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*Aidar Abdychev, Cristian Alonso, Emre Alper, Dominique Desruelle, Siddharth Kothari, Yun Liu, Mathilde Perinet, Sidra Rehman, Axel Schimmelpfennig, and Preya Sharma*

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# Introduction

Far-reaching changes in technology, climate, and global economic integration are transforming the world of work in ways that we do not yet fully understand. Will the swift technological advances of the Fourth Industrial Revolution raise the standards of living for everyone? Or will robots massively displace workers leading to a jobless future where only a few benefit from the fruits of innovation? Will mitigation efforts be able to cushion the adverse effects of climate change, including food shortages and mass migration, which would place extra pressure on urban labor markets? Will countries continue to integrate commercially and financially, fostering growth and employment? Or will trade wars become a norm in a world increasingly fragmented and inward-looking?

In sub-Saharan Africa, these uncertainties meet a dramatic increase in population and a rapid expansion in the labor force, which is becoming increasingly urban. The population is expected to rise from 1 billion today to 1.7 billion by 2040. The working-age population in the region will, on average, experience a net increase of 20 million per year over the next two decades. At the same time, migration toward cities is accelerating, increasing the need for urban jobs. How can sub-Saharan Africa add 20 million jobs a year to keep up with such pace of population growth?

It is not only a question of the quantity of new jobs, but also of their quality. In the recent past, job creation in the region has kept pace with population growth. Since 2000, sub-Saharan Africa has been able to add an average of 9 million jobs per year, leading to a slight increase in the employment-to-population ratio. However, most of the new jobs were created in sectors with low productivity levels, such as subsistence agriculture and low value-added services. Self-employment has continued to be predominant.

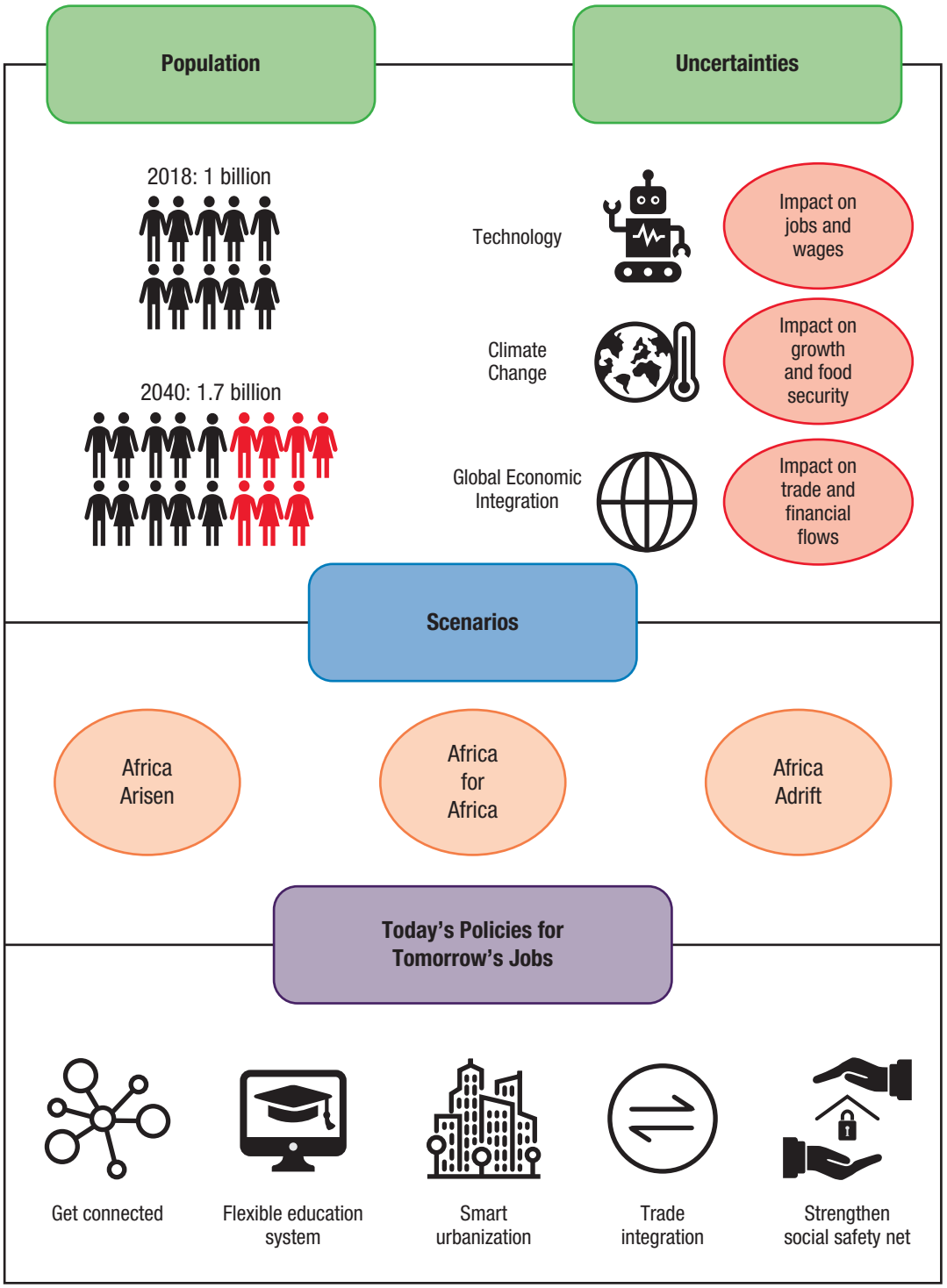
In this paper, we explore the challenges and opportunities of the Fourth Industrial Revolution for sub-Saharan Africa as the region seeks to create jobs for its booming population, tackle the adverse effects of climate change, and face an external environment that may become less supportive. Our approach combines a look at history, economic modeling, empirical evidence, and scenario analysis. The paper's chapters can be read together or selectively, with each chapter starting with a summary of the main findings.

The next three chapters of the paper look separately at labor market developments in sub-Saharan Africa over the last two decades (Chapter 1), the nature and potential impact on sub-Saharan Africa of the Fourth Industrial Revolution (Chapter 2), and the possible effects of demographics and urbanization, climate change, and the future course of global economic integration on the region (Chapter 3). To explore the Fourth Industrial Revolution, Chapter 2 makes use of both a simple economic model and partial equilibrium analysis of exports' vulnerability to automation.

The final two chapters of the paper then seek to bring together these disparate, uncertain, but very real major changes (see Figure 1). Chapter 4 presents three realistic scenarios for sub-Saharan Africa over the next two decades, which incorporate different possible technological, climate, and integration trends. Against this backdrop, Chapter 5 develops policy ideas for sub-Saharan Africa to generate the needed 20 million jobs per year in such uncertain times. Specifically, we argue that decisive policy actions across five key dimensions are needed today to prepare workers and labor market entrants for the jobs of tomorrow:

- **Get connected.** Governments should invest in infrastructure, both traditional and digital, to provide the basis for the region to leverage the opportunities from the Fourth Industrial Revolution.
- **Develop flexible education systems.** A flexible education system will be critical to keep pace with changing technologies to ensure that workers have the skills to complement machines, and not to be substituted by them.
- **Urbanize smartly.** Governments should take advantage of new technologies to institute effective urban planning, formalize land markets, clarify property rights, improve service delivery, and strengthen governance, accountability, and social infrastructure.
- **Boost trade integration on the continent.** Move forward with trade integration in sub-Saharan Africa, for example through the Continental Free Trade Agreement, but also through investing in regional infrastructure.
- **Expand social safety nets.** As labor markets become more volatile, developing social safety nets can smooth transitions between jobs or "gigs" for individuals and buffer income volatility.

**Figure 1. The Future of Work in Sub-Saharan Africa**



CHAPTER

# 1 The Present of Work in Sub-Saharan Africa

*We look at recent employment trends in the region to understand the potential for job creation in the next two decades.*

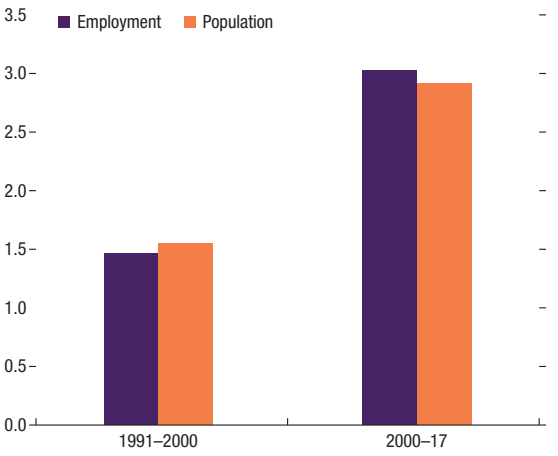
- *Sub-Saharan Africa created sufficient jobs to keep up with population growth over the past two decades.*
- *However, quality did not accompany quantity.*
- *Most of the new jobs created were in agriculture or services with low-value added.*
- *Most of the new jobs created were in self-employment.*

Since 2000, job creation in sub-Saharan Africa has kept pace with population growth, even though demographic pressures doubled compared to the 1990s (Figure 2).[1] The employment-to-population ratio increased from 63 percent in 2000 to 64 percent in 2017, and the region was able to add almost 9 million new jobs per year. Such positive performance was possible thanks to strong economic growth, particularly in the 2000s as many countries benefited from the commodities boom.

Most of those new jobs were in self-employment (Figure 3). Six of the nine million jobs created annually on average since 2000 have gone to own-account and contributing family workers. Only 2.6 million have gone to employees being paid for their work. Thus, self-employment remains a defining characteristic of labor markets in sub-Saharan Africa. Self-employed workers lack the stability and protections of an employment contract and are more likely to operate in the informal economy where productivity is lower.

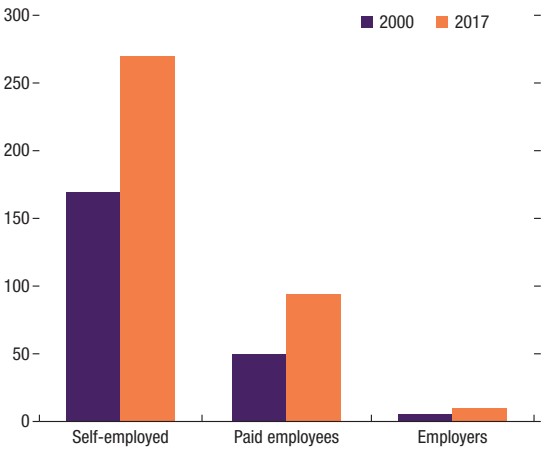
[1]Employment analysis in this section is based on ILO estimates that address the concern of missing data through imputation with econometric models when household surveys or censuses are not available. A person of working age (i.e. aged 15 and older) is said to be employed if they have a paid job or are self-employed.

**Figure 2. Employment and Population Growth**
*(Average annual growth rate)*




Source: International Labour Organization.

**Figure 3. Jobs by Category of Employment**
*(Millions)*



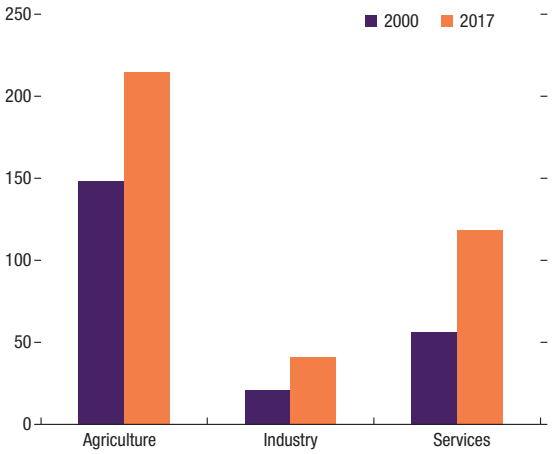

Source: International Labour Organization.
Notes: Self-employment includes own-account workers and contributing family workers.

Most new jobs have been added in sectors with low productivity, such as agriculture and traditional services (Figure 4). Sub-Saharan Africa has the lowest share of employment in manufacturing in the world, which has raised concerns as productivity in manufacturing tends to converge to the global frontier and to grow faster, thus offering a better chance at development (Rodrik 2015). Reallocation toward services can be positive as "modern" services relying on high-end technologies also exhibit convergence to the frontier (IMF 2018a).[2] However, so far, labor did not reallocate toward those most productive and modern services in sub-Saharan Africa. In fact, during the 2000s, the share of modern services in sub-Saharan Africa's exports of services declined (Figure 5). Trade, a traditional service, grew the most in terms of employment shares.

The fast average pace of job creation in the region conceals a great deal of heterogeneity (Figure 6). The employment-to-population ratio declined by 13 percentage points in Burkina Faso as population grew on average by 3.2 percent since 2000, while employment expanded at 2 percent. In Burundi, Côte d'Ivoire, Kenya, Lesotho, Mozambique, and Sierra Leone, population also outgrew job creation. By contrast, in Angola, Botswana,

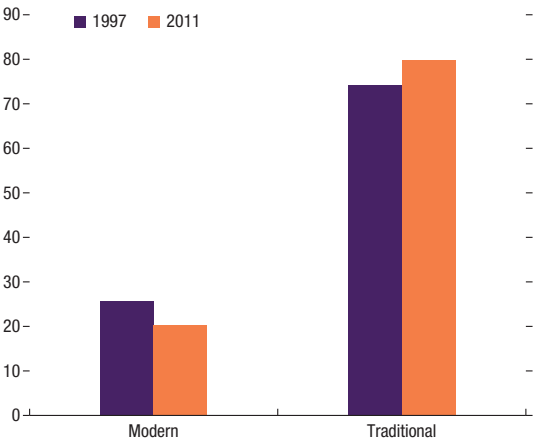
[2]Modern services include telecommunications, computer, and information services; financial services; insurance and pension services; charges for the use of intellectual property; manufacturing services on physical inputs owned by others; maintenance and repair services; and other business services. Traditional services include transport; travel; construction; personal, cultural, and recreational services; and government goods and services. For further discussion of service exports sophistication and economic growth, refer to Mishra, Lundstrom, and Anand (2011).

**Figure 4. Jobs by Industry**
*(Millions)*




Source: International Labour Organization.

**Figure 5. Decomposition of Export Services in Sub-Saharan Africa**
*(Percent of total export services)*

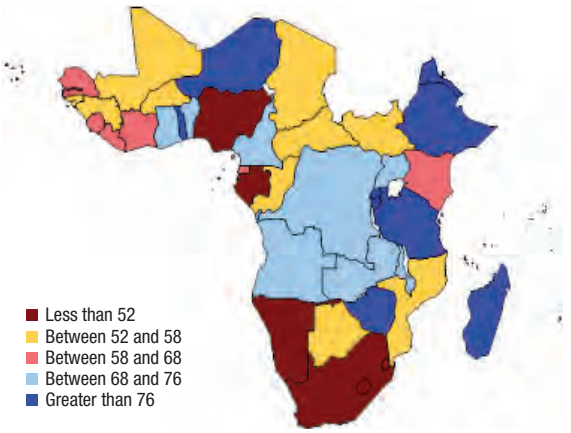



Source: IMF staff calculations.

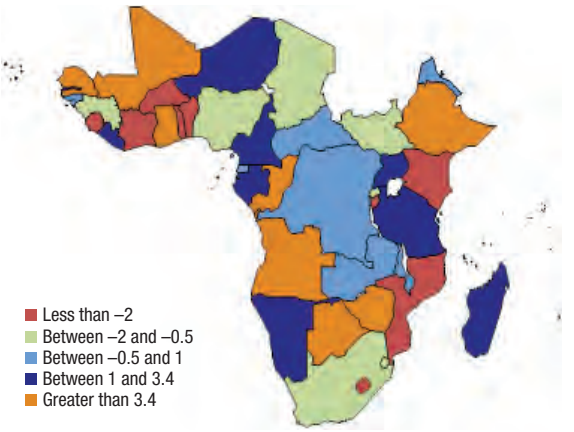
Congo, Ghana, Mali, Senegal, and Zimbabwe, job creation largely outpaced population. Joblessness remains a severe problem for South Africa and Eswatini, whose employment-to-population ratios remained broadly stable at the lowest level for the region, below 40 percent, less than half of the employment rates in Madagascar, Rwanda, and Tanzania.

**Figure 6. Employment-to-Population Rate**

**1. Employment-to-Population Rate (Level, 2017)**




**2. Employment-to-Population Rate (Change, 2000–17)**




Source: International Labour Organization.

CHAPTER

# 2 Technological Change and the Future of Work in Sub-Saharan Africa

*We use history, modeling, and empirical evidence to glimpse at the impact of technology on jobs in sub-Saharan Africa.*

- *There is a fundamental uncertainty about the impact of the Fourth Industrial Revolution on jobs and labor markets: Will technology take away jobs from people or will it lead to the creation of many new products, services, and jobs that we cannot even yet dream of?*
- *If technology helps people do their jobs better, sub-Saharan Africa's convergence with the rest of the world could experience a boost. However, if technology takes jobs away from people, sub-Saharan Africa could diverge from the rest of the world.*
- *The "classical" manufacturing-export-led development model will need to be adapted to the constraints and opportunities brought by the Fourth Industrial Revolution.*

## The Fourth Industrial Revolution

The Fourth Industrial Revolution is the latest stage of a transformation that started in the 18th century. The First Industrial Revolution commenced in Great Britain in the middle of the 18th century, when water and steam power became new engines of production, allowing for a transition from hand production to machine tools and mechanization. The discovery of electric and hydroelectric power, along with the development of chemical industries (for example, petroleum) initiated the Second Industrial Revolution, creating new power-generating tools, increasing the potential for industrialization, and raising productivity. The second part of the 20th century saw the invention of computers and the internet, contributing to what is referred to as the Third Industrial Revolution.

The Fourth Industrial Revolution is massively expanding the scope of what machines can do. It is characterized by breakthroughs in areas such as artificial intelligence, machine learning, robotics, and 3-D printing (Schwab 2016). The internet is becoming faster, more accessible, and more mobile. Increasing data storage and processing capacity makes it possible to manipulate unprecedented amounts of information in a short amount of time. Computers are becoming increasingly able to perform cognitive tasks thanks to machine learning and artificial intelligence, which allow them to develop and refine their own algorithms, expanding the range of automatable tasks beyond routines (Autor 2014; Gibbs 2017).[1]

## Historical Perspective

The main insight from history is that previous industrial revolutions resulted in massive productivity gains and general improvement of human living conditions over the long term. Prior to the First Industrial Revolution, living conditions had been stagnant for millennia. Since then, income per capita has skyrocketed. Changes also included improved and cost-efficient provision of food, rise of international trade, growth of cities, and broader social and cultural transformations. Societies transformed from ones dominated by agrarian economy and cottage industries to ones with mass-scale production industries.

The scope and scale of changes during industrial revolutions were massive, affecting the whole economy and society. The introduction of new general-purpose technologies led to the invention of new machines (for example, steam engine, power loom, spinning jenny, and internal combustion engine) and, in turn, drastic alterations in modes of production that were introduced to reach the full potential of these machines. Whole new modes of consumption were also made possible (for example, mail order companies and department stores). These revolutions were also accompanied by advancements in education with governments taking a more active, forward-looking role. The educational system was redesigned to develop the skills that factories needed. Public schools sprouted, and educational attainment improved dramatically.[2]

Labor reallocated in large scale. New occupations emerged. Machines needed to be operated and maintained by workers, such as engineers and techni-

[1]Until recently, the scope for automation was limited by Polanyi's paradox (Autor 2014), which claims that it is difficult to automate tasks that require flexibility and judgment, that do not follow an explicit set of rules, or that we do not know how we know. Machine learning and artificial intelligence are on their way to break this limit.

[2]In the United States, the high school movement led to an increase in high school enrollment from 9 percent to 73 percent of the youth between 1910 and 1940 (Goldin and Katz 2008).

cians, who needed new types of skills. Higher living standards also gave rise to higher demand, whereas new inventions brought amazing new goods and services, creating new jobs in previously unheard of industries.

During the transition period, the industrial revolutions also had many losers. Skilled artisans saw their jobs disappear and their skills become worthless as milling machines were introduced during the First Industrial Revolution. As their wages fell dramatically, some groups of workers reacted violently and attempted to prevent the "rise of the machines" by destroying them. Working conditions in the first factories were terrible. Tales of poverty and hunger fill the literature of the period. People moved from the relatively safe countryside to unhealthy cities, with poor sanitation and where fresh water was widely available for factories to power their machines, but not for people to drink (Szreter 1988). The issue of income inequality came to the forefront. Periods of dramatic industrial transformation driven by technological changes led to increased inequality (Deaton 2013; Piketty 2013). The social revolutions of the 20th century, such as the October Revolution in Russia, were driven by massive divisions in the society.

Industrial revolutions also led to a great divergence across countries (Pomeranz 2000). Whereas living conditions were not substantially different in Western Europe than in the rest of the world in the 1600s, they massively diverged afterwards. Countries where innovations were developed or adopted early experienced fast and sustained economic growth. Some countries managed to catch up by embracing technological changes during the 20th century (for example, Japan and Korea), whereas others have substantially reduced the gap recently (for example, China and India). However, a large part of the world is still lagging.

## Anxiety and Hope

There is substantial uncertainty regarding the extent to which jobs may be displaced because of the Fourth Industrial Revolution in advanced economies, with estimates for existing jobs at risk ranging from 7 percent to 60 percent. McKinsey Global Institute (2017) analyzes the activities of each occupation and the potential for existing technologies to perform those activities. They find that 40 percent to 55 percent of jobs in advanced economies may be at risk from automation. The World Bank (2016) uses national employment estimates together with occupational automation indices and concludes that almost 60 percent of employment is at risk of automation in Organisation for Economic Co-operation and Development (OECD) economies. Another set of studies, using individual-level data on tasks conducted

by workers to estimate the risk of automation, find that only 7 percent to 15 percent of OECD jobs are at risk (Arntz, Gregory, and Zierahn 2016).

For sub-Saharan Africa, studies also point to a large but uncertain impact on jobs. McKinsey Global Institute (2017) and the World Bank (2016) estimate the number of jobs at risk in some sub-Saharan African countries, adjusting for technological feasibility and diffusion of technology to low-income countries. They find that employment in sub-Saharan Africa is a little less susceptible to automation than in advanced economies but still sizable, with estimates for individual countries in the region ranging from 40 percent to 60 percent.

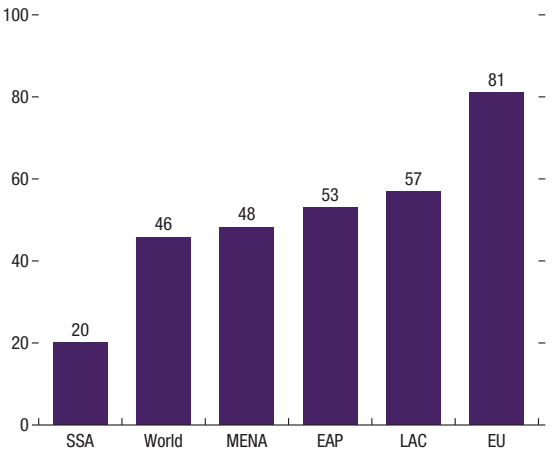
One key difference between advanced economies and sub-Saharan Africa is demographics. Most advanced economies are facing this wave of technological change at a time of declining working populations. They are thus keen to embrace the opportunity to sustain or increase output levels with fewer workers. In sub-Saharan Africa, the challenges are different. With working populations growing rapidly, countries need to add new jobs to their economies year after year for most of this century.

The Fourth Industrial Revolution is not just a source of anxiety, but also one of great hope and inspiration. All across sub-Saharan Africa, governments and entrepreneurs are already taking advantage of the opportunities provided by the Fourth Industrial Revolution. First and foremost, East Africa has led the development of mobile money, providing access to financial services to millions that were previously excluded. But take up of technology has not been limited to finance. For instance, Biscate is a phone-based recruitment solution for blue collar workers in Mozambique. In South Africa, the medical app Vula Mobile has been launched to connect health workers with specialist care providers for their patients. Figure 7 offers further examples of how technology is already providing local solutions across the continent.

To fully harness the benefits of these opportunities, sub-Saharan Africa has some catching up to do. Although use of mobile phones has become widespread, internet penetration in the region remains the lowest in the world—less than half the global average (Figure 8). Only a few countries like Kenya, Nigeria, and Seychelles have achieved penetration levels of close to 50 percent, slightly above the global average. The cost of a fixed broadband connection is the highest in sub-Saharan Africa compared to other regions (Figure 9). Only for mobile broadband are costs comparable to other regions in US dollar terms. However, once costs are scaled by gross national income, sub-Saharan Africa has the least affordable mobile broadband.

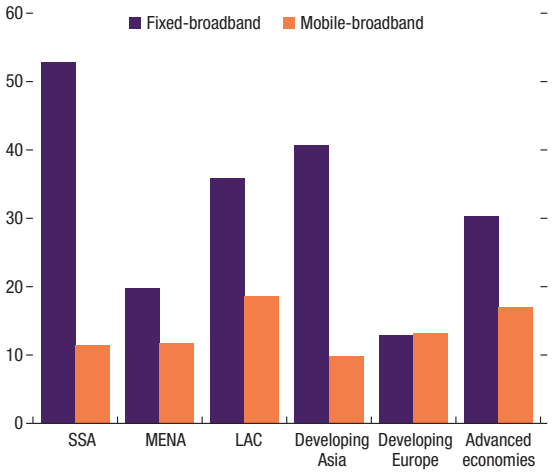
**Figure 7. Technology-based Local Solutions in Sub-Saharan Africa**


**Figure 8. Proportion of Individuals using the Internet, 2016**
*(Percent)*




Source: World Bank, World Development Indicators.
Note: EAP = East Asia and Pacific; EU = European Union; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SSA = sub-Saharan Africa.

**Figure 9. Monthly Cost of Fixed and Mobile Broadband Internet Connection, 2016**
*(Average US dollars)*




Source: ITU-ICT Database.
Note: LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SSA = sub-Saharan Africa.

## The Theory: Modeling the Impact of the Fourth Industrial Revolution

With past experiences and the current juncture in mind, we develop an economic model to analyze the potential impact of the Fourth Industrial Revolution on sub-Saharan Africa.[3] Our model features an advanced economy region and a low-income region, such as sub-Saharan Africa, that can trade with each other. In both regions, goods are produced using traditional capital, labor, and "robots," with robots defined broadly to include the wide range of new technologies that constitute the Fourth Industrial Revolution, including automation, machine learning, and artificial intelligence.

The two regions differ with respect to overall productivity, that is, how many goods can be produced with the same capital stock, workers, and robots. The advanced economy is more productive than sub-Saharan Africa, which results in a gap in wages and per capita incomes between the two regions.[4] Because wages are lower in sub-Saharan Africa, production in the region uses relatively more labor and fewer robots.

In our model, robots and labor can be either complements (help workers do their job better) or substitutes (take jobs away from workers). The use of digital technology in agriculture, like an app that allows farmers to better treat pest infestation, is an example of robots (broadly defined) complementing workers. Robots substitute for workers, for example, if self-checkout machines come to completely replace cashiers in grocery stores.

The Fourth Industrial Revolution can increase per capita GDP in both regions in the long term. We model the impact of the Fourth Industrial Revolution as an increase in robot productivity. When the productivity of robots is doubled, firms invest in robots and traditional capital and increase production. As a result, both regions see an increase in per capita GDP in the long term.

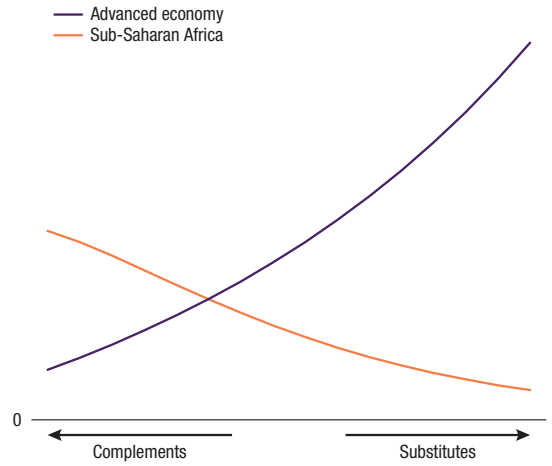
However, the magnitude of the increases in per capita GDP in each region, and so the change in inequality between regions, depends on whether robots substitute for or complement labor (Figure 10):

- If labor and robots are complements, the increase in per capita GDP is larger in sub-Saharan Africa than in the advanced economy in the long term. There is convergence. Sub-Saharan Africa gains because it has lower wages and that makes it more profitable to invest in robots where they are combined with relatively cheap labor.

[3]Refer to the Appendix for further details.

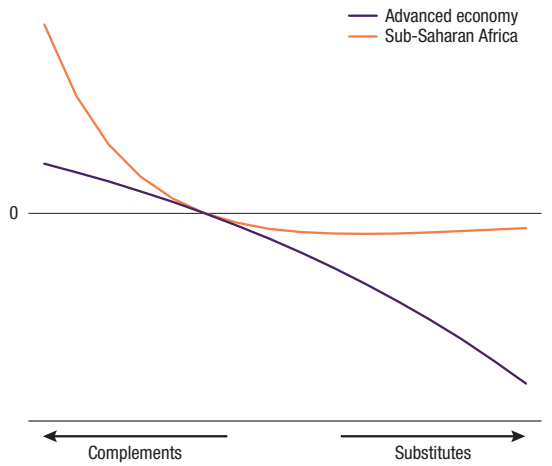
[4]We choose model parameters such that the per capita GDP in advanced economies is 15 times that in sub-Saharan Africa, which matches the gap in income levels between sub-Saharan Africa and the United States in the data.

**Figure 10. GDP per Capita**
*(Percent change across steady states)*




Source: IMF staff calculations.

**Figure 11. Labor Share**
*(Percent change across steady states)*



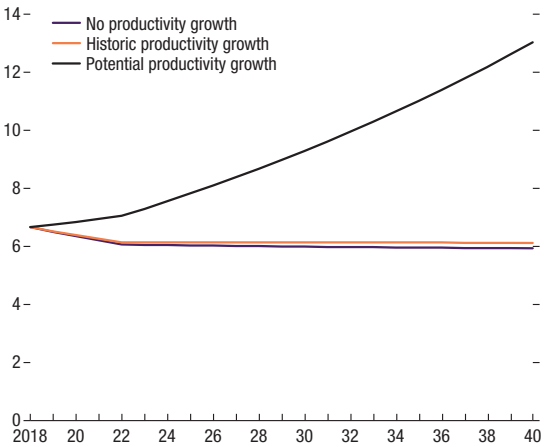

Source: IMF staff calculations.

- If labor and robots are substitutes, the increase in per capita GDP is larger in the advanced economy than in sub-Saharan Africa in the long term. The region falls further behind. In this case, introducing robots and investing in complementary traditional capital is most profitable where wages are high because they save on the cost of employing expensive workers.

While real wages increase in the long term in both regions, the labor share will increase only if robots complement labor (Figure 11). When robots complement labor, the increase in wages is larger than the increase in the stock of robots, leading to a higher labor share in both regions, with the increase being larger for sub-Saharan Africa. Workers in the region obtain a larger increase in real wages and in the labor share than their peers in the advanced economy. By contrast, when robots easily replace workers, the robot stock increases by more than wages, leading to a fall in the labor share in both regions. The increase in real wages is stronger in the advanced economy, but the increase in per capita GDP is even larger, so that the fall in labor share is more pronounced than in sub-Saharan Africa. Relatively higher growth in the advanced economy is then associated with higher inequality as well.

There is an additional policy lever that sub-Saharan Africa has at its disposal in this model. That lever is overall productivity growth, which is influenced by many factors, including infrastructure, skill levels, and the institutional and regulatory framework. The model suggests that this lever is potentially strong enough to achieve convergence even if the impact of automation provides a headwind. How much overall productivity growth is needed? The

**Figure 12. GDP per Capita in Sub-Saharan Africa**
*(Percent of rest of world)*




Source: IMF staff calculations.

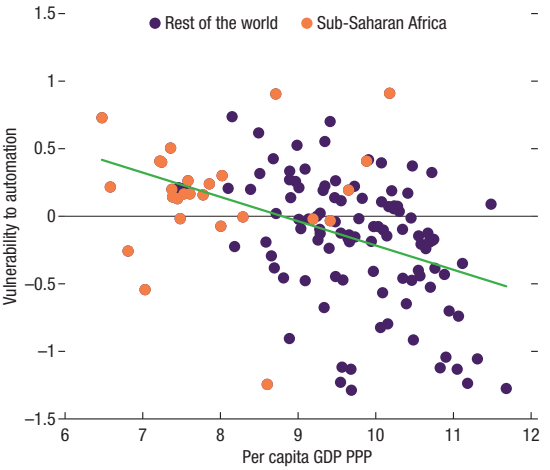
rate of productivity gains realized between 2000 and 2014, 0.9 percent on average, would not be enough to close the gap with advanced economies (historic productivity growth in Figure 12). However, pushing ahead with trade integration and efficiency gains from reduced misallocation of factors of production could boost convergence and reduce the gap in productivity between sub-Saharan Africa and advanced economies by half in two decades, from a factor of 1 to 15 to a factor of 1 to 7 (potential productivity growth in Figure 12). In this scenario, sub-Saharan Africa would bring its income position relative to the United States to a level that would be slightly ahead of where India currently is.

## The Numbers: Assessing the Impact of the Fourth Industrial Revolution on Exports from Sub-Saharan Africa

The impact of the Fourth Industrial Revolution on sub-Saharan Africa can be direct or indirect. Sub-Saharan Africa may be less vulnerable than advanced economies to technology directly replacing jobs given the differences in the structures of the economies and, most importantly, its wage levels. However, sub-Saharan Africa may still be indirectly affected through its exports. What if automation in advanced economies makes it feasible to reshore factories back to the consumer markets rendering less valuable the relative abundance of labor? In this world, what happens to sub-Saharan Africa's comparative advantage? To answer these questions, we look at indices of export vulnerability to automation.

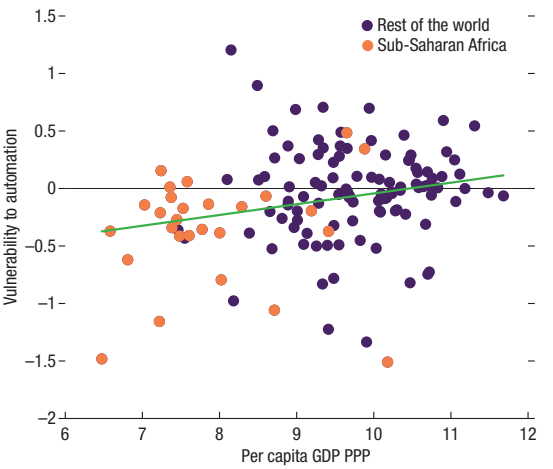
Interestingly, the results for sub-Saharan Africa's export vulnerability to automation mirror those of the model presented previously. How sub-Saharan Africa will be affected depends on the way technology complements or substitutes labor. Sub-Saharan Africa might be especially vulnerable to reshoring if technology makes it easier to replace routine tasks performed by low-skilled workers, thus reducing the cost advantage that low wages give to many countries in the region.

**Figure 13. Frey and Osborne–based Index of Countries' Export Vulnerability to Automation**




Source: Frey and Osborne (2017); UN Comtrade; and World Bank, World Development Indicators.
Note: PPP = purchasing power parity.

**Figure 14. Brynjolfsson, Mitchell, and Rock–based Index of Countries' Export Vulnerability to Automation**




Source: Brynjolfsson, Mitchell, and Rock (2018); UN Comtrade; and World Bank, World Development Indicators.
Note: PPP = purchasing power parity.

We construct two indices to gauge the vulnerability of sub-Saharan Africa's exports to automation in advanced economies.[5] The indices are based on different measures of the automatability of occupations that have been suggested in the literature by Frey and Osborne (2017) and Brynjolfsson, Mitchell, and Rock (2018). These indices are mapped to industries, and then to export goods to ascertain how vulnerable an export sector is to automation.

The two resulting export vulnerability indices provide starkly different results. Whereas the Frey and Osborne–based index suggests that sub-Saharan Africa's exports, and those of low-income and developing countries in general, are relatively more vulnerable to automation than exports of more developed countries (Figure 13), the Brynjolfsson, Mitchell, and Rock–based export vulnerability index shows the opposite (Figure 14).

The contrasting findings reflect the different underlying assumptions on how technology impacts jobs. Whereas Frey and Osborne consider technologies that replace routine jobs, Brynjolfsson, Mitchell, and Rock emphasize machine learning, which is more likely to replace nonroutine cognitive tasks. This key distinction renders two alternate views on an industry's susceptibility to automation and overall country indices. On the one hand, Frey and Osbourne consider crop production and low-end manufacturing, such as food, paper, and wood manufacturing, to be relatively more susceptible to automation. These industries constitute the bulk of noncommodity exports

[5]Refer to the Appendix for further details.

from sub-Saharan Africa. On the other hand, Brynjolfsson, Mitchell, and Rock consider sophisticated electronics and machinery to be relatively more susceptible to automation. These industries contribute toward a large portion of advanced economies' export baskets. That said, there are certain industries on which both indices agree; apparel and textile manufacturing are deemed by both indices to be susceptible to automation, whereas mining is not as vulnerable.[6]

These results again highlight the inherent uncertainty in assessing the impact of technology. In sub-Saharan Africa, the impact of the Fourth Industrial Revolution will depend not only on the pace of technological progress in general, but also the degree to which technology will complement or substitute different types of labor. Technological advances in low-end manufacturing, as indicated by the Frey and Osborne index, could render the traditional export-led growth model infeasible. How quickly this would happen would naturally depend on the pace of technological progress and the evolution of wages relative to the price of new technologies. In addition, the results emphasize the importance of export diversification to reduce exposure to the automation shock.

[6]In the case of mining, the indices refer to the vulnerability of sub-Saharan Africa's exports to automation. This does not imply that jobs in the mining sector are not subject to automation as the use of drone mining, for example, in South Africa illustrates.

CHAPTER

# 3 Other Big Trends Shaping the Future of Work in Sub-Saharan Africa

*We discuss three other "big" trends affecting the future of work in sub-Saharan Africa: the region's demographic expansion and urbanization, the severity of the impact of climate change, and global economic integration. The magnitude and impact of all three trends is subject to great uncertainty.*

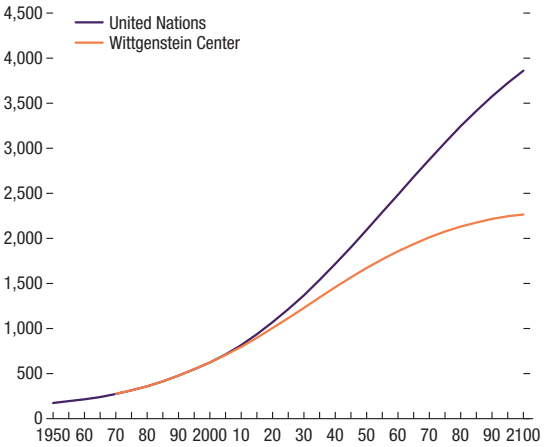
- *The working age population is rising sharply, giving the opportunity to capture a demographic dividend for which educational outcomes need to improve.*
- *Urbanization is advancing rapidly, but without substantial economic benefits so far.*
- *Climate change is threatening growth, undermining food security, and accelerating migration.*
- *The region has become more integrated with the rest of the world and with itself, but still lags behind other regions.*

## Demographics

Sub-Saharan Africa is undergoing a major demographic transition, which is expected to pick up speed in the coming decades. The total population of the region has more than doubled over the past quarter century, increasing from 470 million in 1990 to 1 billion today. Based on UN projections, sub-Saharan Africa's population will continue growing, increasing to 1.7 billion by 2040—a 70 percent increase—and to close to 4 billion by the end of the century (Figure 15). In comparison, the population of the rest of the world is expected to increase by only about 16 percent between now and 2040.

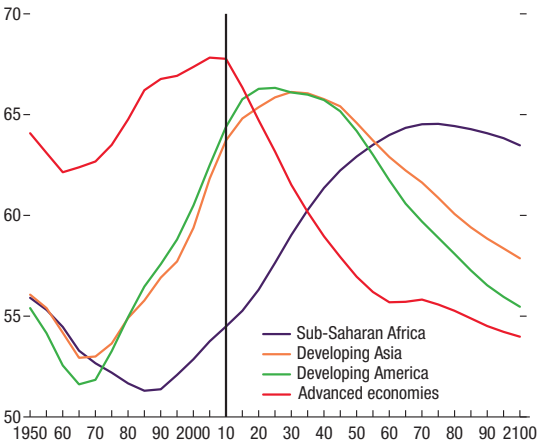
The age structure of the population is also changing rapidly, creating an opportunity to capture a demographic dividend (Figure 16). The share of working age population began to increase in the region in 1985, driven

**Figure 15. Population Projections for Sub-Saharan Africa**
*(Millions of people)*




Sources: World Population Prospects, United Nations 2017; Wittgenstein Centre Data Explorer.

**Figure 16. Share of Working Age Population**
*(Population between the age of 15 and 65 as a ratio of total population)*



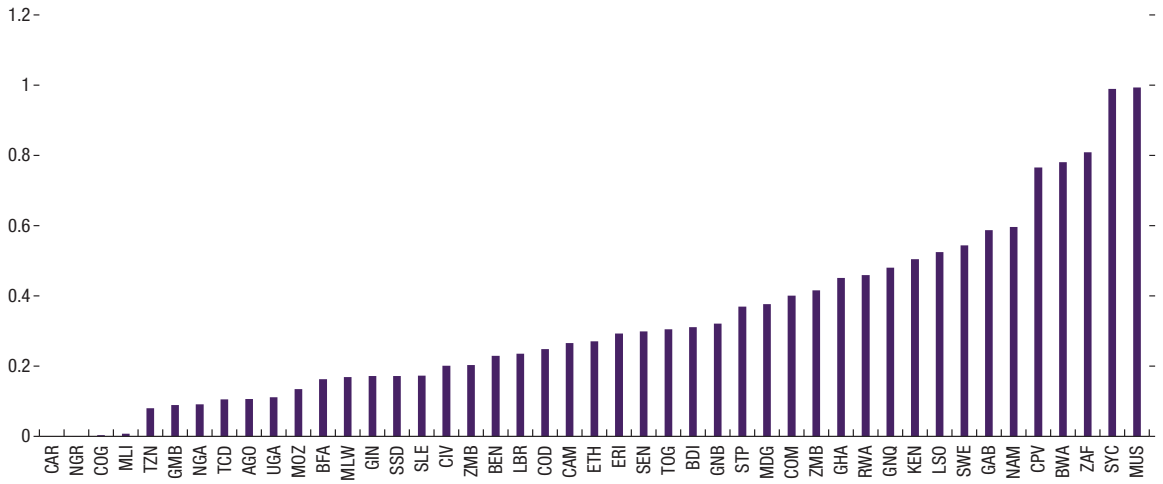

Source: World Population Prospects, United Nations 2017.

by a decline in child mortality and fertility rates. This trend is expected to continue in the future, with the sub-Saharan African share of working age population increasing for several more decades. In most other regions, similar transitions created a demographic dividend as the increase in ratio of working age to dependent population raised savings and investment rates and increased growth (Bloom and Williamson 1998; IMF 2015a).

There is considerable heterogeneity in demographic trends in individual countries (Figure 17). Mauritius already has a fertility rate of less than 2, compared to Niger which has a fertility rate of over 7, the highest in the world. As a consequence, while some countries have almost completed their demographic transitions (Mauritius, South Africa), others have barely started (Central African Republic, Nigeria).

There is some uncertainty around these population projections, driven by assumptions about the path of fertility rates. Population projections from the Wittgenstein Centre and International Institute for Applied Systems Analysis are significantly lower than those from the United Nations, a difference of as much as 300 million by 2040 and 1.6 billion by 2100. The main differences between these projections stem from assumptions regarding the speed at which women gain access to better education and employment opportunities as well as the pace of improvements in child health, which can lead to lower fertility rates. These differences also point to the opportunity for policy to impact population growth and the demographic transition.

**Figure 17. Extent of Demographic Transition Completed until 2015**
*(Ratio of increase in SWAP until 2015 to total projected increase in SWAP)*



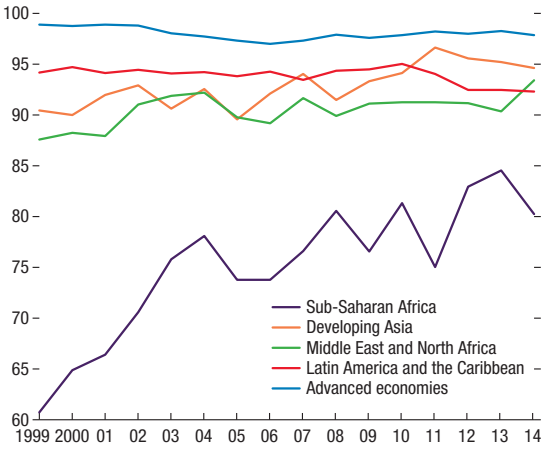

Source: United Nations, World Population Prospects 2017; and IMF staff calculations.
Note: The share is computed as = (SWAP in 2015 – min SWAP before 2015)/(max SWAP – min SWAP before 2015). Data labels in the figure use International Organization for Standardization (ISO) country codes. SWAP = share of working age population.

Irrespective of the projections, sub-Saharan Africa faces the challenge of providing high-quality jobs to its young and growing workforce. The region will need to create 16 to 20 million new jobs on average every year, and by 2030 will contribute half of the annual increase in the global working age population.

The growing population will demand improved education. Sub-Saharan Africa has made important gains in increasing primary completion rates but has not yet caught up with other regions on secondary education (Figures 18 and 19). Secondary enrollment rates, a more forward-looking indicator of likely education outcomes for the next generation, remain well below other regions.

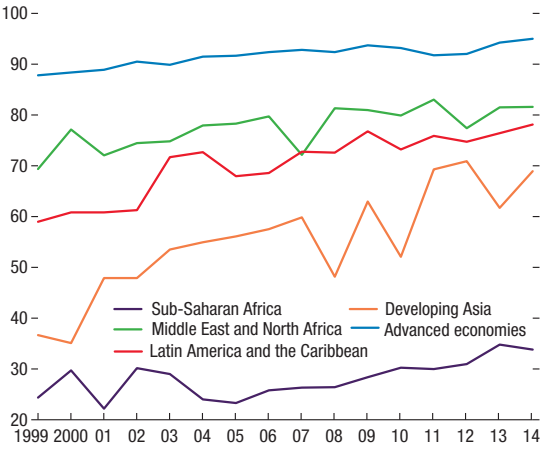
In addition to mounting population pressures, the region is becoming increasingly urban. Urbanization in sub-Saharan Africa has been rapid. Urban population has grown by about 4.4 percent annually over the last 50 years and is reaching close to 400 million at the end of 2015. The average urbanization rate now exceeds 40 percent. Such rapid pace of urbanization reflects pull factors including structural transformation, human capital accumulation, trade shocks, and resource-rent revenues accruing to cities, as well as push factors including civil wars, poor rural infrastructure, and climate change. Unlike the experience of East Asian countries, the pace of increase in income per capita has not kept up with the pace of urbanization in sub-Saharan Africa. Countries are becoming more urban, but not simultaneously richer (Figure 20).

**Figure 18. Primary Net Enrollment Rate**
*(Percent of population that are in primary school age group)*




Source: World Bank, World Development Indicators.

**Figure 19. Secondary Net Enrollment Rate**
*(Percent of population that are in secondary school age group)*

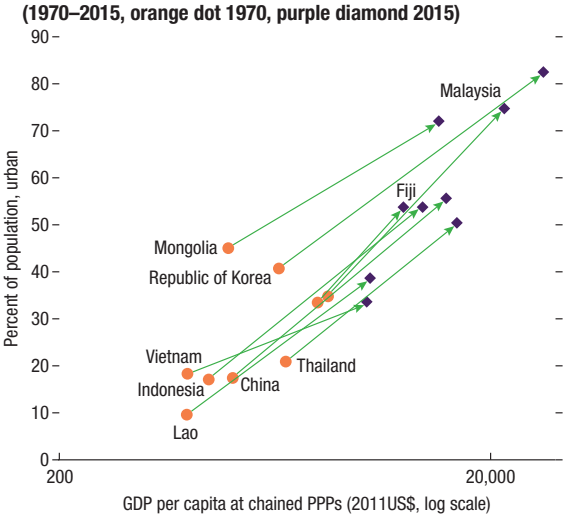



Source: World Bank, World Development Indicators.

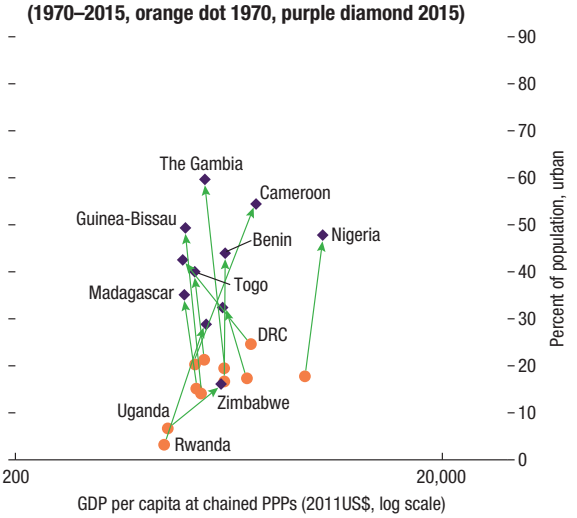
The slower pace of income per capita growth relative to urbanization reflects in part the lack of agglomeration economies in urban areas. Sub-Saharan African cities are, on average, congested but not economically dense, reflecting inadequate residential housing structures close to city centers; highly fragmented with lack of reliable transportation, limiting effective clearing of labor

**Figure 20. Urbanization and GDP per Capita**

**1. East Asia and Pacific**
**(1970–2015, orange dot 1970, purple diamond 2015)**



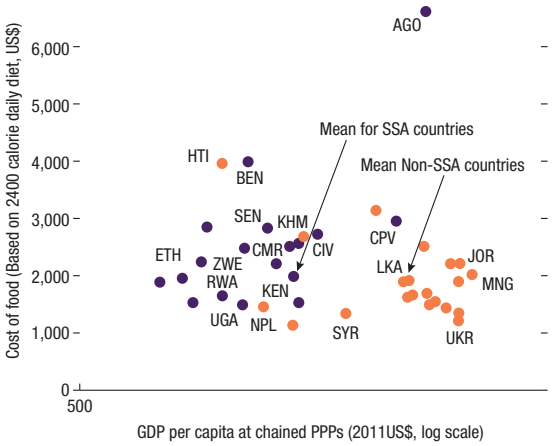

**2. Sub-Saharan Africa**
**(1970–2015, orange dot 1970, purple diamond 2015)**




Sources: Penn World Tables v9.0; and UN World Urbanization Prospects 2014.
Note: DRC = Democratic Republic of Congo; PPP = purchasing power parity.

and product markets; and costly in terms of food and transportation, relative to income levels, putting pressure on formal employment wages (Lall, Henderson, and Venables 2017).

**Figure 21. Food Prices in Sub-Saharan Africa and Middle-Income Countries**
*(Food prices, May 2018, Daily 2400 calories, Western diet; purple dot SSA countries, orange dot non-SSA countries)*




Sources: Numbeo database; and Penn World Tables v9.0.
Note: Data labels in the figure use International Organization for Standardization (ISO) country codes. PPP = purchasing power parity; SSA = sub-Saharan Africa.

In contrast to "production cities" that are more dependent on manufacturing in industrialized and emerging market countries, urbanization in sub-Saharan Africa appears to be concentrated in "consumption cities," with employment mostly in informal, nontradable services (Gollin, Jedwab, and Vollrath 2016). The setup is supported by nondiversified, resource-intensive exports, which, distributed mainly in cities, raise food prices and put upward pressure on formal sector wages, relative to their income level (Figure 21).

## Climate Change

Global temperatures have increased, including across most of sub-Saharan Africa. There is a strong consensus among scientists that the pace of increase in global temperatures over the last 30 to 40 years is unprecedented compared to the historical trend over the past 20,000 years. In Africa, temperatures have increased by about 0.5°C over the last 50 to 100 years. This compares with a global average increase of about 1°C. These temperature increases have been accompanied by a change in rainfall patterns, with a decrease across the Sahel and an increase in east central Africa (Intergovernmental Panel on Climate Change 2014).

Climate change is expected to lead to a continued rise in temperatures in sub-Saharan Africa, with some uncertainty around the magnitude of the increase. Projections from the Intergovernmental Panel on Climate Change range from a low scenario in which temperatures rise by 0.2°C per decade to a high scenario in which temperatures rise by 0.5°C per decade. There are differences across the continent with parts of the Sahara and central southern

Africa expected to experience more warming. In addition, more extreme weather events are predicted such as floods and droughts.

The impact of climate change on the environment will depend upon complex systems and feedback mechanisms, which are difficult to project accurately. Assessments suggest that the impact of temperature and rainfall changes is wide-ranging, with significant consequences for natural resources and biodiversity, human well-being, and the economy. For Africa, the Intergovernmental Panel on Climate Change identifies the following key areas:

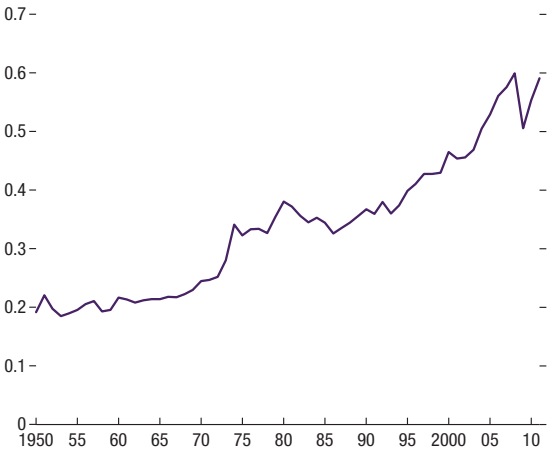
- The main impact of climate change is expected to be a reduction in the availability of water resources on average. This would create a need for more coordination in water management, particularly for internationally shared basins.
- Food insecurity is expected to increase in part due to more extreme weather, potential declines in soil moisture, and water stress affecting agriculture and fisheries.
- Climate change will become an additional force in changing land use through pressures to migrate away from uninhabitable areas. There is also expected to be a loss of biodiversity from temperature changes.
- For populations with inadequate health care, the risk of vector- and water-borne diseases will rise in part due to the increased risk of flooding.
- Increases in sea levels will put coastal areas at risk, exposing transportation networks and buildings to flooding and other extreme weather events.

Economic growth in the region is expected to be negatively impacted by climate change. Based on the historical relationship between temperature fluctuations, precipitations, and economic growth, IMF (2017) estimates that the median low-income country experiencing a 1°C increase in temperature would suffer a fall in per capita GDP growth of 1.2 percentage points in the same year.[1] Importantly, the impact is long-lasting, reducing per capita output by 1.5 percentage points seven years after the shock for the median low-income country. The main channels of impact are through lower output in agriculture and manufacturing, whereas there is little impact on the services sector. While historical-based evidence offers a point of reference, the impact of climate change and the higher than expected incidence of extreme weather may result in a larger adverse impact on countries.

Climate change is also expected to accelerate urbanization in sub-Saharan Africa. Reduced moisture availability encourages migration from rural areas to nearby cities. It is estimated that the urbanization rate increases by 0.45 percent with a reduction in rainfall of 1 percent (Barrios, Bertinelli, and Strobl 2006). Similarly, Henderson, Storeygard, and Deichmann (2017) find

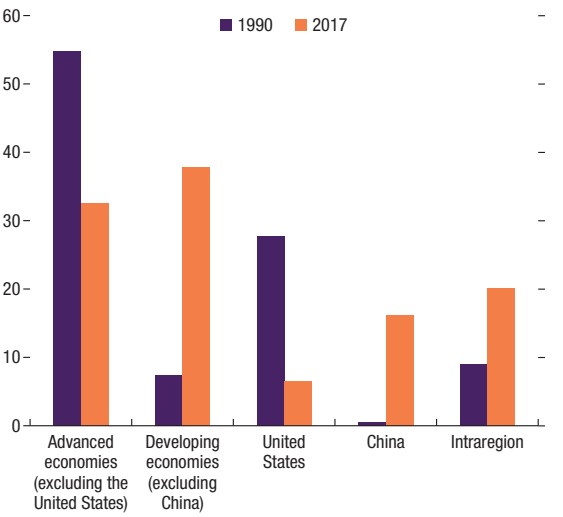
[1]This is the result for a country with a tropical climate with a temperature of 25°C on average.

**Figure 22. Global Trade Flows**
*(World exports and imports as a share of world GDP, percent)*




Source: Penn World Table 8.1.

**Figure 23. Sub-Saharan African Exports of Goods to Different Destinations, 1990 versus 2017**
*(Percent of exports to the world)*




Source: Direction of Trade Statistics.

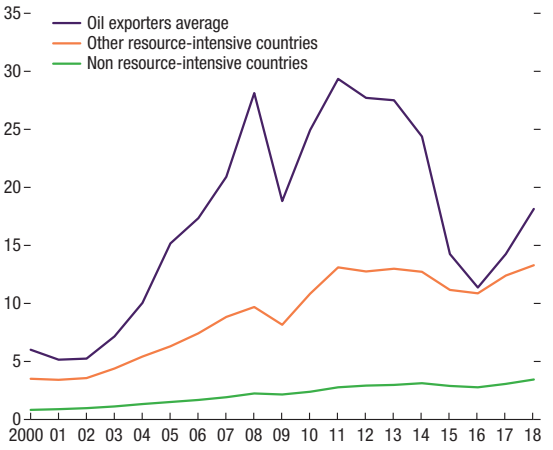
that drier conditions accelerate migration to industrialized cities. Formalization of land markets, clarifying property rights, effective urban planning, making coordinated infrastructure investments, and improving urban transport could help mitigate risks associated with rapid urbanization fostered by demographic and climate changes.

## Global Economic Integration

The global economy has experienced a sustained and rapid phase of integration since the mid-20th century, which fostered growth for many countries. Global economic integration has progressed through increased cross-border flows of goods, services, capital, labor, and ideas (Figure 22). This growth has been fueled by technological advances that have made flows easier by lowering costs and increasing accessibility to markets, and policy reforms to open up markets. A virtuous cycle of trade, economic growth, and accelerated development ensued with some spectacular examples in Asia.

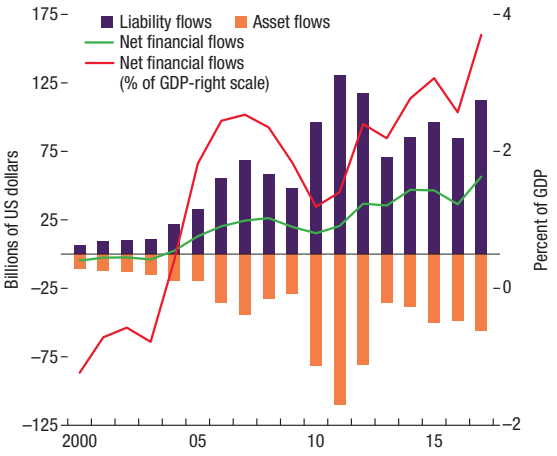
Sub-Saharan Africa's integration with the global economy has picked up since the 1990s. Trade openness accelerated rapidly in the mid-1990s at a time when export destinations expanded from advanced economies to rapidly growing emerging markets, particularly China, which is now Africa's largest trading partner (Figure 23). Much of these exports are dominated by commodities, particularly oil (Figure 24). Financial integration with the rest of

**Figure 24. Sub-Saharan Africa: Exports, 2000–18**
*(Billions of US$)*




Source: IMF, World Economic Outlook database.

**Figure 25. Sub-Saharan Africa: Financial Flows**
*(Billions of US dollars and percent of GDP)*




Source: IMF staff calculations.

the world has increased rapidly, nonofficial net private capital flows increased from $4 billion in the 1980s and 1990s to close to $60 billion in 2017 (Figure 25). Integration in global value chains is also progressing, although from relatively low starting points. The sectors that have benefited from closer integration include manufacturing, agriculture and agro-business, and to a lesser extent, transport, tourism, and textiles.

Still, sub-Saharan Africa remains the region that is the least integrated with the rest of the world and within itself. Measuring integration in global trade by the size of exports, the number of trade partners, and the relative weight of these trade partners in global trade, sub-Saharan Africa's integration is about half that of other emerging and developing countries (IMF 2015b). In a similar way, while intraregional trade has increased over time, rising from 6 percent of total exports in 1980 to 20 percent of GDP in 2016, it remains very low (Arizala and others 2018). Physical distances and socioeconomic differences—including language and colonial history—constitute barriers to trade in sub-Saharan Africa that seem more important than in other regions.

There are growing concerns that further global economic integration is under threat, which could be most damaging for countries that have yet to benefit fully from global trade and investment flows. Most recently, the implementation of higher tariffs between the United States and China and the United Kingdom leaving the European Union have fueled concerns that protectionist pressures could slow or even reverse the integration seen to date. This may reduce the scope for less integrated economies to benefit from the growth opportunities of trade and investment from the rest of the world.

CHAPTER

# 4 Scenario Analysis to Explore the Future of Work in Sub-Saharan Africa

*We use scenario analysis to evaluate how technology, demographics and urbanization, climate change, and global economic integration could interact with each other and shape the future of work in sub-Saharan Africa.*

- *Sub-Saharan Africa has little or no control on how these four key trends will play out, but policy has an important role in shaping how the region can respond.*
- *With the right infrastructure and skill-sets, technology offers opportunities to leapfrogging development and mitigating adverse effects, including from climate change.*
- *A flexible education holds the key to empowering people to work with and benefit from new technology and not be displaced.*

## Introduction

Scenario analysis is used in situations with large and multifaceted uncertainty. The approach can illustrate alternative outcomes rather than one specific baseline projection as a way of dealing with the underlying uncertainties. It is particularly useful then in cases of so-called Knightian uncertainty, when events are so unpredictable that it is impossible to attach quantifiable risk probabilities to different outcomes. Scenario analysis is a tool that helps identify drivers of change and envisage the future differently than the past. The emphasis is on creating plausible, relevant, and challenging scenarios to help decision-making under uncertainty (Ramírez and Wilkinson 2016).[1] Scenario

[1]The specific approach used to develop the scenarios in this paper is based on the so-called inductive method. This means that rather than creating a generalized framework or model from which the scenarios are deduced, the first step is to consider all the data and ideas available about the future and generate insights through a bottom-up process. This helps to develop qualitative scenarios in the form of a narrative that brings together the key ideas, trends, and interplay of outcomes, which are difficult to capture quantitatively.

analysis is used by organizations in both the public and private sectors as a strategic planning tool to make decisions by taking into account the inherent uncertainty of the future rather than basing decisions on just one trajectory of future events (Behar, Kostial, and Ramirez 2018).

Scenarios are helpful when considered as a set, rather than as individual projections of the future. The real value of identifying a set of plausible scenarios is realized by using them to compare, contrast, and assess whether they capture the broad range of most likely outcomes. This creates a framework through which different policies can be generated and tested in alternative possible worlds.

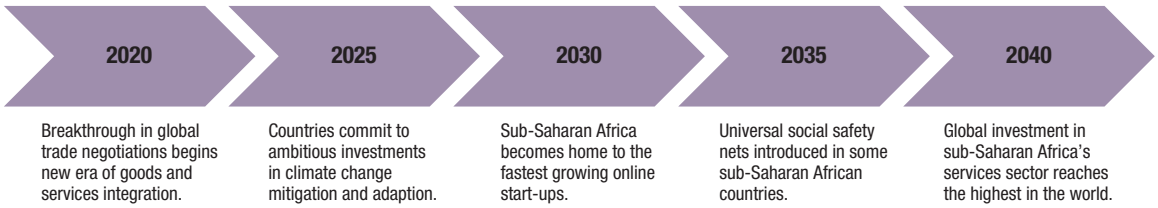
We consider three scenarios for the future of work in sub-Saharan Africa: "Africa Arisen" (Figure 26), "Africa for Africa" (Figure 27), and "Africa Adrift" (Figure 28). In these scenarios, technology, global economic integration, climate change, and demographics evolve and interact in different ways, leading to different outcomes in availability and quality of jobs (Figure 29). In particular:

- Technology increases productivity and empowers workers in Africa Arisen; allows for leapfrogging with limited negative impact on jobs thanks to lower wages in Africa for Africa; and substitutes for workers, wiping out jobs across the region in Africa Adrift.
- Global economic integration deepens in Africa Arisen, is reversed in Africa for Africa—with some offset from strengthened regional integration—and gives way to volatility and trade wars in Africa Adrift.
- Climate change is largely mitigated by technological advances in Africa Arisen, has a negative impact on growth in Africa for Africa, and is devastating in Africa Adrift leading to mass migration and obsolete infrastructure.

## Scenario: Africa Arisen

*This is a world where technology has increased productivity, the global system has remained on a path of integration, and innovations in agriculture have offset the effects of climate change. The opportunities of technological change and global integration have been successfully leveraged by sub-Saharan Africa, creating an emerging vibrant middle class. However, in a gig economy, job volatility is the norm.*

**Figure 26. Timeline: Africa Arisen**




Source: IMF staff.

## Picture This

A rural smallholder farmer holds a simple mobile phone in her hands. It is a worn, chunky device, with a slight crack in the screen. It has been vibrating every few minutes with updates of the latest news from the nearby town. The peak harvest period for sorghum is in full swing and it has been a bumper season. It is an exciting time as the country is soon to become self-sufficient in their staple grain. It had happened slowly at first: new seeds were introduced, text message updates provided irrigation tips, and access to credit helped finance additional inputs. More and more of the families in the village received remittances from relatives who had moved to the city and, unlike the last twenty years, were working in better paying jobs. The transition from agricultural life to urban living was as much due to forces outside of Africa as it was the ingenuity of a new generation that had grown up in a world bursting with creativity. Her daughter is living in the nearby town, maintaining the information technology infrastructure of an African service company headquartered elsewhere on the continent.

## Technology as a Complement to Labor

Technology became a complement to labor in sub-Saharan Africa. Investment in new technologies helped improve the productivity of low-skilled workers and create a small but growing manufacturing base integrated with global value chains. In the agricultural sector, it raised yields and overall output. The increased mechanization and use of big data and analysis to inform decision-making resulted in a reduced demand for labor in rural areas and populations shifting toward cities in search of work. In the services sector, greater digital connectivity within national borders, regionally, and globally spurred employment.

### Deepening Global Integration

The growing trade frictions between major players in the global economy in the late 2010s soon led to the emergence of global trade talks. While contentious, there was a joint agreement on the need to preserve and deepen economic integration through further cooperation. It provided a means for regional trade agreements to form the basis of global agreements and reinvigorated trade in goods while services trade accelerated faster. The development of a stable playing field for services trade helped push forward a new phase of global economic integration. This was supported by financial flows, particularly foreign direct investment, which provided an important source of financing from advanced economies to the rest of the world.

### Climate Change Adaption

While climate change led to new challenges, it spurred global cooperation and investment in identifying mitigation and adaption strategies. For instance, with funding from international organizations, researchers partnered with the private sector on the ground to develop seeds that could resist drier weather conditions. Within sub-Saharan Africa, there was still a movement of people away from some areas that became less habitable, creating further pressures on urban centers.

### A Service-led Economy

The movement of populations to urban centers helped create thriving businesses, mostly in the services sector. A digitally connected youth benefited from being close to innovation hubs where they developed, adopted, and adapted new technologies. The integration into global value chains and a supportive global trading environment enabled these businesses to trade in a global market. This integration created more synchronization with global brands and fashions cycles.

### A Vibrant but Volatile World of Work

Employment is dominated by those working in small-scale businesses in the services sector serving a global market or in multinational companies integrated into global value chains. For example, design firms in the region were able to easily connect with global brands to reach a global audience, if only for one season. Dominant occupations include professional services, tech entrepreneurs, and low-skilled services. While countries are growing rapidly, workers face frequent job transitions driven by changes in global trends.

### Despite Investment, Urbanization Remains a Challenge

The pressure of populations moving to urban cities created a push to invest in transportation networks and low-cost housing to help alleviate congestion. The use of more user fees provided revenue to maintain and continue to invest in urban areas. Nonetheless, cities remain bottlenecks for growth due to congestion and limited availability of efficient, low-cost housing.

### A Supportive Government

Governments focused their investment plans on both physical and digital infrastructure, which facilitated global and regional trade, although finding adequate financing remained a challenge. The growing tax base together with more effective use of new technologies helped somewhat to increase tax revenues and improve service delivery. In light of a more volatile labor market, governments support transitions by slowly expanding social safety nets as the revenue base grew. This helped to reduce informality as incentives to contribute to and benefit from a national system of health, employment, and pension schemes grew.

### Skills for Success

Innovation, creativity, and constant refreshing of skills are rewarded well in a globally competitive system. Digital literacy and access to the digital world is a basic necessity for all. Without them, prospects for employment are limited to low-pay jobs or insecure sectors.

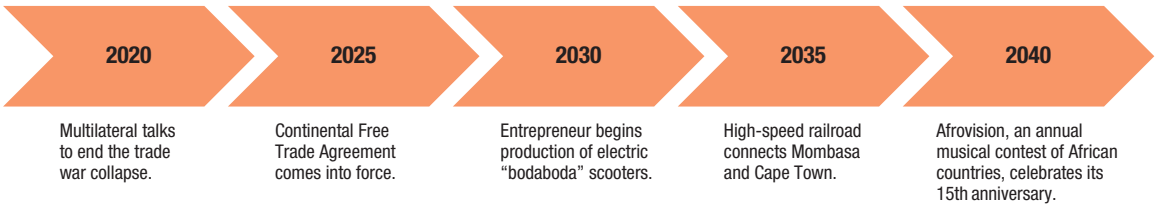
## Scenario: Africa for Africa

*This is a world where inward-looking policies have been dominant in advanced economies, in part fueled by technology displacing workers. Sub-Saharan Africa has had to chart its own course in a volatile global economic and political environment. Regional integration has spurred growth, partly offsetting the effects of reduced trade with the rest of the world. However, with limited tax revenue, governments struggle to keep up with the continent's growing needs.*

### Picture This

Her heart sank. Kali kept staring at the screen and couldn't locate #RD-037. She was pretty sure that it had been sufficiently charged last night. Perhaps a hawk got it? Now her dad must dispatch somebody to try to find the drone

**Figure 27. Timeline: Africa for Africa**




Source: IMF staff.

which, hopefully, can still be fixed. After school, Kali has been helping her father, who has a small business providing services to local farmers. She enjoyed her job of managing the drones that surveyed the fields and collected data on their conditions. Her dad created and managed software that would analyze the data and generate useful information and advice for farmers. Kali dreamed, after completing her education, to start her own business that would combine the knowledge and expertise of established entrepreneurs and professionals to help the youth across the African continent in starting and managing their own businesses.

### Leapfrogging into the 21st Century on the Wave of Technological Revolution

The region leapfrogged, harnessing the power of simple and cheap new technologies. Information technologies provided greater and more affordable access to open source technologies and know-how that could be adopted for specific production and service needs, especially in sub-Saharan Africa. Distributed ledger technology improved public sector efficiency and facilitated financial sector development. An active social media put a spotlight on government accountability. Digital communication technologies allowed open and fast exchange of ideas and information between people across the continent and opened new opportunities for education and knowledge sharing.

### The Rise of Regional Integration as Globalization Hit Roadblocks

Technological innovations caused tectonic shifts in the economic structure and threatened job security across a broad range of skills in advanced economies. Economic powers turned to inward-looking policies in response to the problem. Amid continued trade wars between major economies, the multilateral, rules-based trade order was undermined. Global trade flows slowed and have been limited mostly to bilateral and regional arrangements. The reversal of globalization was accompanied by a slowdown in foreign invest-

ments and transfer of advanced technologies requiring sizable capital investments to emerging market and developing economies. Official development assistance also declined. African economies, which used to rely on exports to major economies, took a hit. In response, African leaders pushed forward with regional integration by implementing and deepening the Continental Free Trade Agreement. To support trade and economic links, countries put emphasis on developing regional physical and digital infrastructure raising the level of public debt. Through a public-private partnership, a high-speed railroad connecting Mombasa and Cape Town was built, allowing cheap transport for locally produced goods along the corridor.

### Facing the Impact of Climate Change

Climate change exacerbated the difficult weather conditions that most African nations already faced. The frequency and severity of extreme weather events, such as droughts and floods, affected agriculture—the main source of livelihood for the rural population. Use of technology helped mitigate some of the impact. Smart water management systems allowed more efficient use of scarce water resources. New technologies helped improve weather forecasting, and digital connectivity allowed targeted interventions to protect crops and livestock. Access to and exchange of knowledge on better farming and more efficient use of auxiliary services helped improve yields and reduce costs. Nevertheless, it is an uphill struggle without a concerted global effort to curb climate change.

### Modern Technologies Reshaped Agriculture and Services, but Industry-led Growth has Been Limited

Agriculture benefited from the adoption of innovative technologies to improve productivity from a low base. But this led to excess supply of labor in rural areas, which forced even more people to seek jobs in the cities. Economic activity became concentrated around major economic centers, putting significant strains on their infrastructure and resources. Industry benefited from low wages and adoption of technologies that allowed small-scale, locally based manufacturing, including based on 3D printing-like technologies. However, there were limitations in industrial growth and productivity given the lack of access to sufficient financing to acquire more advanced technologies. Basic regional value chains emerged, benefiting from regional integration and economies of scale. With limited capacity to absorb the excess labor force in agriculture and industry, service sectors became the primary employer. Due to low entry costs, the competition in services intensified as well as the pace of domestic innovations and adoption of modern technologies. Traditional services, like tourism, transport, and trade, have been reshaped by innova-

tions, whereas new types of services proliferated: information and communication, retirement communities for expatriates from regions with shrinking populations, and entertainment. A high demand for fast and efficient transportation services in the cities have led to domestic mass production of electric scooters that are being charged from solar-powered microgrids.

### Resourcefulness of People Translated into Growing Entrepreneurship

Regional economic integration and improved connectivity fostered a competitive business environment. Opportunities provided by new technologies fueled entrepreneurship and led to proliferation of small-scale enterprises targeting local and regional markets. The most successful ones exploited the benefits of grassroots innovation and adopted technology to local needs. Despite advances in financial innovations, the development of the financial sector was slow, and domestic savings were insufficient. Businesses continued to rely on self-financing and crowdfunding, and efforts to expand were constrained by a lack of a large-scale financing. Open-source education provided opportunities for self-education but required a specific initial set of skills.

### The World of Work Adapts to Changing Conditions, but Challenges Remain

The economy is characterized by a vibrant private sector, which is dominated by small-scale businesses and low-productivity jobs. Despite a high degree of informality, information technologies mitigate the inefficiencies of an informal economy. However, low job security keeps workers highly vulnerable to economic downturns and unemployment is high. In the absence of a strong social safety net, people must rely on themselves to weather the storms. As a result, poverty remains widespread, especially in rural areas.

## Scenario: Africa Adrift

*This is a world where rapid automation has resulted in reshoring of manufacturing to advanced economies, and climate change has hit harder and faster than expected. In sub-Saharan Africa, development policies have been thwarted by the impact of these global developments, leaving most economies stagnant and indebted. Informal jobs in subsistence agriculture and low productivity services remain dominant.*

**Figure 28. Timeline: African Adrift**


Source: IMF staff.

## Picture This

It was another long night. Adamu was staring at the security screens projected by the surveillance drones, hovering around the gated community where he works. His shift started at 8:00 pm, and he will work until 8:00 am. After his shift ends, he will walk home some 10 kilometers to the outskirt of the city's mega slum. He lives there with his wife Ingabire, who takes care of the couple's children. Both his parents and in-laws had moved from rural towns to the city to escape poverty caused by frequent failed harvests in the early 2020s. Lack of affordable housing forced them to settle in slums. Despite his low wage and long hours, and not being able to afford transportation to home, Adamu feels lucky to have been employed full-time for the past seven months. Their older children are not so lucky. He fears for them as lack of full-time jobs means they find the time to join the increasingly frequent mass protests demanding jobs, which sometimes turn violent. However, he has not lost hope for the future and wishes that their younger children can get basic education, following the completion of the new local school which offers teacher-guided online courses. The family believes that this will enable the children to find better-paying jobs abroad, allowing them to help the rest of the family financially.

## Technology Replaces Labor

Technology has become a substitute for labor globally. Rapid technological change has led to reshoring of manufacturing to advanced economies, rendering worthless many infrastructure projects designed to make sub-Saharan Africa the world's next manufacturing hub. In particular, the deployment of robots and artificial intelligence in Asia, Europe, and North America changed the nature of global trade. Even with a shrinking labor force due to an aging population, many advanced and emerging market economies became increasingly self-sufficient as they battled with unemployment and declining wages in their own countries. The impact on sub-Saharan Africa was even

more severe. Government policies to attract jobs through tax exemptions and public infrastructure investments were undermined. This left countries with stranded assets, high debt, low domestic revenues, and no fiscal space. With development partners increasingly focused on their own problems, sub-Saharan Africa saw a painful decline in external financing.

## Global (Dis)Integration

International cooperation is pushed aside by nations competing in a zero-sum game, constantly teetering on the edge of conflict. Trade wars and intellectual property disputes are the order of the day, while the global trading system collapses. Trade within the region also dwindles. Censorship and state control of the media become prevalent, including in sub-Saharan Africa, providing little room for demands for more transparency and accountability by the masses. Frequent economic crises and continued dependence on primary commodities create an "each for their own" mentality. Elites strengthen their hold on key institutions, and tight class ceilings sometimes feel impenetrable.

## Serious Hit from Declining Moisture Availability

In addition, climate change hit sub-Saharan Africa harder and faster than anticipated. A number of major cities literally ran out of water in the late-2020s. Declining humidity rendered cocoa cultivation unfeasible by 2030. Farmers were forced to switch from cash to subsistence crops. As water reservoirs depleted, rapid migration put pressures on cities, further straining poor infrastructure. With limited financing, few governments had sufficient resources to adequately invest in climate change mitigation. Some relatively new infrastructure projects collapsed as design failed to take into account the changing climate conditions. Many living in extreme poverty wanted to migrate to Europe and beyond, but these countries did not have enough job opportunities to warrant letting anybody in.

## A World of Work Characterized by Informality

Informality continues to be the norm. The affluent minority go abroad for their education or are enrolled in international online universities. They maintain their control over commodity monopolies, finding good jobs in large mining companies or the civil service. Most people are involved in providing low-pay services for these elites, earning wages that are not enough to lift households out of poverty. The lack of formal jobs in cities is proving a fertile ground for crime and terrorism. Local or regional conflicts spring up

over access to commodities and water. Private security becomes the largest employer in sub-Saharan Africa.

## Rapid Urbanization and Poverty Trap

In rural areas, weather dependency and subsistence farming coupled with poor access to water, electricity, and roads contribute to a rural poverty trap. In the cities, the lack of affordable housing and transportation and perennial high food prices contribute to an urban poverty trap. Mass migration to cities during bouts of declining moisture lead to further food price increases, inhibiting formal sector jobs in the cities and exacerbating the urban poverty trap. Only those with access to informal networks or remittances can buffer these trends.

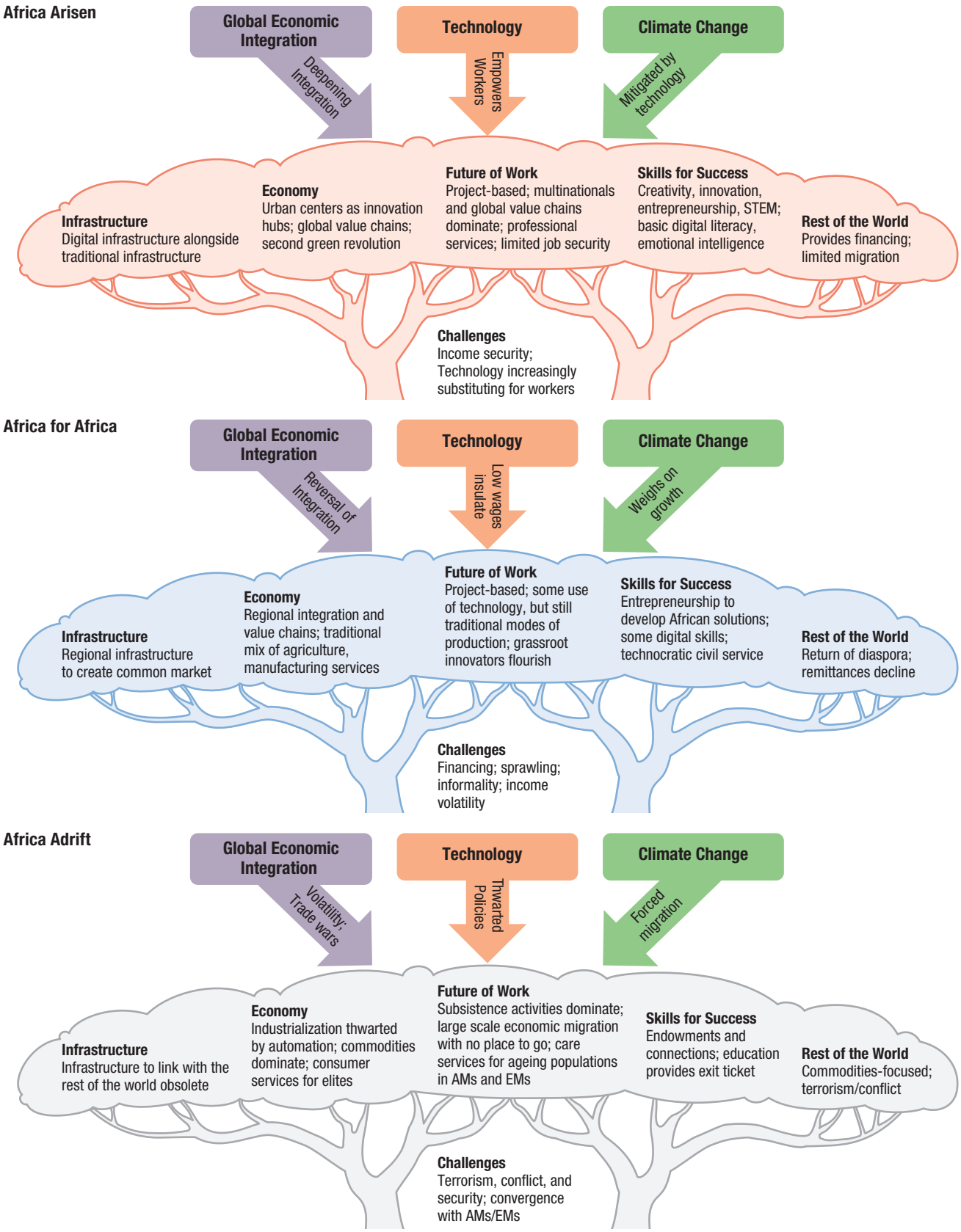
## Ineffective Public Education

Education quality in the region declined. Government efforts to reform the education system failed to introduce enough flexibility. As a result, incorporating new skills demanded by the labor market took a long time. Harnessing technology to improve human capital through global online courses and accreditation remained the only means to break out of poverty, but not everyone can afford it.

## Slow Change Is Coming

Social media remains the critical tool to organize and eventually overcome the power of entrenched interests. Faced with mass demonstrations, governments start to become more accountable, improving social service delivery, albeit from a low basis.

**Figure 29. Future of Work Scenarios: Summary**



CHAPTER

# 5 Policy Recommendations

*We find that to navigate in this uncertain world, governments need to:*

- *Get connected.*
- *Develop flexible education systems.*
- *Urbanize smartly.*
- *Boost trade integration on the continent.*
- *Expand social safety nets.*

Whereas large uncertainties characterize the major trends determining what the future of work will look like in sub-Saharan Africa, decisive policy actions can help harness the opportunities. Looking across the scenarios and our economic model, there are contrasting developments depending on how key uncertainties could play out. Still, some common themes emerge that point toward key policy areas. The overarching implication for policymakers is that there is a premium on being flexible and ready to embrace the emerging opportunities of the Fourth Industrial Revolution, which is profoundly altering the economic structures of countries. That also means being open to revisiting and adapting the traditional growth strategies. The policy actions proposed in this chapter are costly, and so they require concerted efforts of governments, philanthropists, the private sector, and the international community.

## Get Connected

Connectivity goes beyond the need for traditional physical infrastructure of roads, railways, and ports, which is currently the focus of most country investment plans. Experience within the region demonstrates that if there is adequate digital infrastructure and a supportive business environment, new

forms of business spring up and increase the efficiency of existing sectors, particularly services that constitute a growing share of economies. Facilitating a boost in agricultural productivity, not least in the face of climate change, is likely to rely heavily on digital infrastructure and broader investment in climate mitigation strategies. Given limited fiscal space, investments in the capability to store and exchange data through an accessible system will require partnership between the public and private sector.

Developing digital infrastructure may not be too costly compared to the needs for traditional infrastructure. The total annual investment needs for building and maintaining adequate infrastructure in the next 20 years for sub-Saharan Africa is estimated at $130 to 170 billion (African Development Bank Group 2018). The bulk of investments are needed for traditional physical infrastructure with transportation, electrification, and water and sanitation accounting for 96 percent of the total. The remaining investment needs in digital communication are estimated at $4 to 7 billion per year. While digital infrastructure may not be too costly, it is a necessary condition for the region to take advantage of the Fourth Industrial Revolution.

## Develop Flexible Education Systems

Whether technology becomes a substitute for or a complement to labor is not necessarily a force beyond our control. Turning the question around, we should ask: What skills will be complementary to technology? What skills are needed to develop and/or use technology? This puts a high premium on education to empower the youth to succeed in the changing world of work. Digital literacy, adaptability, and lifelong learning will likely be skills for success, and secondary education will become more important.

However, there is considerable uncertainty over what specific skills will be needed. As such, education systems will need to be flexible, while ensuring full enrollment and introducing technology in every classroom. Indeed, technology offers opportunities to radically change the way education is provided, possibly overcoming existing bottlenecks. For example, online courses can be centrally designed, ensuring that up-to-date curricula reach every classroom, using the latest teaching methodologies.

## Urbanize Smartly

Looking at the hotbeds of the Fourth Industrial Revolution, these are all situated in cities or urban centers. At present, too many sub-Saharan African cities have insufficient infrastructure and are oriented more toward local

consumer services. This compares with cities in faster-growing economies where urban centers are drivers of growth. Population pressures put an additional premium on having functioning cities.

To create an environment in which entrepreneurs can become drivers of technological adaptation and innovation, sub-Saharan Africa needs a strong focus on urban planning and development. Modern technologies could help to that end. Taking advantage of the internet of things, big data, and increased connectivity, governments can improve service delivery and strengthen governance, accountability, and social infrastructure. Many cities around the world already have online platforms for citizens to inform authorities about local problems and monitor their solution. Traditional policies such as formalizing land markets and clarifying property rights are still needed, and technology can help with their implementation.

## Boost Trade Integration on the Continent

Further regional trade integration would be a driver of development, not least if the global environment were to become less conducive. The recently agreed Continental Free Trade Agreement is a notable step in this direction and now requires regionwide implementation. Sub-Saharan Africa forms a sizable domestic market if countries move swiftly on trade facilitation and regional infrastructure. This market can provide scale for local firms and make the continent more attractive for foreign direct investment.

## Expand Social Safety Nets

Extrapolating current trends, frequent job transitions may be a key characteristic of a "gig style" world of work. This will be a change for advanced economies. However, many in sub-Saharan Africa, in particular in the subsistence and informal sector, are already living in such a world and struggle to manage the resulting income volatility. Family and social networks provide some backup, but a major challenge is to expand safety nets that offer some income security. Technology, such as biometric identification and financial technology, can help with targeting and administration, but revenue mobilization will be key to create the necessary fiscal space.

# Appendix

## Modeling Approach

In this appendix, we discuss the model used in Chapter 3 to explore the implications of the Fourth Industrial Revolution in sub-Saharan Africa.

Automation is receiving increasing attention in the economic literature. The early literature modeled automation as technological progress that favored either capital or labor.[1] A more recent literature (Acemoglu and Restrepo 2018) employs task-based models to highlight the substitutability between workers and machines by modeling automation as an expansion of the set of tasks that can be performed by machines. Berg, Buffie, and Zanna (2018) also recognize that automation may substitute directly for labor, and model technological change as an increase in robot productivity where robots are treated as a separate input in the production function. Focusing on advanced economies, they find that the more easily robots substitute for workers, the higher the increase in GDP per capita and the greater the decrease in labor share, leading to a richer economy, but with more inequality.

We extend the framework in Berg, Buffie, and Zanna (2018) by adding a low-income region to the model. Our model then features two regions, sub-Saharan Africa (SSA) and an advanced economy (ROW). The regions are allowed to trade with each other. The model is in discrete time and has no uncertainty.

Each region is populated by a household that lives forever and owns the three factors of production: labor ($\boldsymbol{L}$), capital ($\boldsymbol{K}$), and robots ($\boldsymbol{Z}$). As discussed in the main text, the factor "robots" is to be interpreted in a general sense and

[1]Sachs and Kotlikoff (2012) and Nordhaus (2015) model automation as a capital-augmenting shock, whereas Bessen (2017) models automation as labor-augmenting.

is meant to include the broad range of new technologies associated with the Fourth Industrial Revolution. The household also owns the firms operating the production technology and has a financial asset, which allows it to borrow or save against the other region.

Household preferences are given by the utility function:

$$\sum \beta^t \frac{C_{i,t}^{1-\frac{1}{\tau}}}{1-\frac{1}{\tau}}$$

where $C_{i,t}$ is consumption of household $i$ (with $i = SSA, ROW$) in period $t$, $\beta$ is the discount factor, and $\tau$ determines the intertemporal elasticity of substitution.

Household $i$ seeks to maximize utility given its budget constraint:

$$C_{i,t} + I^K_{i,t} + I^Z_{i,t} + \left(B^{-i}_{i,t+1} - B^i_{i,t+1}\right) = r^Z_t Z_{i,t} + r^K_t K_{i,t} + w_t L_{i,t} + \left(1 + r^B_t\right)\left(B^{-i}_{i,t} - B^i_{i,t}\right) + \pi_{i,t}$$

where $I^K_{i,t}$ and $I^Z_{i,t}$ are investment in capital and robots, and $\left(B^{-i}_{i,t+1} - B^i_{i,t+1}\right)$ is the net financial asset holding for country $i$. Return rates to capital, robots, and financial assets are given by $r^K_t$, $r^Z_t$, and $r^B_t$, respectively. No arbitrage across the three assets implies that the rates of net return (after accounting for depreciation) will be equalized across countries in equilibrium. Finally, $\pi_{i,t}$ represents the profits of firms operating the production technology in the country.

The rules of motion for accumulation of capital and robot stock are given by:

$$K_{t+1} = I^K_t + \left(1 - \delta^K\right) K_t$$

$$Z_{t+1} = I^Z_t + \left(1 - \delta^Z\right) Z_t$$

where $\delta^K$ and $\delta^Z$ are depreciation rates of capital and robot stock.

Production technology is the same in both countries. Labor and robots are combined using a CES technology to produce "tasks," and tasks are combined with capital using a Cobb-Douglas function to obtain the final output. The CES technology allows flexibility to model the relationship between labor and robots either as complements or substitutes through the elasticity of substitution $\sigma$ in the production function:

$$Y_{i,t} = A_i K_{i,t}^{\alpha} \left( e L_{i,t}^{\frac{\sigma-1}{\sigma}} + (1-e) \left( b_t Z_{i,t} \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{(1-\alpha)\sigma}{\sigma-1}}$$

Using this production function, the latest wave of technological innovation can be modeled as an increase in the productivity of robots, $b_t$. The level of total factor productivity ($A_i$) is the only parameter allowed to vary across regions. All remaining parameters are assumed to be the same.

The calibration strategy largely follows Berg, Buffie, and Zanna (2018). For each level of the elasticity of substitution σ, we calibrate the level of total factor productivity in SSA and the labor share in the production of tasks ($e$) to match relative GDP per capita between the two regions and the robot share in income in ROW.

Since total factor productivity is lower in SSA, wages will be lower in the initial steady state, and so will be adoption of robots. In the model, the robot ($Z$)-to-labor ($L$) ratio in each country is a function of the wage ($w$) in the country and the elasticity of substitution between robots and labor σ. In particular,

$$\frac{Z}{L} \propto w^{\sigma}$$

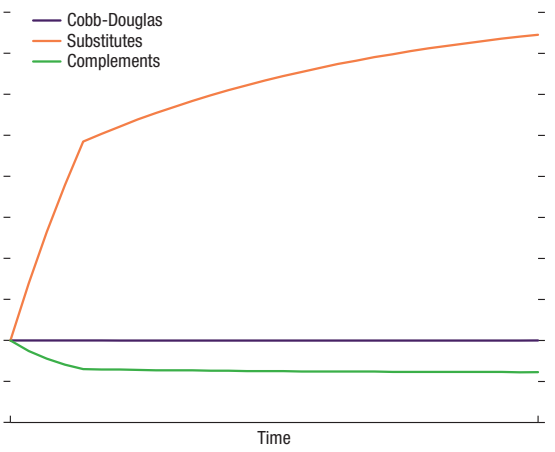
Thus, regions with higher wages have a higher robot-to-labor ratio. At the same time, a higher elasticity of substitution amplifies the effect of wages on the robot-to-labor ratio. For example, the robot-to-labor ratio in the model is 15 times higher in ROW compared to SSA when robots and labor are complements, compared to almost 200 times higher when robots substitute for labor.

In the same way, higher wages in ROW positions the region better to take advantage of an increase in the productivity of robots if robots substitute for workers. The greater the advantage, the higher the degree of substitutability. Thus, the results discussed in the main text for the long term.

Financial flows could amplify the response to technological changes during the transition (Figure 30). When robots and labor are substitutes, the higher demand for robots in ROW is so strong that resources are channeled out of SSA, leading to a fall of GDP per capita in the short term, in addition to the decline in wages and labor share.[2] SSA runs a current account surplus in the transition period, sending resources abroad and building foreign assets. In the

[2]The figures show transition dynamics for economies with three different levels of elasticity of substitution between labor and robots: σ = 2 for the case of substitutes, σ = 1 corresponds to a Cobb-Douglas production function, and σ = 0.8 for the case of complements.

**Figure 30. Sub-Saharan Africa's Net Foreign Assets**
*(Percent of initial global GDP)*




Source: IMF staff calculations.

final steady state, consumption in SSA is greater than output, the difference financed by interest income on the accumulated assets. But if robots and labor are complements, resources may flow into SSA and GDP per capita will grow even more rapidly in the short term than what would be implied by the direct effect of higher robot productivity in a one-country model.

Our model suggests that quantitatively overall productivity gains could have a greater impact on income than higher robot productivity in SSA. Figure 31 shows the annual growth rate implied by the model for SSA and ROW over a 20-year period, for the case where robots and labor are substitutes, and for three alternative assumptions for overall productivity growth.

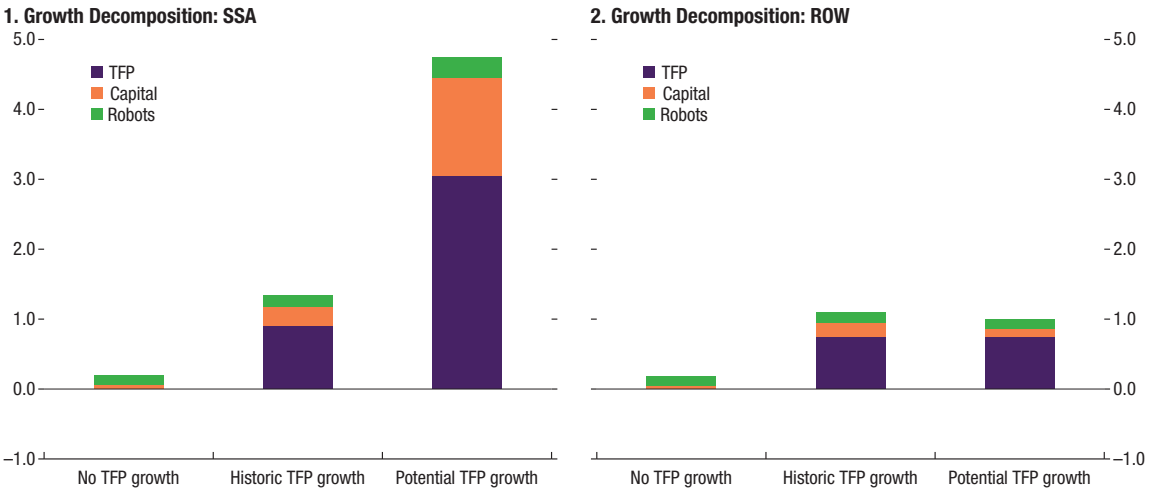
If there is no overall productivity growth in both regions, then a doubling of robot productivity leads to per capita GDP falling slightly in SSA but rising by about 0.5 percent per year in ROW, leading to further divergence.

If overall productivity grows at the historical rate seen between 2000 and 2014 in both regions, the gap in per capita GDP growth rates is much smaller, but SSA still does not converge. In this case, SSA is benefiting from higher overall productivity growth, but ROW has more to gain from the robot productivity increase.

If productivity growth in SSA can be pushed up to a level of 3 percent through trade liberalization and reduced misallocation and efficiency gains, then SSA can catch up, undoing the divergence effect from the robot productivity increase.[3] Importantly, even if automation holds back SSA's convergence to the frontier, the region can more than offset this by realizing economy-wide productivity gains. The results highlight the importance of policies to improve infrastructure, education, access to finance, and the business environment, which are all typically associated with increases in

[3]Ostry, Berg, and Kothari (2018) estimate that current account liberalization can increase total factor productivity growth by 0.25 contemporaneously if moving from the median to the 75th percentile in the index, with a persistence of 0.99. Given the low levels of trade integration in SSA, we assume that the gains from trade could be twice as high. IMF (2018a) estimates that closing efficiency gaps by reducing misallocation could raise average total factor productivity growth by 1.5 to 2 percentage points over the medium term.

**Figure 31. Projected Average Annual Growth Rate**




Source: IMF staff calculations.
Note: ROW = an advanced economy; SSA = sub-Saharan Africa; TFP = total factor productivity.

overall productivity. The Fourth Industrial Revolution could also help realize those gains.

While the modeling exercise provides insights and helps build intuition on the possible impact of technological change in SSA, several caveats must be taken into account when interpreting the results. First, as discussed before, how to model technological change is an open question as our understanding of the impact of new technologies is still nascent. Second, while we have a good sense of how to measure general productivity growth in the data, the extent to which robot productivity will increase is difficult to project, which makes it important to interpret the quantitative results from the model with caution. Third, our framework identifies labor either as a complement or as a substitute of robots, but in reality, some workers will be replaced by robots (for example, those performing the tasks that become automated), whereas others will complement them (for example, those workers designing and operating robots), and so the quantitative results will depend the relative supply of each type of labor. Fourth, the model is very abstract and therefore misses a number of features that could be of interest such as inequality within countries, unemployment, human capital, the role of government, capital market frictions, endogenous innovation, and political economy factors.

## Empirical Approach

Overall export vulnerability for a country is calculated as the export-share weighted sum of industries' automatability indices. For this we first calculate the automation vulnerability index of at the industry level as follows:

$$AV_i^j = \sum_o sh_{o,i} AV_o^j$$

where $AV_o^j$ is the automation vulnerability of occupation $o$. In our analysis, we use two types of occupation vulnerabilities, indexed by $j$: (1) based on Brynjolfsson, Mitchell, and Rock (2018); and (2) based on Frey and Osborne (2017). Using the US Industry-Occupation Matrix, we go from occupation automation vulnerability to industry automation vulnerability ($AV_i^j$)—in particular, $sh_{o,i}$ is the share of industry $i$ workers who are in occupation $o$ in the United States.

Next, using a concordance of products and industries, we go from data on countries' exports by products to exports by industry. For this, we compute $sh_{c,i}$, the share of countries exports coming from industry $i$. Finally, we combine countries export shares by industry ($sh_{c,i}$) with automation vulnerability of industry ($AV_i^j$) to get countries automation vulnerability index ($AV_c^j$). Following this approach, specifically calculated as shown below, we obtain two indices of a country's automation vulnerability, one each for Frey and Osborne (2017) and Brynjolfsson, Mitchell, and Rock (2018):

$$AV_c^j = \sum_i sh_{c,i} AV_i^j$$

## Contributions to Scenario Planning Approach

The scenarios were developed in a workshop that was facilitated by Shirin Elahi (Scenarios Architecture) and Alberto Behar (IMF). The scenarios benefited greatly from insights distilled from interviews conducted with a broad range of experts, including Julius Akinyemi (Massachusetts Institute of Technology), Stone Atwine (Eversend), Brahima Coulibaly (Brookings Institute), Stefan Dercon (University of Oxford), Shanta Devarajan (World Bank), Peter Draper (University of Adelaide), Andreas Freytag (University of Jena), Idayat Hassan (Centre for Democracy and Development), Remi Jedwab (George Washington University), Susan Lund (McKinsey Global Institute), Arthur Muliro (Society for International Development), Elizabeth Nyamayaro (UN Women), Thomas Schäfer (Volkswagen), and Catarina Tully (School of International Futures).

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