *Manufacturing Transformation: Comparative Studies of Industrial Development in Africa and Emerging Asia*. UNU-WIDER Studies in Development Economics, Oxford University Press, Oxford.
- [6] International Labour Organisation, ILO (2012). TVET reform: Designing an inclusive skills development program. Retrieved from http://www.skillsforemployment.org/KSP/en/Details/?dn=FM11G_009612 on 10/08/2019.
- [7] Inclusive Growth Forum (2015). The Fourth Industrial Revolution Growth and Inequality. Retrieved from <https://inclusivegrowthforum.org/the-fourthindustrial-revolution-economic-growth-and-inequality/>, on 19/09/2019.
- [8] Jakkie, C. (2018). *Made in Africa Manufacturing and the fourth industrial revolution*. Africa In The World Report 8, Institute for Security Studies, South Africa.
- [9] OECD (2015), *Measuring Innovation in Education: A New Perspective*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264215696-en>.
- [10] OECD (2016). *Innovating Education and Educating for Innovation: The Power of Digital Technologies and Skills*. OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264265097-en>.
- [11] Phills, J. A., Deiglmeier, K., & Miller, D. T. (2008). Rediscovering Social Innovation. *Stanford Social Innovation Review*, 6 (4): 34–43.
- [12] Schwab, K. (2016). *The Fourth Industrial Revolution*. World Economic Forum: Geneva.
- [13] United Nations Industrial Development Organization (UNIDO). (2018). Industry 4.0 –the opportunities behind the challenge. Vienna, Austria.