Different Strokes of the 4th Industrial Revolution:

Lessons from the COVID-19 pandemic on technological change and prospects for Africa

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Different Strokes of the 4th Industrial Revolution

Lessons from the COVID-19 pandemic on technological change and prospects for Africa

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Abstract

The impact of the 4th Industrial revolution (4IR) on the future of work in Africa is contested. On the one hand, the potential for new automation technologies such as smart robotics and artificial intelligence (AI) to extend the range of tasks that can be automated has led to fears that the main impact will be to eliminate jobs. At the same time, the 4IR is more than industrial automation, and digitalisation is giving rise to a range of new business models and innovative services based on the internet in such diverse areas as finance, agriculture, and health. Moreover, it can be argued that the 4IR may have opened a window of opportunity for accelerated growth, thereby positioning Africa to adopt new digital technologies and solutions faster and potentially to leapfrog. This paper investigates the opportunities and challenges that the unfolding 4IR presents in Africa. It balances a discussion of the potential for leapfrogging and catch-up with the view that the emerging digital platform companies may be establishing monopolistic positions often to the benefit of foreign investors. Drawing on a variety of secondary sources, the paper argues that the COVID-19 crisis has accelerated these trends, as sectors have been forced to rethink their business models in the wake of the imposed shutdowns. The paper examines the impact of the pandemic on the linkages between the formal and informal sectors in Africa and argues that there will be a need for regulations that strike a balance between supporting new business models and ensuring that there is a level of self-determination and equity in the value captured.

Keywords: Fourth industrial revolution (4IR), leapfrogging, technological change, innovation systems, informal economy, COVID-19

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1. Introduction

Technological progress has been a crucial driver of how value is created and thus of the nature of work. For Schumpeter, while development is first and foremost a process of technological change, the latter ultimately takes place through innovations carried out by entrepreneurs (Lima, 1996). Technological breakthroughs, which have seen human capacity multiplied, largely drive economic development as technology has augmented human productive capacity, giving more output for the same input (Rifkin, 2013). The world is currently considered to be at the cusp of a technological revolution that is being referred to as the 4IR (WEF, 2017). This is driven by monumental breakthroughs in the use of Information and Communication Technologies (ICTs) that are unleashing new capabilities and fundamentally changing the nature of work through new forms of automation and digitalisation (see appendix for definitions of 4IR technologies).

The 4IR is seen as presenting unprecedented opportunities. For instance, MGI (2016) argues that systems enabled by machine learning are general purpose in nature and can provide value across the economy and generate productivity gains and improved quality of life. At a macroeconomic level, automation could raise productivity growth on a global basis by as much as 0.8 to 1.4% annually (MGI, 2017a). Businesses everywhere will have an opportunity to capture benefits and achieve a competitive advantage from automation technologies, not just from labour cost reductions but also from performance benefits. The 4IR technologies are also connecting many devices and allowing the development of new business models through the clever use of data generated.

In a study of 12 African countries, ACET (2018) found that Africans are generally positive about AI, with 55% seeing a positive impact on jobs and only 16% expressing a negative view, however many stakeholders found that Africa was largely unprepared for 4IR. The 4IR, therefore, presents clear opportunities, but the current wave of disruptive technologies is causing great anxiety[1] as they have the potential for automating many tasks that were formerly thought to be out of reach of machines. Some authors have raised the possibility that new digital technologies, including AI, are the harbinger of a singularity that will progressively eliminate all or most human labour in industrial production (Brynjolfsson & McAfee, 2014).[2] The impact is not fully understood, however, and the very high estimates of job losses made in earlier studies have been revised downwards, possibly suggesting that the risk was exaggerated.[3]

The shift to the 4IR has been further accelerated by the COVID-19 pandemic, which has seen firms and people rapidly adopt new ways of working and doing business. Business and social activities have significantly moved online (Soto-Acosta, 2020). What is less clear is what the 4IR could practically mean for Africa with its huge informal economies and how the COVID-

[1] Anxiety about new technologies is not new; the rise of the 1st industrial revolution saw resistance by Luddites, who violently opposed new machines and went on destruction rampages. Similar anxiety was seen as computing ushered the third revolution (Autor, 2015; Juma, 2016)
[2] For a critical discussion of the singularity hypothesis, see Nordhaus (2015).
[3] Early estimates by Frey and Osborne (2013) put jobs at high risk of automation at 47% in the United States. Estimates by Arntz, et al. (2016), however, found that only 5-10% of jobs are susceptible to automation. A 2017 MGI report estimated that for 60% of the jobs, at least 30% of the tasks could be automated (MGI, 2017a). McKinsey's latest estimate puts global job losses due to automation at 15% through to 2030 (MGI, 2017b).

19 impact may provide some insights in this regard, which this paper seeks to explore. The paper aims to clarify what the 4IR means for African economies and to identify how opportunities for equitable African development can be leveraged with a focus on lessons that can be derived from the experience of the COVID-19 pandemic. It contributes to the sparse academic literature on 4IR in Africa while also commenting on African policy initiatives such as the African Union's Digital Transformation Strategy for Africa 2020-2030 (2020) and the digital policies of various African nations (including Nigeria, South Africa, Ethiopia, Tanzania, and Kenya). These policies articulate what policymakers consider to be their challenges, opportunities, and expectations.

The paper is structured as follows: The next section will look at the impact of COVID-19 on 4IR developments in Africa. Section 3 explores the impact and potential of 4IR for the largely informal African economies, while section 4 considers the potential for 4IR to help Africa leapfrog. Section 5 concludes with a discussion of the regulatory challenges facing African countries, specifically the risks due to the potential of the emerging digital platforms to establish monopoly positions.

2. COVID-19 and 4IR developments: a global overview

The COVID-19 provides insights into how the 4IR is likely to unfold. As summarised by Marr (2020), the transformative effects of COVID-19 are immense. The reality of everything being conducted remotely saw 4IR technologies being deployed to support a range of activities in distance work, entertainment, education, and as well as connecting with friends. Indeed, the COVID-19 pandemic has accelerated the adoption of many 4IR technologies[4] and pushed them to new levels as they were applied to mitigate the health impact and assure business continuity. Marr (2020) and UNIDO (2020) point to some key developments that are worth noting:[5]

- *Artificial Intelligence (AI)* was a key technology in the pandemic response. Public health officials relied on AI to better understand infection patterns and to try to predict surges in COVID-19. Bots were put into use for contactless deliveries, cleaning, and administering medication. This experience resulted in a learning process leading to improvements in the use of AI over time. The surge in reliance on AI will result in artificial intelligence becoming more advanced (Marr, 2020).
- *Cloud computing* moved mainstream. As workforces moved home to slow down the spread of coronavirus, cloud computing helped companies continue with day-to-day operations. Now that more companies have experienced the flexibility of cloud computing, they can be more strategic about how they will use it.
- The shift to the *5th generation mobile network (5G)* with enhanced connectivity based on a faster data transfer speed will promote the greater use of the *Internet-of-Things (IoT)*. The demand to handle a varied stream of data from interconnected devices at

[4] As Microsoft CEO has commented, "We've seen two years' worth of digital transformation in two months." COVID-19 accelerated the adoption of 4IR technologies as people and companies relied on cloud computing, artificial intelligence, the speed of the 5G network, big data, and more (Marr, 2020)
[5] See the appendix for definitions of these technologies.

a quick speed makes the 5G network crucial to the advance of the 4IR. The pandemic created new use cases and business demands for stable wireless networking.

- *Big Data* and *big data analytics* were relied upon by health officials to understand the pandemic. They tracked the number of cases, traced infections, and modelled spread throughout various cities, regions, and countries. Several tracking tools were created throughout the pandemic.
- *Robotics* has been used to transport essential medical supplies in heavy transmission areas of some countries.[6]
- *3D printing* is filling the gap in order to provide much needed personal protective equipment for medical professionals.[7]

UNIDO (2020) sees the emergence of a "new normal" in the post-pandemic world that will increasingly be driven by advanced technologies and their applications for inclusive and sustainable industrial development. However, there is potential for a few big winners and many small losers, underscoring the need for policies to steer the revolution and to mitigate the potential engendering of inequalities. In the wake of COVID-19, new giants have emerged powered by 4IR, for example, Zoom, which saw meeting participants grow from 10 million in December 2019 to 300 million as of April 2020, as many people have transitioned to working and socialising from home. As of May 2020, Zoom was valued higher than the value of the seven biggest airlines (Ghosh, 2020). More crucially, COVID-19 has exposed deep structural inequalities in Western societies (Pazzanese, 2020). This has revealed a huge chasm with the owners and employees of the big tech companies thriving in the wake of the pandemic while those with low skills often line up for food aid. A recent Eurostat (2020) report observes that low-income workers are more likely to lose their jobs and that the hardest hit are young and low-skilled workers.

3. 4IR and African economies

The potential for 4IR to help transform African economies and unleash new opportunities is substantial. For Africa, 4IR technologies are showing considerable dynamism, with significant potential to support various transformation strategies proposed for Africa (see notably ACET, 2018 AfDB, 2013; AU 2020). Drones, for example, can be deployed to monitor agriculture, supply blood and lifesaving medicines, among other services (FAO, 2018). Blockchain technologies can help in automating land registries (see Appendix B). Arguably mobile money can transform financial inclusion. The transformational impact of 4IR needs to be given more attention through the generation of evidence for policy and practice.

Much of the trepidation about 4IR depends on new technology's automation potential, with the impact on employment likely to be the greatest in the manufacturing sectors due to the potential for industrial robots to replace human workers (Chandy, 2017). While the extent

[6] For the case of Nuro, an autonomous vehicle startup, see https://www.theverge.com/2020/4/22/21231466/nuro-delivery-robot-health-care-workers-food-supplies-california. Accessed on 24/06/2021.
[7] See for example https://www.nihlibrary.nih.gov/services/3d-printing-service/3d-printing-medical-equipment-response-covid-19-pandemic. Accessed on 24/06/2021.

to which this is occurring is debated,[8] in considering the potential impact of automation technologies on employment in the African context, it is important to consider that what may be technically feasible is not necessarily economically feasible. Even though the cost of robots is falling, they are unlikely to offer a viable alternative to more traditional methods for several decades in most African countries.[9] More crucially, manufacturing accounts on average for only 7% of national products in Africa, and even though the sector might be more susceptible to automation, the impact on employment in the short to medium term is likely to be small. The most important impact is the loss of what can be termed "could have been jobs" as Africa's low-cost labour advantage becomes less of a factor in determining patterns of international production and trade (Hallward-Driemeier & Nayyar, 2017). For Africa, the more significant impacts will arguably be in the application of 4IR technologies to public and private services.

In the West, computerisation has resulted in labour market polarisation, with the shares of middle-level jobs declining relative to those of the low and upper skilled groups (Autor, et al., 2003; Goos & Manning, 2007). The evidence is much more uncertain for developing countries (World Bank, 2016). Digitalisation has ushered in the "Gig Economy", with digital platforms being used for commissioning tasks leading to the challenges that come with an increase in informal work, including low pay and lack of social security (Schmid & Wagner, 2017). However, informality has been the dominant way for the majority of people in Africa, and the advent of the 4IR may provide the potential to increase employment through the development of digital platforms that can offer jobs and other services. Further, to the extent that 4IR is spurring new occupations in services and construction, it can lead to an increase in middle-wage occupations (MGI, 2017b).

Some potential innovations leveraging 4IR technologies in the wake of COVID-19 have been explored in the last section. These examples may seem limited in application or scope given the long-standing challenges that Africa has had in leveraging technology-based transformations at scale (Adesida, et al., 2016). However, there is emerging research distinguishing between which of these COVID-inspired innovations could reflect systemic and lasting innovation ecosystem shifts, compared to those which might be rightly considered to be just incidental and transient (Adesida, et al., nd). Indeed, the crisis has stimulated innovations, especially in food security and health across Africa. We are seeing the leveraging of technologies and also innovation in business models to address the COVID-19 induced challenges. Some initiatives include:

- Use of Drones: Drones were deployed in Ghana to send blood samples to testing laboratories (Reuters, 2020), and the country is also planning to use drones to distribute vaccines (Prabhu, 2021).

[8] Empirical research on the impact of robots in European countries, including Germany, shows that after taking into account the compensating effects, the impact of robot adoption on employment is neutral or positive. See, for example, Graetz & Michaels (2018). A recent study by Lorenz and Kraemer-Mbula (2020) in reference to the auto sector in South Africa found that employment levels did not fall with investments in robots because output increased substantially. Further, one component supplier interviewed stated that he had refrained from investing in automation technologies so as to avoid reductions in employment for the unskilled.
[9] For example, Banga and te Velde (2018) point out that given the wage rate of a high-end robot (costing $28 per hour) that can be used to make furniture and assuming an annual decline in the cost of robots of 6.5%, it will take until 2032 for robots to be economically viable in the sector in Kenya.

- Deployment of Robots: In Rwanda, robots were deployed in hospitals to help in screening, including performing temperature checks and reading other vitals, detecting lack of masks and cautioning people to wear them (WHO, 2020).
- Leveraging ICTs for food aid collection and delivery: In Kenya, mobile Apps were developed to collect food packages at designated collection points. Potential donors go to the application's dashboard and generate the list of individuals they have identified as people in need and assign collection points, whether it's large-scale supermarkets or small-scale kiosks.[10]
- Automated border checks: The East Africa Community has developed EAC COVID-19 Test Certificate for truck drivers and crew members. The system has been developed to facilitate a common approach to certifying results of those tested for COVID-19, by using the system to generate a COVID-19 test certificate for drivers and crew members. Consequently, the generated COVID-19 certificate for drivers and crew members who have undergone tests would be shared with all respective stakeholders both at accredited designated testing points and border crossing points in the region. This certificate that is recognised in the EAC is expected to be valid for 14 days and would allow the owner to travel in the region without being subjected to re-testing unless he or she is found to have signs and symptoms for COVID-19 on screening at checkpoints using the screening tool.[11]
- Financial Innovations: In response to COVID-19, Nigerian Consumers are migrating to digital transactions for their financial services, and most consumers surveyed say that they expect to increase their use of digital and mobile banking services post-crisis.[12] The banking sector also saw a significant rise in agent banking during the crisis, which is dramatically opening up the unbanked and underbanked segments. Agent transactions surged by 859% between March and April 2020, with agents able to provide money – including government aid – and perform various transactions (Kola-Oyeneyin, et al., 2020).
- Business Model Innovations: Many businesses were forced to re-invent their business models in the wake of disruptions. Some examples include:
    - In South Africa, *Bottles* which has traditionally been a platform operating in the sales and distribution of alcohol, could no longer operate due to government restrictions on liquor trade and entered into an agreement with retailer Pick 'n Pay to leverage its last-mile delivery network to deliver essential groceries to consumers during lockdown (Johnson, et al., 2020).
    - In Nigeria, e-commerce and payments startup *Jumia* is partnering with vendors to use its ePayment and last-mile delivery capabilities to offer contactless delivery of food and other necessities to all areas, including remote and rural locations (Johnson, et al., 2020).
    - *GetBoda*, a logistics/courier platform, reported a 150% increase in demand for delivery services during one week in April 2020, which they expect to rise

[10]https://www.capitalfm.co.ke/business/2020/04/centum-subsidiary-develops-zero-contact-covid-19-food-distribution-app/
[11]https://eac.int/press-releases/147-health/1736-eac-partner-states-adopt-the-eac-regional-electronic-cargo-and-drivers-tracking-system
[12] This situation may change; following intense lobbying, the central bank has set the capital requirements for payment banks very high, which may slow the pace of progress in financial inclusion.

further (Johnson, et al., 2020). Indeed, the motorcycle delivery man has become the key part of the supply chain as home deliveries have increased.

The success of the above innovations can be attributed to the old adage that necessity is the mother of invention on the one hand and opportunity meets preparedness on the other. Confronted by closure and lockdown, businesses were forced to think of new business models, and these innovations were ready to meet new demands. In addition, some governments provided requisite support accordingly. In Kenya, for instance, the government put up a COVID-19 ICT advisory committee and equipped it to fund ICT innovations to mitigate the effects of the pandemic (Abuya, 2020). Arguably, the policy support and ability of the technologies to adapt to the COVID-19 situation can be attributed to the notable success, which is important for progressive policies and regulations as well as potential scaling up towards sustainability.

The potential of new deeper innovations building on the new business models emerging in the wake of COVID-19 is also huge, as shown by a study by Maastricht School of Management. Examples cited by the study include:

- Peer-to-Peer Humanitarian Aid in Ethiopia, a local home to home (peer-to-peer) food supplier that has emerged during the closure period. This approach can be further leveraged using technology developed to create peer-to-peer food supply programs (MSM, 2020b).
- Rethinking School Feeding and Tying to Online learning: The School feeding program has important social support tools and stimulus packages. This calls for a rethinking of innovative ways of ensuring a sustained delivery of the support (MSM, 2020a).

The impact of innovations is, however, mixed. The impact of COVID-19 on the informal economy is likely to be mixed, as has been experienced through food distribution systems. In some sectors, especially in prepared foods value chains, innovation in new business models has seen greater integration of the informal sector to the formal sector. For example, increased online orders have seen the motorcycle become the key "last mile" connector. Their business has increased considerably. On the other hand, some COVID-19 driven innovations have seen the removal of some informal players from the fresh foods value chain. For example, in Kenya, one development of note is the collaboration between Twiga Foods, which distributes foods for many small farmers (17,000) directly to informal food retailers (mama mboga), and Jumia, which is the biggest e-commerce platform in Africa. Under the arrangement, Jumia will sell bundles of Twiga's fresh produce on its e-commerce website. Jumia's delivery fleet will pick up orders from Twiga's sorting and distribution centres and then complete last mile, contactless delivery.[13] This innovation essentially cuts out the "mama mboga", the retailer, and thus her livelihood.

This implies that policy interventions are needed, and this will vary across value chains if the benefits of innovation are to be distributed more widely. UNIDO (2020) proposes a proactive intervention utilising 4IR technologies in several areas, notably for institutional

[13] https://techcrunch.com/2020/04/28/goldman-backed-ventures-jumia-and-twiga-partner-on-produce-in-kenya/

transformation; strengthening innovation clusters and ecosystems; upgrading the capacities of medium and small-medium enterprises (MSMEs); technology upskilling and learning; enhancing investment promotion agencies; and fortifying quality infrastructure in order to boost business resilience and competitiveness; as well as fostering smart production and effective partnerships.

4. Leveraging 4IR to leapfrog – exploring the potential

Freeman and Perez (1988) argue that if society and economies could adapt gradually and easily to the new products and means of transport and communication associated with a technological revolution, the whole process could be described simply as normal 'progress' and technological change could be treated as an exogenous variable. They provide evidence that such changes are far from smooth as societies are profoundly shaken and shaped by each technological revolution, and, in turn, their technological potential is shaped and steered as a result of intense social, political, and ideological confrontations and compromises. As such, a technological revolution ushers in a new economic and social order depending on the intensity of the confrontations and compromises reached. More developed, stable economies might experience disruption, while relatively less developed economies that make the necessary investments in skills and the new infrastructure might actually get a chance to leapfrog to a new order.

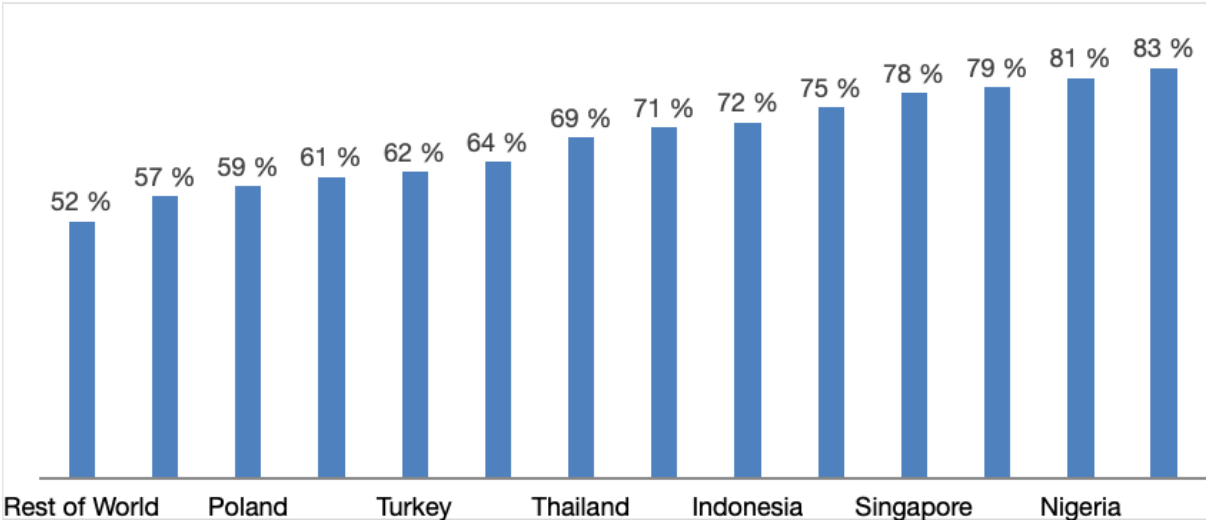
The proposition being made in the last section is that 4IR may have to be considered differently from the perspective of Africa. In addition, the idea that this may provide a window of opportunity for Africa to catch up needs to be put into focus. This requires thinking about how to both mitigate the negative impacts and take advantage of the opportunities of 4IR, as well as to assess these in a context-specific manner. The COVID-19 crisis has opened new perspectives on the application of 4IR, and they point to potential paradigm shifts. Potential pathways to leapfrogging are discussed below.

4.1. Infrastructure provision

The internet is a key enabler of the 4IR, especially for Africa. Banga and te Velde (2018) find that a doubling of the internet penetration rate increases labour productivity by about 11% on average, underscoring the crucial role of infrastructure. However, internet penetration growth has been tepid overall, and Africa lags behind other regions. In addition to suffering lower access to the internet, African countries also suffer from poorer performance, with average download and upload speeds significantly lower than in Asian economies. African internet users also face longer delays in processing network data and pay much higher prices relative to their incomes (Banga & te Velde, 2018).

Debatably, there is an opportunity for Africa to change this. The mobile cellular phone probably gives the best illustration for leapfrogging where many countries leapfrogged the fixed landline infrastructure and went straight to mobile phones. Furthermore, leapfrogging is happening in African countries as mobile phones have become the dominant means to access the internet (Ngunjiri, 2018).

Figure 1: Proportion of internet traffic coming from mobile telecommunications platforms.



Source: Ngunjiri (2018).

The leading e-commerce platform in Africa, Jumia, has an increasing share of its sales coming from the mobile platforms. Some 70% of Nigerian buyers use mobile platforms, while 60% of buyers in Kenya and Egypt also buy using mobile platforms (Kariuki, 2018).

4.2. Financial inclusion

Africa has a huge proportion of people who are not included in the banking system, a consequence of the informal nature of the economies. For example, Global Findex data shows that as of 2017, 60% of Nigeria's population remained unbanked, yet Nigeria is the biggest economy in Africa.

4IR has the potential to bank many unbanked through financial technology (fintech) innovation, especially mobile money. The exemplar of this is the M-Pesa platform in Kenya. In this regard, fintech has provided another opportunity to leapfrog. Mobile banking works to support the further development of the digital platform economy as transactions through a digital platform require access to a bank or a non-bank mobile money service.

While lagging behind China,[14] African countries, and especially Nigeria and Kenya, have emerged as fintech hotbeds. Nigeria is now home to over 200 fintech standalone companies, and between 2014 and 2019, Nigeria's fintech sector raised more than $600 million in funding, attracting 25% ($122 million) of the $491.6 million raised by African tech startups in 2019 alone, second only to Kenya, which attracted $149 million (Kola-Oyeneyin, et al., 2020). The key to the success of fintech innovation in Africa is using inexpensive, accessible tech to mobilise consumers in ways never seen before (Chitavi, et al., 2018). Today the M-Pesa platform has 110,000 agents spread throughout the country, ensuring

[14] In 2018, China's $25.5 billion fintech market accounted for 46% of all fintech investments globally, making it the largest such market in the world (Chitavi, et al., 2018).

anyone can access e-money. Banks are also innovating to fend off competition from mobile phone companies. In Kenya, Equitel, owned by Equity Bank, is pushing boundaries for financial inclusion even further by offering a full suite of banking services on mobile devices. Equitel is a new type of hybrid firm: a telecommunications company born of a bank. The impact of the innovation has been immense. While financial inclusion in Kenya was at just 26% in 2006, this has risen to 83% of the population (Chitavi, et al., 2018). Many countries in Africa are following Kenya's model, and this is promoting a rapid rise in financial inclusion.

Technology innovation is, however, only one requirement. Countries need to change laws on banking, and also social adjustments are needed to make mobile banking work. A strong preference for cash can hinder the adoption of mobile money.[15] The explosive growth of mobile money in Kenya and in other East African countries, including Tanzania and Rwanda, points to the importance of having a supportive regulatory environment. On the other hand, growth sputtered in Nigeria, where until recently, mobile network operators (MNOs) were prohibited by law from issuing mobile money (Evans & Pirchio, 2015).[16]

4.3. The rise of indigenous platforms

Although global platforms like Uber and Airbnb have already settled in Africa, a rapidly growing and vibrant indigenous platform economy is growing alongside and with huge potential to foster inclusive growth based on local entrepreneurship. One such example is the Lynk platform (www.Lynk.co.ke) which connects households and businesses with verified domestic workers, artisans, and blue-collar professionals in Nairobi. As of September 2018, the platform had successfully 'Lynked' 20,000 jobs. The insight2impact facility in South Africa has been tracking the number of platforms in Africa. They identify 365 platforms, of which 301 are indigenous platforms.[17] Kenya's digital entrepreneurship ecosystem has spawned a large number of digital startups providing services to agriculture ranging from information on market pricing, finance, data analytics, and connections along the value chain (World Bank, 2019b). Johnson, et al. (2020) estimate that in 2018, indigenous digital platforms created income-generating opportunities to 4.8 million workers across seven African countries. However, many of the workers lack social protection underscoring the need to further build these platforms beyond being just a place for jobs and adding other services.

Despite the potential of leveraging 4IR for leapfrogging, the impact of 4IR will hinge significantly on the readiness of countries. Readiness may be considered in relation to four key pillars: infrastructure, skills, innovation systems, and regulatory capacity. Recent studies suggest that Africa is quite unprepared in all four pillars, which is a matter of grave concern (ACET, 2018). The education systems are not able to provide the needed skills, the internet infrastructure is generally poor and expensive to access, the innovation systems are still

[15] See GMSA (2019), which identifies the preference for cash as being one of the main reasons that mobile money has not been adopted in Senegal and Mozambique.
[16] Regulatory reform in Nigeria in 2018 allowed non-financial companies, including MNOs such as MTN, to issue e-money. However, the decision in 2020 to raise the minimum capital base requirements to USD 13 million has hindered the development of mobile money service providers. See: https://weetracker.com/2020/09/01/nigeria-mobile-money-license/
[17] See: http://researchictafrica.net/wp/wp-content/uploads/2018/12/DInfo_V11.pdf

nascent, and the regulatory capacity is weak (ACET, 2018). Significant work is needed to improve readiness. ACET (2018) pointed to the following actions:

- *Policies to improve infrastructure*: Incentives for private sector investment in infrastructure, especially for the rollout of 4G and 5G networks. Public investment, especially in key backbone infrastructure such as transport and energy in remote areas.
- *Policies to improve education systems*: The focus on lower education should be to learn good foundational skills and Technical and Vocational Education and Training (TVET) skills. Upper secondary should focus on increasing the uptake of science, technology, engineering and mathematics (STEM) skills. Life-long learning to ensure workers skills match the needs of a rapidly changing labour market. Policies should focus on market failure, for instance, limited information on potential returns to investing in skills and imperfections in credit markets.
- *Policies to improve innovation system*: Investment by government in science and technology parks (for instance, Kigali Innovation City). Strengthening the institutional framework for innovation by ensuring all elements are there.
- *Policies to improve regulatory capacity:* Adopting a sandbox environment that will allow experimentation with technologies before devising an appropriate regulatory regime is recommended. This requires a balance between fostering innovation and safeguarding the public interest. An example in Africa is the out-manoeuvring by ride-hailing companies and the government responses. In response to the Nigerian authorities banning smaller engine motorcycle taxis from some cities, ride-hailing companies entered the market and invested heavily in larger engine motorcycles, only to see the government later ban any motorcycle (Odunsi, 2020). Uganda has also gone for regulatory overkill with the potential to kill a nascent motorcycle ride-hailing industry. The regulation seeks to classify the motorcycle riders as couriers, which carries a license of $1,000 that is out of reach of many young motorcycle riders (Ojakol, 2020).

5. Discussion and recommendation

The process of revolutionary technological change provides a window for leapfrogging for Africa. The 4IR is already disrupting developed economies with fears of huge job losses and growing inequalities. The trend so far has been that those few who control the emerging high-tech platforms powered by 4IR capture the lion's share of the value created. Africa is not being spared either, as demonstrated in this paper. Like mobile telephony, emerging 5G technologies promise to help Africa leapfrog yet again and bypass broadband technology, potentially contributing to levelling the playing field in terms of digital infrastructure. Paradoxically, 4IR platforms, which have the potential to organise the informal sector at the same time, are breaking up the formal sectors in the developed countries and creating gig economies that are more akin to the character of economies in Africa. In this way, 4IR may be enabling a paradoxical type of convergence as the Western job landscape starts to look more like Africa.

As Africa attempts to leapfrog, however, there are clear dangers ahead. While a vibrant innovation system is emerging and creating applications that have the potential to contribute to solving many of the developmental challenges, the weak capacity to execute and regulate, coupled with limited resources, means that the innovations emerging can be easily harvested by well-resourced and more experienced international venture capitalists. Furthermore, the new platforms emerging to organise the economies can easily morph into monopolies that can be very adept at evading regulations while capturing much of the value created.

The fact that the 4IR provides a window to leapfrog does not necessarily mean that the opportunity will automatically yield the expected benefits. The rapidly increased shift to digital transformation as a result of the COVID-19 pandemic has had both positive and negative impacts on social inclusion. The areas of concern include: widened financial and digital gap, security, data privacy, market monopolisation, transparency, and predatory lending (Benni, 2021). In addition, the first-mover advantages mean that network effects can give one big player an unassailable lead. For example, the M-Pesa platform has given Safaricom a dominant position in mobile money transfer in Kenya. This has been parlayed into other businesses, making Safaricom a key player in many sectors where apps are being developed to digitise services, including banking, agriculture, and media. The potential to abuse this monopoly is huge. Governments should look into how digital money could be leveraged to foster integration and interoperability of payment systems (Davidovic, et al., 2020). There may also be a possibility to impose fines, although these may seem insignificant given that many of the tech companies have accumulated huge reserves of cash with which they can easily pay. This underscores the challenge of indiscriminate regulation. Considering that the 4IR and digital tech multinationals are global in nature, governments may consider regional or international cooperation, which may help in addressing some of the regulatory challenges.[18]

Beyond the ability to regulate, African countries need to develop stronger innovation systems that can enable the development of platforms to solve the many pressing development challenges they are faced with (Adesida, et al., nd). Already Africa has begun to form the basis for potentially robust innovation systems with over 442 active technology hubs in Africa and more than $1 billion in venture capital investment on the continent (Bright, 2017). Thus, there is ample potential for the emergence of many innovations that could build versatile platforms to support leapfrogging ambitions. While inventiveness is key, innovation resulting in an impact depends on execution and marketing. The success of Silicon Valley firms is partly due to their huge marketing budgets and ability to execute. International venture capitalists are behind many of the innovations happening in Africa. In fact, it has been pointed out that the motivation behind their support is really to harvest ideas and take the best out of Africa to Silicon Valley or elsewhere for upscaling and execution (ACET, 2018). Thus, the innovations for leapfrogging may not be owned by African entities, and indeed even the most celebrated innovator, M-Pesa, is owned by Vodafone, a UK company. There is a clear and real potential for emerging digital platform

[18] https://ettg.eu/2020/10/26/strengthening-the-digital-partnership-between-africa-and-europe/; https://ettg.eu/wp-content/uploads/2020/10/ETTG-Publication-Strengthening-the-digital-partnership-between-Africa-and-Europe.pdf

enterprises to fall under the ownership of international investors, creating new forms of extraction from the continent with limited local benefits.

While we may celebrate the innovative, upgrading and upskilling potential of the informal sector, there is potential for one or a few international investors to control significant sections of the informal sector and essentially extract all of the value created. This is further enabled by an international political economy that increasingly requires the opening up of all sectors, including services, and an international dispute regime that tends to favour international investors over countries (Viñuales, 2015). The emergence of 4IR platforms raises the risk that significant sectors of developing economies are controlled by international investors with little domestic leverage over their development. The key mitigating factor here is that there are also indigenous platforms that can counter the monopolistic tendencies of well-resourced global platforms. While it is unlikely that indigenous firms will have the marketing resources of Silicon Valley platforms, they have contextual knowledge, and their sheer number shows that entrepreneurial spirit is thriving.

The big challenge for Africa is how to strike a balance so that regulation nurtures innovations and ushers new business models while also ensuring that there is a level of self-determination and equity in the value captured. Russo and Stasi (2016) argue for the need to define the markets covered by the share economy platforms and their relationship to existing markets in order to effectively regulate their new services within current legislative frameworks. They argue that where network effects play a key role, competition law becomes particularly pertinent. However, this does not make it easier because definitions are fluid. For example, is Uber a technology company or a taxi company? Uber has effectively argued that it is a technology company and thus not subject to the regulations that apply to taxi companies. There are no easy answers on how to manage this.

In conclusion, the 4IR is far from being a single story – it may truly be a case of different strokes for different folks.

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Appendices

Appendix A: Fourth Industrial Revolution (4IR) technologies definitions

Technology	Definition
Cloud Computing	This is a computing business model where users buy computing services (including processing power, storage, and applications) rather than owning the infrastructure. The cloud services providers develop the infrastructure and offer the services. The key advantage of this model is that firms can avoid the upfront cost and complexity of owning and maintaining their own infrastructure. In turn, providers of cloud computing services can benefit from significant economies of scale by delivering the same services to a wide range of customers.
Machine learning/AI & Robotics	This is the aspect of technology that perhaps most defines the 4IR. AI is enabling machines to be trained to undertake tasks that previously were the domain of humans. Much like humans, machines are now being enabled to learn and adapt, thus increasing their capability. Significant milestones in this area include the first computer to beat a human in the game of Go, an abstract strategy board game. More recently, a machine has outperformed a human expert at lip-reading. Autonomous (self-driving cars) are also being piloted.
Internet of Things (IoT):	Computing and communication power are increasingly being embedded in all kinds of hardware and devices, including white goods such as washing machines and refrigerators. As more and more of these devices are linked together, they form what is now known as the “Internet of Things” (IoT) – a giant network of connected "things" (which also includes people). The IoT allows for virtually endless opportunities and connections to take place, many of which cannot be fathomed or fully understood yet. Rwanda, for example, has deployed drones (autonomous aerial vehicles) to deliver blood.
Data mining technologies /data science:	The proliferation of mobile devices, online sensors, and other means of collecting information digitally is a key driver of 4IR. The capture of vast amounts of data, when combined with powerful computing capabilities and AI algorithms, generate unprecedented amounts of insights. New businesses are emerging from these digital platforms and disrupting established industries. Shared economy apps (such as Uber, a shared taxi service) and supply and demand matching services (such as Airbnb, an accommodation rental facilitation service) allow for instant interaction, information exchange, and closer and broader collaboration.
3D Printing	3D printing refers to a manufacturing process which additively builds or forms 3D parts in layers from Computer-Aided Design (CAD) data, and the design is printed in a printer. The technology is significant because it offers direct manufacturing, meaning a design goes directly from the designer to the physical product. Other advantages are: the digital design can be tweaked with a few mouse clicks; the 3D printer can run unattended; and the printer can make many things that are too complex for a traditional factory to handle. Thus 3D printing combines the customisation of the cottage industry and also cost efficiencies that can beat the mass-production model. This technology is changing the manufacturing landscape, and as costs fall and technology improves, this technology will completely disrupt the manufacturing industry.

Blockchain	As new technologies connect disparate peoples and disrupt existing models, trust systems developed over a long period of time are being eroded. Specifically, the blockchain lets people who may have no confidence in each other collaborate without having to go through a neutral central authority. Blockchain is an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way. As a result, intermediaries such as lawyers, brokers, bankers, and even government bureaucracies may no longer be necessary. Simply put, it is a machine for creating trust. More crucially, blockchain technologies can cut the time of transactions drastically, from weeks or months to days, hours, or minutes. With blockchain-based sources of influence and control emerging, economies are poised to undergo a radical shift.
5G	The fifth generation of cellular data technology. It succeeds 4G and related technologies. The benefits of 5G include faster speeds, low latency (the time to establish a connection), and greater capacity. The theoretical maximum data transfer rate of 5G is 20 Gbps (2.5 gigabytes per second). That is 20x faster than LTE-Advanced, which has a peak download speed of 1,000 Mbps. 5G latency is estimated to be 10 to 20 milliseconds, compared to 4G's average latency of 40 milliseconds. The maximum traffic capacity of 5G is roughly 100x greater than a typical 4G network.

Sources: Compiled by authors from various sources

Appendix B: Potential applications of 4IR in driving transformation

	4IR technology					
Transformation Strategy	AI/Machine Learning	Internet of Things (IoT)	Big Data/Data Science	3D Printing	Blockchain Technologies	Net Impact on competitiveness
Agricultural transformation	• Application in breeding to speed varietal selection • Intelligent robots are reducing inputs applications by over 90%	• Use of drones for crop monitoring • Internet-enabled irrigation systems	• Telephone farming • E-extension • Inputs-as-service business models • Big Data for credit scoring	• Locally fabricated agricultural machines	• Food traceability system for international trade	• Very High • Agriculture has potentially many entry points and little downside in terms of job losses
Modernised services	• Driverless cars will kill jobs in transportation • Potentially very many applications, e.g. credit scoring using non-standard data	M-Kopa selling solar power as utility/service through internet-enabled cookers and solar panels	• Shared economy e.g. Airbnb • Financial inclusion e.g. Micro-insurance • E-commerce e.g. Jumia, iRoko	• Toll/contract manufacturing • Community workshops	• Numerous trust-based applications (land registries, contracting) • Crypto-currency based transactions	• Very High • This sector is already very dynamic. An e-commerce company, M-Pesa, valued at $1 billion, is the biggest money transfer service in the world
Local content	Potential for development of sophisticated machine-learning algorithms for interpretation and/or exploration data	Drone-based services, e.g. facilities inspection, mapping etc.	Geological data mining may create new opportunities	• Locally manufactured parts • Scope for small scale, flexible production		• High to Moderate • Much potential here but will require much support to build new capability, especially in AI, data

						science and 3D printing
Export-led manufacturing	Advanced robots will kill cheap labour advantage		Will enable fine-grained market segmentation and kill mass markets	Will kill the factory manufacturing model		• Very Low • This will not be a viable strategy in the 4IR world
Infrastructure	Smart metering and smart grid technologies	Alternative infrastructure e.g. drones	Smart cities and other tools to help optimise infrastructure	On site manufacture of parts		
Creative industries	New tools		Platforms for distribution	Ability to convert designs to products		• Very high • Products highly amenable to digitalisation
Tourism	New tools to showcase e.g. virtual reality		• Better targeting of marketing efforts • New platforms e.g. Airbnb expanding potential tourists			• High • 4IR can help create new experiences and improve service delivery
Overall impact of 4IR technology	Will kill traditional paths to industrialisation		• The most dynamic of 4IR technology for Africa • Potential to create many jobs	Presents great opportunity for leapfrogging into manufacturing	Potential to formalise the huge informal sector	

Sources: Compiled by authors from different sources (ACET, 2018; OECD Economic Outlook, 2019, Ch. 2; World Bank, 2016; 2019a; MGI, 2016; 2017a; 2017b; UNCTAD, 2017; 2021; Hallward-Driemeier & Nayyar, 2017).

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