Production Planning & Control
The Management of Operations

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/tppc20

Harnessing AI for business development: a review of drivers and challenges in Africa

Joseph Amankwah-Amoah & Yingfa Lu

To cite this article: Joseph Amankwah-Amoah & Yingfa Lu (2024) Harnessing AI for business development: a review of drivers and challenges in Africa, Production Planning & Control, 35:13, 1551-1560, DOI: 10.1080/09537287.2022.2069049

To link to this article: https://doi.org/10.1080/09537287.2022.2069049

Published online: 28 Apr 2022.

PRODUCTION PLANNING & CONTROL
2024, VOL. 35, NO. 13, 1551–1560
https://doi.org/10.1080/09537287.2022.2069049

Taylor & Francis
Taylor & Francis Group

Harnessing AI for business development: a review of drivers and challenges in Africa

Joseph Amankwah-Amoah[a] and Yingfa Lu[b]

[a]Kent Business School, University of Kent, Kent, UK; [b]University of Nottingham, Ningbo, China

ABSTRACT

An accumulating body of research has demonstrated that artificial intelligence (AI) is an indistinguishable feature of the fourth industrial revolution. This study integrates the literature on AI and new technologies to examine the constraining and facilitating forces for developing and scaling-up AI-enabling technologies in Africa. This article proposes an integrated conceptual model to elucidate the range of external drivers encompassing global competitive drivers, and market and industry drivers. The internal drivers include the potential to enhance product development speed, improve quality, drive production cost down, and minimise errors and manual processes in organisations. The barriers identified include institutional dysfunction, poor infrastructure to support development of large-scale AI, lack of skilled AI experts, and lack of access to latest technologies in the regional population. The public policy implications for Africa as the potential next frontier market for AI development are discussed alongside contributions to theory.

ARTICLE HISTORY
Received 28 December 2021
Accepted 17 April 2022

KEYWORDS
Artificial intelligence; AI; Africa; business development; opportunities

1. Introduction

Since the beginning of the twenty-first century, access to the internet and new digital technologies has become increasingly a cornerstone in creating conditions for gender-inclusive education, poverty alleviation, and firm-level innovation (Asongu et al. 2021). Artificial intelligence (AI) is now an indistinguishable feature of today's global economy and the fourth industrial revolution (i.e. Industry 4.0) (Frank, Dalenogare, and Ayala 2019; World Bank 2021a, 2021b; Schmidt et al. 2021). In parallel, there is a global race underway as AI is weeding out many firms' conventional sources of market advantage and redrawing the competitive boundaries of industries, and in so doing rendering vital resources and expertise obsolete (Fountaine, McCarthy, and Saleh 2021; Schmidt et al. 2021). Buttressed by big data technological advancements and breakthroughs in computing power (such as natural language processing, computer vision, and voice recognition), AI has gathered momentum across the globe, shifting the basis for market competition and firm-customer engagement (Wang, Teo, and Janssen 2021; Haenlein and Kaplan 2019). For many firms, their competitive weapons are not only limited to human and financial resources (Wright, Dunford, and Snell 2001; Wright, McMahan, and McWilliams 1994) but also ability to leverage AI. Indeed, AI is reshaping 'the rules of commerce' and transforming nation economies (Webb 2021).

According to PWC (2019), by 2030 AI is expected to contribute around $15.7 trillion to the global economy, with $6.6 trillion to be accrued from increased productivity and $9.1 trillion coming from consumption side-effects associated with AI. Thus, there are ample opportunities available for nations to reform old and new industries such as manufacturing, farming, automotive, electronics, and pharmaceuticals to capture the positive effects. Despite the recent trend towards global adoption of AI and the great opportunities offered, Africa appears to lag behind with the underlying drivers and constraints remaining unclear. Across the globe, the COVID-19 pandemic has resulted in over 419,147,645 cases and 5,873,066 fatalities (Worldometers 2022) which has hampered countries' healthcare systems and economic development (Amankwah-Amoah 2020a, 2020b). This, in tandem with the fact that Africa's population is set to grow from 1.340 billion in 2021 to 2.489 billion by 2050, exemplifies the need to not only harness new technologies for job creation but also expand technology capabilities and know-how for development (Worldometers 2021). For many nations, AI can propel new types of economic development and business-development activities that lead to job creation. As demonstrated by Travaly and Muvunyi (2020, nd), 'AI for Africa presents opportunities to put the continent at the forefront of the 4th Industrial Revolution'.

Although scholars have demonstrated that businesses are making waves by leveraging AI across their functional activities (Frank, Dalenogare, and Ayala 2019), the current literature lacks a deeper understanding of drivers and challenges in leveraging AI-enabled technologies in Africa. The objective of this study, therefore, is to examine the drivers and constraints in the development and scaling-up of AI-enabled technologies in Africa. This is a pivotal issue because charting the pathways for

CONTACT Joseph Amankwah-Amoah joeaamoah@gmail.com, J.Amankwah-Amoah@kent.ac.u Kent Business School, University of Kent, Kent, UK

ushering greater adoption of AI-enabled technologies has the potential to lay the groundwork for greater industrialisation, commercialisation, and development in Africa.

This study yields a number of vital contributions to the literature from both the approaches adopted and the questions examined. First, the study integrates the literature on AI (Toorajipour et al. 2021) and new-technology adoption (Frank, Dalenogare, and Ayala 2019) to examine a host of related and unrelated factors inhibiting and facilitating the adoption of AI-enabled technologies in Africa. In addition, although some research has examined the challenges of scaling-up technologies such as inclusive information and communications technology, digital and financial access, and gender inclusion (see Asongu and Le Roux 2017; Asongu and Odhiambo 2018), these studies have thus far offered limited insight into AI-enabled technologies but also tend to examine this subject in a piecemeal manner leaving major vacuums in our understanding. Thus, our study provides a comprehensive analysis of both firm-level and external environmental factors, and thereby addresses this important void in the current literature. Furthermore, the present study contributes to the literature by offering an integrated framework that illuminates our understanding of the different pathways to adoption of AI-technologies in weak institutional environments.

The rest of this paper is organised as follows. The first section presents a review of the AI and new-technology literature towards the development of a conceptual framework. The next section then presents the pillars towards our integrated conceptual framework. The following section outlines the drivers and obstacles inherent in developing and scaling-up AI in Africa. In the final section, we outline the implications for theory and the policy-oriented focus for Africa.

2. Conceptual development

Defined as 'a system's ability to process data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation', AI continues to gather momentum across an array of industries in both developed and developing nations (Haenlein and Kaplan 2019; Wang, Teo, and Janssen 2021). AI is typified by machines acquiring knowledge to be able to perform functions, routines, and activities normally performed by humans in organisations. The level of intelligence can be acquired and elevated in organisations to boost performance of machines. In being trained as an 'intelligent agent', machines areable to scan the environment for cues and signals, and are then able to respond to them accordingly. A distinguishing characteristic of AI is that a machine's capability and ability to observe, evaluate, and respond to events in a timely manner and more 'accurately than a human, represents a competitive advantage' (Schmidt et al. 2021).

In this sense, AI consists of a constellation of technologies rather than a piece of hardware or software (Schmidt et al. 2021). AI includes machine learning, automation in business processes, facial-recognition technology, predictive analytics impacting on business processes, etc. It denotes the application of digital technologies and has led to innovations such as speech recognition, facial recognition, autonomous drones, self-driving cars, language-generating computer systems, and machine translation (see The Office for Artificial Intelligence 2020; Schmidt et al. 2021). According to the U.S. Department of State (2021), sustained global financial investments in AI have translated into life-changing breakthroughs in areas such as voice-assisted smartphones, mapping technologies, handwriting recognition, smart logistics, and language translation. Thus, these machine-based systems with potential to make predictions, can also deliver other benefits such as precision medicine, and education (U.S. Department of State 2021).

AI presents opportunities to incorporate machines into processes that allow them improve capability to optimise operations and improve their profitability via cost reduction (Webb 2021). The potential benefits that can be accrued from AI are no longer confined to large enterprises, but also extend to small and mid-size businesses. A large body of literature has demonstrated that AI can boost business performance via increased automation, which reduces errors and faulty product production relative to manual work (see Haenlein and Kaplan 2019). AI also has the potential to mitigate strategic misalignment via intelligent machines that are more likely to predict trends in consumers' behaviour and products/services that are more likely to appeal to particular groups of consumers. The advance in AI has been partially precipitated by advances in machine-learning algorithms, increasing ability to leverage new technologies to mobilise and analyse voluminous amounts of data, and the emergence of more powerful computers with greater processing power (World Bank 2021a, 2021b). Past studies have demonstrated that AI has the potential to yield better utilisation of limited resources and deliver more personalised services (Wang, Teo, and Janssen 2021).

In light of technological development and encroachment of AI in organisational decisions, one can differentiate AI-based decisions from human decision making. First of all, AI-based decision making is predicated on a well-defined decision search space with specific objective functions, capable of accommodating multiple alternative plans or scenarios (Shrestha, Ben-Menahem, and Von Krogh 2019). On the other hand, human decision making can incorporate a lightly defined decision search space and humans tend to have limited capacity to appraise multiple arrays of alternatives (Shrestha, Ben-Menahem, and Von Krogh 2019). Thus, decision-making speed tends to be relatively very slow compared with AI-based decision making.

Another differentiating characteristic that can be deduced is in the area of replicability of decisions. Whilst AI-based decisions are more replicable due to the standard computational procedure (Shrestha, Ben-Menahem, and Von Krogh 2019), human decision making is often subjected to factors such as bias, stereotypes, personal feelings, and emotional state. It is also worth noting that bias can also be fed into the computational procedure.

3. The evolution of Africa's development and ai

Over the last 20 years, Africa has seen an exponential growth in areas such as mobile phone adoption and access to

smartphones signifying the adoption and deployment of new technologies. Around 16% of Africa's one billion population have online access, and more than 720 million Africans have mobile phones, with many using their mobile for internet access (Manyika et al. 2013). Following the adoption of the African Continental Free Trade Area (AfCFTA) Agreement in 2018 and coming into effect in 2021, the easing of restrictions has culminated in increased intra-African trade and investment activities. Although Africa has always been considered rich when it comes to natural resources and human capital, it has often not fully lived up to its full potential in leveraging modern technologies. Scaling-up AI has made an invaluable contribution to boosting Africa's economic development in this century. According to Google and the International Finance Corporation, Africa's digital economy has the potential to reach $180 billion by 2025, accounting for 5.2% of the continent's gross domestic product (GDP) and increasing to $712 billion thus contributing 8.5% of the continent's GDP by 2050 (Google and IFC – International Finance Corporation 2020). Africa's digital economy encompasses cloud computing, cybersecurity, robotics, big-data analytics, blockchain, the Internet of Things, 3 D printing, biotechnology, energy storage, and AI (Travaly and Muvunyi 2020). Given that most sub-Saharan Africa (SSA) countries are predominantly commodity-export dependent nations, AI development provides an opportunity for nations to diversify their economies to facilitate the adoption and development of latest technologies. AI broadly encapsulates technologies that help to perform tasks and routines that previously required human interventions.

AI is not a single technology advancement (Schmidt et al. 2021) but rather a development of machine-based systems anchored in multiple technologies with potential to influence real and virtual environments (U.S. Department of State (2021). In 2019, Google launched its first Africa Artificial Intelligence (AAi) lab in Ghana's capital city, Accra, ushering in a new era for technological developments on the continent (Adeoye 2019). Besides, AI is also making a difference in areas such as farming where new technologies and phones have been adopted by farmers in countries such as Tanzania to help in diagnosing diseases affecting plants and strategies for boosting crop yields (Adeoye 2019). Across the continent farmers have adopted 'an AI-based smartphone app' that aids them in diagnosing crop diseases (Moyo 2021). The app by Agrix Tech has paved the way for some farmers to upload photos of ailing crops and fruit, which then utilises the image to diagnose the malady and suggest a course of treatment (Moyo 2021).

By developing artificial systems that possess a repertoire of intelligent behaviour, AI-encompassing smart devices have potential to alter the business environment in Africa. Prior to the COVID-19 pandemic, the 'commercial applications of AI were growing in emerging markets in industries such as manufacturing, energy, education, and accounting/financial services (Sonneborn and Graf 2020)'. The COVID-19 pandemic demonstrated the need for firms to seek new sources of competitiveness by investing in AI-enabled solutions and enduring innovations (Schmidt et al. 2021). Exacerbated by the waves of digitalisation and technology adoption, AI has played a pivotal role in the development of countries and as an avenue for improving firms' competitiveness in the twenty-first century.

3.1. Drivers of AI

Drawing on prior studies (e.g. Yip 2002), the potential drivers of AI can be conceptualised to include market, cost, social and industrial drivers. In view of the marketplace changes hastened by COVID-19, new-technology adoption has become a 'sine qua non' in enriching organisational competitiveness and survival (Amankwah-Amoah, Debrah, et al. 2021). Figure 1 depicts the extended conceptualisation of the internal and external barriers in Africa, with the shaded areas denoting the major pathways in how the barriers can curtail/foster AI development in the region.

3.1.1. Cost/efficiency drivers

The cost drivers of AI are vital in the sense that an AI-oriented approach to product development has potential for cost-effective products and to deliver timely integrated competitive moves for firms across multiple markets. The value-adding effect can manifest via improved quality of products and minimisation of errors in manual processes, and ensure greater consistency in design and production. For instance, facial-recognition technology can be adopted to improve firm security especially in highly sensitive areas of the businesses (Amankwah-Amoah 2021; Anwarul and Dahiya 2020). Such technology can also be infused into nations' electoral processes to help strengthen security. By adopting AI via facial-recognition technologies to protect sensitive data, it also has the potential to transform workplaces as well as reducing the cost of employing security personnel. The potential cost saving in highly sensitive areas can also be a real saving for organisations. Leveraging AI to eliminate repetitive tasks and some manual labour can create space and time for individuals to become more innovative and focus more on non-repetitive activities. Many of these valuable insights have been associated with the ability to access such technologies.

AI is now at the cornerstone of firms' market competitiveness which emphasises reshaping traditional sources of market advantage, development of new products, and reimagining the whole value chain of the firm that delivers profitability and sustainability. AI has the potential to provide creative solutions to organisational problems. Thus, firms can minimise errors by utilising 'machine learning whereby the software can detect flaws in your product and allow you to correct them before they reach the customer' (McRorey 2021). Due to technology obsolescence and inability to capitalise on AI, firms are likely to gradually withdraw from markets and lose their market competitiveness. Firms are increasingly scanning and scrutinising their environment for new technologies that allow them to achieve greater efficiency. AI technology has the potential to give businesses

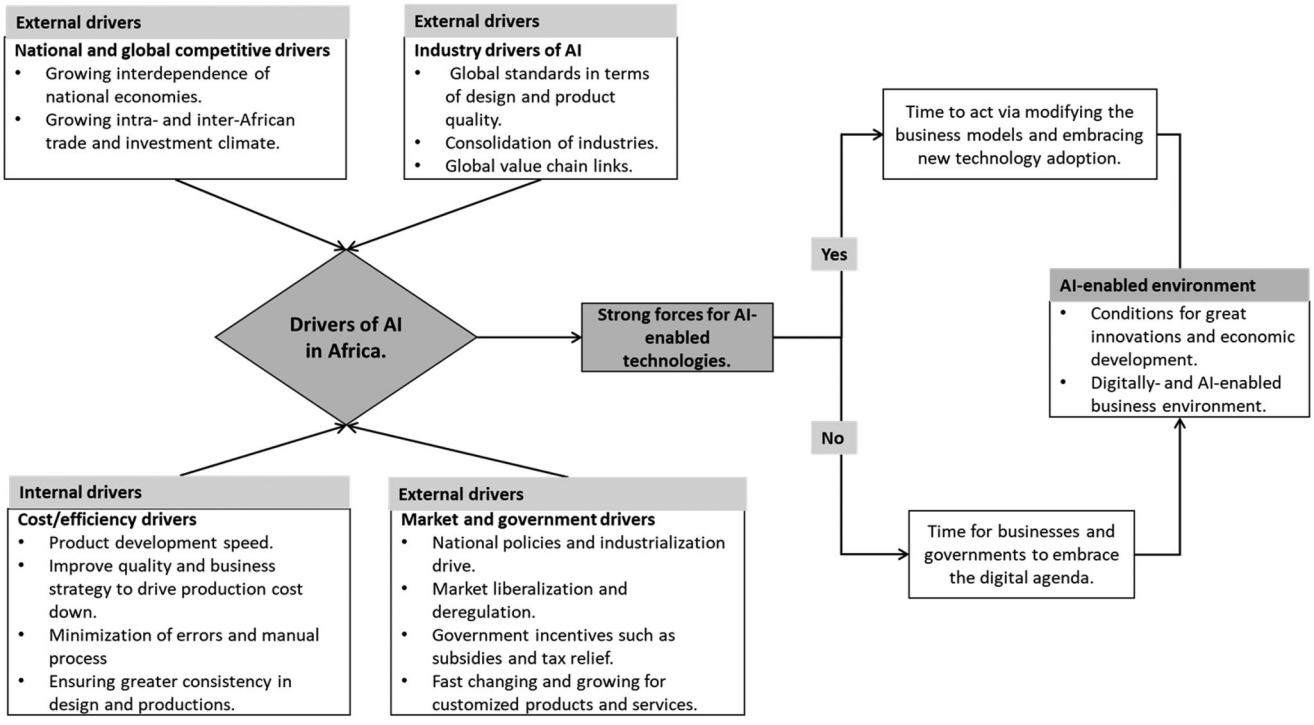


Figure 1. Drivers of AI in Africa.

greater visibility and increase transparency in locations of products. It is increasingly apparent that AI tools and analytics are today's recipe for firms seeking to outcompete rivals by infusing technology and machines in vital aspects of business functions.

3.1.2. Market drivers

In relation to the market drivers for AI, there are factors such as fast-changing and growing needs of customers for customised products and services that lend themselves to AI-enabled solutions. In addition, the global embrace of AI in industrial processes as Pillars of Industry 4.0 also demands realignment by local firms to elevate their standards as well as being better able to tap into the global value chain. For African companies, there is also a pressure to realign their processes and models in line with global standards in terms of design and product quality. One of the drivers of AI is the desire for foreign firms to establish and/or expand their footprint in Africa. In 2019 Google managed to open its first African-based AI research centre in Ghana, however, the AI ecosystem urban infrastructure in Africa remains an obstacle to sustained development and investment in Africa (Ford 2017). African entrepreneurs also face major regulatory burdens pertaining to starting a company, poor record keeping and documentation at government level, business processes, and systems of operating, coupled with the supply chains which can be buttressed with AI-enabled technologies to improve efficiency.

To summarise, as shown in Figure 1, from an external point of view, the development or implementation of AI could be driven by national and global competition; industry development such as standardisation of product design, consolidation of industries, or the impact of global value chain; forces from market and government such as deregulation, subsidies and growing demands for customised products and services. It could also be driven from the internal side, such as the desire to improve cost and efficiency through minimising errors and manual process, improving quality and product development speed, or ensuring consistency in design and productions. It is time for businesses to embrace the digital agenda or modify business models, and it is also time for stakeholders to create an AI-enabled environment and better conditions for great innovation and economic development.

3.1.3. Social drivers

AI has the potential to enhance productivity, improve national and local power grid systems, as well as aiding medical professionals including doctors to diagnose diseases and monitor patients with severe health conditions. For instance, in Rwanda, AI technology has been used to power drones to deliver medical supplies to remote and isolated communities (Moyo 2021), thereby overcoming the major obstacles associated with infrastructure constraints such as road/railway/flight connectivity, and poor telecommunications services that often hamper economic activities and development in rural areas. Taken together, the drivers for AI in Africa can be divided into internal/organisational and external drivers. Table 1 summarises a potentially different range of drivers of AI adoption across industrial sectors. In the area of healthcare, AI via machine-learning system capabilities can be

Table 1. Summary of drivers and challenges.

Spectrum of key sectors	Drivers of application of AI
Healthcare	• To foster the development of drugs, diagnosis of diseases and supports for surgeons/doctors in their work. • AI as forecasting tool for some diseases. • Application of facial technologies to detect diseases.
Framing/agriculture	• Aid farmers in diagnosing crop diseases, monitor land area and help improve plant yields. • The use of robots for precision farming to reduce application of pesticides.
Education	• Harnessing robots for language learning and delivering more targeted support for learning. • Developing tools for remote learning and improving access to education. • Harnessing AI to monitor and assess learners.
Energy	• Smart hydro-electric and power national grid system underpinned by AI. • Adoption of smart technologies including energy metres. • Remote-control devices, energy-conservation devices and delivery of sustainable production.
Transport and logistics	• Applications of AI to monitor and report errors, automation in processing products and transport.
Government and public services	• Facial-verification system for citizens. • Machine-learning algorithms for improving citizen–government interaction.
Production and manufacturing	• Autonomous robots for new product development and use of driverless vehicles. • Potential to help detect manufacturing errors and equipment breakdowns. • Automation of design and development system. • Image-recognition technology for advanced security. • To develop digital twin of products. • Machine-learning algorithms approach to product development. • Economic and social gains from self-driving cars and self-administered production unit.
Staffing and HR management	• AI as hiring tool – leveraging machine learning tools can help to optimise and link job description features to applicants' CVs.
Other functional areas	• Design and deliver customised products. • Potential in cloud-based computing and accounting. • AI-enabled customised marketing communication and campaigns.

Data sources: synthesised by the authors from diverse range of sources including: Amankwah-Amoah 2021; Amankwah-Amoah, Debrah, et al. 2021, Amankwah-Amoah, Khan, and Wood 2021; Arakpogun et al. 2020; Adegbile, Sarpong, and Kolade 2021; Asongu and Le Roux 2017; Dutton 2021; Ford 2017; Fountaine, McCarthy, and Saleh 2021; Haenlein and Kaplan 2019; Manyika et al. 2013; McRorey 2021; Moyo 2021; World Bank 2021a, 2021b.

developed to help in diagnosing diseases, and recognizing/detecting symptoms, thereby helping to reduce mortality rates across rural areas and in some cities. Such AI-based approaches also have potential to reduce error in diagnoses and improve patient safety.

3.2. Barriers to AI-enabled technology adoption in Africa

Besides the drivers outlined, there are also both internal and external barriers that impede the adoption and scaling up of AI.

3.2.1. Institutional constraints, and weak intellectual property protection

Following North's (1990) insightful work, institutions are defined as the 'rules of the game' that govern behaviours and elucidate incentives within a society for behavioural change. Another obstacle to doing business and fostering the development of AI is weak intellectual property protection. Across the continent, enforcement of copyright rules related to music, video and image production and computer software remains weak. AI and technological advances often flourish in countries with some degree of high-level protection for intellectual property protection. However, the mechanisms for enforcing the rule of law in much of sub-Saharan Africa remains weak. These are likely to disincentivize investments in AI-oriented technology. In a recent World Bank Report, only two Sub-Saharan African economies: Mauritius and Rwanda, were ranked in the top 50 global economies for ease of doing business (World Bank 2020). Indeed, 'a lack of flexible and dynamic regulatory systems also frustrates the growth of a digital ecosystem that favors AI technology, especially as tech leaders want to scale across borders' (Travaly and Muvunyi 2020). The often bureaucratic and sluggish law-enforcement mechanism related to unlawful copying also serves as an obstacle to the development. Besides lagging behind China and developed countries rivals, African nations require strong regulatory environment to help offset some of negatives linked to weak protection of intellectual property.

3.2.2. Institutional dysfunction

In the past 20 years, Africa's economy has seen a sharp surge in investments from many emerging nations including China, Brazil, and India. This has provided much-needed funding in sectors such as infrastructure development in the likes of Kenya and Ethiopia, in fact China's Eximbank offered Ethiopia a $2.5bn loan for the development of a standard-gauge railway (see Pilling 2021). These investments have largely delivered improvements in living standards and transportation links which are essential for economic development. In the agricultural sector, for instance, small-scale farmers and SMEs in Africa need to overcome huge infrastructure hurdles in order to develop and flourish. This is more so for those in remote regions and areas outside the cities where road transportation can be hampered by poor road maintenance coupled with unreliable/non-existent rail services and poor internet access, thereby leaving small businesses and farmers with few options for transporting their produce.

Although Africa accounts for over 60% of the global uncultivated arable land and the agricultural sector employs

around two-thirds of the continent's working population, very few farmers rely on scientific data-driven approaches to decision-making and strategies (Dutton 2021). There is also a lack of extensive crop data which has prompted some individuals and businesses to adopt aerial imagery and drone technologies, such as the Aeroview mobile phone platform, to help them assess the characteristics of the plants which are difficult to assess with the naked eye to help save time and reduce a protracted process (Dutton 2021). This AI and drone-integrated approach buttressed by agronomists, engineers, developers, and customer service experts to aid farm yield management has now been adopted in over 18 countries, culminating in increased production, productivity, and profitability (Dutton 2021). For instance, 'in Mozambique, the app Hello Tractor, which lets farmers share equipment, is leveraging machine learning to predict crop yields. And in Kenya, banking service M-Shwari relies on AI to review online loan applications, helping it to field entreaties from customers who live far from bank branches' (Moyo 2021). Greater global digital connectivity can go a long way in buttressing these types of development. Buoyed by growth in telecommunications access, there is a template that enhances access to AI-enabling technologies that can help foster the development of new industries and enterprises. Indeed, 'inadequate basic and digital infrastructure seriously erodes efforts to activate AI-powered solutions as it reduces crucial connectivity' (Travaly and Muvunyi 2020).

3.2.3. Underinvestment in nurturing and attracting top talent for AI development

Studying institutional dysfunction in Africa is also compatible with weak government support for digital and AI-enabled skills-formation activities. Infrastructure that supports human capital development, data preservation, and mining and hardware are essential in leveraging AI in a spectrum of technologies such as 5 G, quantum computing, biotechnology, advanced networking, autonomy and robotics, advanced and additive manufacturing, and energy systems to underpin national policies and many business processes (Schmidt et al. 2021). As demonstrated by Ashok et al. (2022), the development of AI technologies and digital technologies (DT) has historically been typified by a 'purview' of a few highly skilled individuals across functional areas including engineers, scientists, programmers, and architects. One of the challenges facing Africa in developing and leveraging AI is a paucity of specialised talent coupled with a lack of access to the latest global technology. There are very few AI researchers across the continent (Russon 2019). To foster new-venture creations in AI, there is a need for greater access to high-quality education, and access to IT to educate the future workforce as well as the next generation of tech leaders. Many global companies have led the efforts to overcome these obstacles including Google, IBM Research, Microsoft, and Amazon, which have all started AI labs in the continent, thereby contributing to the development of AI researchers and research in Africa (Candelon, Bedraoui, and Maher 2021).

Moreover, 'lack of relevant technical skills, particularly for young people, is a growing threat … preventing the continent from harnessing the full potential of transformative technologies and industries' (Travaly and Muvunyi 2020, nd). For Africa, AI represents a major opportunity to leapfrog into the twenty-first century via adoption of modern technologies in manufacturing and new product development. This means creating a more intensive research and innovation culture that focuses on developing new knowledge but also translation and application of research to industrial application. Another major challenge in technology adoption is the lack of financial credit availability, thereby making upfront costs to many technologies an insurmountable hurdle to overcome. This infrastructure obstacle is intertwined with financial obstacles which hamper expensive technology adoption.

According to the Global System for Mobile Communications Association's (GSMA) report (2020), mobile internet connectivity and mobile internet adoption in 2019 was around 26% in sub-Saharan Africa, which is far below the level needed for robust take-off of new technological innovations. As demonstrated by some scholars, the fourth industrial revolution (i.e. Industry 4.0) is predicated on the adoption of smart manufacturing techniques and digital technologies to mobilise real-time data (Frank, Dalenogare, and Ayala 2019), thus making the adoption of digital technologies even more crucial for Africa's development in the twenty-first century. Yet around 40% of the African population have access to the internet relative to 95% in North America and 87% in Europe, thus lacking reliable internet infrastructure and affordable data, Africa's digital divide is likely to be worsened by the growth and adoption of AI (Candelon, Bedraoui, and Maher 2021). This lack of progress has been hampered by factors such as lack of digital literacy skills, lack of awareness, affordability, and digital divide between cities and rural populations (GSMA Association 2020). Figure 2 demonstrates the obstacles to AI-enabled technology adoption and approaches towards amplifying AI effects in Africa.

3.2.4. Limited R&D activities

According to the United Nations Educational, Scientific and Cultural Organisation (UNESCO) science report, in 2014 the 42 nations in sub-Saharan Africa (SSA) accounted for around 1.4% of the global share of scientific publications and 1.2% in 2008 (UNESCO 2014). The underinvestment in research activities and lack of effective training of the next generation of researchers has contributed to the root cause of the current predicament. Moreover, in 2018 sub-Saharan Africa accounted for 14% of the world's population but a mere 0.7% of the world's researchers (UNESCO 2021). It is apparent that lack of adequate investment in research and development is a major stumbling block in ushering in a new environment for AI development (Travaly and Muvunyi 2020). Buttressed by investment in training, technological adoption, and investment in technological infrastructure, Africa has huge potential to capture a greater share of the world economy. It is well established that AI technological advancement has largely occurred in advanced economies typified by a highly skilled workforce, intensive research and development activities, and access to financial

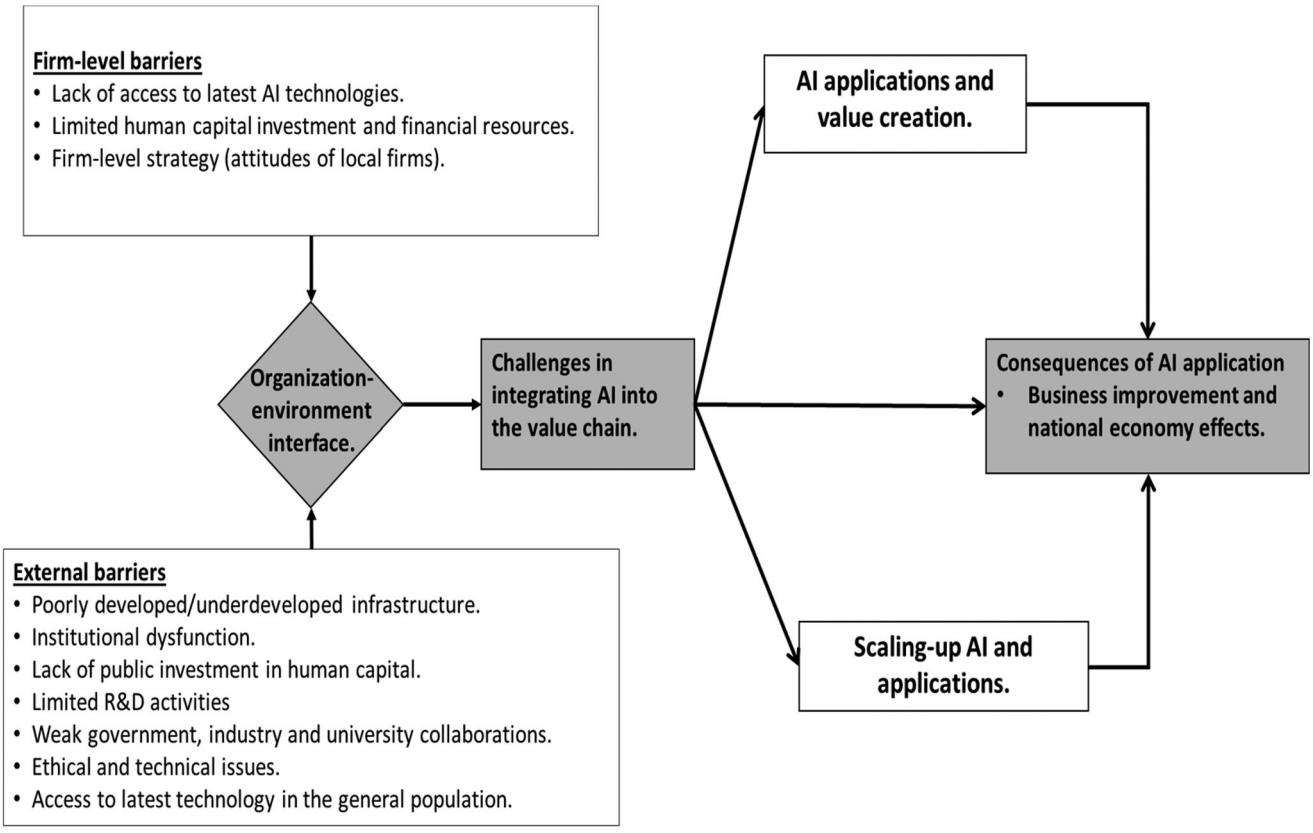


Figure 2. A model towards obstacles to AI in Africa.

capital for investment in new technologies (World Bank 2021a, 2021b). To achieve this means that governments need to shift away from current poorly funded research activities that have often hampered scientific development on the continent to more human capital and skills development activities that focus on nurturing the new generation of academics.

3.2.5. Ethical and technical issues in AI-enabled technologies

In recent times, it has become increasingly apparent that technological bias or biases are often built into AI systems. For instance, facial-recognition systems that work less well or are inaccurate for darker-skinned people, and more so darker-skinned women, are likely to lead to false conclusions when used in business processes and decisions (NPR 2019). Indeed, in many sectors, voice-recognition systems tend to perform poorly with people with accents. In addition, some systems also perform better in detecting male-sounding voices relative to female-sounding voices (NPR 2019). It has also been demonstrated that some emotion-detection tools also tend to assign more negative emotions to black men's faces than white men's faces (NPR 2019). For small and weak nations, the 'commercially available AI applications ranging from 'deepfakes' to lethal drones' also possess threats not only to nation states but also provide opportunities for criminals and illegitimate activities to manifest (Schmidt et al. 2021). Thus, deepfakes pose a risk to accountability and reliability of information, and spread of misinformation to the public.

3.2.6. Attitudes of local firms

One of the fundamental challenges that Africa faces in deploying AI is that many of Africa's large companies are employing AI-enabled technologies only in limited ways and crucially 'are not zealously championing the cause of AI or deploying AI applications widely, causing them to trail behind global rivals. The few that have invested in AI have incurred above-average costs because they have imported talent and technology' (Candelon, Bedraoui, and Maher 2021, nd). Compared to the rise and expansion of Western and Asian multinational enterprises (MNEs), African MNEs have historically lagged behind and are yet to capitalise fully on the region's rich human and natural resources to become highly innovative organisations. In this fast-changing business environment precipitated by COVID-19, achieving higher levels of industrialisation and innovation activities would require businesses and governments to invest in human capital and new technologies. Lack of investment in AI-oriented human capital via training (i.e. local, regional, national, and continental levels) by local firms often hamper their market competitiveness. In a similar vein, small and medium enterprises (SMEs) are also a quintessential element in achieving the global inclusive growth and poverty alleviation (World Bank 2021a, 2021b). Globally, SMEs account for around 90% of businesses and over 50% of global employment (World Bank 2021a, 2021b). AI is transforming not only the competitive landscape of firms but altering the competitiveness of nations. Although SMEs can be harnessed for AI development in Africa, there is often a substantial degree of uncertainty surrounding the risk of

financial resource investments in AI technologies by such firms. Thus, such investments might not yield enough benefits in the short-term for their survival.

4. Discussion and conclusions

This study set out to extend prior scholarly works by examining the drivers and constraints in scaling-up and fostering greater development of AI in Africa. In an attempt to elucidate the features of the subjects, a unified framework (see Figure 1) was advanced to outline the features and dynamics of AI developments and challenges. This article-proposed model elucidates the range of external drivers encompassing competitive drivers, and market and industry drivers of AI. The internal organisational drivers include costs and innovation such as the potential to enhance product-development speed, improve quality, drive production costs down, and minimise errors and manual process. The analysis revealed some internal and external barriers to AI adoption such as limited skill formation, institutional dysfunction, poor infrastructure to support development of large-scale AI, lack of skilled AI experts, and lack of access to latest technologies in addition to curtailing wider local and adoption of AI-enabled technologies.

4.1. Theoretical implications

The present research makes some pivotal contributions to the current AI literature. First, in spite of the growing recognition that development of new industries and new-business development is increasingly predicated on the adoption of new technologies (Krasniqi and Hajrizi 2016), there is a paucity of studies examining contemporary challenges faced by developing nations and their inability to capitalise on such ample and obvious opportunities. Although previous studies have elevated our understanding of AI and AI applications (Ashok et al. 2022; Haenlein and Kaplan 2019), these studies have failed to account for institutional variations in different countries/regions that might impede or facilitate development of AI. In this direction, this study addresses this lacuna by developing and highlighting the deep insights of institutional, organisational, environmental, and market barriers in fostering greater adoption of AI-enabled technologies in an institutionally voided environment of Africa.

In addition, our study also yielded a richer and deeper understanding of AI and challenges confronting some emerging economies in elevating their performance via new-technology adoption geared towards business development. In this direction, a conceptual model is offered outlining the obstacles to AI adoption and how these can be overcome. The conceptual framework offers a pathway to better conceptualise and understand the different range of obstacles/challenges confronting developing nations in ushering in an environment that fosters the adoption and development of AI-enabled technologies. Another void in the current and growing literature on AI is on how firms can harness it to enhance their market competitiveness in an institutionally voided environment. Thus, we shed light on how AI potential gains can be further amplified and delivered.

4.2. Practical implications

From a practical standpoint, the analysis suggests that there is a vital role for developing an AI ecosystem that focuses on linking universities, governments, and businesses in forging collaborations to develop and share expertise geared towards the development of the next generation of tech savvy Africans in all corners of the continent (see also Adegbile, Sarpong, and Kolade 2021). In light of increasing interest in AI-enabled technologies (Ashok et al. 2022), there is a need for robust investment in the sector. Much of the potential success in scaling-up AI-enabled technology adoption in Africa partly hinges on the ability to boost ICT educational attainment and provision of a conducive business environment for new technologies. For African nations seeking to leap forward in the twenty-first century, substantial financial resources and human capital investment towards creating digitally literate workers and labour markets is needed to create the enabling environment that facilitates the development of AI. Given the potential biases built into AI systems, development of systems must incorporate robust principles of fairness, accountability, and accuracy in data collection and data use.

Beyond the important ramifications alluded to above, to capture the advantages of AI requires countries to prioritise research and development (R&D) fully which requires intensive research activities at national universities geared towards industrial uses and connecting industries and universities. The analysis vividly demonstrates that there is a need to bridge the industry–university links by creating an atmosphere that allows local universities to benefit from their collaborations and engagement with local and global businesses. The application and utilisation of AI has the potential to foster innovations and create the foundation for new waves of manufacturing activities and technological development on the continent. The present study contributes to practice by re-emphasising that enhanced public access to ICT in specialised public ventures such as libraries can also amplify the opportunities for leaning and help create a mass development of digital skills for AI take-off. In addition, connecting innovation capabilities (CIC) of SMEs via joint research and investment activities could amplify their strengthening and ability to tap into the opportunities offered by AI. Indeed, effective new industrialisation policies and poverty eradication efforts in Africa are partly predicated on the ability to harness new technologies including AI-enabled technologies in both the public and private sectors.

Just as other technologies, the impact of developing and implementing AI could have two sides. In one way it could improve the welfare of the humankind, while on the other hand it could potentially harm the environment and ethics standards of our society. AI could vastly improve productivity so industries with heavier environment impacts could affect the environment even more with the help of AI. AI enables

corporations to collect, process, store large amounts of information, including personal information, such as purchasing preferences, which could potentially invade individual spaces and raise red flags on privacy. Vital stakeholders including government, businesses, and developers of technologies shall work together to encourage benign technical tools and make sure that technologies are used for justifiable causes.

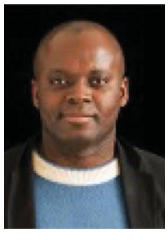
4.3. Limitations and directions for future research

Notwithstanding the vital contributions above, there are some caveats in interpreting the observations outlined above. One potential limitation of the analysis is the limited focus on individual countries. In addition, the paper offers a more generalised picture of the emerging trend. This offers a fruitful avenue for future studies to shed light on country-specific factors such as traditions, tribes, customs, and norms that may prohibit AI adoption and acceptance within wider society. Another interesting domain for future research is the examination of AI adoption in multiple government-owned businesses illustrating the evolution of AI, its adoption and implications for the focal organisation. Additional research is needed to investigate the effects of public investment in innovating and simultaneously overcoming the institutional dysfunctions, poor infrastructure, and lack of skilled AI experts that often impinge on the adoption of the new technologies. Another logical next step for future research in this area would be to examine how non-government or non-profit organisations can leverage AI to monitor their activities around the globe. This has the potential to minimise both human and financial resource utilisation. Future studies could also elucidate the role of non-governmental organisations in fostering the development and spread of ethical AI. Recent development in this domain has raised a number of potential unethical applications of AI and thus such organisations have played, and can continue to play, a pivotal role in ushering in greater emphasis on ethics. It is also worth noting that computers and robots are not necessarily replacing all human interventions but rather require different levels of engagement as old jobs are replaced by new ones.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributors



Dr. Joseph Amankwah-Amoah is a multi-award-winning Professor of International Business at the University of Kent, UK. Joseph has consistently published in many journals of international repute, including Journal of World Business, British Journal of Management, Industrial and Corporate Change, Business History, Long Range Planning, International Business Review, Journal of Institutional Economics, Technological Forecasting and Social Change, International Journal of Human Resource Management, Journal of International Management, Decision Support Systems, Management International Review, Thunderbird International Business Review, R&D Management, Business Strategy and the Environment, Transportation Research Part E, Computers in Industry, Journal of Rural Studies, Group and Organisation Management, International Journal of Production Economics, IEEE Transactions on Engineering Management and Journal of Business Research. In all, he has published over 130 articles in leading journals. Joseph was included in both 2020 and 2021 editions of Stanford University's prestigious list of the World Top 2% scientists for citation impact during the single calendar year.

Dr. Yingfa Lu studied at Nankai, Nanjing and Edinburgh universities. He taught at the University of Bristol and was a visiting fellow at the University of Oxford. Yingfa is a CPA and qualified in law. Yingfa Lu's research focuses on auditing, accounting and corporate governance, particularly audit quality, regulation, accounting profession, legal liability of business professionals, and accounting history. He uses both qualitative and quantitative methods, and is also interested in trying new methodology, such conducting experiment and making use of biometers.

ORCID

Joseph Amankwah-Amoah http://orcid.org/0000-0003-0383-5831

References

Adegbile, A. S., D. Sarpong, and O. Kolade. 2021. "Environments for Joint University-Industry Laboratories (JUIL): Micro-Level Dimensions and Research Implications." *Technological Forecasting and Social Change* 170: 120888. doi:10.1016/j.techfore.2021.120888.

Adeoye, A. 2019. "Google has opened its first Africa Artificial Intelligence lab in Ghana." https://edition.cnn.com/2019/04/14/africa/google-ai-center-accra-intl/index.html.

Amankwah-Amoah, J. 2020a. "Note: Mayday, Mayday, Mayday! Responding to Environmental Shocks: Insights on Global Airlines' Responses to COVID-19." *Transportation Research Part E: Logistics and Transportation Review* 143: 102098. doi:10.1016/j.tre.2020.102098.

Amankwah-Amoah, J. 2020b. "Stepping up and Stepping Out of COVID-19: New Challenges for Environmental Sustainability Policies in the Global Airline Industry." *Journal of Cleaner Production* 271: 123000. doi:10.1016/j.jclepro.2020.123000.

Amankwah-Amoah, J. 2021. "COVID-19 Pandemic and Innovation Activities in the Global Airline Industry: A Review." *Environment International* 156: 106719. doi:10.1016/j.envint.2021.106719.

Amankwah-Amoah, J., Y. A. Debrah, W. Yu, Z. Lin, A. Danso, and S. Adomako. 2021. "Technology Strategies in Emerging Economies: Emerging Issues, Challenges and New Research Agenda." *Technological Forecasting and Social Change* 170: 120881. doi:10.1016/j.techfore.2021.120881.

Amankwah-Amoah, J., Z. Khan, and G. Wood. 2021. "COVID-19 and Business Failures: The Paradoxes of Experience, Scale, and Scope for Theory and Practice." *European Management Journal* 39 (2): 179–184. doi:10.1016/j.emj.2020.09.002.

Amankwah-Amoah, J., Z. Khan, G. Wood, and G. Knight. 2021. "COVID-19 and Digitalization: The Great Acceleration." *Journal of Business Research* 136: 602–611. doi:10.1016/j.jbusres.2021.08.011.

Anwarul, S., and S. Dahiya. 2020. "A Comprehensive Review on Face Recognition Methods and Factors Affecting Facial Recognition Accuracy." *Proceedings of ICRIC 2019*: 2019, 495–514.

Arakpogun, E. O., Z. Elsahn, R. B. Nyuur, and F. Olan. 2020. "Threading the Needle of the Digital Divide in Africa: The Barriers and Mitigations of Infrastructure Sharing." *Technological Forecasting and Social Change* 161: 120263. doi:10.1016/j.techfore.2020.120263.

Ashok, M., R. Madan, A. Joha, and U. Sivarajah. 2022. "Ethical Framework for Artificial Intelligence and Digital Technologies." *International Journal of Information Management* 62: 102433. doi:10.1016/j.ijinfomgt.2021.102433.

Asongu, S. A., and S. Le Roux. 2017. "Enhancing ICT for Inclusive Human Development in Sub-Saharan Africa." *Technological Forecasting and Social Change* 118: 44–54. doi:10.1016/j.techfore.2017.01.026.

Asongu, S. A., and N. M. Odhiambo. 2018. "ICT, Financial Access and Gender Inclusion in the Formal Economic Sector: Evidence from Africa." *African Finance Journal* 20 (2): 45–65.

Asongu, S. A., A. Adegboye, J. Ejemeyovwi, and O. Umukoro. 2021. "The Mobile Phone Technology, Gender Inclusive Education and Public Accountability in Sub-Saharan Africa." *Telecommunications Policy* 45 (4): 102108. doi:10.1016/j.telpol.2021.102108.

Baabdullah, A. M., A. A. Alalwan, E. L. Slade, R. Raman, and K. F. Khatatneh. 2021. "SMEs and Artificial Intelligence (AI): Antecedents and Consequences of AI-Based B2B Practices." *Industrial Marketing Management* 98: 255–270. doi:10.1016/j.indmarman.2021.09.003.

Candelon, F., H. E. Bedraoui, and H. Maher. 2021. "Developing an Artificial Intelligence for Africa Strategy." https://oecd-development-matters.org/2021/02/09/developing-an-artificial-intelligence-for-africa-strategy/.

Dutton, J. 2021. "Drones and AI Move Africa's Farmers to Greener Pastures." *African Business* 482: 50–51.

Ford, N. 2017. "Africa's Urban Infrastructure Challenge." *African Business* 440: 34–35.

Fountaine, T., B. McCarthy, and T. Saleh. 2021. "Getting AI to Scale." *Harvard Business Review* 99 (3): 116–123.

Frank, A. G., L. S. Dalenogare, and N. F. Ayala. 2019. "Industry 4.0 Technologies: Implementation Patterns in Manufacturing Companies." *International Journal of Production Economics* 210: 15–26. doi:10.1016/j.ijpe.2019.01.004.

Google and IFC – International Finance Corporation 2020. *e-Conomy Africa 2020: Africa's $180 Billion Internet Economy Future*. Mountain View, CA; Washington, DC: Google and International Finance Corporation.

GSM Association. 2020. "The State of Mobile Internet Connectivity 2020." https://www.gsma.com/r/wp-content/uploads/2020/09/GSMA-State-of-Mobile-Internet-Connectivity-Report-2020.pdf.

Haenlein, M., and A. Kaplan. 2019. "A Brief History of Artificial Intelligence: On the past, Present, and Future of Artificial Intelligence." *California Management Review* 61 (4): 5–14. doi:10.1177/0008125619864925.

Krasniqi, X., and E. Hajrizi. 2016. "Use of IoT Technology to Drive the Automotive Industry from Connected to Full Autonomous Vehicles." *IFAC-PapersOnLine* 49 (29): 269–274. doi:10.1016/j.ifacol.2016.11.078.

Manyika, J., J. Cabral, L. Moodley, S. Moraje, S. Yeboah-Amankwah, M. Chui, and J. Anthonyrajah. 2013. *Lions Go Digital: The Internet's Transformative Potential in Africa*. McKinsey & Company.

McRorey, L. 2021. "Five Ways AI Can Take Small Businesses to the Next Level." https://www.forbes.com/sites/forbestechcouncil/2021/06/10/five-ways-ai-can-take-small-businesses-to-the-next-level/?sh=2c02dd6f7a53.

Moyo, M.-J. 2021. "The Very Real Benefits of AI in Africa." *African Business* 482: 52–53.

North, D. C. 1990. *Institutions, Institutional Change and Economic Performance*. Cambridge: Cambridge University Press.

NPR 2019. "Artificial Intelligence Can Make Our Lives Easier, But It Can Also Go Awry." Accessed 8 October 2021. https://www.npr.org/2019/05/06/720800666/artificial-intelligence-can-make-our-lives-easier-but-it-can-also-go-awry.

Pilling, D. 2021. "Two Ethiopian Projects Show 'Railpolitik' in Action." https://www.ft.com/content/cc1dc93d-d3d0-4728-8521-14734199c58d.

PWC. 2019. "Sizing the Prize: What's the Real Value of AI for Your Business and How Can You Capitalise?" Accessed 16 October 2021. https://www.pwc.com/gx/en/issues/analytics/assets/pwc-ai-analysis-sizing-the-prize-report.pdf

Russon, M.-A. 2019. "The Push Towards Artificial Intelligence in Africa." https://www.bbc.co.uk/news/business-48139212.

Schmidt, E., B. Work, S. Catz, S. Chien, C. Darby, A. Moore, K. Ford, et al. 2021. *National Security Commission on Artificial Intelligence (AI)*. Arlington, VA: National Security Commission on Artificial Intelligence.

Shrestha, Y. R., S. M. Ben-Menahem, and G. Von Krogh. 2019. "Organizational Decision-Making Structures in the Age of Artificial Intelligence." *California Management Review* 61 (4): 66–83. doi:10.1177/0008125619862257.

Sonneborn, W, and L. Graf. 2020. "How AI Can Help Developing Countries Rebuild After the Pandemic." https://blogs.worldbank.org/digital-development/how-ai-can-help-developing-countries-rebuild-after-pandemic.

The Office for Artificial Intelligence. 2020. *A Guide to Using Artificial Intelligence in the Public Sector*. London: Office for Artificial Intelligence

Toorajipour, R., V. Sohrabpour, A. Nazarpour, P. Oghazi, and M. Fischl. 2021. "Artificial Intelligence in Supply Chain Management: A Systematic Literature Review." *Journal of Business Research* 122: 502–517. doi:10.1016/j.jbusres.2020.09.009.

Travaly, Y, and K. Muvunyi. 2020. *The Future is Intelligent: Harnessing the Potential of Artificial Intelligence in Africa*. Washington, DC: Brookings Institute. httpshttps://www.brookings.edu/blog/africa-in-focus/2020/01/13/the-future-is-intelligent-harnessing-the-potential-of-artificial-intelligence-in-africa/.

U.S. Department of State. 2021. "Artificial Intelligence (AI)." Accessed 9 October 2021. https://www.state.gov/artificial-intelligence/.

UNESCO. 2014. *UNESCO Science Report*. Paris: UNESCO Publishing.

UNESCO. 2021. *UNESCO Science Report: The Race Against Time for Smarter Development*. Edited by S. Schneegans, T. Straza and J. Lewis. Paris: UNESCO Publishing.

Wang, C., T. S. Teo, and M. Janssen. 2021. "Public and Private Value Creation Using Artificial Intelligence: An Empirical Study of AI Voice Robot Users in Chinese Public Sector." *International Journal of Information Management* 61: 102401. doi:10.1016/j.ijinfomgt.2021.102401.

Webb, G. 2021. "Why It's Time Small and Midsize Businesses Embrace the AI Revolution." Accessed 8 October 21. https://www.fastcompany.com/90680614/why-its-time-small-and-midsize-businesses-embrace-the-ai-revolution.

World Bank. 2021a. "Small and Medium Enterprises (SMEs) Finance: Improving SMEs' Access to Finance and Finding Innovative Solutions to Unlock Sources of Capital." https://www.worldbank.org/en/topic/smefinance

World Bank. 2021b. *Harnessing Artificial Intelligence for Development on the Post-COVID-19 Era: A Review of National AI Strategies and Policies. Analytical Insights*. Washington, DC: World Bank.

World Bank. 2020. *Doing Business 2020*. Washington, DC: World Bank.

Worldometers. 2021. "Regions in the World by Population (2021)." Accessed 10 Ocotber 2021. https://www.worldometers.info/world-population/population-by-region/.

Worldometers. 2022. "Coronavirus Cases." Accessed 10 February 2022. https://www.worldometers.info/coronavirus/.

Wright, P. M., B. B. Dunford, and S. A. Snell. 2001. "Human Resources and the Resource Based View of the Firm." *Journal of Management* 27 (6): 701–721. doi:10.1177/014920630102700607.

Wright, P. M., G. C. McMahan, and A. McWilliams. 1994. "Human Resources and Sustained Competitive Advantage: A Resource-Based Perspective." *The International Journal of Human Resource Management* 5 (2): 301–326. doi:10.1080/0958519 9400000020.

Yip, G. S. 2002. *Total Global Strategy II*. Upper Saddle River, NJ: Prentice Hall.