

Effective engagement with Africa

Capitalizing on shifts in
business, technology, and
global partnerships

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APRIL 2022

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April 2022
Africa Growth Initiative
The Brookings Institution

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Acknowledgements

This paper was originally prepared in April 2021.

The authors are incredibly grateful to Brookings President John R. Allen, for his leadership, and writing the foreword for this report, and Brahim S. Coulibaly, Vice President and Director of the Global Economy and Development program for his support. The authors would like to thank the National Intelligence Council for discussions that greatly shaped the drafting of this report. The authors are indebted to the following peer reviewers for their engagement and agreeing to participate in the technical exchange meeting (TEM): Aloysius Ordu, Addisu Lashitew, Chris Meserole, and Witney Schneidman. Finally, the authors greatly appreciate Christina Golubski and Esther Lee Rosen for their editing and comments, Hippolyte Fofack for the discussion, David Batcheck for the design and formatting, Jeannine Ajello for the social media and promotional work, and Molly Sugrue, Justine Hufford, and Emmaline Theobald for the development work.

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Foreword

The world is at a pivotal moment as it attempts to tame the COVID-19 pandemic. Beyond the immediate health impacts, the pandemic has partly undone recent remarkable reductions in the share of people living in poverty and slowed the growth of the global middle class. Technology offers the opportunity to reverse those declines and, instead, put the developing world on an even more impressive growth trajectory. Artificial intelligence and emerging technologies are shaping every corner of the planet, from the economy, to climate, to health and their deployment has only grown during the pandemic. Moreover, the growing fierce competition of new geopolitical players in Africa means that the U.S. can no longer rely on the same strategies that it has for the past three decades.

These themes all promise to play out in Africa across the 21st century. The continent remains home to nearly two-thirds of the world's extreme poor but has also made substantial progress reducing poverty rates in recent years. Now, Fourth Industrial Revolution (4IR) technologies such as artificial intelligence and machine learning, automated vehicles, 3D printing, the Internet of Things, big data, robotics and automation, blockchain, cloud and edge computing, and 5G networks have the potential to inspire rapid growth and reduce poverty, if wielded responsibly. Such technologies have already led to improvements in financial inclusion and connectivity across the region. Although the U.S. is still Africa's most preferred development model, according to Afrobarometer, American leadership will need to find new and creative ways to effectively engage with Africa in spite of the emergence of new partners, new technologies, and a virus that threatens to exacerbate global inequality. The Biden administration also has the opportunity to promote inclusive growth and equitable political access by investing in 4IR and promising technologies.

The U.S.-Africa relationship is no longer one of donor and recipient—and has not been for some time. Rather, as the 4IR is revealing, the dynamic, young, integrated, entrepreneurial African continent is creating opportunities for U.S. businesses and is an increasingly strategic geopolitical partner in a rapidly changing world.

This timely report offers unique insights into how the U.S. can capitalize on recent economic, technological, and business trends to strengthen ties with the African continent and build mutual prosperity. The report should serve as a guide for not only U.S. policymakers, but political and business leaders across the world looking to engage with Africa. "Seizing the momentum for effective engagement with Africa" is an important exploration into how the pandemic offers new opportunities for American leadership to play an important role in Africa's

recovery, a move that can benefit the U.S. financially, strengthen ties with strategic partners on the continent, and counteract attempts of less democratic emerging partners to exert influence in the region.

Importantly, this report also reflects the unique contributions Brookings Institution scholars and staff bring to the world: It is a cutting-edge examination of critical themes at the forefront of global conversations; a fruitful collaboration between a world-renowned senior scholar and emerging junior researcher in a dynamic and diverse environment; and an impactful research product informing key policies with a focus on improving the livelihoods of all.

I encourage you to read the report, share it, and continue the conversation around the transformative potential of these new and innovative technologies for African development that it has sparked.

My very best,

John R. Allen
President
The Brookings Institution

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Executive summary

Africa, enabled by rapid technological change and demographic shifts, is primed for a major socioeconomic and structural revolution. This report analyzes the major trends driving this change, along with the opportunities and challenges stemming from it. Africa has the fastest-growing population in the world. In fact, one in four global citizens will be African by 2050. This growing population is projected to become increasingly concentrated in urban areas as Africa continues to experience a rise in the influence of and opportunities in its major cities. This young, growing workforce will be complemented by a rapidly expanding middle class with trillions of dollars in buying power in the coming decades. This report argues that, if harnessed successfully, these trends represent a significant opportunity for African countries and the U.S. to shape a transformation on the continent that ensures prosperity and equitable growth for all.

Chapter 1 provides an overview of the major trends shaping the business environment in Africa, during and after the COVID-19 pandemic. Following financial liberalization in the 1990s, Africa has seen remarkable economic growth and reductions in poverty. However, Africa has not taken the traditional road to development. Rather, Africa's services sector, with "industries without smokestacks," already is exhibiting remarkably fast growth, outstripping manufacturing in its importance in driving growth on the continent. While COVID-19 has caused precipitous drops in trade and exacerbated poverty, its effects will be short term, and Africa still has tremendous growing business potential that offers rewarding opportunities to global and local businesses alike.

Chapter 2 then discusses the rise of the Fourth Industrial Revolution (4IR) in Africa, illustrating how the 4IR presents Africa with the opportunity to bridge gaps in physical and digital infrastructure, but also raises new challenges associated with stability and cybersecurity. Chapter 2 reveals that Africa is already adopting 4IR technology and explores how such technologies have the potential to increase safety and efficiency in the primary and secondary sectors of the economy and accelerate the growth of Africa's tertiary sector. At the same time, this chapter finds that African governments do not have to limit themselves to promoting manufacturing or service sector growth; rather, mutually supporting policies capitalizing on the 4IR can be implemented to augment development in both sectors. The 4IR presents opportunities for governments to improve service delivery with new tools thanks to the rise in e-governance; however, it also presents significant risks, especially given Africa's comparatively weak cybersecurity.

Chapter 3 illustrates how Africa is becoming increasingly interconnected, both regionally and globally. Regional free trade agreements are facilitating Africa's efforts to transition from dependence on commodities to high-skilled, technologically intensive goods and services and manufactured goods. Also, non-Western countries have significantly increased their trade with and involvement in Africa, while China has become Africa's largest trading partner and creditor. New partners like India and the Arab States are more aggressively engaging Africa economically. By contrast, the U.S. has taken a step back in its economic relationship with Africa, with loans, aid, trade, and foreign direct investment (FDI) inflows all falling in recent years.

Considering these trends, this report argues that it is vital that the U.S. take action to improve its position on the increasingly influential and globally immersed African continent. In particular, the U.S. should target investment and aid to areas that allow the U.S. to leverage the increasing regional trade on the continent and promote U.S.-Africa business integration. Likewise, the U.S. and other international partners should support Africa on its path to growth under the 4IR in order to ensure regional stability and mutual security. Finally, the U.S. can increase lending, using it as well for a further flex of power for mutual profit. Ultimately, this report concludes that Africa's rise in global influence cannot be ignored. Policymakers, businesses, and international players, especially the U.S., need to take action now to ensure the coming decades result in a strategic, coordinated effort to bring about socioeconomic and structural reforms on the African continent that will benefit African, American, and global citizens alike.

Key findings

Key trends shaping Africa's transformation and growth: This report finds that the key trends shaping Africa's future include the continent's rapidly growing population, increasingly young work force, more empowered consumer class, and increased urbanization. Likewise, Africa is becoming increasingly interconnected, whether it be through increased mobile phone penetration on the continent, greater access to electricity, or faster broadband speeds. The 4IR and its associated technologies also represent a key driver of transformation on the continent.

Africa has not taken a traditional path to development: Rather than following the typical development path of transitioning from agriculture to manufacturing, Africa has skipped directly to developing its tertiary sectors, especially in banking/finance, ICT services, and tourism. Likewise, Africa has urbanized at a much lower per capita income relative to other regions of the world, resulting in high inequality and poverty levels, and a larger informal sector. At the same time, Africa also is the only region whose rural population is still growing alongside its urban one.

Developing Africa’s secondary and tertiary sectors is not an either/or choice: African governments do not have to choose between promoting its manufacturing or services sectors. Rather, these sectors can be served by complementary policies, since they share a common business environment, depend on exports, and benefit from agglomeration economies. If African governments adopt policies that are targeted at these three areas, they can create synergies and promote the development of both the secondary and tertiary sectors in the process. More specifically, support for “industries without smokestacks”—sectors traditionally considered services but which share a number of characteristics with industry that make them primed for growth and job creation—can sustain Africa’s current growth trajectory.

The Fourth Industrial Revolution brings both massive opportunities and notable risks: The rise of the 4IR on the African continent presents a massive opportunity for growth and socioeconomic transformation, if managed correctly. Overall, 4IR technologies can allow Africa to bridge existing gaps in its infrastructure and leapfrog to new development stages without accumulating inefficiencies. The 4IR can increase efficiency and safety in Africa’s primary and secondary sectors, and further support the growth of “industries without smokestacks” 4IR innovations building on digitalization, including mobile money, can increase financial inclusion and formalize Africa’s massive informal sector. However, if mismanaged, the 4IR brings with it significant risks for rising inequality stemming from a shift to high-skilled labor and an increased risk of cybercrime, especially considering the Africa’s current cybersecurity weaknesses.

Regional integration can lead to more resilient economies: An increase in regional integration through free trade agreements, especially through the African Continental Free Trade Agreement (AfCFTA), can drive economic diversification and resilience to shocks, as intra-African trade features more diverse goods, including higher rates of manufactured and technologically intensive goods and services. In this way, regional integration will enable African economies to shift away from their traditional dependence on commodities, which continue to dominate its trade in international markets and leave it vulnerable to shocks.

The impacts of the COVID-19 pandemic are a temporary setback: While COVID-19 had a negative impact on the continent, Africa is already recovering and poised for a strong future. COVID-19 was accompanied by a precipitous drop in global trade and has exacerbated poverty in the region. However, prior to the pandemic, Africa had seen several decades of strong growth in per capita GDP and trade, a reduction in poverty, and an improved business environment. Increased access to finance and a fall in corruption have contributed to better business prospects. Extreme poverty is still predicted to decline, with the absolute number of citizens living in extreme poverty anticipated to fall by 27 million by 2030. Trade also is expected to rebound given increased regional integration and a fully implemented AfCFTA.

Africa has large, untapped resources: Key resources in Africa are still not being utilized to their full potential. For example, sub-Saharan Africa has the highest share of uncultivated fertile land in the world. Moreover, large areas of its land are not being utilized relative to the productive capabilities of that land, both for services and manufacturing. Likewise, Africa's workforce also is a largely untapped resource, as gaps in education systems leave workers without the needed skills to compete in the modern economy. African farmers also face challenges related to the quality of seeds, the availability of agricultural machinery, and irrigation systems. In general, inefficiencies and gaps in existing infrastructure, whether it be education systems, electricity grids, internet access, roads, or other areas, are hindering Africa's ability to capitalize fully on its potential.

The U.S. has fallen behind other countries in Africa and must take action now to address this issue: U.S. trade, FDI, aid, and lending with Africa all have fallen in recent years, while international players have increased their involvement and influence on the continent. In contrast, non-Western nations like China (now the region's largest trade partner and lender), India, Japan, and the Middle East have deepened their influence in Africa. Notably, the U.S.'s decline in relations with Africa even eschews that of Western nations, since European countries like the Netherlands have increased their FDI and trade with the region, and the UK post-Brexit has also committed to increase its involvement on the continent. Considering Africa's growing role in the global economy, the U.S. needs to take action to address its declining competitiveness on the continent both for diplomatic and economic reasons. The U.S. should strengthen ties on the continent through increased diplomatic visits, target investments based on opportunities offered by the AfCFTA, increase aid that will facilitate U.S.-Africa business partnerships while creating benefits for all stakeholders.

Introduction

Since the turn of the century, Africa has undergone rapid socioeconomic and technological change, which has created unique momentum for engagement with the rest of the world (Signé, 2020). In the late 1980s and 1990s, African governments committed to economic reforms and liberalization, which contributed to significant economic transformation that made the continent an increasingly attractive opportunity for local and global partners (Radelet, 2010; Signé, 2020) while contributing to more inclusive prosperity for the African people. Over the last two decades, many of the world's fastest growing national economies have been in Africa (Signé, 2020) and the share of Africans living in poverty has declined 16 percentage points (World Development Indicators, 2021; World Poverty Clock, 2021). While the COVID-19 pandemic has put much of this progress in jeopardy, the continent has already begun to recover and poverty reduction projections remain optimistic (Wilhem, 2020). Thus, if Africa can navigate its challenges successfully, the coming decades present significant opportunities for businesses, governments, and everyday citizens to benefit from the dramatic changes occurring there.

A number of trends are transforming the African landscape and driving its growth. First, Africa boasts a rapidly expanding population: By 2050, Africa is projected to account for 50 percent of global population growth, with much of this population expected to be located in urban areas (World Population Prospects, 2019; Slavova & Okwechime, 2016, p. 215). As a result, the continent is also projected to have the largest workforce in the world by 2030 (Nsengimana, 2018). Likewise, Africa's consumer class is rapidly expanding, with the middle class projected to grow to as much as 1.1 billion people by 2060 (Deloitte, 2013). Compared to Western nations, which face lower rates of population growth and an aging workforce, Africa is becoming increasingly competitive for private sector investment and attention (World Economic Forum, 2017a, pp. 7; Deloitte, 2014, p. 5).

Africa also is becoming increasingly connected, whether it be through electricity, mobile phones, or the internet. Between 2010 and 2019, the proportion of people in sub-Saharan Africa with electricity access increased 15 percentage points (IEA, 2020). The number of mobile subscriptions also is expected to rise to over 630 million by 2025 (GSMA, 2019). Prior to the COVID-19 pandemic, broadband coverage had been improving, and the pandemic actually accelerated digitization, with broadband speed increasing by nearly 10 percent in the average sub-Saharan country (UNECA, 2017, p. 6; Signé, 2022; Ookla, 2021).

Considering the rise of the 4IR across the world, the trend of Africa's increasingly interconnected citizenry is all the more salient. More specifically, 4IR technologies like 3D printing, artificial intelligence, and blockchain can improve the safety and efficiency of Africa's primary and secondary sectors (Signé; 2022; Naudé, 2017). Likewise, innovations like mobile money platforms and credit risk models informed by 4IR technologies already are increasing rates of financial inclusion and helping formalize the region's informal sector, which currently accounts for 50 percent of its GDP (Ganguly et al., 2017; Slavova and Okwechime, 2016, p. 215; Signé, 2022).

While the 4IR does present opportunities to Africa, it also brings risks, whether it be exacerbating inequality as jobs shift to higher-skilled sectors or increased cybersecurity threats. In fact, African countries rank low on cybersecurity strength relative to the rest of the world, posing a significant concern for both governments and private businesses operating in the region. This threat must be addressed through both regional government action and international support (ITU, 2017; Signé and Signé, 2018; 2021).

Regional integration is another major trend in Africa over the past decades. In fact, Africa has consciously shifted to promoting a regional model of trade and integration, with eight regional economic communities and accelerated integration at the continental level (Fofack, 2020; Signé, 2021). Notably, intra-Africa trade tends to be more heavily focused on high-skilled, technology-intensive goods and manufactured goods, which implies that regional integration is crucial for promoting economic diversification away from commodities, and, thus, resilience to commodity price shocks (UNCTAD, 2021). The recently launched African Continental Free Trade Agreement (AfCFTA) has created the largest free trade area in the world, covering a market worth a total GDP of \$3.4 trillion. If Africa can increase its regional trade shares to levels similar to that of Asia and Europe via the AfCFTA and other integration efforts, it has the potential to attract new investments, strengthen growth, create millions of new jobs, and reduce poverty (World Bank, 2020; Fofack, 2020).

Africa is also enhancing its connections with international partners. Africa's growing consumer market and inexpensive workforce make the continent increasingly attractive to investors, and Africa has seen FDI increase sixfold between 2000 and 2013 (Chen et al., 2015; Signé, 2022). Non-Western countries are playing a growing role in Africa: India, Russia, Thailand, Turkey, and Indonesia have all seen trade with Africa almost double or double between 2010 and 2017 (Devermont, 2018). European nations also have increased their overall trade with Africa between 2010 and 2017 (UNCTAD, 2021). Importantly, China has emerged as a major player on the African continent, becoming Africa's primary creditor and top trading partner (International Debt Statistics, 2021; UNCTAD, 2021). In the wake of these developments, the U.S. has fallen behind, with its FDI, lending, real aid flows, and trade with Africa all declining during this time.

If leveraged correctly, the trends transforming Africa's landscape underlie significant opportunities for the U.S. to promote mutual security and prosperity on the continent in the coming decades. Thus, the U.S. needs to take action now to strengthen diplomatic ties and capitalize on the remarkable growth and opportunities in the region.

Objective

The following three chapters examine the key trends and opportunities associated with Africa's expanding business potential, the role of the 4IR, and increasing regional integration—and, consequently, implications for local and global partnerships. Additionally, these chapters provide recommendations for governments, businesses, and international stakeholders, particularly the U.S., on how they can take action to capitalize on these recent trends. In particular, three questions are addressed:

- **Chapter 1:** What are the business prospects (and key drivers) for sub-Saharan African economies and their overall implications for the continent and its partners?
- **Chapter 2:** What are the prospects (biggest trends) of the Fourth Industrial Revolution's emerging technologies and their potential impact on sub-Saharan African economies?
- **Chapter 3:** What are the prospects for sub-Saharan Africa's relations with external partners and their implications for U.S. national interests as it pertains to economic and technology trends?

To address these questions, these chapters provide a systematic account of key business, technology, and partnership challenges and opportunities on the continent, and their implications for the relations between Africa and its external partners, especially the U.S. In addition, a comparative method is used to elaborate on the similarities and differences between African countries. Chapter 1 concludes that despite the short-term impact of the global COVID-19 pandemic and other challenges, Africa has a tremendous and expanding business potential and offers rewarding opportunities for local and global businesses looking for new markets and long-term investments with favorable returns and high societal impact. Chapter 2 finds that Africa is adopting the 4IR and its emerging technologies at a faster speed compared to the past and despite notable challenges. Likewise, Chapter 2 argues that if proper policies are adopted and investments made, Africa has a unique opportunity to capitalize on the 4IR to address major socioeconomic and political challenges. Finally, Chapter 3 finds that as Africa's business and technological potential continues to expand with accelerated regional integration, high returns, and socioeconomic impact, the continent is becoming home to increased engagements and competition between global partners looking to seize its economic opportunities and expand geopolitical influence. The U.S. has lost ground in certain sectors, but there is the potential to better compete and collaborate with local and external

players to achieve mutual security and prosperity. In the end, these three chapters will demonstrate the key trends, opportunities, and challenges faced by Africa as it grows its business environment, grapples with the 4IR, and strengthens its regional and international partnerships, ultimately providing recommendations to promote inclusive growth and prosperity on the continent.

1. Capitalizing on Africa's expanding business potential: Key trends, opportunities, challenges, and strategies

Africa had sustained consistent economic growth for much of the last quarter century. GDP per capita across the continent has doubled since 2005. Thanks to its rapidly expanding workforce, its GDP has grown by nearly a factor of four during the same period (World Development Indicators, 2021). This economic growth has gone hand-in-hand with a number of other economic covariates that reflect business potential. Improved governance and liberalization have accelerated the growth of FDI. The formation of the African Union (AU), regional economic communities, and now the AfCFTA have spurred both global and regional integration, both politically and in economically (Kayizzi-Mugerwa, Anyanwu, and Conceição, 2014; UNECA, 2020).

However, key challenges still obstruct the region from meeting its growth potential. Physical and digital infrastructure hinder business development through transportation and information costs (Allard et al., 2016). Businesses too often lack access to the capital they need to tap into expanding opportunities (ACET, 2017; Leke, Chironga, Desvaux, 2018). COVID has both complicated progress and introduced new opportunities for realizing business potential. This chapter begins by describing trends across Africa prior to the COVID-19 pandemic. It then considers how COVID has altered trends and projections for the future, before offering recommendations for regional and global players to capitalize on Africa's growth potential.

1.1. Africa has achieved several decades of strong growth behind business-friendly liberalization and political stability

1.1.1. Africa has shown robust, real per capita growth this millennium, and its path to structural transformation is nontraditional

Over the last half century, two hallmarks of Africa's rise in GDP have been population growth and inflation. Even after accounting for these trends, however, sub-Saharan Africa has been

one of the fastest-growing world regions since 2002. After struggling to attain sustained, real per capita growth in the 1980s and 1990s, sub-Saharan Africa's real per capita GDP grew faster from 2002 to 2014 than every world region except East Asia and the Pacific (World Development Indicators, 2021). The 2014 collapse in commodity prices stalled growth, though: Even by 2019, real GDP per capita had not recovered to its 2014 value (Coulibaly, Gandhi and Senbet, 2019).

There are many characteristics regarding Africa's structural transformation that shed light on its untraditional growth path. Some argue that it is a narrow portfolio of exports that has left the region unable to take full advantage of global and regional integration and susceptible to economic shocks. Others point to Africa's lack of structural transformation toward manufacturing (de Vries, de Vries, and Timmer, 2015; ACET, 2017). Traditionally, countries have oriented their economies toward manufacturing to expand export potential and increase rents. But according to Nguimkeu and Zeufack (2019), sub-Saharan Africa's manufacturing value-added share in GDP has not risen since the 1980s. Moreover, the share of the labor force employed in industry increased only 0.1 percentage points from 1991 to 2019, while the share in GDP of industry value added *contracted* by 2.2 percentage points (World Bank, 2021).

Instead, Africa's structural transformation has shifted from agriculture to services (Rodrik, 2016). In sub-Saharan Africa from 1991 to 2019, industry's share in total employment increased by 10.5 percentage points, while agriculture's share shrank by 10.6 percentage points. Services value added as a share of GDP increased by 4.1 percentage points, compared to a decrease of 6.6 percentage points for agriculture. This has led some (e.g., Rodrik, 2016) to hypothesize that sub-Saharan Africa has run out of opportunities to industrialize further, and employment and output is now shifting from agriculture and industry to services. Others (Nguimkeu and Zeufack, 2019; ACET, 2017), however, argue that, while global trends and technological advancement have limited opportunities for sub-Saharan Africa to utilize a labor-abundant manufacturing model to compete in global markets, it has not spelled a decline in the relevance of manufacturing to its economies, a phenomenon often termed "deindustrialization". Moreover, policymakers across the continent believe that the AfCFTA is the antidote to a stagnant manufacturing growth (Fofack, 2020), as the trade agreement will galvanize domestic and regional consumption as consumers substitute non-African exports for tariff-free regional goods. Increased consumption should spur investment in high-productivity sectors, like manufacturing.

It is clear that manufacturing has not played the same role in the continent's economic growth as it has in quickly growing economies in other regions (McMillan, Rodrik, and Verduzco-Gallo, 2014; ACET, 2017; Nguimkeu and Zeufack, 2019). Yet there are some areas of manufacturing that are rapidly expanding across Africa in terms of both employment and output. A closer look reveals that some non-industry sectors behave similarly to manufacturing in that they are highly productive and can absorb a large semi-skilled labor force. Such sectors, including

tourism, agro-industry, horticulture, transport, and information technology, among others, are collectively known as “industries without smokestacks” (IWOSS). These industries in Africa have a higher employment-to-output elasticity than either manufacturing or non-IWOSS industries, paving a promising pathway to growth, even if it does not follow one familiar to the world’s developed countries (Coulibaly, Gandhi, and Mbaye, 2019; Newfarmer, Page, and Tarp, 2019).

1.1.2. Africa’s urbanization has arrived early

Developed countries have typically seen a rapid urbanization accompany industrialization. Yet sub-Saharan Africa has urbanized at a lower per capita income than other world regions (Lall, Henderson, and Venables, 2017). Sub-Saharan Africa has one of the lowest urbanization levels in the world, but its urban population share is growing quickly, particularly in West Africa, where the urban share has grown from 35 to just under 50 in the last three decades (World Population Prospects, 2019). There are several features about sub-Saharan Africa’s urbanization that distinguish it from other regions: First, sub-Saharan Africa’s urban population tends to be more concentrated in the largest cities in each country. At present, sub-Saharan Africa has the highest primacy rate—the share of the urban population living in a country’s largest city—of any world region, though that rate has declined slightly over the last two decades. Primacy is especially high in Central Africa and East Africa, where at least three of every 10 urbanites live in the country’s largest city (World Development Indicators, 2021).

In developing countries outside of sub-Saharan Africa, urban population has tended to grow according to urban population share since 1970. In other words, if the largest city houses 20 percent of the nation’s urban population in 1970, it typically houses around the same proportion in 2020. In sub-Saharan Africa, however, countries across the continent are seeing their urban populations become increasingly concentrated in the largest cities in the country (measured by the gradient of the population Lorenz curve). This is the opposite trend to what is observed in developed countries across the world, whose urban share has tended to become more equitably distributed across cities over time. Sub-Saharan African cities are the fastest growing in the world. Despite having just 10 percent of the world’s cities with greater than 300,000 people, sub-Saharan Africa had one third of the cities in the top decile of growth from 2010 to 2020 (World Population Prospects, 2019).

1.1.3. Africa’s sharp rural-urban divide

There is a sharp rural-urban divide in sub-Saharan Africa despite not much variation in productivity across cities. Night-time lights data reveal that the cities of sub-Saharan Africa have a lower coefficient of variation than any other region in the world (tied with South Asia). However, data from Henderson et al (2018) tells a different story. The dataset contains night-time lights data of 240,000 one square kilometer grid cells. When comparing how the intensity of night-time lights data varies within geographic areas, Africa emerges as the continent with

the highest mean coefficient of variation of night-time lights. Sub-Saharan Africa has a higher coefficient of variation in this regard than any world region except for North America, Australia, and New Zealand, suggesting that there are large swaths of land in sub-Saharan Africa that are not being utilized relative to the productive capabilities of the land. The productive capabilities are not limited to industry or services: At nearly 50 percent, sub-Saharan Africa also has the highest share of uncultivated fertile land in the world (ACET, 2017). This share represents 60 percent of the world's total unused arable land (Signé, 2020).

Sub-Saharan Africa is home to the fastest-growing rural population in the world and, along with the Middle East and North Africa, is the only World Bank region whose rural population is growing (World Development Indicators, 2021). In part, sub-Saharan Africa's rural population growth is thanks to its rapid growth of its overall population, which has more than doubled since 1993. Moreover, sub-Saharan Africa maintains a high youth (age 15-24) of its working age population, suggesting that its labor force—not mere its population—will remain large and expanding (Sumberg et al, 2021).

1.1.4. Trade growth

Total trade in Africa has increased by 300 percent in the last two decades—faster than the global average of 196 percent and propelled by a 241 percent increase in exports from the continent (UNCTAD, 2021). Africa's expansion, while positive, was small by global standards, however. It still accounts for just 2.8 percent of international trade (down from 4.3 percent in 1970) and has struggled to integrate many of its industries into global value chains (Fofack, 2020). Africa has likewise struggled to diversify its exports, remaining largely dependent on commodities, which constitute 85 percent of merchandise exports (UNCTAD, 2021). Manufacturing makes up just 14.8 percent of total exports destined for non-African countries.

Intra-African trade differs from extra-African trade in key ways: Manufacturing constitutes 41.9 percent of intra-African exports, and intermediate and final goods feature more prominently. Thus, the AfCFTA is a promising, realistic way African economies can utilize a more diverse regional trade portfolio as a vehicle for transformation and diversification. Even before the implementation of the AfCFTA, institutions like RECs led to an increase in regional trade share in sub-Saharan Africa from 12.3 percent in 2006 to a high of 20.4 percent in 2015 (UNCTAD, 2021). Given that integrated regions like Asia and Europe have regional trade shares of 59 and 69 percent, respectively, there is immense room for Africa to grow (Songwe, 2019). If Africa can approach these figures, new trade opportunities will transform industries, attract new investment, create millions of new jobs, and make the region's growth more resilient (World Bank, 2020; Fofack, 2020).

Like trade, FDI has increased notably in recent years. Following the Great Recession, Africa has emerged as a preferred destination for FDI, and, since 2012, only Asia and North America have shown more growth in FDI per capita than Africa.

1.2. COVID-19 will not deter Africa's long-term growth path and opens new opportunities for collaboration and investment

1.2.1. Demographics and urbanization

COVID will not likely alter Africa's urbanization trajectory and demographics. Africa's rapidly expanding population, in both rural and urban settings, is expected to account for one-half of all population growth by 2050 (World Population Prospects, 2019). By then, it is projected that one in four people in the world will be African. Furthermore, sub-Saharan Africa's swift urbanization and growing population is projected to contribute to some of the fastest growing cities in the world: Of cities with 300,000 or more inhabitants, sub-Saharan Africa will have more than three of every four cities in the 90th percentile of growth from 2020-2030, and none of these cities will decline in population over this time (United Nations, 2021). The urban expansion is also expected to be more equitable than in previous decades. Whereas the Gini coefficient of sub-Saharan Africa's cities increased from 1970-2020, estimates for 2030 suggest that the distribution of the urban population will remain roughly equivalent to its 2020 value.

1.2.2. Post-COVID-19 poverty decline

Since the onset of the COVID-19 pandemic, more than 37 million people in Africa have slipped into extreme poverty (living on \$1.90 per day or less) and the share of people living in extreme poverty increased from 37 percent to 39 percent (World Poverty Clock, 2021). That development is not predicted to last: The extreme poverty rate is expected to fall to 30 percent by 2030, the lowest level of the previous 40 years and a significant decline from the 1990 level of 54 percent (Wilhelm, 2020). Importantly, the absolute number of people living in extreme poverty, a figure which has continued to rise despite the falling extreme poverty share even before the pandemic, is also projected to decrease by 27 million by 2030, though not to below its pre-pandemic level.

1.2.3. Led by the AfCFTA, trade is projected to rebound

Overall, African exports of goods and services contracted by 7.3 percent in 2020 (IMF, 2021). The pandemic had an especially profound effect on oil exporters: In April 2020, WTI Crude had lost 69 percent of its value and Brent Crude had lost 61 percent of its value. With the international market for oil depressed, exporters reliant on oil faced significantly less demand and large revenue shortfalls (World Economic Outlook, 2020). As a result, governments collected less in royalties and lower revenue from state-run enterprises. Faced with declining profits, exporting enterprises laid off workers, and economic recessions followed. Risk-averse investors scared by the swiftly changing economic landscape of these countries withdrew their capital, leaving domestic financial institutions unequipped to meet the rising credit demands of households and firms in their respective countries.

The picture looks brighter now. Vaccination programs in Africa and in many of their principal trading partners are well under way. African economies have started to trade under the AfCFTA. Bond prices have fallen from their precipitous high in March and April of 2020 (Bloomberg, 2020). Capital, including private equity, has begun to flow back into the region (Regional Economic Outlook, 2020). On the coattails of this hopeful news, the IMF forecasts robust trade growth over the next five years vis-à-vis the five years preceding the pandemic (8.5 percent per year vs 4.2 percent per year). Non-resource rich countries stand to prosper more under these circumstances: Exports are projected to grow at an average of 10.6 percent per year over the next five years as commodity prices rebound. Indeed, commodity prices have already begun to rebound. Oil prices have doubled since hitting their low in April 2020 (World Economic Outlook Database, 2020). Prices of iron ore, gold, uranium, and copper have all exceeded their pre-pandemic levels, and the prices of many non-oil commodities have returned to their pre-pandemic levels.

1.2.4. The pandemic has accelerated digitization

Despite stubborn progress in broadband coverage, the pandemic has seen a marked uptick in broadband speed; Ookla data show that the average sub-Saharan African country has seen their median fixed broadband speed increase by nearly 10 percent since the pandemic started, the third-highest increase of any (World Bank) region (Ookla, 2021). The last decade has also seen a notable uptick in mobile subscriptions in sub-Saharan Africa from 45 to 77 subscriptions per 100 people since 2011 (World Development Indicators, 2021).

1.2.5. Business environment has improved, but unevenly

World Bank Enterprise Surveys interview a representative sample of private-sector firms in a given country. Enterprise Surveys are not carried out with consistent regularity, but many countries conducted multiple rounds of surveying between 2006 and 2017. In particular, 29 African countries have completed multiple rounds of the World Bank's enterprise surveys during this period. On average, the first round of surveying was done in 2007 and the second was done in 2014, or seven years between rounds. Taking the most recent two waves of surveying paints a picture of how the business environment of the region has evolved over the last decade or so.

The results of the two rounds show a clear trend toward better access to finance in the region. The percentage of firms that cited finance as a major concern decreased from 47 percent to 38 percent. A major reason for this is a greater facility with loans. The proportion of firms using banks to finance working capital increased by 29 percent, and reported loan application rejection rates decreased by 25 percent. Yet businesses also reported better financing outside of credit: The share of firms not needing a loan increased from 30 to 37 percent.

Several indicators of measuring bribery decreased between rounds. The share of firms expected to give gifts to public officials in order to get something done fell to 27 percent from 37 percent. The bribery index, which measures the incidence of bribery in public transactions, decreased from 19.6 to 18.2. Despite this fall, the political atmosphere in other dimensions increasingly impedes the functioning of enterprises. The share of firms citing corruption as their biggest obstacle increased by 45 percent over this period, while the share of firms citing political instability as their biggest obstacle increased by 57 percent. The share of firms identifying corruption as a major obstacle to conducting business increased from 34 to 40 percent.

The proportion of people in sub-Saharan Africa with access to electricity increased from 33 percent in 2010 to 48 percent in 2019 (International Energy Agency, 2020). Importantly, Enterprise Survey data confirm this trend and offers insights into what drives increased electrification and how it coincides with digitization. In general, firms are less impeded by electrical needs: The percentage of firms that cited electricity as a major concern decreased from 49 percent to 39 percent. In addition, the share of firms owning or sharing a generator increased from 42 percent to 51 percent. As broadband and especially mobile coverage expands across the continent, firms are conducting business electronically. Nearly 60 percent of firms reported using email to interact with clients, up from 45 percent from the first round of surveying.

1.3. Business prospects and opportunities for future growth have emerged as business and consumer spending alongside positive economic growth

The AfCFTA, a growing consumer class, and expanding infrastructure will drive growth in business spending, now projected to reach \$8.2 trillion by 2050 (Signé, 2020). Eighty percent of this sum will be spent by just four sectors, which will be led by construction, utilities, and transportation at \$1.8 trillion. The other three that make up the top four—agriculture and agro-processing, wholesale and retail, and manufacturing—are all projected to be trillion-dollar industries in Africa by 2050 as well.

Africa is not only home to individual-run businesses and small and medium-sized enterprises (SMEs). It is also home to 400 companies with annual revenues in excess of \$1 billion. In fact, large companies account for a sizeable share of the continent's consumption: The continent's 700 largest companies earn a combined \$1.4 trillion per annum. Africa's large companies are not evenly distributed geographically, however: Nearly half (300 of 616) of all companies earning more than \$500 million per year are based in South Africa. Just 4 percent (or 25) of such companies are based in East Africa, while just 3 percent (or 19) are based in Central Africa.

Africa is also quickly becoming a massive consumer market: Estimates reveal the middle class in sub-Saharan Africa to be somewhere in the magnitude of 114 million and 425 million people (Signé, 2020). By 2060, the middle class is expected to be as small as 500 million to as large as 1.1 billion people (Deloitte, 2013). However, estimates of the middle class vary widely according to the methodology used, and there is no agreed definition of the middle class. In fact, as far as it concerns both local and global business leaders and policymakers, many definitions of the middle class may not be appropriate (Signé, 2020). Instead, it is important to understand how these definitions harmonize with each other and with measures of population living above the poverty line. For instance, the share of sub-Saharan Africans living above the poverty line increased from 45 percent in 1990 to 59 percent in 2015 and is expected to eclipse 65 percent by 2030 (World Poverty Clock, 2021). These figures are relevant to business leaders and policymakers because a vast majority of this demographic is projected to have disposable income (Signé, 2020).

As the low-income working class grows, discretionary purchases will rise; thus, despite low per capita income levels now, projected consumer and business spending in the region is expected to reach \$5.6 trillion by 2025, with expected consumer spending to reach \$8 trillion by 2050 (Leke, Chironga, and Desvaux, 2018). Nigeria and South Africa are projected to account for 34 percent of household consumption in the continent by 2025. Africa's consumers will be younger than most: By 2050, Africa will have an enormous labor force of 1.56 billion people, roughly the same size as China and the Americas put together. Africa's consumer base, however, is not an educated one: Just 12 percent of students enroll in tertiary education in Africa, compared to 25 percent in India, 30 percent in China, and 89 percent in the U.S. Nonetheless, Africa's consumers are accustomed to using mobile money for financial services and transactions. In fact, sub-Saharan Africa had more mobile money subscriptions (121.9 million) in 2017 than South Asia, the Middle East, Latin America and the Caribbean, East Asia and the Pacific, and Europe and Central Asia combined.

1.4. Challenges facing African economies in terms of business, growth, and international cooperation

Despite these positive trends and opportunities for domestic and international players to participate in Africa's growth, formidable challenges remain.

1.4.1. Increasing debt levels and more diffuse sources of debt

Inflated debt levels have left governments with limited ability to deal with rising poverty and food insecurity as a result of the COVID-19 pandemic (Addison, Sen, and Tarp, 2020). From 2012-2017, the average debt as a percent of GDP rose from 35 percent to 55 percent. While this figure is below the global average as well as sub-Saharan Africa's peak of 110 percent in

2001 (Coulibaly, Gandhi, and Senbet, 2018), debt servicing costs doubled over this time, and the pandemic likely exacerbated the situation (International Debt Statistics, 2021).

In recent years, African economies have turned increasingly toward private sector credit lines, but this route remains costly and volatile, especially during the pandemic. Coupon rates on domestic bonds can exceed 10 percentage points in some countries, and eurobonds are not much more affordable (Bloomberg, 2020). During the pandemic, many countries, especially those highly dependent on mineral exports, saw bond yields rise exponentially: Zambia's 10-year government bond nearly eclipsed 40 percent. In taking advantage of private sector and non-traditional bilateral credit lines, sub-Saharan Africa has diversified its creditor base. Africa's more diverse creditor base is a double-edged sword: Countries have a large pot of capital to draw from, but debt and payment restructuring also becomes more difficult (Coulibaly, Gandhi, and Senbet, 2018).¹

1.4.2. Increased need due to COVID-19 has further increased debt levels

The pandemic has accentuated the needs plaguing these economies: More than 37 million people in Africa have slipped into extreme poverty (living on \$1.90 per day or less) and the share of people living in extreme poverty increased from 37 percent to 39 percent (World Poverty Clock, 2021). Furthermore, supply chain disruptions, food price inflation (global food prices increased by 20 percent in 2020), and locust swarms in East Africa have raised alarms at rising food insecurity across the continent. World Bank high frequency surveys confirm rising food insecurities in a number of countries. As debt servicing costs consume a higher share of government revenue, governments face greater difficulties to meet all the demands before them: Poverty and food insecurity, health care investments, infrastructure, and many others.

One additional need is investment. African businesses of all sizes—individual-run business, SMEs, and multinationals—remain undercapitalized and lack the infrastructure to take full advantage of domestic and international markets or find new customers and potential business partners. While mobile subscriptions have risen dramatically since 2011, broadband and internet speeds have lagged behind (Ookla, 2021). Sub-Saharan Africa still has less than one broadband subscription per 100 people (World Development Indicators, 2021). Those who are connected, face slow speeds. As of December 2020, only Middle East and North Africa (14.6 mbps) had a slower median broadband speed than sub-Saharan Africa (16.9 mbps).

¹ African economies have felt this new inflexibility acutely during the pandemic, as its efforts to secure participation in the Debt Service Suspension Initiative have not been met with enthusiasm from non-official bilateral (e.g. export-import banks) and private creditors (The Economist, 2020). Private creditors have yet to participate in bulk. The Chinese Exim Bank delayed participation by more than 5 months.

1.4.3 Infrastructure needs remain great

Africa's physical infrastructure makes trade in the region costly and inefficient. Sub-Saharan Africa's paved road coverage is the lowest in the world and is low even compared to the average for low-income countries (31 km vs 134 km per 100 km²) (Graff, 2019). Rural communities in sub-Saharan Africa remain disbursed and disconnected with more than two-thirds of the rural population living more than two kilometers from an all-season road. At 7.1 km of track per square km, rail construction in Africa scores better than road construction but still lags behind BRIC counterparts (10.4 km) (Leke, Chironga, and Desvaux, 2018). Historically, the private sector has not played a significant role in infrastructure projects, though this has changed notably the last few decades. Moreover, electrical infrastructure lags far behind comparison countries. Africa averages 632 kilowatt hours per person per year, compared to a BRIC country average of 2,622 kilowatt hours per person. This lack of electrical infrastructure inhibits not only personal connectivity but also business investment. Businesses regularly do not have the electricity needed to power their production goals.

1.4.4. Integration and diversification are still in early stages

The formation of regional economic communities following the Abuja Treaty has facilitated closer economic ties among member countries, but it has not led to a significant rise in the share of intra-African trade in overall trade. In fact, removing South Africa from consideration, the intra-African trade share has not increased since the mid-1990s (UNCTAD, 2021). If the AfCFTA cannot deliver on its promises, the region may continue to be reliant on its portfolio of trade with the rest of the world, which is skewed toward commodity exports, and therefore susceptible to economic shocks.

Although African exports have grown steadily over the last two decades, its growth is less than the global average (both weighted and unweighted). This trend raises concerns that Africa is not truly integrating itself into the global economy. Moreover, its export basket has actually become less diverse since 1990 (Songwe, 2019). While it is true that the share of sub-Saharan African exports traded in the region is increasing and that these goods tend to be more diverse than exports to the rest of the world, the share excluding South Africa is much lower and has not grown significantly over the last few decades. Region-wide, more than 85 percent of merchandise exports are commodities (UNCTAD, 2021). However, resource rents as a percentage of GDP have gone from a high of 20 percent in 2008 to just 10 percent in 2018, suggesting that the region is, in some dimensions, pivoting away from its dependence on resources (World Development Indicators, 2021).

Diversified economies tend to have service plus manufacturing value added as a share of GDP. At 57 percent, Africa's average ranks in the bottom 25 percent globally. Only North Africa and Southern Africa, whose shares are 70 and 73 percent respectively, have shares above the global average (World Development Indicators, 2021). The lack of diversity in other African

regions leaves them susceptible to shocks in the sectors on which their economies are dependent.

1.4.5. Economic growth is similar to, though slightly below, other IDA eligible countries

From 2002 to 2014, sub-Saharan Africa experienced average annual growth in real GDP per capita of 2.5 percent. While this period was among its strongest ever recorded, it is natural to wonder how it compares with International Development Association (IDA)-eligible peers in other parts of the world (IDA-eligible countries were selected for comparison because more than four in every five countries in sub-Saharan Africa are eligible for IDA support). During this same period, IDA-eligible countries averaged 3.9 percent annual growth, slightly above sub-Saharan Africa's mark. IDA-eligible countries also showed more resilient over the last five years, following the collapse of commodity prices. Growth among IDA-eligible countries differs widely by region. While IDA-eligible countries in Europe and Central Asia and East Asia and the Pacific outperformed sub-Saharan Africa, sub-Saharan Africa outperformed IDA-eligible countries in the Middle East and in Latin America and the Caribbean, who averaged -0.3 and 1.7 percent annual growth from 2002 to 2014. Sub-Saharan Africa's growth advantage is not limited to this time period either. Sub-Saharan Africa grew by 1.6 percent per year over the last two decades, which exceeded the Middle East (IDA eligible only) and Latin America and the Caribbean's (IDA eligible only) average of -2.5 percent and 1.4 percent respectively. Sub-Saharan Africa's growth figure exceeded overall average for these two regions as well.

Ultimately, however, sub-Saharan Africa's growth remained around global averages over the last two decades. Its middle-of-the-road growth poses challenges to policymakers looking to achieve export growth and structural transformation to improve growth prospects. Particularly challenging is achieving sustainable, resilient growth. From 2014 to 2019, the economies of sub-Saharan Africa contracted by 0.5 percent on average. Moving forward, policymakers must find not only pro-growth policies, but pro-sustainable growth policies to obviate periods of slow growth such as the one experienced by sub-Saharan Africa from 2014 to 2019.

1.5. Policy opportunities

1.5.1. Africa should double down on regional integration

Access to regional goods is now easier and cheaper than ever thanks to the AfCFTA. While Africa's exports to the rest of the world tend to be narrow and focused on commodities, its exports within the continent tend to be diverse and include manufacturing goods that Africa is uniquely positioned to export. Investing in the infrastructure and AfCFTA adoption will help regional trade take on a more prominent role, thereby diversifying Africa's economies and

making them less susceptible to shocks associated with commodity exports and services-centered sectors like tourism.

Ameliorating poor electrical and physical infrastructure will provide immense benefits. The difficulty is financing it. Wherever possible, African policymakers should appeal to foreign businesses and governments to invest in sectors and locations wherein their investment stands to benefit them. In cases where international players are unable to make an investment that is of vital national interest, African governments should consider reordering expenditure priorities to finance the investment, as it would pay immediate and future dividends (in the form of attracting future business investments).

Growing into a trade model in which regional trade plays a more significant role will transform other aspects of the economies across the continent, as it will change incentives for investment, opportunities for profit, and labor inputs, among other things. These changes will likely yield production and employment that is more centered on manufacturing than at present. Because most manufactured goods are covered under the Africa Growth and Opportunity Act, countries could stand to benefit from forming closer ties to U.S. companies as they expand their manufacturing production (USTR, 2003). As of 2020, however, only 16 of 39 countries eligible for exporting under AGOA have published publicly available AGOA strategies (USITC, 2020). As AfCFTA and regional integration augment capacity for manufacturing, countries should look to integrate into the global market. In addition, countries should work with the Biden administration on the next iteration of AGOA, which is due to expire in 2025.

1.5.2. Opportunities for private sector to step up

Africa's indebtedness and rising debt servicing costs is making it increasingly harder to finance both economic recovery from COVID and growth-centered investments for the medium and long term. The indebtedness has led governments to increasingly partner with the private sector for such investments. For instance, private sector participation in infrastructure as a share of GDP has increased by 473 percent since 1994, the second-largest growth after Europe. There are plenty of opportunities for capital markets to lend to African governments and to invest in promising African enterprises with Africa's urbanization, demographics, and recent strong economic growth trends as collateral.

In order to attract private sector involvement, governments should make a concerted effort to digitize their economies and administrative operations. Digitization will help curb corruption and will help the private sector have more information about investments. As it stands, many investors are more risk adverse than fundamentals suggest, and digitization will help assuage their fears. Regional leadership, such as the African Union, should take a strong stance against digital authoritarianism, whereby governments shut down internet and social media to obscure the truth (e.g., to help win an election).

2. Capitalizing on the Fourth Industrial Revolution and emerging technologies in Africa—key trends, opportunities, challenges, and strategies

The 4IR is characterized by the “fusion of technologies that is blurring the lines between the physical, digital, and biological spheres” (Schwab, 2016). Features of the 4IR also include the velocity, scope, and system impact (Schwab, 2016; Signé, 2022) of emerging technologies such as artificial intelligence, the internet of things, big data, automation, virtual and augmented reality, automated vehicles, among others (Table 2.1: Landscape of 4IR technologies). The 4IR is often presented as being more disruptive than the first industrial revolution (water and steam power), the second industrial revolution (electric power and mass production), and the third industrial revolution (digital electronic and information technology) (Table 2.2: The four waves of industrial revolution).

Given the velocity and scale of these changes, countries around the world are grappling with how to address the benefits and risks accompanying the 4IR. New technologies, including artificial intelligence (AI), 3D printing, and cloud computing, present exciting new opportunities to enhance productivity and transform business practices. Likewise, 4IR innovations can improve the functions of diverse sectors from finance and mining to governance (Ganguly et al., 2017; Gaus & Hoxtell, 2019; Signé, 2022). Emerging economies have the potential to use the 4IR to leapfrog into their next phase of development, adopting new technologies to fill gaps in existing infrastructure without accumulating inefficiencies in the process (Signé, 2022). At the same time, however, the 4IR brings with it challenges, whether it be security concerns arising from the adoption of new technologies or the need for skilled workers to leverage these new innovations.

In Africa, there is massive potential for growth stemming from the 4IR if it is managed correctly. Africa’s primary and secondary sectors have the potential to experience significant efficiency and safety improvements through the 4IR, and there is significant momentum

around uptake for such tools: The impact of the growth in financial technology (FinTech) and telecommunications sectors has been seen in the rising rates of financial inclusion across countries like Kenya, Tanzania, and the Democratic Republic of Congo (IFC, 2018). Aside from augmenting the growth of Africa's tertiary sector, innovations like mobile money platforms or enhanced credit risk models supported through 4IR technologies can increase economic inclusion, especially in the informal sector (Ganguly et al., 2017). In agriculture, 71 percent of farmers were already using ICTs to improve their farming processes as of 2015 (Signé, 2022). In the extractive sectors, it is estimated that digital solutions can lessen costs of oil and gas production by 10 to 20 percent and improve safety (Fraser et al., 2018, pp. 1-2; Signé, 2022). 3D printing also represents an accessible, low-cost technology that can improve the manufacturing sector in Africa (Naudé, 2017). As companies migrate from China to new low-cost manufacturing regions, technologies from the 4IR can support Africa in becoming the next big region for manufacturing (Leke and Signé, 2019, p. 78). Aside from traditional manufacturing, "industries without smokestacks," inclusive of service industries such as banking and finance, ICT services, and tourism, already have seen growth due to the 4IR.

The overall impact of the 4IR in Africa will be driven by several factors, including its growing young and urban workforce, entrepreneurial culture, attractive government policies that promote innovation, rising income levels, and increased connectivity on the continent (Signé, 2022). As incomes rise and mobile phone connectivity increases on the continent, demand for 4IR technologies will only increase. As Africa's workforce increases to a projected 600 million by 2030, its high concentration of young workers will make Africa more competitive compared to many Western nations, which are seeing the average age of citizens rise over time (World Economic Forum, 2017a, pp. 7; Deloitte 2014, pp. 5). Since more than one half of the African population will come to live in a city in the next 25 years, this clustering of the population will promote innovation as entrepreneurs and innovators find each other and share knowledge. Furthermore, Africa saw the fastest growth in demand for internet bandwidth out of all regions in the world between 2009 and 2013 (GSMA, 2019; UNECA, 2017, p. 6; Signé, 2022).

Overall, government responsiveness to and involvement in the 4IR is crucial, and the current 4IR leaders in Africa, South Africa, Mauritius, and Kenya, all showcase proactive government leadership on these issues, developing strategies to capitalize on the opportunities while managing risks (Box 1). Africa now has the potential to see a structural shift from the predominance of traditional agricultural and extraction industries to services, with global trade in services growing faster than that of goods in recent years (Signé, 2022). Africa's ICT sector alone saw a 50 percent increase in growth between 2015 and 2016, one of the highest growth rates seen on the continent and represents a huge opportunity for economic growth and job creation (Signé, 2022). However, Africa does not have to choose between developing its secondary and tertiary sectors; evidence suggests that leveraging synergies between the two can allow for mutually reinforcing growth (Page, 2018, pp. 66-68).

While there are significant opportunities for Africa in the 4IR, there are challenges as well. Africa's young workforce needs to be educated to gain the new skills needed in the 4IR, but is currently far behind other regions (World Economic Forum, 2017b, pp. iii-1). Although "e-government platforms" in countries like Ghana, Mauritius, Tunisia, Rwanda, Kenya, Egypt, South Africa, Mozambique, and Botswana better connect citizens to their governments and enhance service delivery (Hafkin, 2019, pp. 5-6; Wille, 2017), most African citizens have yet to see the benefits of e-governance solutions, with the majority of benefits accrued in the upper and middle classes (Daramola, 2019). In addition, 4IR technologies can be misused by autocratic states, increasing political instability (Howard, 2015; Crocker, 2019). Further use of advanced technologies also exposes governments to security breaches that can cripple public infrastructure, result in significant business costs, and undermine public trust (Signé and Signé, 2018). This concern is particularly salient for African countries, which rank comparatively low on their cybersecurity infrastructure and ability to respond to threats (ITU, 2017).

Objective

The main objective of this chapter is to discuss prospects and biggest trends of the 4IR's emerging technologies and their potential impact on sub-Saharan African economies. In addition, this section will focus on providing recommendations for African governments as well as U.S. federal agencies and international stakeholders on how they can take action to improve the prospects of the continent in the wake of the 4IR, expanding on the following questions:

1. What are the prospects (biggest trends) of the 4IR's emerging technologies and their potential impact on sub-Saharan African economies?
2. Which countries are the leaders, emerging leaders, and laggards in the 4IR in Africa, and how can they bridge the 4IR gap to achieve economic prosperity?
3. Which sectors will face the biggest transformation in the 4IR context? How do we expect African governments to respond to these challenges?
4. What can be done now to smooth the process for governments in the future so that they can further capitalize on the 4IR for economic prosperity? What can the international community do now to facilitate integration of these technologies in the future?

To address these questions, we conduct a systematic review to identify both opportunities and challenges associated with the 4IR in Africa and use a comparative method to explore the contrasts and similarities among different African countries regarding their performance concerning the 4IR. We then offer a series of policy recommendations for both African countries and interested stakeholders, especially the U.S., to ensure Africa is able to effectively capitalize on the 4IR.

2.1. Overview of key trends in emerging technologies and the Fourth Industrial Revolution in Africa

While there is a plethora of definitions for the 4IR, the majority argue that so-called next generation digital technology is the underlying catalyst and facilitator of technological transformation. Another common concept associated with the 4IR is that its technologies boast synergies and interconnections with each other. These “cyber-physical” systems incorporate a mix of big data, automation, sensor technology, and connectivity to yield innovations like 3D printing, cloud computing, and artificial intelligence, among others (Alur, 2015; Signé, 2022). Table 2.1 (Landscape of 4IR technologies) shows a summary of 4IR technologies and their potential applications on the African continent. While 4IR technologies are infamous for disrupting existing industries in developed nations, in Africa they typically play a different role, compensating for gaps in sectors like banking and finance, information and communication technology (ICT) infrastructure, and even tourism. The 4IR will have an indisputable impact on practically every facet of life in Africa; however, its impact will be most dramatic in the areas of skills, training, and employment. Africa’s young population will have to grapple with the need to cultivate skills to be successful in a labor market shaped by the 4IR, even as they struggle with a dearth in access to basic education and digital technologies (Smith, 2019).

2.1.1. Why is the 4IR relevant for Africa?

Already, much of Africa’s recent growth has been propelled by technological innovation, especially in financial services, transportation, wholesale and retail, and telecommunications, and the ongoing COVID-19 pandemic has only served to further drive digitalization and remote solutions across the world, including in Africa (WHO, 2020). The 4IR will give nations and businesses the ability to leverage new technological innovations like automation, artificial intelligence (AI), and 3D printing to augment the speed, efficiency, and sustainability of production (Akileswaran and Hutchinson, 2019). There is potential for these innovations to drive growth as industrial productivity rises, the small-scale production of customized goods becomes feasible, and the Internet facilitates access to global markets.

Certain 4IR technologies in particular offer new opportunities for inclusion in the global economy for developing countries, SMEs, and entrepreneurs alike. Technologies like cloud computing, 3D printing, and mobile money can lessen the up-front expenses of infrastructure, ensure the production of small-scale goods is more cost effective, and enhance access to finance, banking, software and other computer services for populations that are currently underserved (Ndung’u and Signé, 2020).

At the same time, the risk that the benefits of the 4IR will accrue solely in developed economies and cause developing economies to fall behind even further is very real.

Furthermore, within countries, new technologies also have the risk of worsening inequality, especially because these technologies tend to benefit highly skilled workers and reduce the need for low-skilled labor (Schwab, 2016). Ultimately, there needs to be comprehensive national, regional, and global strategies, especially in the context of improving access to technology and high-speed, high-bandwidth internet and mitigating the disruptive impacts of automation and other related 4IR innovations. Otherwise, the 4IR could result in increased levels of inequality, both within countries and between them (AfDB and KOAFEC, 2019; Signé, 2022).

2.1.2. Key Fourth Industrial Revolution technologies and trends in Africa

The primary sector: Agriculture, metal mining, and oil/gas extraction

Agriculture. For the foreseeable future, agriculture will play a crucial role in African employment. In sub-Saharan Africa, farming by itself is responsible for 60 percent of overall employment, while it is projected that the food system will add more jobs than any other sector of the economy between 2010 and 2025 (Ehui, 2018). In addition, income growth across the continent will coincide with a burgeoning consumer demand for food and beverages, along with growth in business-to-business spending on agro-processing. By 2030, food and beverages will become the largest sector for consumer spending at \$740 billion (Signé, 2018b). At the same time, agriculture and agro-processing will reach \$915 billion, becoming the largest sector for business-to-business expenditures (Signé, 2022).

However, a range of challenges, which can include a failure to use modern inputs, a scarcity of irrigation systems, and a lack of security in property rights, have resulted in low productivity in the sector. Likewise, poor infrastructure, including underdeveloped roads, increases transportation costs, resulting in higher input prices and lower returns for farmers. Finally, a lack of public investment in the sector, particularly in the areas of research and development, has limited the number of available science-based tools that can address the requirements of sub-Saharan Africa's variety of microclimates (Jayne et al., 2020). These challenges have made much of Africa's agricultural production uncompetitive in global markets (Fox & Signé, 2021).

While these challenges are still germane, the proliferation of ICTs and other 4IR innovations has allowed for significant improvements in the agriculture sector. As access to mobile devices increases, a knowledge-based agriculture community has grown as well, promoting the sharing of best practices through various internet forums and services. In fact, as of 2015, it was estimated that 71 percent of African farmers were using ICTs to improve their farming practices, and 90 percent of those farmers agreed that using ICTs allowed for better food security, income, yields, and sustainable production (Theunissen, 2015; Signé, 2022). An example of the positive influence of ICT infrastructure in the agricultural sector can be found in the Ghanaian companies Farmerline and Agrocenter, which provide farmers with mobile and

web technology that allows them to receive agricultural and financial tips, along with information about weather (Theunissen, 2015). In addition, Hello Tractor, a start-up in Nigeria and Kenya, gives farmers the ability to hire affordable tractors by mobile phone, while the Nigerian start-up Zenvus helps farmers choose the right fertilizer and irrigation strategy by measuring and analyzing soil data (Theunissen, 2015).

Finally, the decline in the costs of mechanization and automation imply that a myriad of 4IR products have the potential to play a key role in achieving food security on the African continent, especially considering the increasing number of challenges faced due to climate change and population growth. Food waste, a characteristic of agriculture production that contributes to hunger, poverty, and disease, has been reduced in the wake of innovations like food refrigeration and dehydration. They represent easily produced, economical technologies that can solve these issues.

A lack of coordination between traditional agricultural reform and industrialization policies and public and private 4IR innovation will represent the most significant challenge to transforming the agricultural sector during the 4IR. In order to transform agriculture across the African continent, it is necessary to establish a comprehensive approach to cultivating the development of agro-industries while linking local production with global value chains, ultimately creating lasting improvements in income levels and value-added production (Signé, 2022). The potential to shift from agriculture focused solely on raw production to agro-industry is discussed in greater detail in a later section of this report.

Mining and energy. The oil and gas sector also will be significantly impacted by the 4IR. Technologies like blockchain, AI, and advanced sensors can increase the amount and quality of operational data received from oil wells and basins, which can provide the foundation for predictive maintenance and real-time monitoring of yields (Fraser et al., 2018, pp. 1-2). These efficiency improvements have the potential to produce significant benefits; the International Energy Agency has proposed digital solutions that can decrease production costs by 10 to 20 percent. (Fraser et al., 2018, pp. 1-2). In sum, the expansion of digitalization presents stakeholders in oil and natural gas with both opportunities to improve production and new threats as 4IR technology makes renewables more economical.

As global demand for “rare earth” minerals used in technological devices like smartphones rises, the African mining sector, which supplies many of these minerals, is seeing significant changes and transformation stemming from the usage of 4IR technology. If additional “rare earth” mineral reserves can be found, Africa has the potential to capitalize on rising global demand. The 4IR will play a key role in prospecting for these reserves, since technology like drones and satellite imagery represent more efficient methods for prospecting (Gaus & Hoxtell, 2019). Globally, robots are increasingly being utilized for large mining operations. The Internet of things (IoT) also can improve safety conditions in the mining sector by allowing better

monitoring of conditions underground. Overall, however, this technology is being mostly utilized by large multinational companies, whereas the dangerous informal, artisanal mining industry in Africa has yet to adopt 4IR technologies. At the same time, blockchain can increase the traceability of extracted resources, reducing the power of gangs and militias. For instance, using blockchain tracking in the artisanal diamond industry, infamous for its “blood diamonds,” could increase legitimate sales and earnings. Rising demand for rare earth minerals, coupled with the adoption of 4IR technologies to increase the chances of new mineral discoveries, has the potential to increase mining employment.

The 4IR will increase the ability of societies to shift to using solely renewable energy sources. However, many 4IR technologies are reliant on using significant quantities of electricity, implying that the oil and gas sector will remain a primary driver of economies for decades to come. African governments can work to satisfy climate change goals by integrating the use of renewables in high-pollution areas, allowing them to decrease CO2 emissions and become more environmentally sustainable. The oil and gas industry will probably be the main funding source for most of this transition, and oil and gas will remain key tools to expand access to electricity for lower-income citizens who cannot afford renewable energy sources, which remain more expensive in the short term (Signé, 2022).

In the end, African oil and gas companies can use 4IR technology to augment production, significantly reduce waste, and create more efficient exploration and production systems. Renewable energy, fuel efficiency, and energy storage investments are becoming significantly profitable; however, these investments also often have other negative externalities, including environmental consequences. Since new technologies can make it possible to overcome the “Environmental Kuznets Curve,” these negative externalities can ultimately be addressed by transforming the oil and gas sector during the 4IR (Signé, 2022).

The secondary sector: manufacturing and agro-business

The 4IR will impact the manufacturing sector by driving democratization and dematerialization in the sector. For instance, the involvement of SMEs will increase due to technologies like 3D printing. The maintenance, design, and adaptability of machines also will be enhanced by the use of artificial intelligence. Nanomaterials and carbon filter composites lessen the need to keep stock, reduce the use of physical inputs, and make lengthy production runs less necessary, ultimately leading to a dematerialization of manufacturing. These cases show how 4IR technology can be implemented in production through both inputs and machinery, facilitating employment processes, the organization of production, and worker training.

Looking at the sector level, digitalization can augment productivity, demand for new and existing products, and participation in the global value chain. At the same time, digitization will likely lower production costs and lower barriers to market entry for firms. In high skill areas in

particular, these changes will filter into the labor market, increasing the number of available jobs and even creating new jobs (Signé, 2022). Lower-quality, more economical goods that are regionally traded may see the largest gains in productivity, since countries can capitalize on opportunities to export beyond their domestic market. In Africa, this is particularly promising, and nearly all African manufacturing segments have recently experienced large increases in intra-Africa trade (Hallward-Driemeier & Nayyar, 2018, p. 70).

The constantly evolving global landscape of the 4IR can offer more manufacturing opportunities in the African market, especially through the use of next generation manufacturing processes like 3D printing and IoT “smart” systems of production. For instance, these production systems could result in significant improvements within the subsector of metal manufacturing. This would be incredibly beneficial for Africa, as the continent boasts the largest global reserves of chromium, cobalt, diamonds, aluminum, gold, phosphate, manganese, vanadium, and platinum-group metals (Assegaf et al., 2017).

In order to promote long-term industrialization and growth, African governments and entrepreneurs alike must creatively find niches in the 4IR that can be entry points into Industry 4.0. 3D printers can represent one of these entry points, since they are becoming more affordable, require less energy than other forms of production, and are more portable compared to other types of manufacturing equipment (Naudé, 2017, pp. 7-8). If entrepreneurs are operating in attractive fiscal and regulatory environments, 3D printing can become a catalyst for growth and innovation (Signé, 2022).

Aside from traditional manufacturing, the agro-industry and agro-processing sector have the potential to be some of the greatest drivers of economic growth in Africa in the wake of efficiency improvements stemming from the 4IR. In Senegal and Ethiopia, for instance, food and beverage processing already makes up 70 percent of value added in the agro-industry (FAO, 2017). Overall, food and beverage subsectors account for 30 to 50 percent of total manufacturing value and therefore represent a significant opportunity for growth if food production processes as well as food waste management can be improved using 4IR technologies (Signé, 2022).

The tertiary sector: banking/finance, ICT services, and tourism

Banking/finance. As of 2012, access to traditional or electronic financial services was only available to around one-quarter of African adults. Limits on access to credit, insurance, and other financial services encumbered the growth of small businesses, investments in health and education, planning for future household expenses, and the ability to respond to emergencies, especially for rural populations, women, and poorer populations (IFC, 2018). However, the 4IR has dramatically transformed the future of financial services, banking, and capital investment and development on the continent. In a period of just 6 years, the increase in digital financial

services supported through financial technology (FinTech) sector and telecommunications companies has resulted in significant growth in financial inclusion. Between 2012 and 2018, the financial inclusion rate more than doubled in countries like Kenya, Tanzania, and the DRC, with 43 percent of African adults now having access to financial services (IFC, 2018).

Sub-Saharan Africa now leads the world in digital financial inclusion. While less than a third of individuals are able to access formal financial services, mobile money platforms boasted a total subscriber penetration of 44 percent in 2017 in Africa. Notably, countries where mobile money platforms were first introduced, including Kenya and Tanzania, have even higher penetration numbers. In particular, Kenya's M-Pesa galvanized the expansion of financial inclusion via mobile and digital devices and has continued to spread across the continent. As of 2017, there were 338 million mobile money accounts in sub-Saharan Africa, the greatest number in any region of the globe (GSMA, 2017b). Now, mobile financial services are expanding their offerings to include a wide range of services, including insurance, credit, and cross border remittances. Further improvement and new applications are possible using 4IR technologies like machine learning and blockchain (Signé, 2022).

The accuracy of credit risk models also can be enhanced using the 4IR technologies of machine learning and advanced analytics (Ganguly et al., 2017). An example of this can be found in Kenya, where IBM analyzed purchase records from mobile devices and used machine learning algorithms to predict credit worthiness, which provided lenders with confidence and enabled them to supply \$3 million in small business loans (Kinai, 2018). The MaTontine company in Senegal also has used a credit scoring system to improve access to small loans and additional financial services (Vidal, 2017). In developed nations, these technologies have the potential to disrupt existing financial markets; in Africa, however, they represent a way to fill the gaps left by a failure to offer certain financial services. Aside from improving access to digital financial services, 4IR technologies can increase access to formal financial services as well. In Nigeria, biometric identification systems have facilitated registration for formal banking services by citizens (GSMA, 2017b; Signé, 2022).

ICT services. Developing and growing the African ICT sector indubitably intersects with the 4IR. ICT services like internet access are the foundation of other 4IR developments, so continuing the expansion of ICTs can enable additional forms of entrepreneurship and job growth like accessible manufacturing practices and offering services through 3D printing and mobile applications (Naudé, 2017). In addition, innovation among African firms will be positively and significantly impacted by ICT adoption (Cirera et al., 2016). A plethora of 4IR technologies actually are within the bounds of the ICT sector, including AI, big data, cloud computing, blockchain, and others. As a result, it is likely that the ICT sector will continue to expand dramatically as the 4IR progresses in Africa and across the world (Signé, 2022).

Tourism. Although COVID-19 has led to a temporary halt in international travel, 4IR technologies have the potential to encourage international travelers to visit Africa and experience the diverse natural resources and cultures on the continent. Consumer spending on hospitality, recreation, and tourism in Africa is predicted to reach approximately \$260 billion by 2030, which is nearly double the amount that was spent in 2015. However, only 10 countries in Africa have a tourism market with more than \$1 billion in revenues, implying that there are massive opportunities for growth across the continent. Considering the embryonic nature of the African tourism industry, there is significant potential for 4IR innovations to fill underdeveloped gaps in the sector, including logistics, communication, infrastructure, and security, rather than disrupt it (Signé, 2022).

In the tourism industry, big data analysis and cloud computing are driving significant changes. Digital tools that allow airline passengers to make flight reservations and check in online already have become commonplace. As time progresses, AI, cloud computing, and blockchain can further enhance access to transportation and other services. Blockchain in particular could completely transform the African tourism industry by expediting visa and entry processes for foreign visitors, along with the registration process for companies in the industry that have access to travelers' personal data. The 4IR also can impact the safety of foreign travelers and reduce crime. In 2018, Interpol and VoguePay launched a blockchain-based digital platform to protect both international visitors and locals, enabling citizen engagement and collaboration with partner networks to monitor criminal activity. Foreign travelers navigating unfamiliar urban environments can leverage smart city infrastructure and connectivity. Likewise, developing "smart tourism" experiences in cities like Kigali and Nairobi is a viable option, allowing tourists to connect with city attractions and local businesses (Gretzel et al., 2016). Virtual and augmented reality represent additional opportunities to develop the tourism sector; VR can enhance marketing efforts through "virtual tour" offerings and can even help 3D planning of tourist destinations (Guttentag 2010, pp. 640-2). Through the use of 4IR technologies, the African tourism and travel industry has the potential to capitalize on and access a larger share of market for international tourism (Signé, 2022).

2.1. Key drivers of the Fourth Industrial Revolution in Africa

2.2.1. Demographics: youth and urbanization

Africa's rapidly expanding population has significant potential to drive investment and new technology growth on the continent. In 2010, there were 370 million working-age adults in Africa; by 2030, this is projected to rise to over 600 million (World Economic Forum, 2017a, p. 7), an increase driven by over 11 million new, young entrants to the workforce every year (Coulibaly, 2017). Globally, this young workforce and consumer market represents a significant competitive advantage for Africa. In comparison, over one-fifth of the European population will be 65 years or older by 2025; this aging population in the West has the potential to cause

investments to increasingly migrate towards Africa’s youthful and growing market (Deloitte 2014, p. 5).

Increasing urbanization is also a key trend as indicated in Chapter 1. In the next 30 years, nearly two-thirds of Africans will come to live in cities, which represents an over 20 percent increase compared to 2010. The economically active population in Africa also will expand from 56 percent to 66 percent of the continent (Hatch et al., 2011).

The increase in Africa’s urban population will increasingly promote the closer clustering of entrepreneurs and innovators, which presents new opportunities for knowledge sharing. According to the United Nations, over half of the Africa’s population will come to live in cities in the next 25 years (Slavova & Okwechime, 2016, p. 215). Consolidation in urban environments will facilitate the growth of different industries and the emergence of entrepreneurship, supporting ecosystems where businesses can learn and benefit from each other.

Already, urbanization has driven the rise in the number tech hubs across the continent. These hubs are centered around fostering and supporting tech start-ups and have had a significant impact on both the creation and long-term viability of start-ups (Bayen, 2018a). Over the 618 total tech hubs identified by GSMA, there were 80 in South Africa, 85 in Nigeria, 56 in Egypt, 48 in Kenya, and 31 in Morocco. While these represent the top five countries, other tech hubs can be found in countries like Ghana, Tunisia, Uganda, Zimbabwe, Côte d’Ivoire, and Senegal. There is even at least one tech hub in countries that are categorized as having lower levels of development in their innovation ecosystems, including Chad, Cape Verde, Mauritania, Swaziland, and Djibouti (Signé, 2022).

2.2.2. Culture and policy: entrepreneurial culture, innovation-friendly government policy

Between 2011 and 2016 in Africa, entrepreneurship represented the second fastest growing profession on LinkedIn, boasting a growth rate of 20 percent (World Economic Forum (2017a, p. 14). Already, African entrepreneurs are finding areas to employ 4IR technology across the continent (World Economic Forum, 2017b, pp. iii-1). Indicators from the Global Innovation Index (GII) support this idea, since African countries tend to score relatively high on the area measuring the local competition intensity. This entrepreneurship and competition can drive Africa to become the vanguard of innovation during the 4IR (Signé, 2022).

Overall, many countries that are leading Africa in the 4IR boast strong government leadership and strategic plans to develop ICT and promote innovation. This is true in Mauritius, Tunisia, Morocco, and South Africa, where government support has represented a major catalyst for innovation. In addition, in the 2013 East African Northern Corridor Agreement, ICT development was integrated as a strategic priority (Meads, 2017). In Rwanda and Nigeria, both governments have initiated large public research programs to develop “smart city” technology, incorporating

digital services and the internet into urban infrastructure in an effort to enhance efficiency and quality of life in cities (Siba and Sow, 2017). The role of institutions in innovation represents a relative strength for Africa on the GII, and countries that have positive GII scores also tend to feature strong institutional environments that enable this. Through improvements in regulatory and business environments, investors and businesses are becoming increasingly encouraged to work in Africa, which is promoting both innovation and inclusion into the 4IR (Signé, 2022).

2.2.3. Economic conditions: increased connectivity and discretionary income

Increased connectivity, including in electricity, fuel, broadband, and mobile phones, also is a catalyst for the 4IR on the African continent. According to GSMA predictions, the number of unique mobile subscriptions will rise to 634 million by 2025, which is a growth of almost 200 million from 2017 levels (GSMA, 2019). While mobile devices currently are being used as platforms for financial and banking services, they can be employed for other uses, such as the creation of online shopping platforms or even for education and health services, especially in the wake of improvements in mobile internet speeds and the rise in the use of smartphones (Signé, 2022). Increasing income levels and high rates of access to smartphones, tablets, and computers will drive demand for high-speed, high-bandwidth internet and mobile internet. In fact, between 2009 and 2013, there was a 69 percent growth in demand for international bandwidth in Africa, which was the fastest growth seen in all regions of the world measured during that period (UNECA, 2017, p. 6; Signé, 2022).

Today, increased mobile phone usage and enhanced internet has given African consumers greater market access. ICTs have provided consumers with new and innovative ways to spend, such as e-commerce, and have given access to Africa's large, burgeoning consumer market through a plethora of new channels (See Figure 2.1 Africa's ICT development indicators). Companies can connect with consumers more easily as a result, improving mobile market and promotions that drive spending and brand loyalty (Signé, 2022). According to one analysis, in Ghana, Kenya, Nigeria, Rwanda, South Africa, Tanzania, Uganda, and Zambia, there were over 300 unique digital platforms operating, matching suppliers of goods and services to interested consumers (Makuvaza et al., 2018). Most of these platforms were used to connect consumers with services, including mail and transportation, while online shopping platforms made up 27 percent of the 300. It is notable that over 80 percent of digital platforms surveyed were founded in Africa, with 37 of these serving multiple countries (Makuvaza et al., 2018).

Increasing income levels and consumer spending will represent catalysts that further push Africa into the 4IR. Africa's high- and middle-income groups are projected to increase by 100 million people by 2030. At the same time, average household spending is expected to increase at a rate of 5 percent, which exceeds the average rate of 3.8 percent that is typically seen in the developing world (Aykut and Blaszkiewicz-Schwartzman, 2018, pp. 13–14). Since Africa's consumer market is significantly less advanced and saturated compared to that of other

developing economies, it offers incredibly large opportunities for investment and growth (Signé, 2018b, p. 17). In sub-Saharan Africa, consumer spending has risen with an annual rate of 4 percent since the year 2000, ultimately growing to \$600 billion in 2010 (Hatch et al., 2011). A good amount of consumer spending will be directed into new technology and infrastructure, which will only drive the 4IR. In fact, transportation and ICT expenditures are projected to increase faster compared to spending on other areas (Aykut and Blaszkiewicz-Schwartzman, 2018, p. 14; Signé, 2022). Considering the increasing number of options for connectivity, digital platforms, and localization of product offerings made possible by the 4IR, businesses will be better equipped to access this burgeoning consumer market and achieve growth on the continent (Signé, 2022).

2.3. Key implications of the Fourth Industrial Revolution in Africa

2.3.1. Economic growth and structural transformation

Through the 4IR, there are significant opportunities for growth on the African continent, including through a potential shift away from the extractive industries and traditional agriculture. In the context of the 4IR, nonmanufacturing “industries without smokestacks,” including telecommunications and ICT-based services, agro-processing, tourism, and horticulture, can be important catalysts for growth, industrialization, and job creation. Already, innovations in technology, especially in wholesale and retail, financial services, transportation, and telecommunications, have driven much of recent growth on the continent. In particular, the ICT sector has experienced the highest levels of growth seen in Africa and represents a huge opportunity to drive growth in both jobs and public funding. Since many investors are aware of this potential, there has been an increase in resources invested into developing these sectors. In sub-Saharan Africa, FDI flows increased six-fold between 2000 and 2013, rising to \$45 billion and illustrating a transition from extractive sectors to manufacturing (Chen et al., 2015; Signé, 2022). Looking specifically at the manufacturing sector, digitization has the potential to result in increased productivity, larger demand for new and existing products, decreased production costs, greater access to new markets for firms, lower trade costs, and increased participation in the global value chain (Signé, 2022).

Looking specifically at trade, 4IR technologies like AI, blockchain, IoT, and 3D printing can have a significant influence over the future of trade and therefore economic growth. Countries that export commodities, especially small countries, can see their efficiency and sustainability increase in the wake of the 4IR, which will also improve cross-border trade flows by enhancing standardization and traceability (Tsagkalidis et al., 2018, pp. 3). For instance, blockchain can enable better supply chain tracking for goods and services and improve processes in cross-border payments by decreasing both fees and currency exchange rate costs. (Tsagkalidis et al., 2018, pp. 9). Through the AfCFTA, African governments can create cohesive regional trade laws and regulations that can better accommodate the rapid changes resulting from the 4IR. It

also can mitigate the fact that some 4IR technologies have the tendency to increase inequality by allowing landlocked and smaller countries to have access to regional and global markets. Lastly, the AfCFTA promotes economic integration on the continent, which in turn enhances the chances that businesses can share learning and incorporate themselves into regional supply chains, which can potentially augment innovation and economic growth (Signé, 2022).

2.3.2. Employment, skills, education, training, and youth/future workers

The technologies associated with the 4IR have the tendency to replace low-skilled workers and increase the profile of and need for high-skilled workers (Signé, 2022). Technologies that reduce the need for manual labor, including robots and AI, improve manufacturing processes but can lessen the comparative advantage of countries that have lower labor costs. This increases pressure on the work force and reveals the need to enhance the quality of human capital in the economy (Signé, 2022). As a result, a key determinant of whether an economy's manufacturing sector is prepared to participate in the 4IR is the skills of its workforce (Naudé, 2017, p. 4; Signé, 2022).

Overall, the workforce in Africa is becoming better educated, with the percentage of workers with at least a secondary education projected to rise from 36 percent in 2010 to 52 percent in 2030 (World Economic Forum, 2017b, pp. 7). Crucially, however, a lack of digital skills and knowledge is limiting company innovation and local employment rates. The African workforce is currently very far from reaching its full potential; the World Economic Forum's Human Capital Index has shown that, on average, sub-Saharan Africa captures only 55 percent of its full human capital, which is a full 10 percentage points less than the global average of 65 percent. This lack of a skilled workforce is constraining businesses, with 41 percent of all firms in Tanzania and 30 percent in Kenya noting this is a major constraint for their businesses (World Economic Forum, 2017b, pp. iii-1). While the manufacturing sectors in Ethiopia, Senegal, South Africa, and Nigeria employ over 10 percent of these countries' populations, they consistently are ranked low on the drivers of production that allow firms to utilize 4IR technologies (World Economic Forum & A.T. Kearney, 2018). As a whole, many African countries lack the structures needed to leverage technology and innovation or access global value chains, trade, and investment (Signé, 2022).

In sum, Africa is not sufficiently prepared to address the coming disruption to jobs and skills that the 4IR will bring. As African firms undertake the process of modernization and development, employees will need skills to manage, work with digital interfaces, and analyze data. Aside from entrepreneurship, the fastest growing job categories on LinkedIn in Africa are characterized by jobs that require both quantitative skills and skills in creativity and decision making, including business and data center managers. Importantly, these jobs can be complementary to rather than substituted by labor-saving technologies like AI and automation. Globally, these labor-saving innovations are transforming job markets, and emerging 4IR

technologies require that African workers acquire a wider, more varied skillset that complements these new production systems (Signé, 2022).

Apart from challenges associated with cultivating superior human capital, there are also difficulties associated with creating quality employment in the formal sector. While the global average high-skilled employment share is 24 percent, the average for sub-Saharan Africa is just 6 percent (World Economic Forum, 2017b, p. 4). This lack of opportunities in the formal sector has resulted in high unemployment levels among educated youth on the continent, especially in North Africa. Ultimately, a versatile and multidimensional approach is needed to address the disruptive effects of the 4IR, align the skills taught by education systems with rapidly evolving industry needs, and increase high-skill formal sector jobs (Signé, 2022).

By investing in developing a workforce's skills in science, tech science, technology, engineering, and mathematics (STEM) fields, countries can help support local innovation and growth, especially when focusing on the areas like data analysis, computer science, and engineering where the 4IR is projected to spawn a plethora of new jobs (Newman et al., 2017). It is recommended that governments better develop education systems through curriculum that addresses future trends, investments in digital fluency and ICT literacy, well developed technical and vocational education and training, and openness to innovations in education, among other recommendations (World Economic Forum, 2017c, p. 10; Signé, 2022).

In order to develop the modern-day skills needed by African workers, some have argued in favor of expanding vocational education and training. This strategy has been used by several developing countries in Asia, which instituted quality technical and vocational education and training (TVET) systems to help cultivate the skills demanded by companies. In general, Africa has not seen this trend, with antiquated TVET curriculum and teaching strategies largely focusing on a mid-20th century view of the job market, where having a narrow set of vocational skills training guaranteed a lifetime of work. As a result, African TVET systems are out of touch with the needs of modern companies, an issue exacerbated by the fact that there is little outreach to firms to dialogue and better understand their needs. Likewise, TVET in Africa frequently is similar to general secondary school, whereas technical jobs in the 21st century need employees to have general education knowledge, particularly in the hard sciences and mathematics, at the higher secondary school level. Since TVET can be 2 to 6 times more expensive than general secondary education, questions have been raised about expanding the sector when many students still need to complete general secondary school. In Egypt, a study showed that TVET graduates lost their life earnings due to their attendance at these institutions (Krafft, 2018). These findings were not isolated just to Egypt, however, with another study finding similar occurrences in Kenya (Hamory Hicks et al., 2015; Fox and Signé, 2021).

To summarize, improvements in education quality at all levels is necessary to cultivate the skilled workforce that will be needed and well remunerated in the future. To start, hiring

qualified teachers and improving pedagogical methods is needed improve the quality of primary, secondary, TVET, and higher education offerings. Countries that have high fertility rates and therefore high growth in the population of school-age children face particular challenges in enhancing education quality, since this growing population creates the need to expand existing education infrastructure through construction of new school buildings, printing new textbooks, and training additional teaching staff. While it is difficult to change, systemic structure change is vital to addressing demands for new skills and knowledge in the modern day (Fox and Signé, 2021). Equitable access to quality basic education is crucial, while both theoretical knowledge and socio-emotional development should be emphasized and imparted at an affordable cost. Informal sector workers need basic education, but most currently do not have access to it.

Curricula reform and investments in education should target training for the high-skill, high-productivity employment that characterizes the 4IR, as seen in the STEM fields. Countries in Africa can investigate the potential to use 4IR innovations to improve education systems via initiatives like distance learning, increased accessibility of learning materials, collaborative and adaptive learning platforms, and the dissemination of advanced materials (Akileswaran and Hutchinson 2019, p. 42). Across the continent, creative programs are forming to promote inclusive education and training during the 4IR. For instance, to combat youth unemployment, Educate!, an NGO, is working with secondary schools and national education schools in Kenya, Rwanda, and Uganda to revamp school curriculums and teaching strategies in order to provide students with the knowledge and skills needed for the 4IR (Signé, 2022). Finally, considering the role of personal savings in financing education, it is necessary to continue support of mobile banking and financial development in order to expand educational access as well (Akileswaran and Hutchinson, 2019, p. 17; Signé, 2022).

Ultimately, innovations stemming from the 4IR necessitate the development of a broader, more diverse skillset among the African workforce, better equipping them to add value to transformed systems of production. While Africa's higher education system has been rapidly growing due to augmented demand, system quality needs to be improved, since it is charged with providing African workers with the skills and training to use 4IR technology. Africa must modernize and grow education access, since this rapidly evolving and constantly disrupted global economy requires workers and entrepreneurs who are trained to have a diverse skillset. Considering the fact that market structures during the 4IR will be relatively unpredictable due to constant shifts in production and distribution systems, the workforce in Africa needs to be endowed with a variety of soft and hard skills in order to be dynamic and flexible. In order to promote beneficial, inclusive growth as automation increases, workers need to complement, not substitute, the new technology. By confirming education is relevant and provides the knowledge demanded by high-performing firms today and in the future, Africa will ensure that a lack of educated, skilled workers is not the constraint that prevents its economies from fully participating in the 4IR (Fox and Signé, 2021).

2.3.3. Poverty and inequality: formalizing the informal sector, the promise of mobile money and FinTech for inclusion, increasing tax revenue and decreasing corruption

Economic inclusion is yet another area where 4IR innovations hold serious potential to improve the lives of everyday citizens. There has been extensive attention lavished on mobile money platforms like M-Pesa, considering their potential to provide previously unbanked or underbanked populations with banking, insurance, and other financial services. However, there are other lesser-known applications that are also very promising. For instance, the application Poverty Spotlight, which has already launched in 18 countries, allows users to evaluate their poverty levels on the basis of 50 indicators, measuring well-being and items like their access to transportation and sanitation (Burt, 2016; Signé, 2022).

Overall, the capital potential associated with the informal sector has not been realized. This has resulted in a niche where firms, entrepreneurs, and lenders can use tools like AI, blockchain, or machine learning for assessing credit worthiness (credit scores). Formalizing this informal sector through formal credit access and proper record keeping will result in massive gains. In sub-Saharan Africa, the informal sector is responsible for over half of GDP, accounting for \$20 billion in Kenya alone (Slavova and Okwechime, 2016, p. 215; Signé, 2022).

2.3.4. Could the Fourth Industrial Revolution reverse premature de-industrialization?

The 4IR also can change strategies to promote growth and development in African economies. Traditionally, the path of economic development taken by developing nations requires them to first grow their manufacturing base, which raises national levels of income and standards of living. Countries then undergo the process of deindustrialization as other parts of the economy, such as the service sector, grow, and the proportion of manufacturing jobs relative to total employment declines. However, researchers have raised concerns that countries in sub-Saharan Africa are undergoing this process of deindustrialization prematurely due to the rise of technologies that reduce the need for manual labor (Rodrik, 2016). Compared to other advanced economies like the U.S., countries are deindustrializing while still at lower income levels, meaning the benefits of manufacturing have not been entirely realized (Rodrik, 2016). However, evidence for this theory is inconclusive, and other researchers have disputed the claim, arguing that there is only evidence for premature deindustrialization in the Southern part of the region and even that could be attributed to other factors like the Dutch disease (Nguimkeu and Zeufack, 2019, pp. 24-25), with additional suggestions that industrialization has picked up in recent years (The Economist, 2021). Furthermore, the rise of “industries without smokestacks” with associated exports which have grown six times faster than the ones in traditional manufacturing between 1998 and 2015, demonstrates additional industrial development paths should be considered as complementary to traditional manufacturing

(Page 2018). In fact, “industries without smokestacks” (ICT-based services, agri-processing, horticulture, tourism, etc.) shared the characteristics of traditional manufacturing such as tradability, high productivity, and job-intensiveness (Page 2018).

Africa actually can see significant benefits from the development of its tertiary sector during the 4IR. In fact, Africa has already seen growth in its industrial and service sectors due to the ICT revolution on the continent, and 4IR innovations like blockchain, high-speed internet, and virtual reality (VR) also represent opportunities to increase the size of Africa’s service sector. Globally, trade in services is already expanding faster than trading of goods; from 2005 to 2015, trade in services almost doubled, reaching a staggering \$240 billion by 2015. Compared to manufacturing, the tertiary sector can provide developing countries with many benefits. Trade in intangible services can help Africa overcome the challenges of logistic and customs barriers, which are particularly salient for landlocked countries on the continent. Likewise, trade in services is driven by technological change and generally promote more inclusive, environmentally sustainable, and gender-friendly growth (AfDB, OECD, and UNDP, 2017, p. 167; Signé, 2022).

Africa can develop both its secondary and tertiary sectors in the era of the 4IR, capitalizing on synergies between the two sectors (Page, 2018, p. 68). Sectors like tradable services, horticulture, and agro-industry actually are similar to manufacturing because they all share a common business environment, depend on the ability to export, and benefit from agglomeration economies (Page, 2018, p. 66). As a result, African governments can adopt strategies for structural change that are targeted at benefiting these three areas of intersection, promoting the growth of both the secondary and tertiary sectors in the process. Likewise, Africa has the opportunity to become the next manufacturing center as companies move their operations from China to other lower-cost regions, and technologies from the 4IR and the growth of the tertiary sector, including services based on communications technology and the agro-industry, can serve as catalysts for this growth (Leke and Signé, 2019, p. 78).

2.4. Implications of the emerging trends

2.4.1. Potential implications for governance and politics

The 4IR will be a critical phenomenon for African governments as they encounter both opportunities and challenges. For example, in the public sector, technology offers governments the opportunity to streamline institutional efficiencies by integrating processes, managing data, and ultimately providing better communication, services, and security to citizens. At the same time, citizens are provided with an avenue to be involved in governance and innovation. To leverage the opportunities provided by the 4IR, governments will need to engage and encourage innovation and action among public, private, and civil society actors, identifying shared goals in order to improve infrastructure, services, and the overall development and

enhancement of institutional environments. Ultimately, technology and governance have the potential to be beneficial, bringing about improvements and innovation in both the public and private sectors (Signé, 2022).

New technologies provide citizens with the opportunity to engage more effectively with their governments, while simultaneously encouraging transparency and resulting in more accountability. Connected devices will allow citizens to monitor and track government activities, express preferences, and potentially impact policy development and services. In addition to providing citizens with the opportunity for monitoring and tracking, governments can use online services for more efficient communication, tax collection, and enforcement of regulations. Across Africa, particularly in Ghana, Mauritius, Tunisia, Rwanda, Kenya, Egypt, South Africa, Mozambique, and Botswana, “e-government” platforms have been established to perform these functions (Hafkin, 2009, pp. 5-6; Wille, 2017).

Conversely, the 4IR includes risks for African societies. Technological advancements can be utilized and abused by those with autocratic ambitions, with technology being an instrument for monitoring, intimidating, and repressing citizens (Howard, 2015). New technologies also could exacerbate the chances of toppling fragile states without improving governance and therefore can augment the tendency of leaders seeking methods to increase their political influence and control (Crocker, 2019). Furthermore, misinformation promoted through social media and messaging platforms can inflame already tense relationships among ethnic and religious groups. Even more concerning, advanced technologies can provide opportunities for “deep fakes,” or artificially-produced videos and voice recordings that misrepresent individuals and events. These types of abuses can be particularly damaging for emerging democracies, especially during combative elections, where citizens have limited understanding of the potential for misuse of technologies. Additionally, the potential for hacking even beneficial e-government systems can put sensitive data about citizens into jeopardy and result in citizen mistrust. Although the future of 4IR holds a great deal of potential and promise for African governments and their citizens, proactive measures must be put into place to address the aforementioned potential risks.

In order to realize the full benefits of the 4IR, African governments must address rapidly evolving developments in technology, business, and the economy in order to support entrepreneurs and businesses and to address both the existing and emerging needs of their infrastructure and institutions. When the development of information and communication technology is led by and/or supported at the highest level of government, a country’s digital transformation has been expedited and sustained. Overall, governments play a key role in developing and sustaining ICT infrastructure, promoting the success of local and multinational businesses, and enhancing human capital quality. Government leadership is an important contributor to technological infrastructure enhancements, and further innovation is possible when countries successfully leverage ICTs to create public data centers for gathering, storing,

and managing information from government institutions as well as private organizations. These governments are often able to digitize public records data and invest in developing a framework for effective planning and development purposes, potentially resulting in additional innovation (OECD, 2018; Signé, 2022).

African countries that have emerged as leaders in the 4IR have governments that are supportive and responsive to the technology needs of the private sector, entrepreneurs, and research institutions. To this end, most have established government agencies specifically for technology and innovation. For example, South Africa's State Information and Technology Agency works to streamline current technologies while developing new systems to improve processes in all government departments, with the end goal of promoting democratic practices through better information and service offerings to the public (Mphidi, 2008). The development of innovative cities in Fez, Rabat, and Marrakesh is the result of Morocco's Ministry of Industry, Investment, Trade, and the Digital Economy's support of research in advanced technologies. Furthermore, Morocco's Digital Development Agency coordinates Morocco's network of interconnected digital systems to assist the public and private sectors as well as foreign investors (UNESCO, 2016; Mellah, 2018; Signé, 2022).

Four African countries, Ghana, Mauritius, South Africa, and Tunisia, were rated by the UN's 2018 e-Government Development Index as having high e-government development as a result of the significant number of public services these countries offer online. In addition, notable progress in e-government development has been identified in over 30 African countries, including Nigeria, Rwanda, Cameroon, and Togo (Daramola, 2019). Electronic ID systems exist in approximately half of African countries, and about 14 countries have used biometric polling. For example, South Africa has extensive biometric identification, including a central biometric data repository and an extensive commercial data analysis sector. Biometric data contained in smart card-equipped ID cards have been issued by other countries, such as Côte d'Ivoire (Sutherland, 2017, pp. 83-112). Likewise, Zimbabwe has launched a mobile app in an effort to provide citizens with relevant information as well as the ability to review parliament's work through access to parliamentary acts and bills, publications, events, news and live recordings. Similarly, Ghana created Odekro, which provides online access to parliamentary bills, motions, and debates ("Africa Gradually Embracing," 2017). Digital solutions for accomplishing basic tasks, such as the collection and management of revenue, human resource audits, and basic services in the areas of health and education, are being used by the governments of Guinea-Bissau and São Tomé and Príncipe. With a focus on addressing issues related to systems interoperability, the governments of Angola, Cape Verde, and Mozambique are focused on using technology to improve efficiency at the administrative level (OECD, 2018). The private sector and nonprofits have also introduced e-government innovations. For example, Ushahidi is Kenya's open-source software system that uses Google Maps to enable users to report geo-tagged voting irregularities and political violence. As a result of this software, Kenyans were

able to identify outbreaks of violence more speedily and more often than traditional media sources during Kenya's 2008-2009 political crisis (Turianskyi and Gruzd, 2016).

Despite such innovations, the majority of African citizens have not been aided by e-government platforms. E-government initiatives like e-taxation, e-billing, and e-payment have been helpful for middle and upper-class citizens; however, initiatives that could be helpful to the poor, such as services designed to assist in skills development or promote microenterprises, remain unavailable. (Daramola, 2019). Furthermore, African governments are extending e-policy elements from Europe and the U.S. without adapting these policies to context of the locality, nor taking into account the locality's ability to implement the proposed measures or the potential impact or risks associated with the measures (Sutherland, 2017, pp. 83-112). In addition, African political leaders have rarely viewed e-government as a priority, lacking the commitment needed to bring about change in the public sector, while most African countries also lack the legal framework needed to license and sustain digital governance or the dissemination of new technologies. (Mphidi, 2008). Fundamentally, African governments need to prioritize meeting the needs of the majority of their citizens, redesigning and re-contextualizing e-government initiatives in an effort to do so. If governments lag in adopting new technologies, they will be unable to secure the advantages necessary to effectively meet the needs of their citizens

2.4.2. Implications for security and conflicts, including cybersecurity and cyberwarfare

New technologies present both opportunities and risks: The potential for maintaining security as well as the potential for increasing vulnerability. For example, in an effort to defend against terrorism and crime, technologies such as drones can be invaluable. ATLAN, which is a Moroccan startup, is developing AI-powered drones to identify environmental crimes like illegal fishing and poaching (Scott, 2018). Conversely, as countries become more reliant on technology to ensure the functioning of critical infrastructure that underlies sectors like energy, water, transportation, and heavy industry, cyberattacks against these technologies can disrupt whole segments of society. Ultimately, if technology disruption creates inordinately dramatic or rapid changes in society, the consequences can include social unrest when unemployment and inequality are exacerbated by the disruption (Lye, 2017). In order to ensure stability and success during the 4IR, African states will need to evaluate and plan for these potential threats (Signé, 2022).

As a result of the 4IR's penetration into almost all sectors of society, including social, political, and economic systems, cybersecurity has become a prominent issue. As both the public and private sectors increasingly utilize technology, the potential for disruption will ultimately remake the security landscape. In fact, the number and intricacies of technological attacks have intensified, as well as their impact on the operations and finances of individuals, firms,

and states (PwC, 2015; Symantec, 2017). Despite being fairly limited in communications infrastructure, Africa is more frequently being targeted by cybercriminals because of the increased incorporation of new technologies with the limited availability of the legal, technical, and organizational structures that should accompany these developments (Signé, 2022). As a result of these cybersecurity issues, all stakeholders impacted by the 4IR must be made aware of and work together to ensure that regulations are successfully created and implemented to ensure the effective promotion of technology and innovation (Signé, 2022).

When assessed for their ability to respond to cybersecurity threats, African countries continue to rank comparatively low to other countries. As reported in the 2017 International Union's Global Cybersecurity Index, 38 of the 44 African countries reviewed were described as being at the "initial" level of involvement (ITU, 2017). Additionally, a 2016 study by the Business Software Alliance in 2016 concluded that of the software installed in the Middle East and Africa, 57 percent is unlicensed, making cyberattacks and data breaches a potential risk. As a result of poor cybersecurity, African companies are vulnerable to multiple risks, including legal and regulatory noncompliance (Signé and Signé, 2018). Lags in legal and regulatory compliance can threaten African companies' ability to engage with trade partners, as they may not be able to meet established requirements like the European Union's General Data Protection Regulation (Signé and Signé, 2018).

Businesses can also experience both financial and productivity losses as a result of lacking strong cybersecurity. Profits and production can be impeded when data is lost or stolen and when delays occur due to the time period needed to recover from a cyberattack. For example, in 2017, a worldwide cyberattack known as the Wannacry attack impacted 150 countries, including Kenyan financial institutions, and forced a full-day closure of the Moroccan automobile plant, Renault Tanger- Méditerranée (Signé and Signé, 2018). In 2017, cybercrime resulted in Nigeria losing an estimated 649 million dollars and Kenya losing an estimated 210 million dollars (Signé and Signé, 2018).

Cybersecurity breaches have multiple consequences, including theft of intellectual property and other sensitive information as well as legal ramifications and reputational damage. When data breaches result in the compromise of individual privacy, companies can face costly lawsuits involving millions of consumers. For example, in 2017, personal data of sixty million people (including deceased) in South Africa were stolen in what was the country's largest data breach (Signé and Signé, 2018). In Africa, where legal standards for protecting intellectual property do not match with international norms, the risk of losing classified data like patents, commercial plans, or government security information can cause significant setbacks to years of labor and research (Business Software Alliance, 2016, pp. 7). Ultimately, the public is wary of companies who have failed to stop a cyberattack, and breaches result in damage to a company's image with key stakeholders, from partners and investors to customers and employees. Consequently, it is of utmost importance that African governments and businesses

fortify their cybersecurity systems as the world becomes increasingly connected in order to protect their information and avoid the harmful impact a breach can have on their finances and reputation. To best combat cybercrime, a coordinated approach involving both the public and private sectors is necessary to ensure that all possibilities available in the Fourth Industrial Revolution—economic growth, personal freedom, and improved society, can be realized. (Signé, 2022).

2.5. Policy priorities, strategies, and recommendations

The U.S. has a unique opportunity to build from its areas of strengths and sustainable competitive advantage, at the intersections of its interests in security, stability, prosperity, and principles (e.g., development, human rights, etc.), to build a mutually beneficial relations with African countries and the continent.

Support African countries in the Grand Strategy for the 4IR. The U.S. has the opportunity to support African countries developing and implementing the multi-stakeholder 4IR national task force or commission to assess country readiness and adopt a comprehensive national strategy through initiatives and agencies providing support like technical assistance, knowledge transfer, and funding. Initiatives such as the Centers for the Fourth Industrial Revolution (South Africa and Rwanda), or the Presidential Commission on 4IR (South Africa) should be supported and replicated across the continent. On a micro level, the U.S. could help to fund and develop safety nets that African entrepreneurs often lack that could stimulate increased participation from those who may have held back because they could not afford to fail (Columbo, 2020; Andrews et al., 2018 p. 87).

Support the adoption of the principles of agile regulation or technology governance.

Regulation, without reform, could suppress technological innovation while simultaneously not addressing the risks these innovations possess (Almond and Signé, 2021). Thus, African governments must approach the governance of the 4IR with an agile regulatory approach. Anticipation is key, and governments investing in regulatory foresight will be better prepared and more resilient as new technologies emerge. Building from its experience, the U.S. can provide capacity building support to help African countries foster foresight upstream as opposed to reacting downstream, to emphasize outcomes over rules, learn to adapt to change, and adopt the mindset of working across the private sector, institutional boundaries, and internationally (Almond and Signé, 2021). Technology should also be included on this list, as it too has the capability to enhance governance and innovation. As the world becomes more connected, technological devices will increase citizens' abilities to engage with government agencies, which allows for more informed policymaking and the ability of users to monitor and track government performance (Signé, 2022).

Leverage and accelerate the implementation of existing initiatives. The U.S. has an advantage to utilize programs that it has previously created to advance technological developments, specifically to promote a more stable electricity grid and increased internet penetration (Columbo, 2020). An example of this is the Connect Africa initiative launched in 2018 by the Overseas Private Investment Corporation (OPIC), in which it invested \$1 billion to projects in three key areas: transportation and logistics, information and communications technology, and value chains (USDFC, 2018). The BUILD Act, which converted OPIC into the more nimble USDFC, raised the spending cap of investments in lower-income and lower-middle-income countries to \$60 billion, doubling the agency's current funding cap for emerging market infrastructure projects (Runde and Bandura, 2018). The U.S. Trade and Development Agency (USTDA) also has the opportunity to advance its "Access Africa" initiative, which was developed to stimulate entrepreneurship and help those underserved by traditional banking, to now assist in the creation of information and communication technology infrastructure (USDFC, 2019). Prosper Africa, a \$50 million program, was designed not to act as a foreign aid program but to organize resources and capabilities of existing U.S. agencies and departments to help U.S. business expansion overseas (Signé and Olander, 2019). With further refinement and a new set of priorities, this program could distribute resources and personnel to aid in the development of strategic technologies to support businesses in this area, as many are still under the radar (Columbo, 2020). The U.S. government should also build on the Power Africa Initiative that has resulted in past successes for both the U.S. and its African partners. The Biden administration has the chance to greatly enhance the program's effectiveness, which could, at the same time, help to repair the damaged relationship between the U.S. and sub-Saharan Africa (Auth et al., 2021).

Capitalize on a multilateral approach to capacity building and technology advancement. UNCTAD has unveiled a new technology assessment project aimed at African countries. The project will be inclusive, taking into account women and marginalized groups, to foster "community-level participation," as it supports countries who are trying to solve sustainable development challenges through technology assessments (UNCTAD, 2020). A key area of the program includes capacity-building workshops on the African continent concerning technology assessment. These sessions will aim to support action plans that are developed by each country for a sustainable future (UNCTAD, 2020). The project is slated to begin in 2021 and UNCTAD will utilize the support of UNEP, FAO, UNECA, and UNDP (UNCTAD, 2020).

Close the gap in the physical and digital infrastructure, including internet. In order to advance its U.S. commercial goals in the region, the U.S. government will have to expand Prosper Africa's vision to include deals and transactions that foster more "creative outreach" to the U.S. private sectors, as well as increased partnership with African governments to foster improved business environments (Devermont and Harris, 2021). The following reforms have been specifically identified as next steps for Prosper Africa: prioritizing sectoral focus, strengthening storytelling, admit trade-offs exist, strengthen enabling environments, and team

up with like-minded partners (Devermont and Harris, 2021). Increasing two-way trade has the added benefit of eliminating foreign competition that often utilize corruption and non-transparent dealings to gain a foundation in Africa (Runde and Bandura, 2019 p. 16). Acquisitions have also been a positive indicator of future growth and gap closure in African countries. Recent acquisitions include Nigeria's Paystack by Silicon Valley's Stripe, a successful Series B funding round for Chipper Cash, an African fintech company, with additional investments from the Bezos Expeditions, as well as investments from Visa and Goldman Sachs in Nigeria (Wolken, 2020). U.S. policy needs to fine tune its approach to make sure that it is focusing on African needs while adhering to its own strengths; infrastructure is one such area (Moore, 2021). Importantly, the U.S. must be cautious of its inclination for a bilateral trade model, as they should not undermine AfCFTA efforts (Moore, 2021). Power Africa provides examples of existing U.S. government-led partnerships that could be enhanced and built upon (Power Africa, 2021).

Increase access to technologies by promoting effective investment models. Long-standing tensions have surrounded the African startup investment world as the Silicon Valley funding model has been insufficient for Africa's diverse tech hubs (Adegoke, 2021). Early-stage investing in Africa is different than elsewhere given the complex scalability in African markets, which will hopefully be fixed with the implementation of single continental market (AfCFTA). Moreover, startups in Africa may share characteristics as those elsewhere, but context affects how they are perceived on impact, which develops operational norms that influence the behavior of startups and funds (Akinyemi, 2021). Understanding the context for early stage investing in Africa is key to identifying profitable opportunities that exist. It is also important that investors curb assumptions and biases that could cloud their ability to understand the context in which they are operating, and the U.S. government can contribute by documenting and disseminating more accurate information about Africa's technology opportunities and investment contexts to U.S. businesses. B2B investments are another approach that should be considered as a more focused investment strategy for more mature companies (Adegoke, 2021).

Bridge the digital skills and human capital gap. There are educational opportunities among the U.S. and Africa that could help bridge the gap with competitors like China. U.S. policy needs to provide support that incentivizes more American universities to open more campuses and degree programs throughout Africa. Currently, over half of African developers are self-taught, or they are paying for online programs through various schools. U.S. universities could establish programs that create win-win scenarios for everyone involved: For example, Carnegie Mellon University opened a campus in Rwanda that offers master's degrees in information technology and in electrical and computer engineering (Moore, 2021). Another university that has followed suit is Morgan State University which, after unanimous board approval, will offer three different degree programs in Ghana (Morgan State, 2020). The university even has plans to establish a more physical presence in Africa if this pilot program is successful.

Support reforms aimed at improving the business environment, which can increase competitiveness encourage technology adoption, and spur firm-level innovation for the Fourth Industrial Revolution. The U.S. government has an opportunity to support institutions that develop indexes which could be a credible complement or alternative to the World Bank’s “Ease of Doing Business rankings,” which ranked economies based on the ease of performing business there (World Bank, 2020). While the rankings provided useful insight into the regulatory environment in specific countries, it has been suspended due to irregular data and altered statistics—providing an opening for the U.S. to fill. Another useful tool the U.S. could adopt and monitor are sector-specific rankings, including better leveraging MCC scorecards, which help to lay the foundation for increasing private sector investment in specific regions and areas, and is currently tracked using third-party data points through Power Africa’s Enabling Environment Tracker. The U.S. also has the opportunity to provide technical assistance to African governments who are seeking out higher production standards or who wish to initiate market reforms. Support to local watchdogs, like the media and civil society, can also help to hold those in power accountable (Devermont and Harris, 2021). More broadly, the U.S. should increase its investments in both democratic institutions and processes in Africa: A better and more transparent investment environment has the added benefit of creating a more even playing field for American companies and their competitors, like China (Schneidman, 2020).

Ensure the adoption of inclusive policies so that no one is left behind in the Fourth Industrial Revolution context. The U.S. could play a big role in helping African governments turn to more collaborative approaches to ensure inclusivity, especially in the educational field. The online education market is set to reach \$350 billion by 2025, meaning it is ripe for public-private sector investment (Adotey, 2021). Trainings and technologies could easily be scaled-up if the proper infrastructure and inclusive policies were put in place given that unfair distribution and unequal opportunities inhibit learning and future potential remain throughout the continent. Marginalized groups, especially young girls, continue to face inordinate challenges that severely impact their education. In fact, 30 percent of primary school age girls are not in school (Patel and Jesse, 2019). The U.S. needs to fund and support policies that are inclusive, especially given school closures under COVID-19. While online learning is the way of the future in the U.S. and elsewhere, 89 percent of learners across sub-Saharan Africa do not have computers in their home, and 82 percent do not have access to the internet (Adotey, 2021). The U.S. is well-equipped to bridge these gaps and help invest in and fund the future of education in Africa.

Enhance cybersecurity.² It is becoming increasingly evident that no one and no border is immune to cyberattacks. To effectively advance U.S. interests, it is critical that investment and policy initiatives in Africa are accompanied by a holistic cybersecurity approach. Attacks on electrical infrastructure, which are increasing given the digitization of electrical grid operations, can have detrimental effects to national security, the economy, and public health (Power Africa, 2020). African utilities need to start thinking about ways in which to secure their infrastructure against these cyber threats as their operations become more automated. Given that the U.S. has been a pioneer in creating approaches and new technologies to fight against cybersecurity threats (Power Africa, 2020), the U.S. must work directly with African governments and utilities to help them build up secure systems. The U.S. has acknowledged the need for open communication, lesson sharing, and a multiple stakeholder approach to prevent attacks and raise awareness (Power Africa, 2020). Other ways in which cybersecurity can be enhanced is to require state reporting that exposes cyber vulnerabilities as well as the creation of an independent, international cyber court that would be respected by all parties involved, and could help with government-level cyber conflicts (Chernenko, Demidov, and Lukyanov, 2018). Countries also need to adjust their own national frameworks to make them more agile when it comes to adopting and adapting cybersecurity strategies (Contreras, 2020).

Conclusion

Given that Africa is positioned to capitalize on the opportunities offered by the 4IR, the degree to which African countries are ready to harness the 4IR for true economic transformation varies widely, from powerhouses like South Africa and Mauritius to ambitious nations like Rwanda and Nigeria to those sorely in need of reform and support, like Chad and the Democratic Republic of the Congo (DRC).

Understanding, investing in, and supporting Africa to capitalize on the 4IR and emerging technologies is critical for the U.S. to advance mutual prosperity, whether in terms of technology, trade, investment, stability, cybersecurity, global influence, foreign aid, or governance. Given that well-governed technology innovation, an area of global sustained competitive advantage for the U.S. (Signé and Olander, 2019), is a critical tool for inclusive economic prosperity and more effective and representative governance, it can be a foundation for productive U.S.-Africa engagement.

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² The World Energy Council states that between 2014 and 2019, cyberattacks doubled (Power Africa, 2020). These attacks had a real impact on national electricity sectors around the world, as their operations are becoming increasingly digitized. Attacks on electrical infrastructure can have detrimental effects to national security, the economy, and public health (Power Africa, 2020). African utilities need to start thinking about ways in which to secure their infrastructure against these cyber threats as their operations become more automated.

By becoming the leading partners for the 4IR and emerging technologies in Africa, the U.S. will help grow inclusive prosperity and can counter the efforts of less democratic emerging powers to establish economic and political dominance in Africa, including the attempt to share political leadership through digital campaigns. Such American leadership will also allow U.S. and African investors to seize tremendous opportunities associated with the 4IR while building safer physical and digital infrastructure, preventing cybersecurity breaches that can cripple infrastructure, cost businesses time, and lead to intellectual property theft, reputational damage, and legal ramifications, among other issues (Signé and Signé, 2018). Since African cybersecurity threats also present threats to U.S. national security and stability worldwide, targeted support from the U.S. government for the 4IR in Africa will therefore also contribute to American and global security and stability.

As discussed earlier, the U.S. government can help its African partners, at a low cost, to adopt agile, proactive, and inclusive regulations that stimulate innovation, or they risk suppressing innovation and failing to deal with potential risks associated with new technologies (Signé and Almond, 2021). The additional benefit of such technology regulatory support is the low cost of interventions, such as capacity building efforts and dialogues that foster innovation and information-sharing or regulations and best practices that help protect critical infrastructure from attacks.

3. Africa's expanding integration and global partnerships: An opportunity for effective engagement

In recent decades, Africa has begun to shed its commodity dependent and Europe-centric trading model. It has oriented itself to non-traditional economic partners like China, India, Japan, and the Middle East. Conscious efforts among the continent's leaders have culminated in regional integration, first through the creation of the African Union and regional economic communities and now with the implementation of the African Continental Free Trade Agreement. The AfCFTA, the largest free trade area in the world by country membership, covers 1.3 billion people from 55 countries with a total GDP of \$3.4 trillion. Bilateral efforts between countries have secured a more facile flow of labor across borders. Multilateral and bilateral efforts alike have led to a closer knit and regionally interdependent Africa. Policymakers aim to leverage this cohesion into a more regional, diversified trade portfolio, which, in addition to attracting FDI, will reign in rungs in supply chains that have typically been outsourced.

Accompanying this increased regional integration and broader transformation has been the emergence of new global partnerships. Africa's relationship to the rest of the world has changed monumentally over the last two decades. China has captured the headlines following ballooning trade and loans with Africa. But Africa has also sought closer ties with other countries, both western and non-western, who aim to take advantage of Africa's growth and regional integration. As these new partners have emerged, the U.S. has taken a step back: from 2010 to 2017, its FDI, trade, aid, and debt holdings with respect to Africa all declined. With the turn of administration, there is an opportunity for the U.S. to regain lost ground in these areas. New partners have their own ways of engaging with Africa; the U.S. will have to decide whether to double down on its own model or innovate.

3.1 There are clear forces driving Africa's growth in the coming years and tangible ways for international players to tap into this growth

3.1.1. Bilateral and regional integration spur growth

Over the last half century, there has been a conscious economic and political shift away from integration with Africa's former colonizers and Europe more broadly to a more regional model of trade and integration (Fofack, 2020). Indeed, sub-Saharan Africa went from receiving 13.8 percent of its own exports in 1995 to a high of 21.4 percent in 2016. These efforts have been propelled by the formation of regional economic communities of various kinds. The African Union recognizes eight such RECs, including the Economic Community of West African States (ECOWAS), which is comprised of a monetary union, a customs union, and a free trade area, and the East African Community, which has a customs union and free trade area. One of oldest customs unions in the world, the Southern African Customs Union, was founded in 1910 and regulates trade for five countries in Southern Africa (Hartzenberg, 2011).

The RECs have ambitions to evolve beyond their present state (SADC Council, 2001). Many of the RECs themselves aspire to becoming a full economic union. Some the RECs have made expressed efforts to develop closer ties among themselves. For example, member states of COMESA, SADC, and EAC have made a commitment to founding a Tripartite Free Trade Area. The RECs themselves were guided by political documents expressing a will for economic integration. Before the Abuja treaty, the Lagos Plan of Action proffered political will for industrialization driven by import-substitution. The SADC and EAC each had strategic documents that mapped plans for regional integration that carried political legitimacy (Hartzenberg, 2011).

In recent decades, countries of sub-Saharan Africa capitalized on the region's rapidly growing urban population, and population expansion more broadly, through regional and global integration. Since 2000, exports from Africa have increased 241 percent and imports have increased by 353 percent, which both outpace the global trend of 199 percent and 196 percent respectively (UNCTAD, 2021). While it is true that the rise of China—which was responsible for roughly 20 percent of Africa's growth in both exports and imports during this time—can partially explain this increased activity, it also has its roots in deepening regional integration. The formation of RECs has facilitated new intra-African partnerships, including new tradeable products. Since 2006, the share of intra-regional trade in overall trade in sub-Saharan Africa has increased from 12.3 to 17.8. The intra-regional trade has not merely taken advantage of the proximity of regional trade partners; the regional trade portfolio's of sub-Saharan African economies do not mirror their portfolio's with the rest of the world (Allard et al 2016). Whereas raw commodities account for just under 50 percent of exports from sub-Saharan Africa to the rest of the world, they account for just a quarter of trade within sub-Saharan Africa (Allard et al., 2016). Instead, final demand of manufacturing goods play a much more central role,

accounting for nearly 40 percent of all exports (compared to just 17 percent with the rest of the world).

Interestingly, manufactures traded within sub-Saharan Africa tend to be high-skilled and technology-intensive (UNCTAD, 2021). And this class of manufactured goods is increasingly being traded in the region, having increased in prevalence by 15 percent over the last 15 years. Electronics (excluding parts and components) is the traded manufactured good that has the highest regional trade share (84 percent of exports are destined elsewhere in sub-Saharan Africa). South Africa influences these figures significantly, but many of the trends still hold when excluding it from the data: Sub-Saharan Africa excluding South Africa still trades 41 percent of its high-skill and technology-intensive goods regionally.

Commodities make up a smaller share than the overall share of regionally traded goods. Though commodities are generally exported outside of Africa, certain commodities, such as refined iron and steel are more frequently traded within the continent. In fact, in 2019, 72 percent of traded iron and steel outside of South Africa was shipped within sub-Saharan Africa. For both groups—sub-Saharan Africa and sub-Saharan Africa without South Africa—the regional share of traded iron and steel has doubled since 1995. Food items are also less traded regionally than the overall average, but this share has grown by 62 percent since 1995 (73 percent excluding South Africa)

The signs of regional integration are not limited to a larger regional trade share. The West African Economic and Monetary Union was established in 1994, under which eight countries use the CFA franc. The East African Monetary Union Protocol was signed by the EAC in 2013 and is due to take effect this decade (EAC, 2021). Seychelles, Benin, and The Gambia offer visa-free access to all Africans (AfDB, 2021). In 2020, Africans could travel visa-free or through a visa on arrival at 54 percent of the continent, a 9 percent increase since 2016. Acquiring a visa has also become easier: The number of countries in Africa that offer eVisas increased from 9 in 2016 to 24 in 2020.

3.1.2. The promise of the AfCFTA

Though Africa has become increasingly regionally integrated, it has had less success integrating itself into the global economy and changing its portfolio of exports (Afreximbank, 2019). Africa's share of global trade was just 2.8 percent in 2019 (Fofack, 2020). Resources and commodities still comprise a majority of African exports, susceptible to the same shocks and whims of the global economy. But the AfCFTA could change all of that.

Three decades after the African Union's predecessor formally conceived the idea of a pan-African free trade area with the Abuja Treaty, 35 nations began trading under the AfCFTA's rules on January 1, 2021 (OAU, 1991). The idea of close economic and political integration in Africa dates back to post-independence movements in the 1960s, which then was, in part, a

way to safeguard independence (UNECA, 2020). In a very real sense, the implementation of the AfCFTA is a step toward a dream shared by policymakers across the continent to an African Economic Community boasting free movement of goods and people and a customs union.

The AfCFTA is still far away from this dream, but nonetheless promises to improve Africa's trade environment by eliminating tariff and non-tariff barriers (NTBs) alike (UNTAD, 2019a). Previous negotiations led to rules of origin that cover approximately 80 percent of goods, which means that the AfCFTA's reduced tariffs already apply to these goods. The AfCFTA comes at a time when customs times are trending in the wrong direction: firms across the continent are reporting increased delays in goods passing customs (World Bank, 2021). Over the last decade or so, the average reported time for exports to clear customs increased from 8.5 days to 10.3 days, while the average for imports increased from 13.9 days to 16.8 days. The AfCFTA promises to usher in trade facilitation policies that reduce NTBs. UNECA estimates that the share of intra-African trade could increase by 6.4 percentage points—above and beyond the impact of AfCFTA itself—by introducing complementary trade facilitation policies such as standardizing procedures, formulating a common rule of origin, and installing one-stop border posts (UNTAD, 2019a).

The potential benefits of the AfCFTA are enormous. The AfCFTA is capable of securing longer-term prosperity for Africa through spurring trade and investment in manufacturing. Increased manufacturing will steer Africa away from a volatile commodity-dependent model of trade, to which many of its economies currently belong (Rodrik, 2016; ACET, 2017; UNECA, 2020; Fofack, 2021). Indeed, a majority of the projected \$560 billion increase in exports resulting from the AfCFTA's implementation will be in manufacturing (World Bank, 2020c).

Much of the immediate benefit of the AfCFTA will come from the reduction of tariffs on AfCFTA imports (the majority of which are destined to phase out over the next five years) as well as the elimination of NTBs as a result of harmonizing trading framework. Projected reductions in tariffs vary substantially by sector, as shown in Figure 10 (World Bank, 2020). Producers of chemical, rubber, and plastic products are expected to witness an 85 percent reduction in tariffs by 2035, the largest of any sector. Additionally, wood and paper products, textiles and wearing apparel, and many sub-categories of manufacturing are all projected to experience tariff reductions of upwards of 75 percent. Tariffs on processed food and petroleum and coal products are projected to fall by 64 percent and 60 percent respectively. The tariff reductions in other sectors are more modest, but still sizeable. Tariffs on agricultural products and fossil fuels are expected to fall by 55 percent and 40 percent respectively. Natural resources and minerals are not projected to experience a reduction in tariffs over this period, perhaps because these sectors have very low tariffs already.

In the medium and long term, however, tariff reduction will likely play a small role in spurring trade across Africa. If achieved, the reduction of NTBs will play a large role in spur intra-

regional trade. Projected NTB reductions display less variation across sectors, with most sectors projected to experience a reduction in NTBs of between 35 and 50 percent. The only sectors that are projected to experience a smaller degree of reduction are natural resources (34 percent) and services (21 percent).

The greatest benefit of the AfCFTA, however, could come from enhanced trade facilitation with African and global partners alike (World Bank, 2020c). Expected and realized gains from trade could attract investment in physical infrastructure (e.g. new plants, new ports, transportation terminals, etc.) and digital infrastructure (software to facilitate transactions, improved internet connectivity, the development of digital processes, etc.). These investments could improve Africa's trade prospects with the rest of the world. A decade from now, Africa could develop new comparative advantages vis-à-vis the world and will be in a better position to facilitate trade in these areas thanks to investments made possible by the AfCFTA.

Trade literature suggests that trade liberalization tends to reduce between-country inequality but increase within-country inequality (Pavcnik, 2017). Who gains from trade likewise depends on labor mobility, the sectors that will benefit most from trade liberalization, and the constitution of the labor force of those sectors. In the face of this evidence, the latest estimates by the World Bank suggest that the AfCFTA will reduce the number of African living in extreme poverty by 30 million and those living on \$5.50 or less by 68 million (World Bank, 2020c). The AfCFTA is also expected to raise incomes by \$450 billion by 2035. Importantly, traditionally disadvantaged groups are expected to prosper the most from the agreement: the incomes of women are expected to increase by 10.5 percent (compared to 9.9 percent for men) and that of unskilled workers by 10.3 percent (compared to 9.8 percent for skilled workers).

3.2. Africa is becoming increasingly economically interlinked in diverse ways with the rest of the world

3.2.1. The African diaspora and the rapid rise of remittances

In 2019, remittances overtook FDI as the single greatest source of incoming capital to low- and middle-income countries (Knomad, 2020a). In 2018, sub-Saharan Africa received nearly \$50 billion in remittances, a 66 percent increase since 2009 (Knomad, 2020b). And the cost of these remittances is steadily falling: costs decreased by 3.8 percent from the first quarter in 2019 to the same point in 2020, a larger decrease than any other region. The pandemic is projected to have slowed the inflow of remittances to Africa and developing countries more broadly. Developed countries are the origin for a large share of remittances and are also responsible for a large share of the confirmed covid cases. Indeed, 75 percent of migrants reside in countries responsible for 75 percent of the world's COVID-19 cases (and 90 percent of global remittances). Though the pandemic to cause a dip in global remittances, it will likely

be restored once developed countries rebound. In fact, many such countries have already shown signs of doing so.

Remittances are also thought to be more robust than other forms of capital inflows, like FDI and private equity. This robustness is significant, because remittances may even increase to African economies when they fall into a recession, whereas FDI and private equity tend to flee when met with economic turmoil. The countercyclical nature of remittances has its roots in the African diaspora, which has, for various reasons, led Africans to migrate all over the world. African immigrants still feel close ethnic, cultural, or religious ties to their communities of origin (BU Center for Finance, Law & Policy, 2015).

3.2.2. Private sector lending and foreign direct investment

With public and private debt accumulating across the African continent, economies find themselves increasingly more reliant on FDI to play an important role in both economic and human development in the continent. At present, Africa lacks investment, attracting just 3.5 percent of global FDI and below the level needed to achieve the SDGs (UNCTAD, 2019a). Nonetheless, Africa is becoming an increasingly attractive source of FDI. In 2018, FDI flows to Africa increased by 11 percent, despite a global slide in FDI flows. A huge draw for FDI is rebounding commodity prices in the short run and the AfCFTA in the long run. The AfCFTA itself invites FDI, as multinational corporations can take advantage of the reduced tariffs and standardized processes. Because regional trade is significantly more diverse, the AfCFTA also invites investments that are more diversified across sectors, time horizons, and destinations. In addition to economic benefit, FDI correlates positively with higher future SDG achievement in even non-economic indicators (Aust, Morais, and Pinto, 2020).

3.3. The U.S. has ceded ground to other countries in terms of the economic relationship

3.3.1. Key trends in U.S.-Africa relations

Until 2008, the U.S. was one of Africa's largest bilateral creditors. In fact, in 2000, the U.S. held \$12 billion of Africa's bilateral debt, a higher figure than all except France's \$19 billion. U.S. lending has fallen sharply since then: The U.S. now holds only \$1.9 billion, just 16 percent of its total two decades prior. Moreover, U.S. loans to Africa now carry a cheaper price tag. Africa pays the U.S. just \$360 million per year in debt servicing, down from \$760 million in 2000 and a peak of \$2 billion in 2006. According to the World Bank's IDS data, the U.S. does not have debt disbursements lined up in the immediate future, rendering debt servicing to fall to just \$38 million in 2025.

On the heels of Africa's financial liberalization reforms of the 1980s and 1990s, the U.S., which directly and indirectly (via its influence in multilateral institutions) sought the reforms, introduced the Africa Growth and Opportunity Act (AGOA), which unilaterally erased tariffs on a selection of goods from qualifying African nations. AGOA, which expires in 2025, extends coverage of the Generalized System of Preferences and the WTO's most-favored-nation status by nearly seven thousand tariff lines according to a certain set of criteria (Williams, 2015). AGOA was administered with great effect, at least in the short run, boosting both African imports and exports with the U.S. without reducing trade with key trading partners in Europe. Indeed, from its conception in 2000 to 2011, imports from AGOA countries grew 228 percent, a compound annual growth rate of 11 percent. In contrast to growth in the previous decade, imports (but not exports) decreased each year from 2011 to 2015 (USITC 2021). The contraction was smaller than imports from the African continent at large, but it nonetheless raises questions about the resilience of African exports to the U.S. and AGOA's role in facilitating accelerated export diversification and propelling Africa into higher-skilled manufacturers (Cook and Jones, 2015). Even though AGOA imports rebounded from 2016 to 2018, nearly three-quarters of this growth was due to increased imports from one product from a single country: crude petroleum imports from Nigeria (USITC, 2020).

In addition, stalled trade growth since 2015 has coincided with the U.S. becoming less competitive across a broad range of exports over the last few decades. Annual U.S. exports to Africa increased by \$13.5 billion between 1995 to 2019, significantly slower than the overall growth in exports to Africa over the same period (\$430 billion). Importantly, U.S. exports to Africa also declined from \$80.3 billion in 2010 to just \$36.7 billion in 2017, revealing uneven growth. In this context, the U.S.'s share in trade with Africa halved from a peak of 8.5 percent in 2001 to 4.3 percent in both 2018 and 2019. To understand how the U.S.'s role in trade with Africa has evolved since 1995, it is helpful to categorize the U.S.'s exports to Africa into three groups: (1) Those for which the U.S. share is increasing; (2) Those for which the U.S. volume is growing but share is shrinking; and (3) those for which the U.S. volume is hardly growing (at an annual compound rate of less than three percent) and whose share is shrinking (a complete list can be found in Table 7 in the annex). The second category, in which most goods fall, includes non-fuel commodities such as ores, metals, pearls, and precious stones. It also includes agriculture and husbandry, and industries for which agricultural products are inputs, such as agriculture-based manufacturing. Many other types of manufacturing, including many categories of medium- and high-tech manufacturing, fall into category two.

The U.S. is gaining an advantage in a small selection of goods. Fuel exports to Africa, for instance, have grown by a compound average of 33 percent per year since 1995, compared to a global average of 20 percent. The growth of transaction-based commodity exports destined for Africa like non-monetary gold and non-gold coins has outstripped the global average, more than doubling since 1995. The last decade or two have seen the U.S.'s competitiveness

diminish across many manufacturing categories; notably, though, the U.S. has become more competitive in medium-technology automotive manufactures.

The goods in category three—that is, those whose volume is hardly growing—all have one feature in common—they are all industries that are increasingly being regionally sourced. U.S. iron and steel exports, for instance, grew at a compound rate of just 1.8 percent per year since 1995, yet the share of iron and steel imports sourced from sub-Saharan African countries has increased by 245 percent since then. Similar stories can be made for the other classes of goods that fall in category three: beverages and tobacco (most likely due to the rise of the bottling industry in Africa); clothing, textile fibers, and fabrics; and oils and fats from animals and vegetables. In these sectors, the U.S. should rethink its strategy to compete, as other global partners have seen their shares increase in these African industries.

3.3.2. China continues to rapidly grow its influence in Africa

China's economy has undergone tremendous structural change in the last three decades (Dollar, Huang, and Yao, 2020). In 1990, China accounted for less than 2 percent of the global share of both exports and GDP. In 2018, China accounts for nearly 14 of global exports and 16 percent of global GDP. Liberal reforms in the 1980s, advantageous demographics, high rates of savings and investment, and access to global markets via the World Trade Organization are all factors that explain China's rapid ascent to one of the world's largest economies and one of Africa's primary partners.

Perhaps where China's influence is most noticeable is as Africa's top trading partner. China's annual imports from Africa, consisting mostly of primary goods and manufacturing inputs, increased by a compound annual rate of 18 percent from 2000 to 2019, more than twice the global average (UNCTAD, 2021). At 15 percent per year, Chinese exports to Africa also grew at a compound rate more than double that of the rest of the world.

Importantly, China has emerged far and away as the primary bilateral creditor of Africa. IDA data estimate China to hold upwards of \$47 billion worth of African debt—as much as the next 10 bilateral creditors combined. China's express ascent is particularly noteworthy: Since 2011, its African debt holdings expanded by \$35 billion, or a compound annual growth rate of almost 19 percent, meaning its debt holdings for the continent have doubled every four years (International Debt Statistics, 2021). Nearly every country in the continent has borrowed money from Chinese lenders, and eight have debited more than \$5 billion (Cotterill, Munshi, and Wheatley, 2020). The burden of this debt is significant: In 2020, Africa is estimated to have paid Chinese bilateral lenders \$6.3 billion in debt servicing, a figure which is forecasted to balloon to more than \$7 billion in 2021 (International Debt Statistics, 2021). Because bilateral creditors do not include unofficial governmental creditors like China Development Bank and private creditors, the total extent of the credit flowing into Africa from China is likely severely understated. In addition, much of this alternatively sourced credit is less flexible for

renegotiations under extraneous circumstances (like the pandemic, for example), and hence not obligated to be suspended under the Debt Service Suspension Initiative.

3.3.3. The rise of new players outside Paris Club

In addition to China, additional non-Western countries have deepened their ties with Africa in recent years. For example, India has increased its engagement with Africa both economically and politically, recently becoming the second-largest buyer of Africa goods at nearly \$40 billion per year. Africa has also become its most significant destination for lending; India holds \$11 billion in outstanding loans to 41 countries (Kurzydowski, 2020). In 2018 alone, India established 18 new diplomatic missions in the region. In addition, India already had natural reasons for close ties with the continent, with more than three million people with Indian heritage living in there, including 1 in every 42 South Africans (Thomas, 2018).

The list is not limited to India. Russia, Thailand, Turkey, and Indonesia all either doubled or close to doubled their trade with Africa from 2010 to 2017 (Devermont, 2018). Oil-rich nations Kuwait and Saudi Arabia have recently emerged among Africa's biggest creditors, with their respective debt holdings roughly tripling over the last few decades (International Debt Statistics, 2021).

The U.S.'s step back is not simply following Western trends. Spain, the Netherlands, Germany, Switzerland, Belgium, Norway, Ireland, Poland, Bulgaria, Denmark, Romania, Slovenia, Croatia, and others increased their total trade with Africa from 2010 to 2017 (UNTAD, 2021). The Netherlands tripled its FDI in Africa from 2013 to 2017 (UNCTAD, 2019a). Canada's aid flows to Africa increased slightly from 2010 to 2017 and jumped by more than 19 percent from 2017 to 2020 (CIDP, 2021)

3.4. Policy opportunities: Ways the U.S. can take advantage of Africa's augmented global integration

With FDI, foreign aid, and exports to Africa all having declined since 2014, the U.S. has lost ground, both diplomatically and commercially, in Africa. This trend is reversible though, as there are practical ways for the U.S. to familiarize itself with the evolving economic and political landscape of Africa.

3.4.1. Strengthen diplomatic ties

Trump is the only president in the past few decades that did not visit a sub-Saharan African nation (Signé, 2019). Beyond a lack of presidential visits, however, even U.S. Cabinet members have only visited the African continent infrequently, which does not improve the reputation among Africans that the U.S. does not care about Africa, as such visits signal to both Africa and American business leaders alike that U.S. lawmakers are serious about strengthening U.S.-

African ties (Devermont, 2021). Finally, the U.S. could second additional foreign service officers to their missions with regional groups like the African Union and Africa's numerous regional economic communities (Devermont, 2020).

The U.S. could also make the Africa Leaders Summit an annual or biannual event that features the U.S. and African heads of state and other political and business leaders. The Corporate Council on Africa's U.S.-Africa Business Summit has been a promising event that meets with the regularity needed to keep participants informed, but the most recent conference had no U.S. Cabinet members in attendance. The attendance of Cabinet members or the president himself would send a strong signal to the private sector of the event's, and thus the region's, importance.

3.4.2. Take advantage of the AfCFTA and enhanced regional integration

Africa's trade landscape will change, and potentially rapidly, under the AfCFTA, necessitating that partners to stay ahead of the curve. The U.S. can take advantage of the implementation AfCFTA and expanding RECs by using regular events to disseminate information and targeted investment and lending to help U.S. multinationals to prepare for the change in demand for regionally sourced products and inputs that will accompany recent trends. The U.S. can also target and expand its infrastructure and electrification projects to support industries under the AfCFTA (Cook et al., 2020). Analysis shows that industrial and manufactured products demonstrate the most regional trade potential under the AfCFTA (Afreximbank, 2021).

The physical, digital, electrical, and legal infrastructure to take advantage of AGOA do not develop overnight. As of 2020, only 16 of 39 AGOA countries had developed AGOA strategies; but political will does not immediately translate into better infrastructure in other domains (USITC, 2020). Africa's economic landscape is changing fast, and the Biden administration should begin to formulate what an extension or replacement to AGOA would look like once the current arrangement expires in 2025. U.S. policymakers should aim for another iteration of AGOA that focuses on bilateral trade concessions with the region as a whole. So far, the U.S. strategic response to the AfCFTA has so far favored a bilateral, country-specific approach, such as negotiating a free trade agreement with Kenya, rather than devoting efforts toward tapping into Africa's regional integration (Schneidman and Signé, 2018). The U.S. has already announced support for the AfCFTA, and now should commit to using trade and investment to facilitate enhanced integration (Treiber, 2021).

3.4.3. Invest in Africa, targeting areas that facilitate U.S.-Africa business integration

The real value of foreign assistance (technically funding from the State Department and USAID) to Africa has decreased slowly but steadily since 2009 (Cook et al., 2020). The U.S. devoted more than \$7 billion in aid each year to Africa from 2009 to 2019, accounting for

roughly one quarter of overall U.S. foreign assistance during that time. Very little of this aid, however, is devoted to economic sources of development: In 2019, for instance, only 8 percent (or \$751 million) of \$7.1 billion U.S. aid to Africa was allocated specifically to economic areas. To put this in perspective, the U.S. spent more in 2019 on contractors to construct a border wall with Mexico than they did on economic interests in Africa (Trevizo and Schwartz, 2020).

Moreover, only a fraction of this money is devoted to facilitating economic integration between the U.S. and Africa. The U.S.'s aid targeting economic programs is instead focused on agriculture development assistance, such as bolstering agricultural value chains land tenure systems, and rural road development (Cook et al., 2020). The U.S. already has programs that facilitate expanding trade capacity, infrastructure development, and microenterprise growth, but U.S. involvement in these areas is declining. Expanding assistance to extant projects in these areas could reverse the U.S.'s declining trade and FDI in Africa.

Over the last two decades, U.S. assistance in Africa has centered on health care, with emphasis on HIV/AIDS. Now that the pandemic has become the most pressing health care issue facing the region, the U.S. should invest aggressively in vaccine diplomacy. As evidenced by the emergence of more contagious and deadly COVID-19 variants, the pandemic will remain a grave threat to the entire world so long as there remain countries without widespread access to vaccines. Securing vaccines for Africa will also provide economic benefit for the U.S. because many vaccine producers are U.S. companies (Pfizer, Moderna, Johnson & Johnson, for instance).

That many U.S. companies have neglected to invest in Africa is, in part, an information issue. As discussed above, the limited interaction between U.S. senior officials and their African counterparts has not facilitated an improvement of U.S.-Africa relations. As a result, U.S. agencies have not always communicated clearly with U.S. firms' ways in which they may prosper in dealing with Africa, which accentuates the information problem many U.S. firms face when doing business in Africa. Prosper Africa offers an opportunity to fix some of these coordination and information challenges, while the USDFC and the USTDA have the resources to support U.S. companies doing businesses in Africa (Signe, 2029). Another way to fix this would be to follow other nations in having annual meetings of key players in bilateral relations with the African continent. For instance, when key American representatives are in attendance, AGOA's Ministerial Forum can also be an effective medium of engagement.

3.4.4. Use lending as a means for mutual profit and influence

U.S. lending to the African continent has plummeted since the turn of the century. There is room, however, for the U.S. to reverse this trend. While China has become the continent's largest creditor, but not through generous terms. World Bank loans, for instance, are to be 2.3 times likely to have a grant component than Chinese loans (Morris, Parks, and Gardner, 2020). Instead, signs point to China lending according to terms closer to those offered by the private

sector. Even though U.S. loans have traditionally been tied to government restructuring, there is significant scope to increase lending to the continent with the aims of profiting and increasing geopolitical influence in the region. Placing conditions on loans is not the only way to promote democratic reforms via lending; prudent, targeting lending can improve economic growth and financial stability more broadly, which are also precursors to political stability. Bilateral loans can be profitable: At the turn of the century, the U.S. was earning nearly \$1 billion per year in debt servicing (International Debt Statistics, 2021). Though susceptible to shocks and defaults, locally denominated sovereign bonds have shown to be, on average, more profitable than bonds in other markets and do not the same political significance as do bilateral loans (Miyajima, Mohanty, and Chan, 2015).

Importantly, Chinese lending is not crowding out opportunities for the U.S. (and other international players) to lend to Africa. Indeed, China's objectives for lending are not identical to the US: China uses loans to facilitate commodity exports, improve their security position, and win contracts for their companies. Nearly nine in every 10 Belt and Road Initiative projects are carried out by Chinese contractors, compared to just three percent by non-Chinese foreign firms (CSIS, 2018). The U.S. should increase funding to lending agencies like the Development Finance Corporation (DFC) and the U.S. Export-Import (Exim) Bank. More than that, however, USDFC and Exim loans can be used to enhance the competitiveness of U.S. firms in Africa, bolster trade and digital infrastructure, and help the U.S. tap into Africa's quickly evolving regional integration. The United States Trade & Development Agency (USTDA) can play a more decisive role in connecting U.S. companies to Africa-based projects.

In reality, developing and emerging-market economies are taking up Chinese loans not due to obscure, predatory policies, but simply because they are available. These economies are populated by smart, experienced policymakers that are capable of evaluating opportunities available to them. The U.S. can take advantage of Africa's expanding influence in global politics and burgeoning business potential by using existing financial institutions to make strategic loans targeting areas in which the U.S. is competitive or has vested interest.

4. Conclusion and final recommendations

This report sought to describe recent economic, business, and technological trends in Africa and provide recommendations for key international stakeholders, particularly the U.S., to effectively engage with Africa and ensure mutual prosperity as the continent undergoes a dramatic structural transformation in the coming decades.

After eluding Africa for much of the 1980s and 1990s, real per capita increases in output are finally driving socioeconomic transformation on the continent since the turn of the millennium. The region's growth has coincided with a burgeoning consumer class with a checkbook worth trillions of dollars per year. Boasting the fastest growing urban population in the world, Africa is increasingly able to harness its large youth labor force to reap benefits stemming from agglomeration economies and economies of scale, as long as these workers are supported through robust education programs that prepare them with the skills needed in the era of the 4IR. Moreover, improvements to the business environment, the expanding middle class, and increased flows of capital in the form of remittances and FDI will all be pillars supporting Africa's growth into the future. Regional integration has led to more imports carrying a "made in Africa" label, and these tradeable goods tend to belong more to intermediate and final products rather than raw materials. The implementation of the AfCFTA will only accelerate regional integration and has the potential to inspire structural transformation as firms take advantage of the removal of both tariffs and non-tariff barriers alike.

Importantly, the terms-of-trade and pandemic shocks will prove to be transitory setbacks. The trends described above will create an economy more resilient to fluctuating commodity prices and more impervious to downturns in the global economy. Africa is already home to hundreds of companies with billion-dollar revenue streams, but its evolving economy promises to pave the way for the emergence of diversified multinationals in emerging sectors. In tandem with SMEs, these firms are in an excellent position to employ an increasingly skilled, young, forward-looking labor force, creating millions of quality jobs.

Whether Africa can attain real, sustainable increases to productivity depends in large part on its ability to harness new technologies emerging from the Fourth Industrial Revolution. Innovations in fintech have already brought and will continue to bring people into the formal economy, especially through avenues like mobile money accounts and credit risk sharing microcredit models. Increased financial inclusion facilitates financial planning and

expenditure. Since the informal sector is responsible for over half of GDP in sub-Saharan Africa, formalizing this sector creates incredible business opportunities on both the demand and supply side. Now, technologies such as artificial intelligence, cloud computing, the internet of things, and 3D printing, among others, stand to significantly improve the efficiency and safety of Africa's primary and secondary sectors. Moreover, although the pandemic has had a ruinous effect on economies in Africa and across the world, it has accelerated adoption of digital solutions and investment in ICT, which has put Africa in a better position to capitalize on the 4IR going forward.

Africa has real challenges it must tackle if it hopes to realize its tremendous potential. The region is poorly equipped to deal with cybersecurity issues, including cybertheft and cyberwarfare. 4IR technologies also have the potential to exacerbate inequality, both between nations and within them, if they are not properly managed. Africa's challenges are not limited to the 4IR. Demographics have as much potential to bust as boom: If African economies cannot effectively educate and supply their growing labor forces with jobs, the resulting unemployment could spell social unrest that threatens to undo recent progress in government stability and transparency. Furthermore, Africa's infrastructure at present does not permit it to take full advantage of the AfCFTA and the structural transformation policymakers hope will emanate from it—let alone the 4IR. Languishing roads, ports, and transportation terminals limit the efficient transportation of goods and labor. Insufficient electrical infrastructure makes it difficult for industries to meet their production targets and plan ahead to meet the needs of their clients. Digital infrastructure, while improving, has yet to make significant efficiency gains and allow businesses to tap into new networks of potential consumers. Poor planning in cities has resulted in businesses inefficiently organized, unable to realize the full benefits of urban agglomerations. Rising debt levels used to cover revenue shortfalls due to falling commodity prices and rising expenditures stemming from the pandemic only serve to limit the ability of governments to make expedient investments in their people and businesses. Many of these challenges will not evaporate with time and must be addressed head on.

Despite these challenges, Africa's bright prospects have garnered substantial interest from international partners. For example, China has become Africa's largest creditor and trading partner. The Netherlands in this decade alone tripled its FDI. Investment banks and car manufacturers have opened up headquarters in African cities. In recent years, Africa has shed its colonial roots and taken up trade with nontraditional partners. For example, Japan and China feature heavily in Africa's infrastructure development. Countries like India, Russia, Turkey, and Indonesia have all doubled their trade with Africa in the last decade. Kuwait and Saudi Arabia have become some of the largest holders of African debt. Complementing international involvement, remittances have emerged as the largest inflow of capital into the region, which offers synergies with these new partners.

As the international market has sharpened its focus on Africa, the U.S. has taken a step back in several respects. From 2010 to 2017, U.S. investment in Africa, lending to Africa, real aid flows to Africa, and trade with Africa all declined. This trend countered that of many European countries, who strengthened their ties to Africa in terms of trade and investment. Though the U.S. is competing with international players, the its declining engagement with Africa cannot be explained by crowding out alone. There are plenty of ways that the U.S. can take advantage of Africa's business potential and fast-moving economic transformation. Below is a succinct summary of five recommendations for US policymakers substantiated in this report.

1. The U.S. should develop and implement a comprehensive Africa strategy, building on areas of competitive advantages. Such a strategy should simultaneously enable Africa to achieve durable growth that is less dependent on commodity exports and focus on sectors in which the U.S. has a strong competitive advantage (e.g., cybersecurity, ICT, and certain manufactures). It should begin to imagine the next iteration of AGOA, which is set to expire in 2025. AGOA's successor should feature bilateral trade concessions, recognizing Africa's dynamic trade environment and growing capacity to both consume and export products. Furthermore, the strategy should focus on ways the U.S. can facilitate ties between American companies and their African counterparts to accelerate trade and investment in the context of the single continental market created with the African Continental Free Trade Area.
2. Beyond supporting Africa's digital infrastructure, the U.S. should support the development of skills aligned with the future of work. Despite its retreat in recent years, the U.S. remains one of Africa's key economic partners and is thus in a unique position to direct investment into opportunities primed to flourish in the new business environment created by the 4IR. The U.S. Department of State should consider expanding its Young African Leaders Initiative (YALI) to include a technological skills component. For instance, it could partner Mandela Washington Fellows with ICT companies so that they may gain valuable skills appealing to ICT firms looking to expand in Africa. It also could build on their four Regional Leadership Centers, introducing ICT entrepreneurship training.
3. The U.S. should expand its investment in sectors that support Africa's integration agenda. Helping close the physical and digital infrastructure gaps could boost U.S.-African trade, benefiting not only African exporters but also offering business opportunities for U.S. companies. The U.S. should pay close attention to private sector efforts such as Facebook's partnership with MTN (South Africa), Orange (France), China Mobile, and Vodafone (Britain) to build a 37,000 km underwater fiber-optic cable to enhance broadband coverage in Africa, supporting efforts that yield especially high benefits to society.

4. The U.S. should strengthen political and diplomatic ties to African leaders. President Trump did not pay an official visit to Africa during his presidency, and presidential cabinet members made infrequent visits to meet with their African equals. If the U.S. is going to communicate its interest in establishing close ties with Africa, it must send clear signals by having its top figureheads present. In particular, the Biden administration should consider reintroducing the U.S.-Africa Leaders Summit, as an annual or bi-annual event. Like the inaugural event in 2014, the president should extend invitations to African heads of state and other leaders across the continent and should focus on trade and investment.
5. The U.S. should aggressively pursue vaccine diplomacy in Africa. Though vaccines are becoming increasingly available, the pandemic will remain a grave threat to every country in the world until every country has access to vaccines. Moreover, the end of the pandemic will not bring an end to pandemics. If anything, COVID has revealed the need for investments in national and international systems of healthcare. Vaccine diplomacy is an important first step toward ending the pandemic and achieving quality healthcare infrastructure. It also will likely accrue economic benefits, as many of the most prolific vaccine producers are U.S. companies.

Africa's recent robust growth, promising future, and swiftly evolving economic structure all inspire intrigue from international players. Africa—and the world—will look very different in 2050. Africa's future will depend on the choices African policymakers and international players make now. Because circumstances are changing so rapidly, the time to act is now. Though Africa's evolution is complex, this report offers clear recommendations to all relevant stakeholders in order to shape the next decades in a direction that benefits all.

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Annex: Figures and tables

Figure 1. Africa GDP per capita (constant 2010 USD)

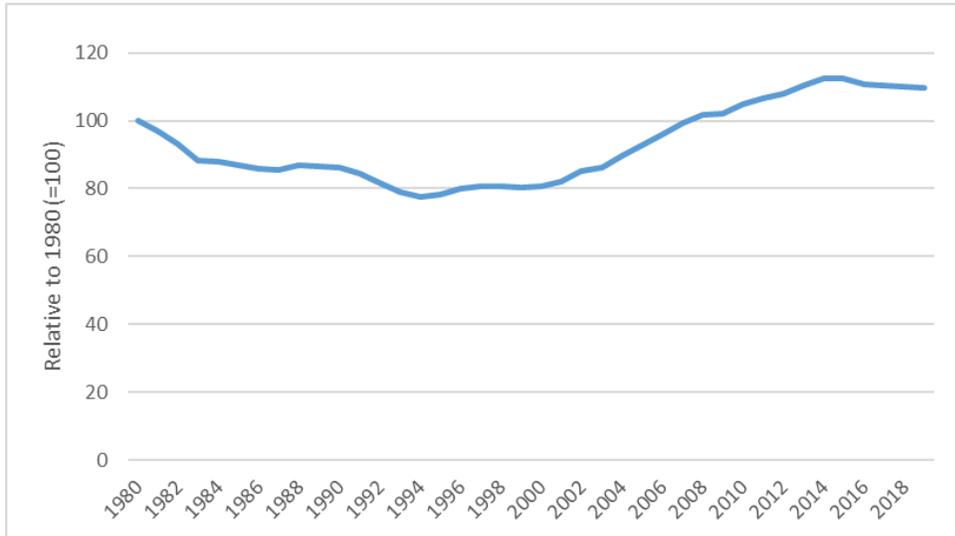


Figure 2. Growth of real GDP per capita and IMF commodity price index, 3-year averages

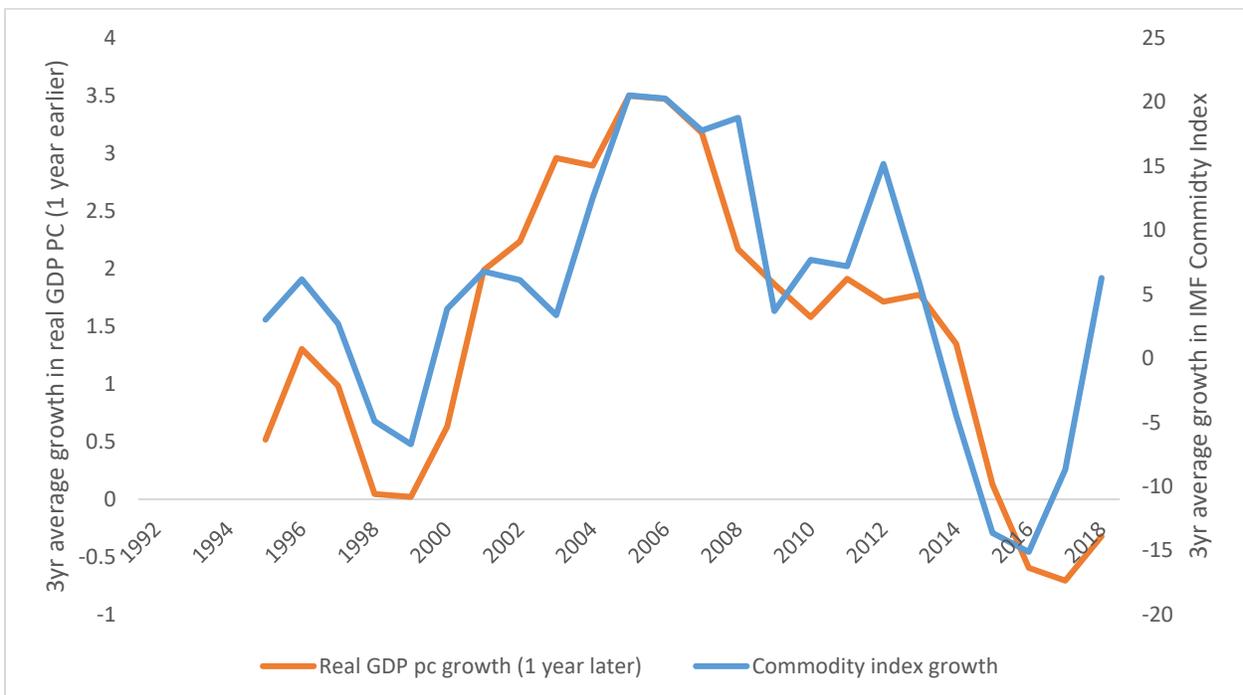


Figure 3. Evolution of output 1980-2019, Africa (1980=100)

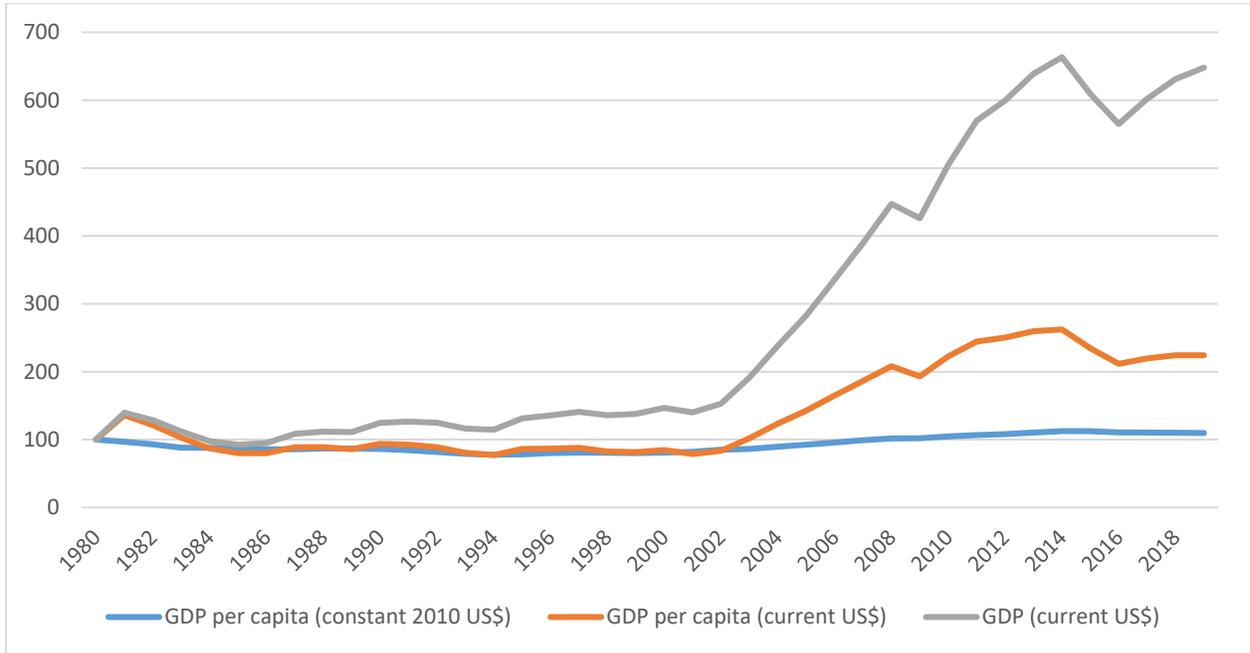


Figure 4. Urbanization and urban primacy by continent

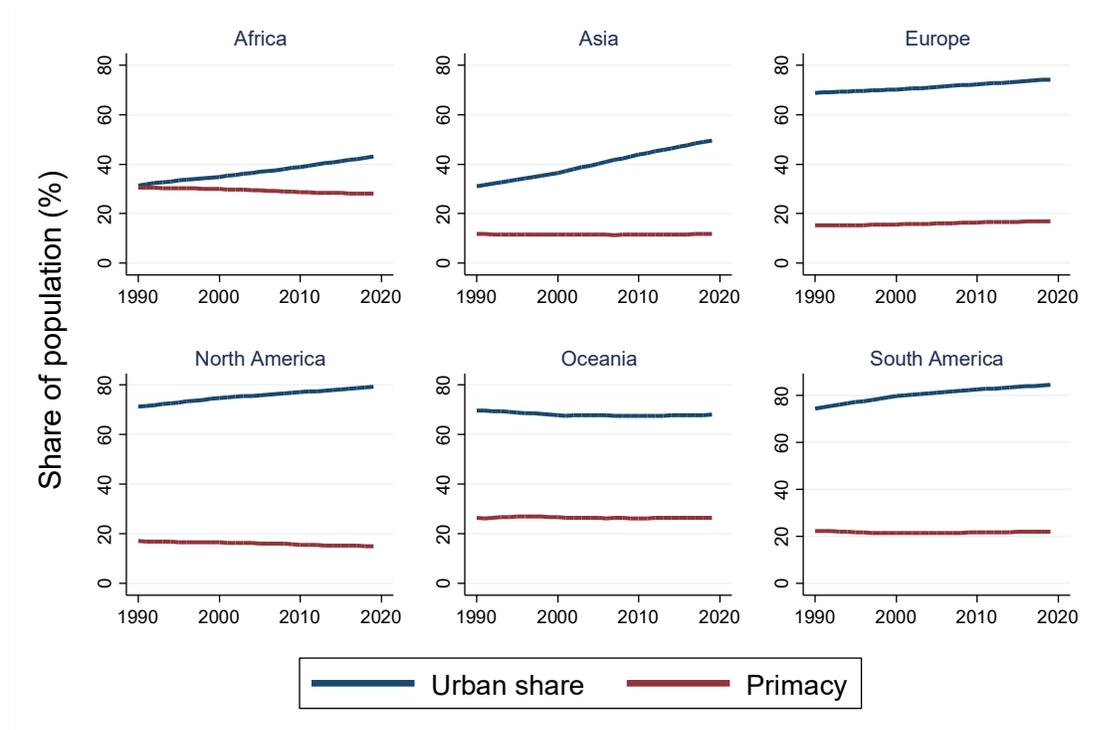


Figure 5. Urbanization and urban primacy by African region

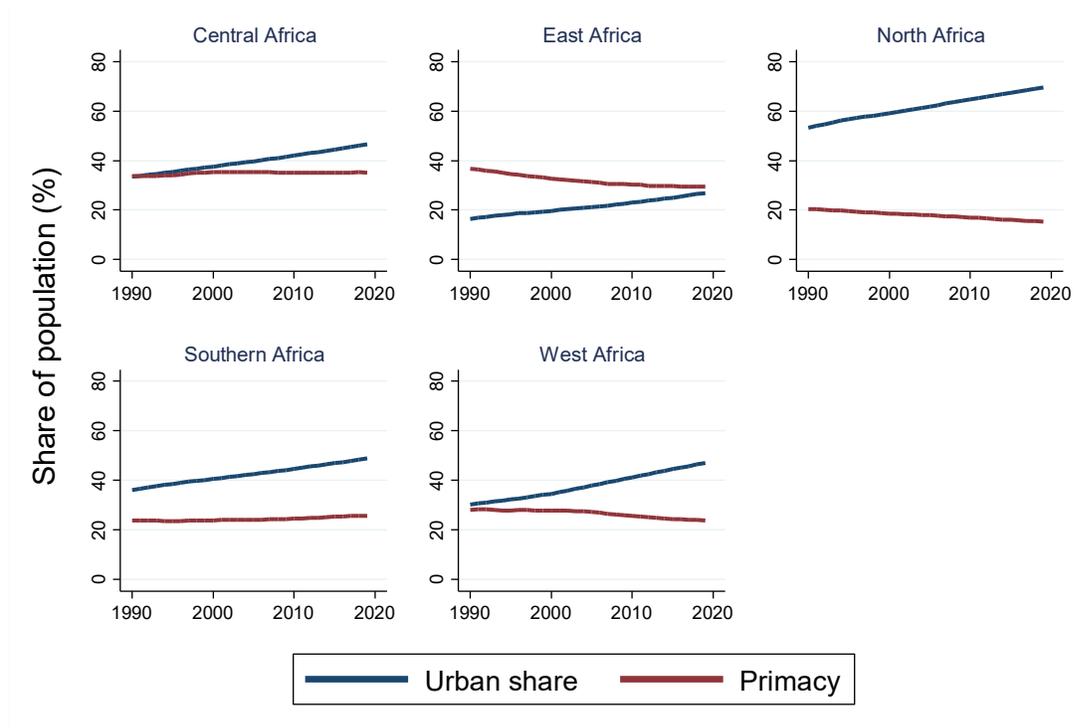


Figure 6. Urban population Lorenz curve by group

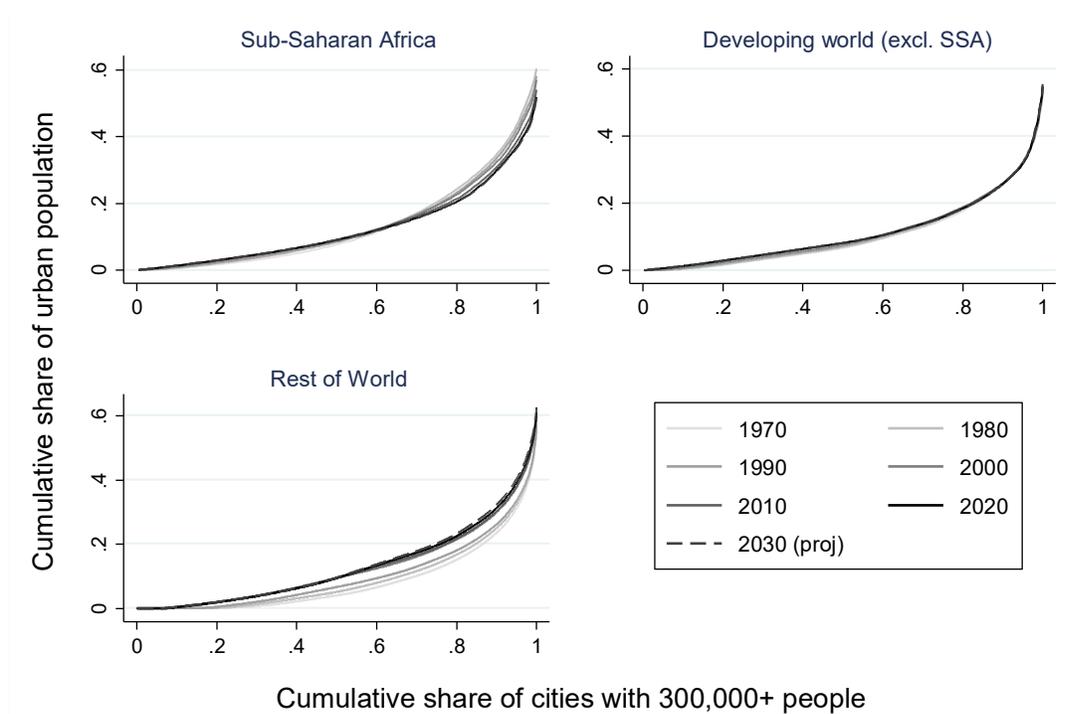


Table 1. Population growth in large cities by region

Region		Percent change from 2010 to 2020				Predicted percent change from 2020 to 2030			
		Negative growth	Normal growth (positive and below 90th percentile)	Exception (above 90th percentile)	Total	Negative growth	Normal growth (positive and below 90th percentile)	Exception (above 90th percentile)	Total
East Asia & Pacific	Count	26	535	72	633	34	592	7	633
	Row share	27.66	34.01	38.71	34.16	41.46	37.35	3.76	34.16
ECA	Count	43	264	2	309	45	264	0	309
	Row share	45.74	16.78	1.08	16.68	54.88	16.66	0	16.68
LAC	Count	4	205	1	210	2	208	0	210
	Row share	4.26	13.03	0.54	11.33	2.44	13.12	0	11.33
MENA	Count	11	112	17	140	1	121	18	140
	Row share	11.7	7.12	9.14	7.56	1.22	7.63	9.68	7.56
North America	Count	8	142	11	161	0	160	1	161
	Row share	8.51	9.03	5.91	8.69	0	10.09	0.54	8.69
South Asia	Count	1	200	23	224	0	207	17	224
	Row share	1.06	12.71	12.37	12.09	0	13.06	9.14	12.09
SSA	Count	1	115	60	176	0	33	143	176
	Row share	1.06	7.31	32.26	9.5	0	2.08	76.88	9.5

Note: Data come from the United Nations' World Population Prospects and include all cities with populations greater than 300,000 in 2010.

Table 2. How night-time lights vary across geographic spaces, by world region

Region	Mean (unweighted) coefficient of variation of night-time lights
<u>Continent</u>	
Africa	6.5
Oceania	5.0
Americas	4.3
Asia	3.3
Europe	1.7
<u>Subregion</u>	
Northern America	9.5
Australia and Ne	8.2
Sub-Saharan Africa	6.6
Northern Africa	5.7
Eastern Asia	4.8
Central Asia	4.6
Melanesia	4.3
Latin America & Caribbean	3.8
South-eastern Asia	3.2
Southern Asia	2.9
Western Asia	2.4
Northern Europe	2.2
Polynesia	2.0
Eastern Europe	2.0
Southern Europe	1.5
Western Europe	1.0
Total	4.2

Table 3. Distribution of night-time lights across cities, by world region

World Bank Region	Mean coefficient of variation of 50 largest cities in each country	
	Night-time lights	Population
North America	2.5	0.9
South America	1.8	0.4
Europe & Central Asia	1.8	1.3
Caribbean	1.6	0.5
Middle East & North Africa	1.5	0.4
East Asia & Pacific	1.4	0.6
Central America	1.3	0.4
Sub-Saharan Africa	0.9	0.4
South Asia	0.9	0.4
Total	1.4	0.6

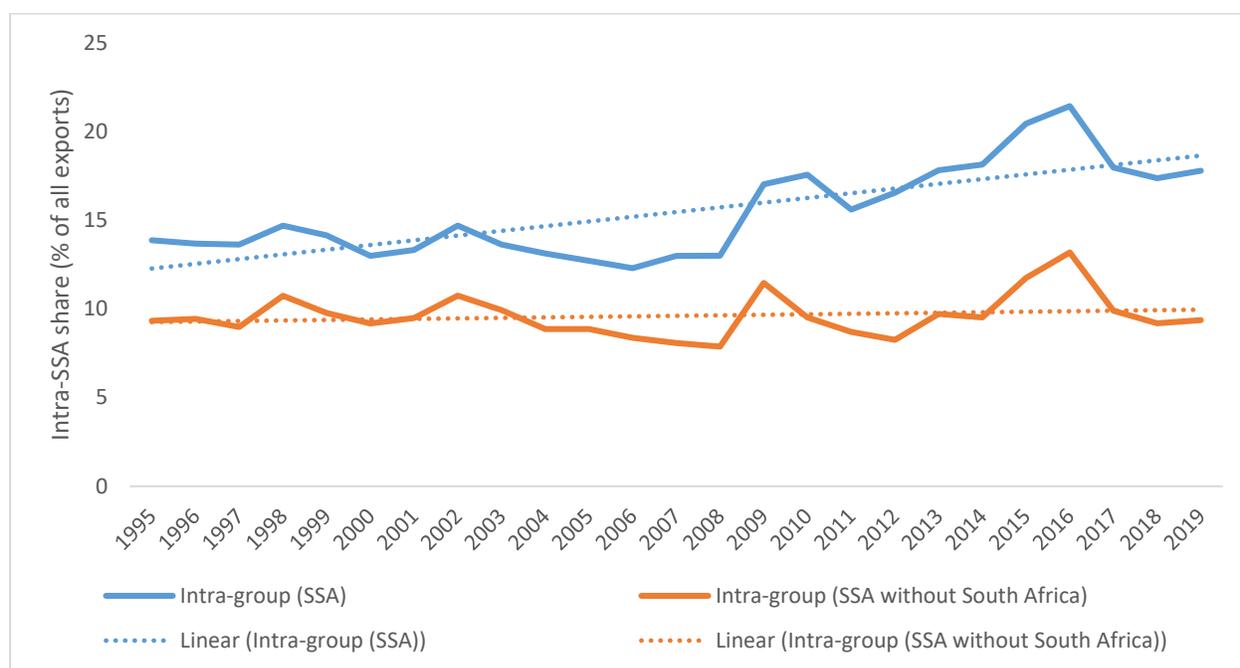
Figure 7. Intra-sub-Saharan Africa trade share

Figure 8. COVID-19 projected impact on poverty in Africa

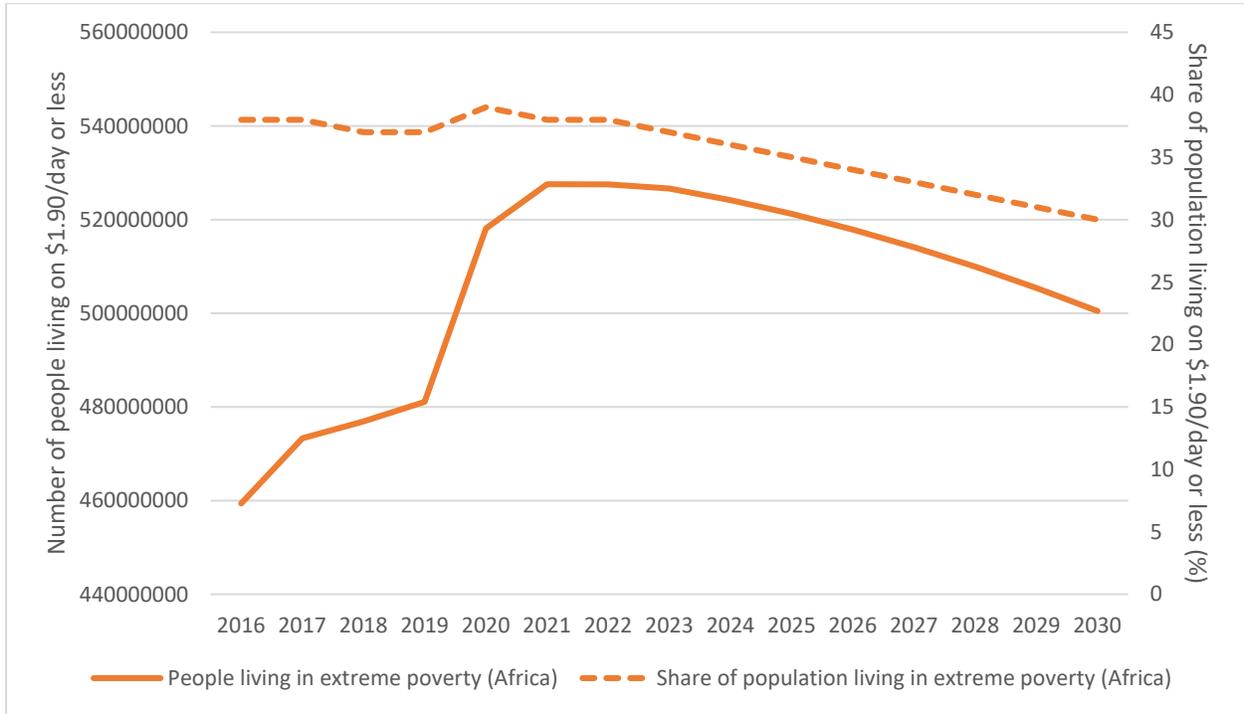


Figure 9. Broadband and mobile phone subscription

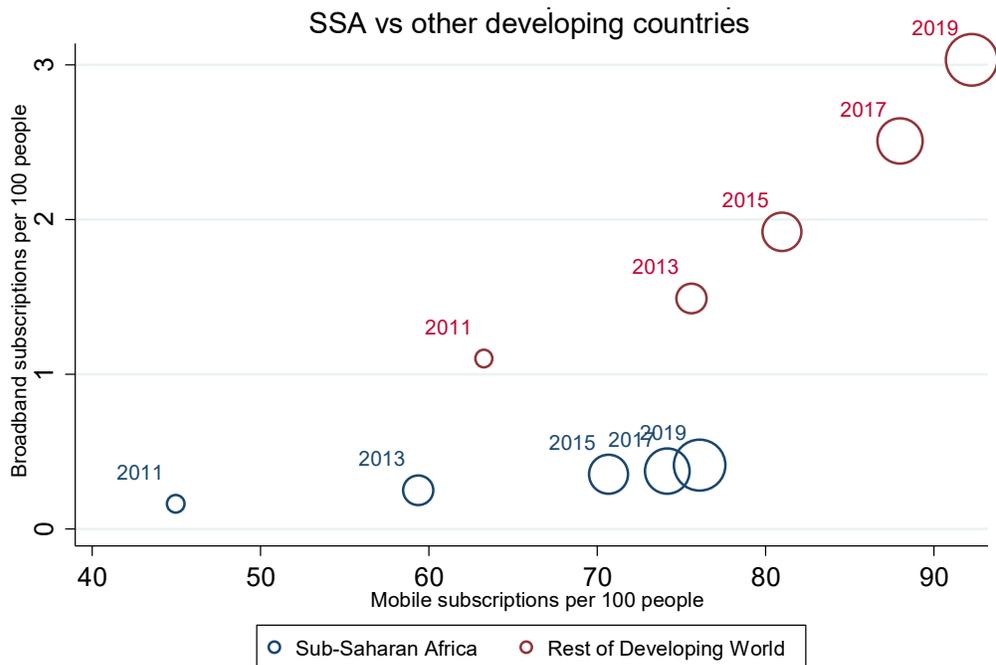
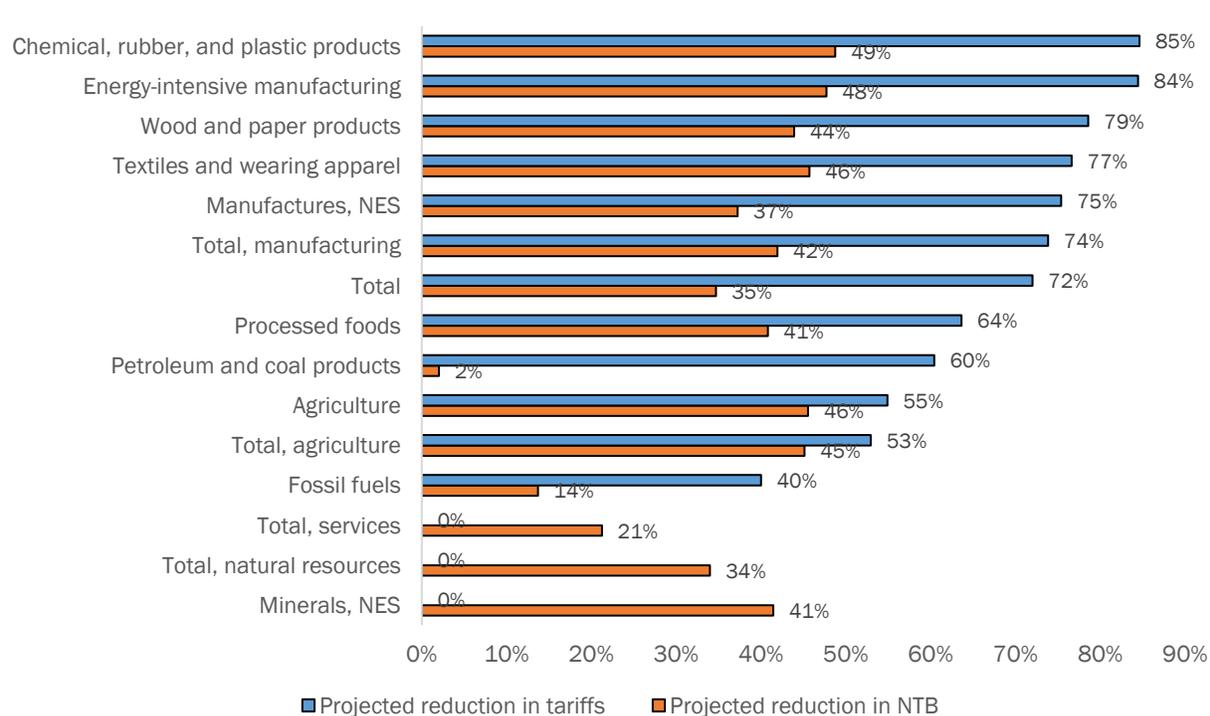


Table 4. Internet speeds by region

Region (low- and lower-middle income countries only)	Broadband speed in Dec (mbps)	Mobile internet speed in Dec (mbps)
Europe and Central Asia	53.6	22.3
East Asia and the Pacific	33.0	24.8
South Asia	25.8	15.5
Latin America and the Caribbean	18.9	20.7
Sub-Saharan Africa	16.9	17.8
Middle East and North Africa	14.6	23.9
Average	22.4	20.3

Table 5. COVID impact on internet speeds

Region	<u>Unweighted average</u>		<u>Weighted average</u>	
	Median change in fixed broadband (% change)	Median change in mobile internet (% change)	Median change in fixed broadband (% change)	Median change in mobile internet (% change)
Middle East & North Africa	21.8	21.3	17.6	35.5
East Asia and the Pacific	13.1	4.5	20.4	12.7
Sub-Saharan Africa	9.9	0.8	3.6	-5.2
Latin America & the Caribbean	9.3	15.6	10.5	15.1
Europe and Central Asia	6.5	0.1	7.2	4.0
North America	3.5	-10.5	4.7	-1.4
South Asia	-0.3	2.4	5.2	6.1
Total	9.7	6.2	11.2	8.5

Figure 10. Projected reduction in AfCFTA import-related tariffs and non-tariff barriers

Source: The World Bank. (2020c). "The African Continental Free Trade Area: Economic and Distributional Effects." tariffs and non-tariff barriers are weighted by aggregate imports.

Table 6. Real per capita growth in GDP

Area	Lending group	2000-2019 average	2002-2014 average	2015-2019 average
Africa	All	1.6%	2.2%	0.1%
SSA	All	1.6%	2.5%	-0.5%
World	All	1.7%	1.7%	1.7%
World, excl. SSA	IBRD	4.2%	4.8%	3.2%
World, excl. SSA & China	IBRD	2.6%	3.1%	1.5%
World, excl. SSA	IDA	3.9%	3.9%	3.6%
Middle East	IDA	-2.5%	-0.3%	-10.1%
Latin America & Caribbean	IDA	1.4%	1.7%	1.0%

Source: Growth figures come from the World Development Indicators and are reported in constant 2010 USD.

Table 7. Landscape of 4IR technologies

Technology	Definition and Purpose	Potential Application in Africa
<i>Additive manufacturing (3D printing)</i>	Produces objects by computer-aided, layer-by-layer addition of materials, resulting in a much more customizable process than traditional (subtractive) manufacturing.	Lowers economies of scale in manufacturing, benefitting small countries and SMEs.
<i>Advanced materials science</i>	Optimizes the use of raw materials and develops new sustainable materials for use in batteries, electronics, water filtration, etc.	Evolving battery technology using advanced materials science could allow Africa to realize its vast potential for renewable energy generation (wind and solar).
<i>Artificial intelligence (AI)</i>	AI refers to the ability of machines, computers, or computer-controlled robots to perform operations analogous to human intelligence, including processing information, recognizing complex patterns, drawing conclusions, and making decisions.	Could improve planning processes, supply chain management, equipment maintenance plans, medical diagnoses, among other uses.
<i>Automation (robotics)</i>	Design, construction, and use of machines to execute tasks automatically, with speed and precision.	Improve quality and speed of routine tasks; reduce hazardous work.
<i>Big data</i>	Extremely large data sets that can be computationally analyzed to reveal otherwise hidden patterns and trends; is an underlying requirement for many other 4IR technologies. Supports better informed decisions.	Could provide analysis to improve planning and decision-making across a range of activities including demand forecasting, public health surveillance, and traffic management in cities.
<i>Blockchain (distributed ledger technology)</i>	Create and exchange digital records without a centralized, trusted agent. It includes a suite of computing services supporting the digital recording process of transactions that is distributed across computing systems over the internet using cryptography.	Managing land and property records, recording and completing financial transactions, managing sensitive supply chains such as in the health sector.
<i>Cloud computing</i>	On-demand, remote availability of computer system resources such as software, infrastructure, platforms, data storage, and computing power to users over the internet. Reduces computing costs.	Extend access to information and communications technology (ICT) by minimizing up-front ICT infrastructure costs; protect valuable data. Particularly useful in countries where inconsistent electricity has the potential to damage data and electronic devices.
<i>Drones/Autonomous vehicles</i>	Use AI to move remotely with minimal or no human input. These have a wide range of applications, from information collection to transportation of people and goods.	Drones will have wide application in agriculture, industry, and energy services in Africa, and are already improving cargo delivery to remote areas (e.g., emergency medical supplies).
<i>High-speed, high-bandwidth internet</i>	Massively increases the speed of wireless networks, extending internet access.	5G will allow African countries to leapfrog over the stage of fixed broadband internet,

<i>(including 5G technology)</i> <i>The Internet of Things (IoT)</i>	Network of devices, machines, animals, or people with sensors that have unique identifiers and transfer data over a network without requiring human interaction. IoT has wide-ranging applications both on a small scale (devices that connect home appliances, reduce home energy usage) and on a large scale (national energy and water systems, manufacturing, tracking cargo, health, and waste management).	avoiding the costly process of laying fiberoptics cables all over the country. IoT could increase trade and reduce counterfeiting by increasing traceability.
<i>Nanotechnology</i>	Microscopic materials and service robots. Nanobots can serve welfare-enhancing purposes (e.g., deliver drugs to repair cellular damage) or welfare-diminishing purposes (enhance chemical weapons and explosives).	Technology is expensive, therefore not many uses in Africa yet.
<i>Quantum computers</i>	Exponential increase in computing power by manipulating information based on quantum bits instead of digitally.	Quantum computers are still in the development stage. High energy requirements reduce their potential uses in Africa

Sources: Signé (2021); Technopolis (2019) [as presented in Fox & Signé (2021)]

Table 8. Categorization of U.S. exports to Africa, 1995-2019

U.S. Share is increasing	U.S. volume is increasing (>3% CAGR) but share is shrinking	U.S. volume is hardly growing (<3% CAGR) and share is shrinking
Fuels (SITC 3)	Primary commodities	Beverages and tobacco (SITC 1)
Non-electrical machinery & transport equipment	All food items (SITC 0 + 1 + 22 + 4)	Iron and steel (SITC 67)
Mineral fuels, lubricants and related materials	Food, basic (SITC 0 + 22 + 4)	Textile fibres, yarn, fabrics & clothing
Commodities and transactions, n.e.s.	Food, basic excl. tea, coffee, cocoa and spices	Beverages and tobacco
Resource-based manufactures: other	Agricultural raw materials	Animal & vegetable oils, fats & waxes
Low technology manufactures: other products	Ores and metals (SITC 27 + 28 + 68)	
Medium technology manufactures: automotive	Non-ferrous metals (SITC 68)	
	Other ores and metals (SITC 27 + 28)	
	Pearls, precious stones, and non-monetary gold	
	Manufactured goods (SITC 5 to 8 less 667 and 68)	
	Chemical products (SITC 5)	
	Machinery and transport equipment (SITC 7)	
	Electronic excluding parts and components	
	Parts & components for electrical & electronic goods	
	Other manufactured goods	
	Food and live animals	
	Crude materials, inedible, except fuels	
	Chemicals and related products, n.e.s.	
	Manufactured goods	
	Machinery and transport equipment	
	Miscellaneous manufactured articles	
	Primary products (Lall classification)	
	Resource-based manufactures: agro-based	

Low tech manufactures: Textile, garment & footwear

Medium tech manufactures: Process

Medium tech manufactures: Engineering

High tech manufactures: Electronic and electrical

High tech manufactures: Other

Figure 11. U.S. economic disintegration with Africa

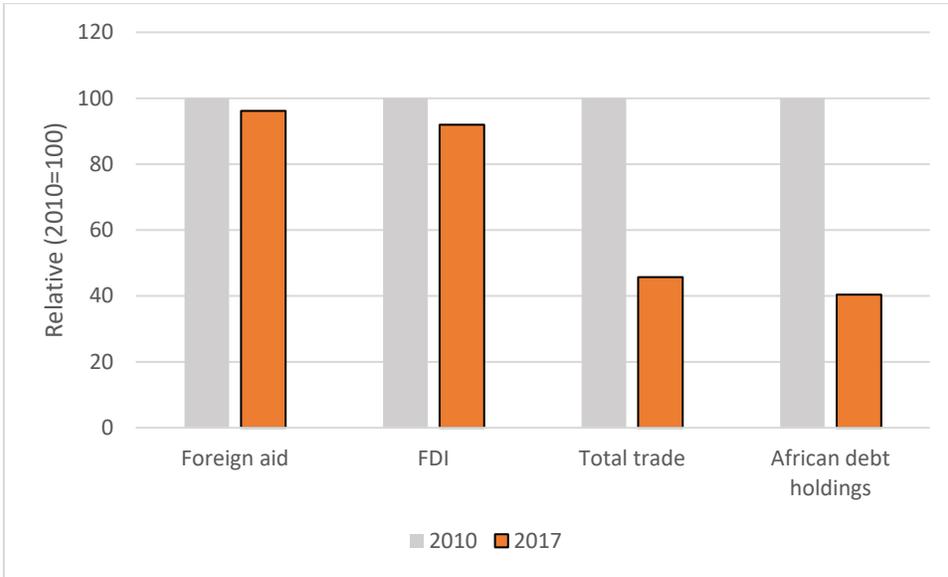
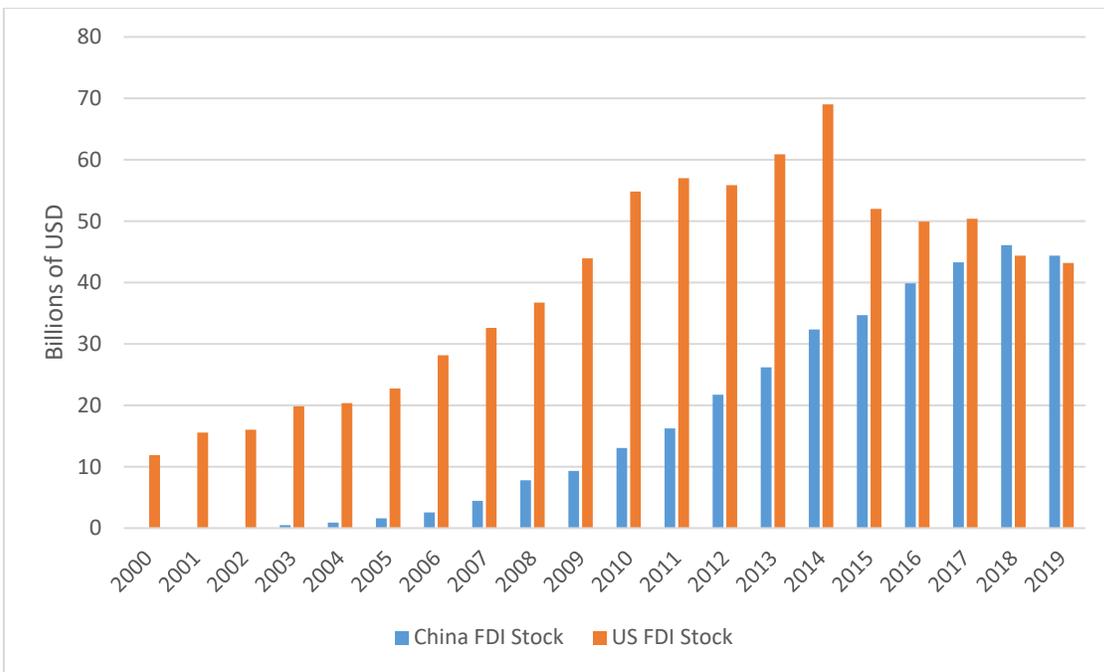


Figure 12. China vs. U.S. FDI stock in Africa



Box 1: The attempt to bridge the Fourth Industrial Revolution gap for economic prosperity in Africa and the remaining challenges for emerging leaders/followers and laggards

[extracted and adapted from Signé, 2022]

According to the Global Innovation Index (GII), African countries are not well prepared for the 4IR relative to other countries in the world. As previously mentioned, South Africa is a 4IR leader in Africa and is ranked in 60th place, the highest ranking in Africa among developing countries. Mauritius, a high-income country is eight places ahead of South Africa, and Tunisia, the next best performer, is ranked in 65th place, while Morocco is ranked 75th. Kenya, the highest ranked sub-Saharan Africa country after South Africa, is ranked in 86th place, followed closely by Tanzania, Botswana (an upper middle-income economy along with South Africa), and Rwanda (the highest ranked low-income country at 91st place). However, a number of low- and middle-income countries (LMICs) are ahead of South Africa, including Vietnam (42), Ukraine (45), India (48), the Philippines (50), and Mongolia (58) (Cornell et al., 2020). Low rankings in sub-Saharan African countries are mostly because of low levels of science and technology activities, limited industry linkages, low absorptive capacity of firms, and a challenging business environment. The higher ranked countries in Africa tend to have higher expenditures on research and development (R&D), an improving resource base, and deeper financial markets, including in terms of venture capital. Likewise, these countries have more open economies, especially to technology imports, and high penetration and active use of ICT technologies (Cornell et al., 2020 p. xxvi).

These low rankings strongly suggest that African governments need strategies to increase new technology adoption and foster innovation to maximize growth, transformation, and inclusion. Strategies developed jointly with diverse stakeholders are likely to be more successful; regional and continental strategies would be beneficial as well (Signé, 2022). Several countries in the region have already developed strategies, while others are sitting on the sidelines. Those countries without strategies are likely to be disadvantaged going forward. Strategies should address the challenges faced by the public as well as actions of other important actors, including businesses, educational institutions, NGOs, associations, and the broader population, can take to increase technological readiness and adoption, while ensuring fair and open processes (Signé, 2022).

Some countries such as South Africa and Mauritius have been among the leaders of innovation in sub-Saharan Africa, by developing and implementing comprehensive and specific strategies. Other countries that are emerging leaders on the continent like Rwanda are closely following. On the other hand, there are some laggards such as the Democratic Republic of Congo with minimal progress. As the leaders of the 4IR have

been extensively discussed previously, this section will focus on the emerging leaders/followers and laggards.

B.1.1. Current leaders of the Fourth Industrial Revolution in sub-Saharan Africa and the strategies behind their success

There are certain African countries that are currently at the head of the pack in terms of their preparedness for and implementation of the 4IR. While these countries have adopted a myriad of different strategies, there are commonalities among them, and proactive government involvement to address the 4IR is an overarching theme. In this section, Global Innovation Index (GII) and Global Competitiveness Index (GCI) scores are used as a proxy to measure the relative readiness of various African countries for the 4IR.

South Africa. South Africa is one of the highest performing economies in Africa and also represents a leader in the region in 4IR innovation, significantly outperforming other nations in its income group. South Africa's GI indicates strong performance on the areas of market and business sophistication. For instance, South Africa ranks higher than other countries at its income level when considering the measures of market capitalization as a percentage of GDP, intellectual property payments as a percent of total trade, and research collaboration between universities and industry, with this final measure being particularly important in driving meaningful innovation.

A major strength of the innovation ecosystem in South Africa is government support programs, although there is room to enhance the efficacy of these programs. Among other methods, South Africa uses a tax-based incentive, known as the November 2006 R&D Tax Incentive, to promote R&D in the private sector. The Department of Science and Technology manages this incentive simultaneously with other programs and agencies that drive innovation efforts, including the Council for Scientific and Industrial Research, which is responsible for R&D in sectors like health, high-tech manufacturing, energy, and mining; the Technology Innovation Agency, which provides funding for strategic technological innovations that promote commercialization; the Technology for Human Resources in Industry Program, which promotes collaboration on R&D efforts between universities, private sector institutions, and science councils; and the Support Program for Industrial Innovation and Industrial Innovation Partnership Program (Naudé 2017, p. 8). Finally, to promote and protect domestic innovation, South Africa has enshrined strong intellectual property rights in its legal system (World Bank, 2017, p. 35).

South Africa's strong research ecosystem, which includes exceptional university and world-class scientific facilities, has supported the training of entrepreneurs and innovators and the creation and usage of new technologies in the country. In fact, of the

top 500 universities in the world, three are found in South Africa. Compared to other emerging economies, South Africa boasts high international collaboration on research publications, illustrating the country's involvement in the global scientific community. The majority of South Africa's patents also come from public research institutions (World Bank, 2017, pp. 34-5). At the same time, while there are high quality educational institutions and relatively high levels of expenditures on education relative to GDP, only 19.8 percent of the population is enrolled in tertiary education, which implies an area for improvement.

South Africa has a relatively diversified and dynamic private sector that promotes innovation and collaboration across many economic sectors. Multinational companies like Google and Microsoft have located offices in the country, which can support knowledge and technology transfer. South Africa also represents the most popular destination for FDI in sub-Saharan Africa (World Bank, 2017, p. 33). These trends have enabled South Africa to become a leader in innovation on the African continent, but the country is still lagging at a global scale.

Mauritius. The economy of Mauritius is consistently categorized as one of the most innovative and competitive on the African continent. When evaluated via the GII, Mauritius is ranked as especially strong in the categories of governmental effectiveness, business environment, and institutions, which reflect the country's political stability. Likewise, the country's infrastructure is highlighted as a strength, including its e-governance capabilities and ICT infrastructure, along with its market sophistication, which is particularly strong due to an attractive investment environment and credit availability. Finally, the country is strong in the area of creative outputs, including outputs that utilize ICTs. When ranked with the GCI, Mauritius has relatively high rankings for eight of the twelve pillars, receiving its highest marks for the areas of institutions, business dynamism, and product market. However, Mauritius did receive lower scores for pillars associated with human capital, including the labor market, health, and skills (World Economic Forum, 2018e).

Early in the country's development, Mauritius instituted a National Information Technology Strategy Plan and created a special ministry that promotes ICT applications in a variety of sectors (Wijkman & Affi, 2002). In the development plan, there is heavy focus on the digital economy and on creativity, innovation, and high value addition. The country's current digital strategy has five principal pillars: e-government and business facilitation, cybersecurity, ICT infrastructure, innovation and emerging technologies, and talent management. The government has centered its efforts around enhancing ICT availability, accessibility, and affordability in order to promote innovation (Digital Mauritius 2030 Strategy, 2018).

Through these initiatives, Mauritius has seen a large number of technology-based projects and relatively significant funding for innovation. For instance, funding for eight smart cities and five “technoparks” was included in Mauritius’s 2015 budget, with the goal of supporting the economy and increasing the country’s competitiveness both regionally and internationally. Mauritius’s innovation areas of focus are centered around a range of industries, including tourism and hospitality, ICT, air transport, health, agriculture, and government administration (Sahadut et al., 2015). In 2017 alone, the government devoted \$4.3 million to promoting innovation. After receiving over 130 research project proposals, the Mauritius Research Council also saw its budget rise from \$1 million to \$2.5 million that same year to support the development of those innovative projects (Hamuth 2017).

In order to improve digital literacy levels and create an inclusive information society, the National Computer Board (NCB) of Mauritius is working with the Community Empowerment program, an initiative surrounded around citizen outreach with the goal of creating and disseminating community development information and knowledge. Across Mauritius, the NCB has successfully established over 180 computer clubs in community and social welfare centers and manages 94 public WiFi hotspots located in local postal offices. With regards to cybersecurity, Mauritius has a National Computer Emergency Response Team, which is tasked with providing help and information to users looking to institute proactive safeguards that can lessen the risk of facing an information security incident; Mauritius is one of very few African countries that has established this type of organization (Oolun et al., 2012, pp. 161-8).

The Financial Services Commission of Mauritius also has made huge strides in transforming the Mauritius International Financial Center into a fintech hub for the African continent (Financial Services Commission of Mauritius, 2018, pp. 1-2). Through high levels of outsourcing, Mauritius has benefited from its involvement with multinational companies, which provide both knowledge and technology transfer. At the same time, innovation in Mauritius is not concentrated solely in the operations and staff of large multinational companies. Government efforts have allowed Mauritius to attract many small- and medium-sized ICT enterprises (Wijkman & Affi, 2002). Likewise, the country has now set the goal of using ICT incubators to cultivate emerging tech entrepreneurs (Hamuth 2017; Signé, 2022).

B.1.2. The emerging leaders/followers in sub-Saharan Africa

A few countries are emerging leaders in 4IR innovation in Sub-Saharan Africa, including Egypt, Rwanda, and Nigeria. As presented by Signé (2022), these countries are ranked lower than Africa’s innovation leaders on the GII and GCI but have either made consistent and significant gains in recent years (in the case of Rwanda) or have become major sources of innovation despite significant challenges (in the case of Nigeria).

These countries have diverse strengths and weaknesses; Rwanda, for example, has a small market size and strong institutions, while Nigeria and Egypt have large markets but score relatively poorly on indicators for institutions (World Economic Forum, 2019). They can learn from the leading countries to improve their country's ability to capitalize on the Fourth Industrial Revolution. For example, Rwanda significantly outperforms other countries in income levels, with a GII score more than four standard deviations above the score predicted for a country with the same GDP per capita measured at purchasing power parity. Rwanda particularly excels in the areas of institutions due to its political stability, along with government effectiveness and business environment strength. Likewise, Rwanda ranks favorably on market sophistication due to its high scores on ease of doing business-related indicators and business sophistication (Cornell et al., 2020 p. 17). These strengths are also evident in Rwanda's performance on the Global Competitiveness Index, where the country scores highly in the areas of institutions, product market, labor market, and business dynamism. However, weak scores in the areas of workforce education and skills, innovation capability, infrastructure, and ICT adoption lower Rwanda's overall GCI ranking (World Economic Forum, 2019, p.486-489). Furthermore, government agencies have been active in helping to build innovation hubs and train entrepreneurs, but these initiatives have not always been inclusive or efficient, as they have generally targeted Rwanda's highly educated population. Deeper scrutiny of the scale and effectiveness of both public and private projects may be key to enhancing the impact of innovation in Rwanda. Nevertheless, the government's policy decisions, which reflect an understanding of the country's comparative advantages and the need to strengthen areas including education and infrastructure, and a growing community of entrepreneurs and innovators suggests that Rwanda has great potential to take advantage of the opportunities presented in the Fourth Industrial Revolution (AfDB and KOAFEC, 2019; World Bank and the Government of Rwanda, 2020)

B.1.3. The laggards in sub-Saharan Africa

As discussed earlier, the 4IR's leaders and followers in Africa have a somewhat heterogeneous performance across the 4IR and associated indicators, combining good, average, and bad performance on different indicators. Laggards have a more converging or homogenously low performance for most indicators. In addition to having their own country-specific challenges, they are drastically underperforming for almost all the 4IR and associated indicators, whether related to technology and innovation, competitiveness, drivers of production, human capital, regulatory and enabling environment, investment. For example, Chad, a 4IR laggard and the worst performer of the Global Competitiveness Index, is ranked last for ICT adoption globally, 140 for utility infrastructure, 137 for interaction and diversity, 139 for entrepreneurial culture, and 137 for the incidence of corruption (World Economic Forum, 2019, pp. 147-149). In other underperforming countries such as the Democratic Republic of Congo, less than 1

percent of the population in rural areas has access to electricity (Lighting Africa, 2018). Furthermore, South Sudan is the third most fragile state in the world, and citizens lack access to most basic public services and goods, let alone internet access (Fragile States Index, 2020). All these countries have drastic infrastructure deficiencies, including the ones which are fundamental to unlock the 4IR potential. Overall, whether we assess the physical capital, human capital, state capacity and institutional framework, technological innovation and adoption, competitiveness and enabling environment, laggards are behind for almost all indicators, whereas African leaders, although not outperforming compared to their peers, have a more heterogeneous performance.

All in all, the countries leading the 4IR in Africa have demonstrated the potential of 4IR innovations and technology by implementing strategies that both followers and laggards can also adopt and tailor to their own country-specific circumstances. Successful strategies to implement digital transformation can result in many benefits for African countries, including the creation of new advanced and high paying jobs (Ndung'u and Signé, 2020). The African countries that are lagging behind in digital transformation should channel more resources, including political capital, into resolving the key challenges and barriers which hamper digital innovation.